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EDITORIAL

DEVELOPING THE SOPHISTICATION OF LISTENING IN ORGANISATIONS

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The critical impact of effective leaders listening in healthcare organisations is fundamentally about gathering and gaining operational intelligence from within the organisation. This core operational capability correlates with improved care and effectiveness across patient safety and clinical risk; quality and patient/resident outcomes; workforce sustainability; improvement innovation; and organisational resilience. Listening within organisations has become a hallmark of organisational capability, enabling leaders and managers to acquire operational intelligence. Comprehensive listening extends beyond providing staff and followers opportunities to speak, as it requires a comprehensive organisational capability (irrespective of, but proportional to, the size of the organisation). Annual surveys, suggestion schemes, and speak-up mechanisms provide valuable channels to hear feedback and enhanced listening approaches demonstrate a progressive and effective connection to those who make up and enable health organisations.

The listening paradox describes the tension between speakers' perceptions and listeners' experiences [1], with leader and manager listening most operationally valuable when information is difficult, challenging, or inconsistent with current assumptions. In these precise situations, listening places the greatest cognitive and emotional demands on leaders.

Developing listening maturity and capability in a health organisation enables a shift from episodic listening to relational, and then organisational, levels of maturity.

Employee voice needs to be an organisational capability, with systematic eliciting, collecting, processing, and clear responses to staff and followers input in our organisations [2]. Where there is minimal, or only occasional, discussion of what is happening and why, engagement to address it may be difficult. Triangulated listening enables us to use a range of listening channels already in place (surveys, operational data, exit interviews, complaints) to identify patterns across sources. Similarly, listening at upstream and downstream points of organisational decision-making creates a continuous learning cycle rather than a consultation once before change. Diagnostic and responsive listening shapes opportunities for leaders to detect what is missing, uncomfortable information signals and isolation of disparity signals. Contemporary internal digital platforms enable leaders and managers to continuously hear collective employee voice, identify any weak signals and pre-empt emerging concerns [3].

Health organisations need listening mechanisms that are broad in reach, inclusive, psychologically safe, responsive, integrated, and capable of measuring impact [2].

International Conference on SMART Technologies for Medical & Health Sciences: AI-Driven Health Care Innovation & Integration - 13th to 15th March 2026

Selected papers from this conference are included in this issue:

Guest Sub-Editor(s):

Prof. (Dr.) Anuj Kumar, Rushford Business School, Switzerland

Dr Anil Managutti, Sankalchand Patel University, Visnagar, Gujarat

Assistant Guest Sub-Editor
Dr Sri Sakuntala, Confab 360 Degree, India

The international conference on SMART Technologies for Medical & Health Sciences was conceptualised as a platform to bring together researchers, academics, clinicians, technologists and industry experts to share their knowledge, experiences and innovative ideas. The conference featured exceptional keynote speeches from healthcare experts worldwide. They shared their views on how healthcare is advancing through the integration of artificial intelligence and other technologies. The theme, *AI-Driven Healthcare Innovation & Integration*, reflected the growing significance of artificial intelligence and emerging technologies in reshaping modern healthcare systems and promoting efficient, accessible and patient-centric healthcare services. Sankalchand Patel University, Visnagar, Gujarat; National Science Forensic University, Gandhinagar, Gujarat; Confab 360 Degree, India; Rushford Business School, Switzerland; the European Global Institute of Innovation and Technology, Malta; and several other academic institutions organised this conference.

Mark Avery
Editor-in-Chief

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COMMENTARY

STRATEGIC POLICY APPROACHES TO ADVANCING INTERDISCIPLINARY NURSING RESEARCH: CHALLENGES AND DIRECTIONS FOR SYSTEMIC CHANGE

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ABSTRACT

As a response to the complex demands of contemporary health systems, interdisciplinary research has been a central strategy in the development of nursing practice, education, and scholarship in Iran. Despite being pivotal, the advancement of interdisciplinary research in nursing is impeded by a lack of enduring institutional infrastructure and restricted faculty capacity to perform successful cross-disciplinary collaboration. This policy analysis examines the structural barriers to interdisciplinary nursing research in Iran and proposes a phased set of policy responses.

Nursing's four pillars education, clinical practice, research, and leadership/management are significant opportunities for strengthening its interdisciplinary nature. Each pillar overlaps naturally with adjacent disciplines, including educational sciences, psychology, health sociology, ethics, and public policy. The "Four-Season-Symphony" conceptual model of intellectuality, spirituality, ethics, and aesthetics provides both philosophical justification and practical guidance for integrating interdisciplinary perspectives into nursing research. The model promotes a richer epistemological understanding of nursing.

To implement this vision, we recommend revising academic and research policies in all medical universities to highlight building interdisciplinary competencies among nursing faculty. Approaches include establishing interschool research centers that transcend faculties, developing interdisciplinary curricula for academics, initiating targeted research funding for interdisciplinary projects, revising faculty promotion criteria to recognize interdisciplinary work, and establishing international research partnerships. Collectively, these measures will facilitate innovative, impactful nursing scholarship and its contribution to interdisciplinary health research.

KEYWORDS

nursing faculty, interdisciplinary research, research policy, nursing education, policy analysis

INTRODUCTION

In the recent decades, interdisciplinary research has been a viable approach to addressing the complex and multidimensional concerns of healthcare systems, such as chronic diseases, aging population, mental illness, and global health pandemics [1]. Global evidence shows that countries that managed to institutionalize interdisciplinary strategies in their healthcare research systems have registered significant innovations towards improving quality care, designing

inclusive interventions, and informing health-enabling policies [2, 3]. For instance, in the major nations such as the United States and Canada, a large proportion of the product of nursing research is published with other disciplines [4].

Despite the significance of this approach, nursing faculty involvement in interdisciplinary research in Iran is confronted with multiple obstacles. Lack of strategic empowerment policies, no proper training for interdisciplinary methods, limited exposure to scientific networks, and lack of supporting infrastructure are some of the main areas of difficulty in propelling such research. In addition, Iran's system of faculty promotion in medical universities is essentially discipline-oriented, which reduces the motivation to work interdisciplinarity and hinders nursing's ability to offer creative solutions to healthcare system problems [5, 6].

If the trend persists, it can potentially lead to missed opportunities to address unprecedented and multifaceted challenges such as population aging, control of chronic diseases, mental health crises, and climate change problems that by definition require cross-disciplinary collaboration and the creation of integrated expertise. For this reason, strategic faculty empowerment in nursing for successful involvement in interdisciplinary research must be considered a national imperative. Policy officials responsible in both the health and the higher education sectors must make strategic capacity-building issues priorities. In doing so, it will be possible to achieve systematic advancement in nursing research, increase its international prominence, and position the profession in a better position to address the increasingly complex challenges posed by modern healthcare systems [7, 8].

CURRENT POLICIES

Although Iran's scientific production in the field of nursing has increased numerically over the last two decades, the global influence of Iranian nursing research remains limited. In addition, according to the Ministry of Health scientometric database, the average research performance indicators of faculty members of nursing such as the number of published papers, citation, and H-index are still below in a broad scope of clinical and basic sciences disciplines [9].

To overcome such dilemmas, the National Nursing Research Network (NNRN) as the representative organization commissioned with enhancing nursing research in Iran has been charged with coordinating scholarly efforts in nursing with the evolving demands of the national health system [10]. In particular, NNRN has also been designated as a World Health Organization (WHO) Collaborating Center for the Eastern Mediterranean Region (EMRO), positioning it as a focal institution capable of enabling interdisciplinary research and international collaboration.

Despite the institutional capacities at hand, the proportion of interdisciplinary studies in Iranian nursing is very low. A systematic review found that only roughly 0.09% of Iranian nursing papers represent interdisciplinary scholarship. This figure sharply differs from that of developed countries such as Canada and Japan, with their respective figures standing at 35% and 29% [11, 12]. This represents a substantial structural deficiency that has undermined cross-disciplinary collaboration and limited most of the research production to descriptive and clinically oriented work.

On the other hand, research high-performance countries such as members of the Florence Network in Europe, with more than 38 institutions spread across 18 countries have established robust infrastructures that support multidisciplinary research. These have been attained through joint development and operation of common research and educational programs [13]. It is estimated that the body of interprofessional nursing scholarship in Iran is at least 30 to 400 times smaller than in these high-performing systems, a discrepancy with profound implications for the quality of health policy making, educational advancement, and performance of healthcare delivery systems.

Several key factors explain this underdevelopment. These include the absence of institutional incentives for interdisciplinary work, a lack of sustainable infrastructure for planning and governance of team-based research projects, and narrow interdisciplinary skills sets among the nursing faculty. Furthermore, existing academic promotion criteria built mainly on mono-disciplinary publication also discourage faculty members from engaging in interdisciplinary work [1].

Furthermore, the current structure of nursing education in Iran offers limited preparation for developing interdisciplinary research skills. Current curricula are dominated by clinical training and technical skill building, with limited opportunity for theoretical depth, macro-level project work, or collaborative research participation. Moreover, professional development courses that are framed to advance faculty capacity in interdisciplinary research design, coordination, and implementation are few, poorly integrated, and institutionally underdeveloped [14].

Moreover, the lack of national nursing megaprojects rooted in interdisciplinary traditions with the potential for addressing challenging issues such as population aging, mental illness, and management of chronic diseases is a crucial structural deficiency. In contrast, several countries have used the conceptualization and execution of national nursing megaprojects as strategic instruments to help solidify the position of the profession in the field of health policy.

In addition, the absence of basic infrastructures for foundation like interdisciplinary data banks, computer platforms for support of research collaboration, and direct financial investment has effectively nullified nurses' involvement in collaborative research. Taken collectively, all these constraints reinforce a paradox: while nursing carries gigantic potential in furnishing integral information regarding patient needs, its authentic input toward interdisciplinary knowledge advancement is disproportionately wasted. Addressing this gap warrants urgent, concerted, and evidence-based policy intervention [10-12].

The aim of this policy analysis is to examine the structural, educational, and institutional barriers that constrain interdisciplinary nursing research in Iran and to propose a phased set of policy responses to address them. The analysis is centered specifically on the Iranian context; evidence from other national systems, such as Canada, Japan, and the Florence Network countries, is drawn upon only as comparative benchmarking to inform recommendations relevant to Iran, and this work does not aim to produce generalizable findings for other national settings.

METHODOLOGY

This policy analysis utilized a documentary and policy discourse analysis approach to gather and analyze pertinent information systematically. Literature searches were conducted in PubMed, Scopus, and Google Scholar using combinations of the terms "interdisciplinary," "nursing research," "research policy," "faculty promotion," "nursing education," and "Iran," restricted to sources published between 2010 and 2026, with priority given to publications from the most recent five-year window (2021–2026) to ensure contemporaneity. As this study is centered on the Iranian context, records were included if they (a) directly addressed nursing faculty involvement in interdisciplinary research, research policy, or academic promotion criteria within Iran, or (b) described the policies, structures, or outcomes of interdisciplinary nursing/health research in other national systems that could serve as comparative benchmarks for the Iranian context. Records were excluded if they lacked policy relevance, were non-peer-reviewed opinion pieces, or were duplicates.

Then, major national policy papers related to higher education and health were carefully studied. These documents included the Country's Comprehensive Scientific Map, the Medical Education Transformation Plan, overall national health policies, and significantly, the National Nursing Comprehensive Map, prepared and released by the Deputy of the Ministry of Health for Nursing.

In addition, strategic reports of the Iranian National Nursing Research Network aimed at promoting and developing interdisciplinary research were studied and thoughtfully considered. To contextualize these results and inform practical recommendations, best practices and best practice experiences from pioneer nations such as the United States, Canada, and Australia and member institutions of the Florence Network were also structured for systematic review.

Finally, informal consultative discussions were held with nursing educators, health policy specialists, and active participants of the National Nursing Research Network to contextualize the documentary findings; these consultations were exploratory and advisory in nature and did not constitute a formal qualitative research design with structured participant sampling, a

defined sample size, or a thematic coding framework**.** The aggregate data from these different sources were utilized to develop evidence-based policy recommendations guided by the scientific literature, official policy documentation, and best national and international models. Data extracted from national policy documents and international benchmarks were synthesized using a directed content-analysis approach, in which recurring themes were organized according to nursing's four pillars (education, clinical practice, research, and leadership/management) and cross-referenced against the four domains of the Four-Season-Symphony model [38] (intellectuality, spirituality, ethics, and aesthetics) to inform the policy recommendations presented below (see Table 1).

Overall, the evidence base drawn upon for this analysis comprised three broad categories of material: peer-reviewed literature retrieved from PubMed, Scopus, and Google Scholar addressing interdisciplinary research policy, nursing faculty development, and comparator health-system models; national policy and institutional documents, including the Ministry of Health and Medical Education scientometric database, the Country's Comprehensive Scientific Map, the Medical Education Transformation Plan, and National Nursing Research Network strategic planning materials; and international benchmarking sources describing interdisciplinary research infrastructures, such as the Florence Network and university-based interdisciplinary nursing research centers. These sources were jointly used, together with the consultative discussions described above, to characterize the current state of interdisciplinary nursing research policy in Iran and to derive the phased policy recommendations presented in the following section.

POLICY IMPLICATIONS AND RECOMMENDATIONS

DEVELOPMENT OF INTERDISCIPLINARY RESEARCH CENTERS IN MEDICAL UNIVERSITIES (MEDIUM-TERM, STRUCTURAL ACTION)

Given the comparatively low international status of Iranian nursing in interdisciplinary collaboration and co-authored scientific output, the development of interdisciplinary research centers in medical universities is a strategic necessity. They are necessary to enhance the quality of education and research as well as to address complex problems in the healthcare system [15]. These centers should adopt an integrative model that involves meshing nursing competencies with other supporting fields such as psychology, health management, social sciences, and health technologies, thereby becoming sites of innovation particularly in the framing and solution of complex issues such as population aging, chronic illness, mental health, and long-term care.

Such institutes can develop a structured environment favorable to inter-disciplinary knowledge generation by creating strategic research blueprints, establishing technology-supported infrastructure and intrinsic data warehouses, knowledge sharing through databases, and driving massive national initiatives. This endeavor requires collective action from nurses, physicians, data scientists, biomedical engineers, and sociologists. Benchmark centers such as the Health Innovation Research Center in the University of Toronto and others in the University of Oxford offer models on how centers can drive innovation, enhance the quality of health policy, and enhance the global prestige of the nursing profession [16, 17].

In Iran, initiatives like the National Nursing Research Network have offered infrastructural capacities for the creation of interdisciplinarity-based research centers; however, these initiatives have not developed into enduring systems due to insufficient institutional support, the absence of explicit financial policies, and the lack of explicit regulatory standards.
The key hindrances to the development of such institutions are scarcity of finance, lack of technical infrastructure, conservatism in interdisciplinary research activity especially among traditional academic fields and absence of research incentives. To offset these obstacles, the following are proposed:

- Dispensation of special funding packages procured from national grants and university budgets to support the establishment of interdisciplinary research centers for nursing;
- Awareness and advocacy for faculty members in rolling out such programs to highlight the benefits of interdisciplinary research;

- Develop interdisciplinary teams with the mandate to identify national health research priorities by an interdisciplinary approach;
- Establish partnerships with other institutions in the world for mobilization of external funding resources, including grants from Horizon Europe, WHO, UNDP in public health.

The establishment of these centers is expected not just to enhance the quality of evidence-based health policymaking but also to boost the global prestige of Iranian nursing, augment its contribution to global scientific production, and enable foreign funds for research. Therefore, the establishment of interdisciplinary research centers is both a scientific imperative and a strategic instrument to maximize the contribution of nursing in Iran's national health system [18, 19]. Concretely, this could be operationalized by having the Ministry of Health and Medical Education's Deputy of Research and Technology ring-fence a dedicated line within existing university research budgets for nursing-led interdisciplinary centers, with the National Nursing Research Network coordinating common accreditation criteria across universities. Within the Four-Season-Symphony framework, this recommendation corresponds primarily to the Intellectuality domain, reflecting its emphasis on evidence-based, scientifically rigorous knowledge generation.

PLANNING AND IMPLEMENTATION OF INTERDISCIPLINARY SKILLS TRAINING PROGRAMS (SHORT-TERM, TACTICAL ACTION)

Based on the multi-dimensionality of problems confronting healthcare systems, it is essential to increase the interdisciplinary capacities of nursing instructors in order to support better quality research and proper reaction to the complex needs of society. The development and implementation of systematic training programs in this field will enable nurses to actively engage in innovative and integrative research projects. These programs should incorporate a wide range of competencies, such as:

- Developing interdisciplinary research proposals and co-authoring research-based scholarly articles;
- Mixed methods research skills;
- Proficiency in big data analytics and data mining
- Large-scale research project management leadership;
- Communication and teamwork skills for interdisciplinary settings [20].

Offering these programs through a combination of short- and long-term courses, experiential workshops, study fellowships, and online or blended learning modalities can enhance faculty participation while avoiding temporal and spatial constraints. Policies such as providing internationally recognized certifications, producing culturally relevant content, and forming alliances with leading international universities are proposed to enhance motivation and enhance the quality of education [21]. The absence of integrated and convergent training curricula in Iran and the insufficient financial and technical capacity as well as academic and research workload pressures on the faculty are significant barriers to the success of policy implementation. These challenges can be overcome only through direct assistance by the Ministry of Health, coordinated planning between foreign schools of medicine, and institution of professional incentives like academic progress credits for participation in these programs [14, 15, 18]. Concretely, university research deputies could be mandated to integrate accredited interdisciplinary training modules into existing continuing-education requirements for nursing faculty, coordinated nationally by the National Nursing Research Network. Within the Four-Season-Symphony framework, this recommendation corresponds primarily to the Aesthetics domain, reflecting its emphasis on creativity, innovation, and humanistic scholarship.

DEDICATED ALLOCATION OF RESEARCH GRANTS FOR NURSING-ORIENTED INTERDISCIPLINARY PROJECTS (SHORT-TERM, TACTICAL ACTION)

Focused financial investments in inter-disciplinary nursing research specifically, in areas of healthcare priority such as aging, mental health, chronic disease management, and healthcare equity are a strategic approach to enhancing the quality and value of research. Although sporadic efforts have been made in Iran, a regular and transparent funding system for interdisciplinary nursing research remains unavailable, thereby discouraging the development of nurses' roles in scientific knowledge and innovation.

Experience from countries such as the Netherlands, Canada, and Australia indicates that reserving dedicated budget lines for interdisciplinary research projects and open calls for proposals and rigorous evaluation processes are success determinants. Further strengthening this framework is proposed through the following steps:

1. Developing targeted funding calls for interdisciplinary health and nursing research projects;
2. Establishing review committees with disciplinary representation to enable unbiased and rigorous scientific review.
3. Offering further incentives such as expert scientific counsel, access to national archives of data, and technology and publications services support;
4. Ensuring ongoing monitoring and assessment systems to assess the effectiveness and usefulness of funded research;
5. Increasing access to international funding by ensuring projects become consonant with global health priorities [22, 23].

The potential to motivate research teams, improve research quality, and secure international funding through cross-disciplinary coordination underscores the necessity of implementing these policies. Such policies would not only boost the rewards of research teams but also raise the international scientific and innovative reputation of Iranian nursing, hence creating the appeal for international scientific and financial investments. In contrast, the lack of these policies in the existing research setup threatens to underutilize nursing's inherent potential for confronting the multifaceted, multidimensional problems of health [14, 19]. Concretely, the Ministry of Health and Medical Education's Deputy of Research and Technology could establish an annual ring-fenced budget line for competitive interdisciplinary nursing research grants, administered jointly with the National Nursing Research Network. Within the Four-Season-Symphony framework, this recommendation corresponds primarily to the Intellectuality domain, reflecting its emphasis on evidence-based, scientifically rigorous knowledge generation.

REVISION OF FACULTY PROMOTION REGULATIONS (LONG-TERM, STRATEGIC ACTION)

The promotion regulations of faculties operating in Iranian medical universities primarily concentrate on quantitative, individual-focused, and discipline-specific criteria and fail to equally take into account interdisciplinary research participation as a valuable criterion. This system discourages faculties' motivation particularly in areas such as nursing to join interdisciplinary activities and hinders cross-disciplinary scientific collaboration.

These regulations need to be revised in order to include qualitative indicators applicable to interdisciplinary research. These include co-authorship of inter-disciplinary papers, receiving sole grants for inter-disciplinary works, participating in large-scale national schemes, and producing inter-disciplinary policy reports. These measures would provide strong incentives to faculty members [24, 25]. Concretely, this requires the Ministry of Health and Medical Education's Deputy of Research and Technology to amend the central national faculty-promotion scoring rubric so that specific, quantified point weightings are assigned to interdisciplinary co-authorship, leadership of interdisciplinary grants, and authorship of interdisciplinary policy reports, rather than leaving such recognition to the discretion of individual university promotion committees.

Furthermore, training promotion committee members and evaluators in expert reviews of interdisciplinary research and creating scoring systems that capture the size and complexity of such projects appropriately are essential components of revision.

However, various obstacles stand in the way of regulatory reform. They include cultural and structural resistance from faculty to change, the need for coordination among diverse university departments, and the absence of standardized and transparent systems for assessing interdisciplinary research [26]. To overcome such obstacles, the following strategies are recommended:

- Creation of specialized interdisciplinary committees that will examine and redefine promotion standards;
- Development and mass dissemination of clear, easy-to-comprehend documentation of the modified promotion standards;

- Establishment and implementation of powerful, multi-dimensional evaluation models capable of properly measuring the impact of interdisciplinary research;
- Hosting training workshops to introduce evaluators and scholars to the significance and unique characteristics of interdisciplinary research [20, 25, 26].

Combined, these measures are aimed at strengthening the role of nursing and other medical science disciplines in interdisciplinary research and facilitating the long-term development of health research in Iran. Within the Four-Season-Symphony framework, this recommendation corresponds primarily to the Ethics domain, reflecting its emphasis on justice, integrity, and equitable recognition of collaborative work.

FORMULATION OF NATIONAL POLICIES FOR THE DEVELOPMENT OF INTERDISCIPLINARY NURSING RESEARCH (LONG-TERM, STRATEGIC ACTION)

Despite cross-cutting orders in Iran's health system strategic documents such as the Comprehensive Scientific Map of the Country, the Medical Education Transformation Document, and national health policies that emphasize the expansion of applied research attuned to national demands, explicit, operational, and concentrated strategies for the advancement of interdisciplinary nursing research have not yet been formulated and executed. This gap is a significant barrier to the complete realization of nursing's potential role in solving complex, multilateral health problems.

On the other hand, more specialized documents like the National Nursing Comprehensive Map (developed by the Nursing Deputy of the Ministry of Health) highlights the central role of nurses in policymaking and interdisciplinary collaboration with particular emphasis on scientific collaboration between disciplines [27]. In addition, the strategic plan of the National Nursing Research Network of Iran places high priority on carrying out participatory and interdisciplinary research based on the health system needs [28]. Therefore, the formulation of definitive, operational, and targeted national policies aimed at enhancing nursing's role in major health initiatives, promoting interdisciplinary collaboration, and aligning research funding with integrated health priorities is a strategic imperative. Such policies need to have inherent financial support systems, make provision for coordinating bodies, and have clear evaluation criteria for interdisciplinary research. These steps will guarantee a transformative elevation of nursing's scientific and practical contributions to Iran's healthcare landscape [29]. Within the Four-Season-Symphony framework, this national-policy recommendation draws primarily on the Intellectuality domain, by grounding policy formulation in evidence-based, scientifically rigorous priority-setting, and on the Ethics domain, by ensuring that resulting funding and evaluation criteria recognize interdisciplinary contributions equitably.

INITIATION AND FACILITATION OF NATIONAL MEGA PROJECTS WITH AN INTERDISCIPLINARY ORIENTATION IN NURSING (LONG-TERM, STRATEGIC ACTION)

National mega projects that are health sector-focused and involve an interdisciplinary approach have been recognized in the developed world as potent answers for addressing complex public health issues such as aging, chronic diseases, mental illness, and long-term care [30]. Such projects typically come into being through a synthesis of inputs by different specialized fields such as medical science, social sciences, technology, and management. They play a critical role in enhancing high-level knowledge creation and enhancing the quality of healthcare delivery [31].

In Iran, despite extensive growth in the field of nursing research production, there remains an acute shortage of national mega projects grounded in interdisciplinary strategies. Such a lack has led to systematic under-investment in the potential of nursing towards effective response to the complexities and multi-dimensionality of the healthcare system [32]. Therefore, the gap hinders the scientific and practical advancement of nursing professionals simultaneously with lowering prospects for receiving domestic and foreign funding and multidisciplinary partnerships [33].

The creation of national mega projects in the field of nursing, with the backing of sufficient financial and administrative potentials most importantly, in priority fields like aging, chronic diseases, and mental health could be a determining factor in the scientific promotion of nursing in Iran and in creating overall solutions to Iran's formidable health problems [30]. These activities can prepare the ground for larger investment, facilitate international cooperation, and enhance the quality of health services across the country as a whole.

Thus, it is recommended that health and higher education policymakers establish robust support mechanisms and allocate sustainable resources to facilitate the initiation and successful completion of interdisciplinary-based national mega projects in nursing. In addition, repeated evaluation and monitoring of project outcomes will be essential to ensuring their sustained role in advancing the profession [34]. Concretely, this could begin with the Ministry of Health and Medical Education's Deputy of Research and Technology commissioning a single national interdisciplinary nursing mega-project on population aging, coordinated jointly with the National Nursing Research Network and university-affiliated research centers, with monitoring aligned to the program-evaluation framework already cited above [34]. Within the Four-Season-Symphony framework, this recommendation corresponds primarily to the Spirituality domain, reflecting its emphasis on meaning, purpose, and holistic, person-centered inquiry.

ENHANCING INTERNATIONAL AND INTER-UNIVERSITY COLLABORATIONS IN INTERDISCIPLINARY NURSING RESEARCH (MEDIUM-TERM, STRUCTURAL ACTION)

While memoranda of understanding and cooperation exist between Iranian universities and other institutions from abroad in the nursing field, they are usually intermittent and lack systematic, target-oriented approaches. To improve interdisciplinary research capacity and benefit from global experience and expertise, it is important to establish international consortia with top-level universities and research centers. Furthermore, facilitating research fellowships, promoting faculty mobility, and building electronic platforms for information and ideas sharing are the most important strategies. These measures are bound to improve the quality and volume of scientific production in nursing and elevate the reputation of the discipline within the national health system [35, 36].

Nonetheless, there are economic deficiencies, administrative hurdles, foreign sanctions, and political constraints that present significant barriers to enhancing global cooperation. To overcome these barriers, supporting and strategic policies need to be put in place. These need to address formalized cooperation accords, establishing special mechanisms of funding to sponsor international research fellowships, and designing joint educational programs in collaboration with the world's leading universities. All these actions combined would offer a healthy environment for interdisciplinary studies and increasing the degree of scientific evidence in nursing in Iran [37]. Concretely, this could be formalized through a rolling annual budget line for outbound faculty fellowships, jointly administered by the Ministry of Health and Medical Education and university international offices. Within the Four-Season-Symphony framework, this recommendation corresponds primarily to the Aesthetics domain, reflecting its emphasis on creativity, innovation, and humanistic scholarship.

APPLICATION OF THE "FOUR-SEASON-SYMPHONY" CONCEPTUAL MODEL TO NURSING RESEARCH POLICY (MEDIUM-TERM, STRUCTURAL ACTION)

Advancing the quality and theoretical rigor of interdisciplinary nursing research demands the adoption of substantial, contextually relevant conceptual frameworks. The "Four-Season-Symphony" approach, grounded in four pillars of intellectuality, spirituality, ethics, and aesthetics, is an integrative and holistic structure for the design, direction, and evaluation of nursing research. In emphasizing the integration of humanistic, epistemological, and ethical aspects, the approach promotes the creation of interdisciplinary scholarship that is beyond those purely technical and quantitative paradigms.

It is suggested that this conceptual framework be incorporated into national nursing education and research policy and used as a working document for project planning and evaluation of research in the National Nursing Research Network and academic research institutions. It could contribute significantly to qualitative, integrative, and human-centered research in nursing, ultimately taking nurses' professional role in the healthcare system above traditional clinical service provision [38].

To translate this framework into concrete policy action, Table 1 maps each of the four domains onto the specific recommendations above.

TABLE 1. MAPPING OF THE FOUR-SEASON-SYMPHONY DOMAINS ONTO POLICY RECOMMENDATIONS AND IMPLEMENTATION TIMEFRAME

Domain	Core Focus	Corresponding Policy Recommendation(s)	Implementation Timeframe
Intellectuality	Evidence-based rigor, scientific reasoning	Interdisciplinary research centers; dedicated research grants; scientometric-informed promotion criteria; national interdisciplinary policy formulation	Short- to medium-term
Spirituality	Meaning, purpose, holistic and person-centered inquiry	National interdisciplinary mega projects addressing aging, chronic disease, and mental health	Long-term
Ethics	Justice, integrity, equitable recognition of collaborative work	Revision of faculty promotion regulations; disciplinary-representative grant-review committees; national interdisciplinary policy formulation	Long-term
Aesthetics	Creativity, innovation, humanistic scholarship	Interdisciplinary skills training programs; international and inter-university collaboration	Short- to medium-term

CONCLUSION

Despite its great scientific potential and strategic role in the health care system, Iranian nursing has thus far been unable to contribute a solid dividend to interdisciplinary knowledge production and innovative studies. An analysis of the current situation reveals that structural barriers such as inefficient policy incentives, absence of necessary research infrastructure, de-linkage of education courses with the needs of interdisciplinary research, and absence of mega national projects have dampened the research potential of the profession. Moreover, promotion criteria for faculty and the lack of specialized training programs have undermined interdisciplinary collaboration.

To overcome these barriers, it is essential to establish interdisciplinary research centers, develop training programs for interdisciplinary competence, offer targeted research grants, reform promotion rules, develop clear national policies, support large projects, and improve international collaborations. Additionally, the application of indigenous and substantive conceptual structures like the "Four-Season-Symphony" can significantly contribute to theoretical depth and overall excellence in nursing research.

Empowerment of nursing faculty members in these areas will become a motor for the scientific and practical progress of the profession of nursing in Iran. In addition to enhancing the standing of the profession in the health sector, empowerment will enlarge its capacity to tackle the complex, multidimensional challenges facing the health care system. Such change requires strategic vision, steady financial and ethical support, and a lot of collaboration among universities, research institutions, and policymakers. Long-term, nursing can be a proactive, innovative, and influential force in inter-professional health research, thereby contributing significantly to knowledge advancement and enhancing the quality of care nationwide [39].

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COMMENTARY

BURNOUT AND WORKFORCE SHORTAGES IN HEALTHCARE: AN EMERGING PUBLIC HEALTH CRISIS

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ABSTRACT

Burnout and workforce shortages among healthcare professionals have emerged as major concerns across healthcare systems worldwide. Global estimates project a shortfall of about 18 million health workers by 2030, and a meta-analysis estimated that roughly one in ten nurses experience burnout, although estimates vary across professions, settings, and measurement approaches. Although these problems became more visible during the COVID-19 pandemic, they did not end with the pandemic and continue to affect healthcare delivery in many settings. In daily practice, many healthcare workers face excessive workload, prolonged working hours, emotional exhaustion, staffing shortages, and increasing administrative responsibilities. These pressures are often more severe in rural and underserved areas where healthcare resources and trained professionals are already limited.

In my view, burnout and workforce shortages should not be treated as separate workplace issues alone. They are closely connected public health challenges. They appear to be interrelated public health challenges that may influence the quality, safety, and sustainability of healthcare systems. When healthcare professionals work under persistent physical and emotional strain, the effects extend beyond individual well-being and can ultimately affect patient care, service delivery, and health system resilience. This commentary discusses the structural factors contributing to workforce exhaustion and highlights the need for long-term organizational and policy-level responses to support a more sustainable healthcare workforce.

KEYWORDS

burnout, healthcare workforce, workforce shortages, health system resilience, public health.

BACKGROUND

Healthcare systems across the world are facing increasing pressure due to burnout among healthcare professionals and persistent workforce shortages. Although these concerns became more visible during the COVID-19 pandemic, the underlying problems existed long before the pandemic and continue to affect healthcare delivery in many countries [1]. In many healthcare settings, professionals are expected to maintain quality care despite overcrowded facilities, staffing shortages, long working hours, emotional stress, and growing administrative responsibilities.

Burnout is often discussed mainly as an individual psychological problem. However, this explanation does not fully capture the broader structural pressures within healthcare systems that contribute to workforce exhaustion. Excessive workload, inadequate staffing, poor organizational support, and inefficient workplace systems can all contribute to chronic stress

among healthcare workers [2,3]. When burnout becomes normalized within healthcare environments, it may gradually affect both workforce stability and the quality of healthcare delivery.

At the same time, workforce shortages continue to place additional pressure on existing healthcare staff. In many hospitals and primary healthcare settings, a limited number of professionals are expected to manage increasing healthcare demands with insufficient support and resources. This creates a cycle in which workforce shortages increase burnout, while burnout itself may contribute to absenteeism. These pressures may form a reinforcing cycle in which workforce shortages are associated with higher burnout, while burnout may in turn contribute to absenteeism, workforce attrition, migration, and early retirement [2]. From a public health perspective, this interconnected crisis has important implications for healthcare accessibility, patient safety, continuity of care, and long-term health system resilience. However, this relationship should be interpreted cautiously: most available evidence shows association rather than proven causation, and the direction and strength of the effects are likely to differ across professions, health systems, and settings.

BURNOUT AMONG HEALTHCARE WORKERS

Burnout among healthcare workers has become an increasingly important concern in healthcare systems worldwide. It is commonly described as a state of emotional exhaustion, depersonalization, and reduced professional accomplishment resulting from prolonged workplace stress [3]. Healthcare professionals often work under physically and emotionally demanding conditions that involve continuous patient care, emergency decision-making, long working hours, and repeated exposure to suffering, illness, and death. Over time, these experiences may lead to significant mental and emotional fatigue. Burnout is best understood as a work-related syndrome arising from chronic occupational stress, rather than as a general mental disorder. It overlaps with, but is conceptually distinct from, depression and occupational stress. Depression is not limited to the work context, whereas burnout is specifically related to the work environment and is characterized by emotional exhaustion, depersonalization, and reduced personal accomplishment. Occupational stress may contribute to burnout but is conceptually distinct from the burnout syndrome [3,4]. These conditions may coexist, but the distinction matters because understanding burnout as a work-related syndrome shifts attention towards organizational and structural determinants rather than framing it solely as an individual weakness or failure.

Several studies have reported that burnout among healthcare workers is associated with anxiety, depression, sleep disturbances, reduced job satisfaction, and emotional detachment from work [4,5]. For example, a meta-analysis of 49 countries estimated the pooled prevalence of burnout among nurses at 11.23%, although estimates varied considerably across countries and measurement approaches [5]. In some healthcare settings, professionals may also experience frustration, helplessness, and declining motivation toward their work. Despite increasing evidence about these effects, burnout is still often treated as something unavoidable within the healthcare profession [6].

In my view, the normalization of burnout reflects a deeper institutional problem. Healthcare workers are frequently praised for resilience, dedication, and sacrifice, but the structural conditions contributing to exhaustion often receive less attention. Expecting healthcare professionals to continue functioning under constant pressure without adequate support is neither realistic nor sustainable over time.

Burnout may also affect healthcare quality and patient safety. Evidence suggests that exhausted healthcare workers can experience reduced concentration, communication difficulties, lower emotional engagement, and increased risk of medical errors [7,8]. In already overstretched healthcare systems, these consequences may gradually affect patient satisfaction, continuity of care, and overall healthcare quality. Burnout, therefore, should not be viewed only as an occupational issue, but also as an important public health concern.

Another important issue is the psychological impact experienced by frontline healthcare workers during and after the COVID-19 pandemic. Many healthcare professionals worked under extraordinary physical and emotional pressure while facing fear of infection, uncertainty, resource limitations, and high patient mortality [9]. Although the emergency phase

of the pandemic has passed, its long-term mental health effects on healthcare workers continue to remain significant in many settings.

WORKFORCE SHORTAGES AND SYSTEMIC PRESSURE

Healthcare workforce shortages have become a major challenge affecting healthcare systems in both high-income and low- and middle-income countries. The World Health Organization has repeatedly raised concerns about the global shortage and unequal distribution of healthcare professionals [10]. Projections indicate a global shortfall of about 18 million health workers by 2030, mainly in low- and middle-income countries [10]. Multiple factors continue to contribute to this problem, including population growth, aging populations, increasing healthcare demands, workforce migration, limited recruitment, and difficulties in retaining trained professionals [10,11].

Rural and underserved areas are often affected most severely. In many such settings, healthcare facilities operate with limited staff and inadequate infrastructure, requiring healthcare workers to serve large populations under difficult conditions. This may increase workload, extend waiting times, reduce the amount of time available for patient interaction, and affect continuity of care [10,12].

The migration of healthcare professionals from low-resource settings to urban centers or higher-income countries has also widened workforce imbalances [11]. Although migration may offer better professional and financial opportunities for healthcare workers, it can place additional strain on already fragile healthcare systems in underserved regions. It can be argued that workforce shortages should not be viewed only as numerical gaps in staffing. They also reflect broader structural and policy challenges related to workforce planning, working conditions, professional support, and long-term investment in healthcare systems.

Previous studies have shown that inadequate staffing levels may contribute not only to burnout among healthcare workers but also to poorer patient outcomes and lower professional satisfaction [12]. In many healthcare systems, these shortages are now affecting both hospital services and primary healthcare delivery.

Another issue receiving increasing attention is the growing administrative burden placed on healthcare workers. Although digital systems and electronic records were introduced to improve efficiency, many professionals now spend substantial amounts of time on documentation and reporting requirements [13]. In some settings, administrative responsibilities may reduce the time available for direct patient care and meaningful interaction with patients.

It can be argued that healthcare systems sometimes place strong emphasis on documentation and performance indicators without fully considering their impact on workforce well-being. Technology should support healthcare delivery and reduce unnecessary workload, rather than increase workflow complexity and emotional exhaustion among healthcare professionals.

THE INTERCONNECTED CYCLE BETWEEN BURNOUT AND WORKFORCE SHORTAGES

Burnout and workforce shortages in healthcare are closely interconnected and often reinforce one another. Burnout and workforce shortages in healthcare may be interconnected, with evidence suggesting potential effects in both directions. When healthcare facilities operate with insufficient staff, the remaining professionals are frequently required to manage heavier workloads, longer working hours, and continuous emotional pressure [4,6]. However, much of the available evidence on this relationship is cross-sectional, so it shows association rather than establishing causation, and well-designed longitudinal studies are needed to clarify the direction and size of these effects [6,12]. Over time, this may contribute to fatigue, frustration, emotional exhaustion, and reduced professional satisfaction.

At the same time, healthcare workers experiencing burnout may reduce their working hours, leave clinical practice, migrate to other regions or countries, or retire earlier than expected [14]. This further intensifies workforce shortages. This may further intensify workforce shortages and place additional pressure on those who remain within the system. As this cycle continues, healthcare systems may gradually become less stable and more difficult to sustain. If these pressures persist, healthcare systems may become less stable and more difficult to sustain.

From my perspective, this cycle represents one of the most underestimated threats to long-term health system resilience. Discussions on healthcare reform often focus heavily on infrastructure, technology, and expansion of services, all of which are important. However, healthcare systems ultimately depend on people. No healthcare system can function effectively for prolonged periods. It is difficult for any healthcare system to function effectively for prolonged periods if its workforce remains continuously overworked and emotionally exhausted.

The consequences become even more visible during disease outbreaks, natural disasters, and other public health emergencies. The COVID-19 pandemic demonstrated how strongly healthcare systems depend on a stable, protected, and adequately supported workforce [15]. In many settings, exhausted healthcare professionals continued working under extreme pressure despite personal risk, staffing shortages, and limited resources. These experiences demonstrated that health system resilience is closely linked to workforce resilience.

Several experts have argued that burnout in healthcare should be addressed through organizational and systemic reforms rather than placing responsibility entirely on individual healthcare workers [16]. This perspective is important because workplace conditions, staffing patterns, institutional culture, and administrative pressures often contribute substantially to workforce exhaustion.

PUBLIC HEALTH IMPLICATIONS

Burnout and workforce shortages in healthcare have important implications for public health and healthcare delivery. These challenges may affect healthcare accessibility, patient safety, continuity of care, emergency preparedness, and healthcare equity. In underserved and geographically difficult areas, shortages of healthcare professionals can create even greater barriers to timely and quality care. [1,8,10]

Another growing concern is the long-term sustainability of the healthcare workforce itself. Continuous workplace stress, emotional exhaustion, and declining professional satisfaction may discourage younger people from choosing healthcare professions or remaining in them for long periods. Burnout and poor working conditions have been linked to intention to leave and attrition among existing healthcare workers [14,17]. Whether they also discourage younger people from entering healthcare professions is less well documented; this remains a plausible concern that requires further research. This could further worsen workforce shortages in the coming years. Continued attrition among existing staff could further worsen workforce shortages in the coming years [17].

Workforce instability may also gradually affect public trust in healthcare systems. In overcrowded and understaffed healthcare settings, patients may experience long waiting times, communication difficulties, reduced continuity of care, and lower satisfaction with healthcare services [8,12,14]. Over time, such experiences can weaken confidence in healthcare institutions and the systems meant to support communities.

Discussions on healthcare quality often focus mainly on patient outcomes, while workforce well-being receives less attention [14,18]. However, these issues are closely connected. This highlights that healthcare systems cannot consistently provide safe, compassionate, and high-quality care if healthcare professionals continue to work under conditions of chronic physical and emotional exhaustion.
Way Forward:

Addressing burnout and workforce shortages in healthcare requires long-term commitment at both the organizational and policy levels. Short-term solutions alone are unlikely to resolve the deeper structural pressures that many healthcare systems continue to face [1,10,16].

Healthcare institutions should try to create working environments where professionals feel supported rather than constantly overwhelmed. Adequate staffing, fair distribution of workload, reasonable working hours, mental health support, and professional well-being should be treated as important parts of healthcare management. Burnout should not be accepted as a normal or unavoidable part of working in healthcare [14,16,18]. Three priorities should be emphasized. First, healthcare organizations should align staffing and workload with service demand and establish routine mechanisms to identify and address workforce strain [14,16,18]. Second, policymakers should prioritize retention through equitable workforce distribution, rural recruitment, and supportive working conditions, rather than relying on recruitment alone [10,19]. Third, health systems should reduce avoidable administrative and documentation burdens so that digital systems return time to patient care rather than add workflow complexity [13]. Progress could be monitored using measurable indicators such as staff-to-patient ratios, workload and overtime monitoring, flexible scheduling, protected well-being time, staff turnover and sick-leave rates, and periodic burnout assessments [14,18].

At the policy level, stronger workforce planning is also necessary. Investments in healthcare education, workforce retention, rural recruitment, and equitable distribution of healthcare professionals may help strengthen healthcare systems over time [10,19]. In many regions, retaining trained professionals has become just as important as recruiting new ones. Reducing unnecessary administrative burden may also improve workforce well-being. Digital systems are intended to support healthcare delivery, but in some settings, they have added documentation pressure and increased workflow complexity. Many healthcare professionals now spend large amounts of time completing reports and interacting with screens instead of directly engaging with patients [13]. Over time, this may affect both professional satisfaction and the quality of patient-provider relationships.

Several recent reports have highlighted the importance of organizational strategies to protect clinician well-being and reduce burnout [18,20]. I can argue that healthcare worker well-being and patient care should not be treated as separate priorities. A healthcare system cannot remain strong if its workforce continues to experience chronic exhaustion without adequate support. Protecting healthcare professionals is therefore not only an occupational responsibility, but also an important investment in sustainable healthcare systems and future public health resilience.

CONCLUSION

Burnout and workforce shortages in healthcare are becoming serious public health concerns that affect healthcare systems across the world. Available evidence indicates that burnout and workforce shortages are serious public health concerns in many healthcare systems, although their magnitude varies substantially across professions, health systems, and geographic settings. These challenges are closely connected and continue to influence associated with each other and may influence the quality of care, patient safety, and the overall stability of health services. In many settings, healthcare professionals work under constant pressure, long working hours, emotional stress, and increasing workloads, often with limited support.

Healthcare workers are frequently expected to keep adapting and continue working despite these pressures. However, resilience should not mean silently carrying exhaustion for long periods without proper support or recognition. In my view, a healthcare system cannot truly be considered resilient if it is difficult to regard a healthcare system as resilient if the people delivering care are physically and emotionally overwhelmed. Protecting the well-being of healthcare professionals is therefore not only an occupational issue but also an essential part of building sustainable, equitable, and effective public health systems. Protecting the well-being of healthcare professionals is therefore best seen not only as an occupational issue but also as an important part of building sustainable public health systems. While the evidence supports organizational and systemic action, further longitudinal and context-specific research is needed to guide interventions.

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RESEARCH ARTICLE

HOW LEADERSHIP COMMUNICATION SHAPES THE WELL-BEING OF AUSTRALIAN HEALTHCARE WORKERS IN NON-LINEAR SYSTEMS

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ABSTRACT

Workplace dynamics within the Australian public healthcare sector influences the well-being and psychosocial safety of healthcare workers, which subsequently impacts occupational commitment and operational stability. This study examines the influence of leadership communication on healthcare worker well-being– a relationship that remains under-examined within the Australian context. Drawing on 16 in-depth interviews with frontline staff and healthcare sector leaders, data were analysed through the theoretical lenses of Complex Adaptive Systems and Dissipative Structures theories to account for the healthcare sectors characteristic unpredictability. The analysis identified repetitive behavioural and emotional patterns of interaction, shaped by leadership communication, which influenced healthcare workers' responses to systemic turbulence. Healthcare workers' adverse well-being outcomes and perceived organisational instability were closely coupled with restrictive and inaccessible leadership communication practices. These attractor-like states triggered novel behavioural adaptations, underscoring the critical role of leadership in modulating systemic resilience. The study was weighted toward regional nursing perspectives with broader relevance across the healthcare sector, and provides actionable insights for healthcare managers and leaders, highlighting the necessity of adaptive communication strategies to mitigate psychosocial risks and prevent cascading organisational instability.

KEYWORDS

public healthcare sector; Australia; leader communication; workforce well-being; complex adaptive systems; sustainability; system resilience

INTRODUCTION

Globally, healthcare sectors (HCS) are entrusted with the continuous provision of health and well-being services to the public. Achieving these outcomes, places substantial demands on both HCS organisations and healthcare workers (HCWs). In the Australian public HCS, barriers to consistent care are increasing driven by the multifaceted challenges such as workforce shortages [1], sociodemographic factors including population health disparities, and the country's vast geographic expanse [2].

Gomersall [3] describes the HCS as a complex adaptive system (CAS), defined as an interconnected, nested, and networked structure of diverse agents and stakeholders. For the HCS to deliver care, meet organisational objectives, and

facilitate system transformation, continuous exchanges of communication and resources are required [4]. During these exchanges, interactions generate multidirectional feedback between individuals, teams, and across the nested subsystems [5]. Importantly, communication, signals, and resources are forms of social energy that are exchanged and accumulate within an organisation. Subsequently, the effective dissipation of this energy is essential for maintaining functional system states and preventing the escalation of systemic energy into states of disorder [4].

In social CAS, attractor states refer to recurring patterns of behaviour, interpretation, meaning, or interaction toward which individuals, teams or a system tends to move over time [6]. These dynamic interactions, feedback processes and information flows are inextricably entangled with system feedback rather than through cause-and-effect mechanisms [7]. Attractor states can represent a 'gravitational pull' – that is, the behaviour patterns or emotional states towards which an individual's or system's trajectory evolves. While these patterns emerge from local interactions, they eventually become the default states that govern the system's future trajectory [7]. In social CAS, attractor states represent a set of conditions individuals are drawn towards to assist in sense-making amidst disorder [8]. Since leaders exert influence over these conditions, evaluating leadership communication – through a lens of attractor states – offers a novel interpretation of how local interactions can manifest as systemic outcomes [9]. While Mackenzie [10] asserts that applying theories of attractor states in social CAS can illuminate organisational social dynamics, empirical examination within healthcare settings remains limited.

Globally, HCWs experience disproportionately high levels of occupational stress, adverse well-being, and poor mental health outcomes [11]. According to recent Australian data, anxiety affects 59.8% of HCWs, with emotional exhaustion and burnout are recorded at a significantly higher prevalence of 70.9%. Similarly, rates of post-traumatic stress disorder (PTSD) and depression were at 29% and 57%, respectively [12]. Salari, Khazaie [13] argue that HCWs are uniquely susceptible to psychological strain arising from the inherent intensity of clinical work and interpersonal conflicts. During the COVID-19 pandemic, these outcomes were exacerbated, and leadership communication was identified as a primary driver of increased anxiety [14], diminished motivation [15], and psychological strain [16]. However, the specific mechanisms through which leadership communication shapes the HCWs' experiences of well-being remain underexplored. This highlights a critical gap in the literature, particularly within the Australian public healthcare context.

METHODS

The study adopted an interpretivist qualitative approach and used reflexive thematic analysis to identify recurrent patterns across participant accounts [17]. The interviews explored participants lived experiences of leadership communication, workforce pressure, and system strain. Complex Adaptive Systems [18] was the primary interpretive lens for examining feedback, emergence, adaptation, and self-organisation. Attractor logic was then used to assess whether recurrent themes reflected patterned social sates. Finally, Dissipative Structures Theory [4] further informed the interpretation of far-from-equilibrium conditions, instability, and potential system reorganisation. To support analytic rigour, the research team documented coding and interpretation decisions, compared patterns across data sources, and emergent system relationships against relevant literature. To enhance transparency, Tables 1–4 make visible the data analysis procedure from code creation to thematic analysis, attractor characteristics, and final attractor-like states.

DATA COLLECTION

The target population comprised public HCWs and leaders across Australia. Healthcare worker participants included nurses, midwives, general practitioners, and specialist practitioners. Frontline managers or leaders such as clinical nurse managers and nurse unit managers. Clinical nurse managers and nurse unit managers represented frontline leadership, while senior leadership spanned hospital unit heads, department heads, and executives. These cohorts were selected because they represent the primary agents of clinical delivery, operational and strategic oversight within the public HCS. To ensure depth of insight, recruitment targeted individuals currently registered and actively working in the HCS. This ensured that while professional roles varied, the phenomenon under investigation remained the central focus of the inquiry. Participants were recruited via purposive and snowball sampling through human research ethics-approved professional social networks and industry-specific channels to ensure sample diversity [19].

DATA COLLECTION INSTRUMENT

In this study, the primary data collection instrument was an interview guide developed following a comprehensive literature review [19]. The guide focused on three domains: participants well-being, workplace experiences, and leadership communication. Within the communication domain, emphasis was placed on communication modification and feedback processes. This semi-structured approach provided a consistent framework across all interviews while allowing for the "rich, deep" data collection – typical of qualitative inquiry [20]. This approach allowed for the emergence of unanticipated topics, which were recorded and transcribed via *Zoom* software. All transcripts were manually audited and de-identified to ensure verbatim accuracy and participant anonymity.

ETHICS APPROVAL

The study formed part of a larger PhD research study. Study approval was received from by Central Queensland University Human Research Ethics Committee (0000024290) prior to data collection commencing. All participants received written study information packs and their consent was confirmed before each interview commenced.

DATA ANALYSIS

Data analysis followed a multi-phase approach**.** First, participant accounts were coded to identify recurrent meanings relating to leadership communication, psychosocial safety, workload, well-being, and adaptive responses. Second, these codes were grouped into broader themes reflecting patterned relationships across the dataset**.** Third, the emergent themes were interpreted through the theoretical lenses of Complex Adaptive Systems theory [21] and Dissipative Structures Theory [4] to identify recurring system characteristics, including reinforcement, recurrence, attractor behaviour, stability, emotional salience, and resistance to disruption. Finally, this approach informed the identification of underlying mechanisms such as behavioural patterns and system-level outcomes identifying attractor-like states, thereby providing a nuanced understanding of how leadership communication dynamics modulate psychological responses within healthcare organisations [22]. Tables 1–4 summarise this analytic progression, while the findings section provides examples showing how codes and themes informed each attractor state interpretation. To distinguish attractor-like patterns from strong qualitative codes, recurrent themes were not assumed as attractor states solely because of frequency or salience. Rather, a pattern was interpreted as attractor-like only where participant accounts suggested a recurrent configuration of interacting conditions that appeared to stabilise, reinforce, or draw the individual or healthcare system back toward particular behavioural, emotional, or communication patterns over time (Table 1).

TABLE 1. NINE CHARACTERISTICS OF ATTRACTOR STATES, IDENTIFIED THROUGH THE LENSES OF COMPLEX ADAPTIVE SYSTEMS AND DISSIPATIVE STRUCTURES THEORIES, UTILISED FOR MAPPING AGAINST INTERVIEW DATA

Attractor State Characteristic in a social CAS	Description	Reference
Occur in a Complex Adaptive System	A hierarchical arrangement of complex nested systems that influence one other through dynamic interactions.	Gomersall (2018)
Spontaneous Evolution	The evolution of HCWs towards a certain point arising from local system dynamics.	Morales-Matamoros (2010)
Fractal Properties	Behaviour patterns or outcomes are evidenced across multiple organisational contexts and nested sub-systems.	Dimitrov and Woog (2000)
Initial Conditions	A specific set of system variables, factors, or a starting point to which the HCWs respond.	Richardson (2014)

Path Dependence	Future system states or outcomes depend on past system states, historic events, or previous choices made.	Morales-Matamoros (2010)
Context Dependent	The conditions, parameters, or environment to which the HCWs respond has various meanings and values for the HCWs.	Dimitrov and Woog (2000)
Purpose	The attractor state has a purpose for the HCWs – to make sense of information, disorder, or guide behaviours.	Morales-Matamoros (2010)
Self-Organisation	Responses and decisions from HCWs evidence behaviours and patterns of self-organisation.	Weber (2022)
System Entanglement	Mechanisms such as feedback show multi-system entanglement that can provoke system change.	Radzicki (1990)

FINDINGS

Sixteen in-depth interviews were conducted, comprising nine HCWs and seven HCS leaders. Participants' demographics are summarised in Table 2. The HCW cohort represented a diverse range of multidisciplinary backgrounds, spanning 5-44 years of experience in the Australian HCS. Geographically, the sample was primarily concentrated in Western Australia (n = 12; 75%), with further representation from Queensland (n = 2; 13%), New South Wales (n = 1; 6%), and Tasmania (n = 1; 6%). Within the HCW cohort, the majority were nurses (n = 8; 89%), over half of whom were specifically situated within Emergency Departments (ED). Notably, many participants held experience across multiple Australian HCS disciplines and geographical states, providing a diverse perspective on the HCS. The leadership participant cohort was highly experienced, possessing a collective 113 years of service within the HCS (median=16.1 years). Experience within the leadership cohort ranged from frontline management experience through to senior leadership roles, representing clinical management, administrative, and strategic leadership.

TABLE 2: INTERVIEW PARTICIPANT DEMOGRAPHIC INFORMATION

Legend: FLL- Frontline leader, HCW- Healthcare Worker SL-Senior Leader NSW-New South Wales, TAS-Tasmania, QLD-Queensland, WA-Western Australia

Identifier	Country of Birth	Total years working in HCS	State in Australia	Role in public HCS	HCS Discipline
Healthcare worker participants					
HCW1	South Africa	5	QLD	Nurse	Theatre Department
HCW2	Australia	16	WA	Specialist Practitioner	Emergency Department
HCW3	Australia	5	WA	Nurse	Emergency Department
HCW4	England	39	WA	Nurse	Anaesthesia
HCW5	Australia	9	WA	Nurse	General Medical and Emergency Department

HCW6	Australia	6.5	WA	Nurse	General medical
HCW7	England	13	WA	Nurse	Acute care and Emergency Department
HCW8	Australia	9	WA	Nurse	Emergency Department
HCW9	England	44	WA	Nurse	Clinical
Healthcare sector leader participants					
FLL1	Australia	12	QLD	Frontline Leader	Clinical Nurse Manager Aged Care
FLL2	South Africa	20	WA	Frontline Leader	Clinical Nurse Manager- Hospital
FLL3	Zimbabwe	10	WA	Ass. Frontline Leader	ass Nurse Unit Manager- Acute Care
FLL4	Australia	14	WA	Frontline Leader	Nurse Unit Manager- ED
SL5	South Africa	9	TAS	Senior Leader	Director of People and Culture
SL6	Australia	22	WA	Senior Leader	Director of Women's Health Portfolio
SL7	South Africa	26	NSW	Senior Leader	Director of People and Culture

Reflexive thematic analysis of the interview transcripts revealed six primary themes and two integrated sub-themes (see Table 3). The primary themes, which are unranked to prioritise thematic depth over frequency, include: Well-being and Psychological Safety; Resource Constraints; Transformation and Turbulence; Bureaucratic Challenges; Leadership Efficacy; and Communication Processes and Feedback Mechanisms. Within these broader themes, two sub-themes emerged: Normalising Trauma (situated within Well-being), and A New Generation of HCWs (situated within Transformation and Turbulence). Table 3 provides a summary of the codes extracted from *NVivo 14,* including the main themes, associated interview questions, and the density of participant contributions as indicated by code reference counts.

TABLE 3: PARENT AND CHILD CODES FROM THEMATIC ANALYSIS RESULTING IN MAIN THEMES

Main Theme/Code	Select example of interview questions	Child codes	No. of References
Well-being and psychological safety	-Describe working in the HCS over the past 2-3 years -How would you describe your current state of well-being?	-Cultural divide -Feeling devalued -Hierarchy or dominant communication -Importance of psychological safety -Leader intolerance and lack of understanding	131

		-Leaders' effort to support -Experiences of well-being -Normalising Trauma	
Resource constraints	-Why is leader communication important (to you)?	-Structural and Huaman Resources -Training and clinical development -Workload and increased demand	119
Transformation and turbulence	-Describe the current culture in the workplace	-Changed perspective -Conflicting agendas -COVID-19 -HCW warnings of crisis -Loss of cultural identity -Staff changes -System changes	105
Bureaucratic challenges	-How do you feel the (Healthcare Worker) Unions could be more efficient?	-Bureaucracy -Compliance -Leadership visibility -Government participation -HCW Unions -Public vs private -Renumeration	66
Leadership efficacy	-What do you feel are important factors in leader communication? -How do you think communication in the HCS could be improved?	-Adapting communication -Different work ethic -Don't listen to HCW -Front Line Leaders action -Lack of support -Leader communication style -Psychological safety	220
Communication processes and feedback mechanisms	-Can you describe any experiences of speaking out or voicing your concerns to the leader? -How is conflict or uncomfortable situations managed?	-Accessibility and hierarchy -Adaptation of communication -Communication gaps -Debrief and feedback -Poor experiences of feedback -Roles of workplace communication	159

To identify the presence of attractor-like states within the Australian public HCS, data were analysed through the lenses of Complex Adaptive Systems (CAS) [21] and Dissipative Structures Theory (DST) [4]. Participants discussed experiences of chronic fatigue, stress, and burnout stemming from the confluence of escalating clinical demands and HCS resource scarcity. The cumulative pressure of operational requirements often exceeded the HCS's functional capacity which further contributed to HCWs' experiences of disorder. Healthcare workers explained how high levels of affective distress, including anxiety, anger, burnout, and Post-Traumatic Stress Disorder (PTSD), were precipitated by repeated exposure to high-acuity and traumatic patient cases, amidst excessive workloads. The HCWs' specific roles modulated their experiences of occupational distress, where understaffing, leaders' normalisation of occupational trauma and sub-optimal staff-patient ratios variably modulated their perceptions of workplace disorder. Notably, HCWs within emergency departments (EDs)

identified frequent "bottleneck points" of systemic friction – characterised by periods of system strain and operational overcapacity. Consequently, leadership intervention was sought to mitigate the cascading effects of psychological distress and manage resulting pressures on patient service provision.

Leadership communication was predominantly described as authoritative and transactional. For example, subordinate cohorts, including nursing staff and frontline managers, describe barriers to communicating non-clinical challenges or engaging in discussions regarding psychosocial support. Leadership were widely perceived as detached from the relational and emotional complexities and realities of clinical practice. Consequently, participants expressed how available psychological services and leadership accessibility for feedback and debriefing were inadequate. The absence of structured communication platforms contributed to participants feeling undervalued and was incongruent with the HCWs' requirements for trauma-informed debriefing.

Mapping the themes of participants' experiences of leadership communication, system disorder and well-being against the attractor characteristics (Table 1), revealed recursive and reinforcing patterns across individual, team, organisational, and system levels (8). These patterns repeated across diverse clinical disciplines and geographic contexts suggesting feedback dynamics recur across multiple levels of the HCS. Fourteen comparable attractor states were identified and grouped into five main types, each associated with leadership communication patterns linked to organisational instability or workplace disorder (see Table 4). First, these attractor states were marked by adverse occupational and psychological conditions experienced by the subordinate HCW. Second, the fluctuations in psychosocial well-being were situationally shaped. For example, the duration of an HCW's unaddressed adverse well-being appeared to trigger low expectations in the leader's competence and the likelihood of support [23]. This combination of factors coincided with the HCWs' support-seeking interactions with leadership to obtain psychological assistance or systemic relief [24] (See Table 3). Third, the subordinate HCWs frequently described leadership communication mechanisms within these attractor states as deflective, dismissive, and ambiguous (see Table 4). These communication mechanisms inhibited reciprocal dialogue, thereby damping information flows necessary for HCWs to resolve concerns or feel adequately supported.

Consequently, subordinate HCWs discussed their associated responses to these communication engagements, including anxiety, exhaustion, burnout, PTSD, emotional breakdown, and workplace withdrawal. These responses shaped the HCWs consequent decisions to reduce their work hours and, in some instances, resign from their roles.

TABLE 4: ATTRACTOR STATES IDENTIFIED IN THE AUSTRALIAN HCS– ASSOCIATED LEADERSHIP COMMUNICATION STYLE AND HEALTHCARE WORKER BEHAVIOURAL PATTERNS: SELECT REPRESENTATIVE QUOTES

Attractor State Descriptor	Dominant Leadership Communication Style	Manifested Workplace Disorder Outcomes	Representative Interview Quotes
Leadership Deflection	Intentional redirection of systemic concerns toward individual resilience	Chronic affective distress; erosion of trust	*Occurred in EDs and Medical Wards across numerous states and multiple time periods.* "I said to my manager that we are not ok, we are all getting a bit psychologically affected. And she went- yes, it is really bad isn't it? Are you free to do an early shift tomorrow?" - Nurse "I had a private meeting with my manager about my concerns, and it backfired on me" - Nurse
Hierarchical Silence	Authoritative blocking of feedback, restrictive top-down communication flows	Emotional breakdown. Feeling 'disregarded' by leadership	*Consistent across Metropolitan and Regional Hospitals* "There was no sense of support from management. It was as though the whole unit itself has such a low morale and there was so much negativity as well. We were dreading going to work. There were shifts in the end where I left in tears." – Nurse "The more burnout you develop, and when you ask for help, there is no help to be given. Do the managers not care, or they are stuck and they can't help from higher up themselves? The burnout is astronomical." – Nurse "I find that there are often too many people at the top end of the organisation that have no idea what it is like to actually be on the floor. They get paid so much money and do not listen to those on the ground. It is so infuriating." - Nurse
Ambiguity	Vague or non-committal responses to resource constraints or subordinates communications	Anxiety and inability to plan; challenges clinical workflows	*Occurred between HCWs and frontline managers and between frontline managers and senior leaders.* "After a discussion with her manager, an Indian nurse was terrified she was going to lose her job. She was fearful of the consequences. A couple of us were able to explain it to her and reassure her."- Nurse "When we have to treat patients in the corridors, and we give feedback to the manager, there isn't really a response. It makes me feel horrible when I go home, I feel bad for the patients. "- Nurse

Trauma Normalisation	Dismissal of HCW's expressed high patient acuity, stress, and debriefing needs as a "part of the job"	PTSD symptoms, increasing adverse well-being or stress desensitisation	*More prominent in the ED. Also occurring in medical wards and the theatres.* "You were dreading going to work. There were shifts in the end where I left in tears, and I thought-why am I doing his job anymore. So, I needed to leave." - Nurse "The problem is that when you come into this profession, you are expected to see horrific things. It's an emotional yo-yo to go from one extreme to the other without any recognition, that is inhumane and without debriefing. There is no emotion." - Nurse
The Exit Attractor State	Cessation of dialogue, "information damping" at a noticeable dialogue point	Workplace withdrawal and formal resignation	*Observed across numerous disciplines and states in the HCS.* "None of the nurses who work around me work full time, they have all reduced their hours." – Nurse Two survey respondents stated they had recently resigned from previous roles due to unrealistic workloads and a toxic workplace culture.

DISCUSSION

This study examined the influences of leadership communication on HCWs' well-being within the Australian public HCS, through the lens of Complex Adaptive Systems and Dissipative Structures Theories. The study reveals in-depth, regional, and transferable insights into how workload pressure, leadership communication, psychosocial safety, and workforce instability may interact recursively in high-pressure public healthcare settings. The study identified numerous attractor states, indicating repeating social patterns across geographic and organisational contexts. While organisational isomorphism has been observed regarding bureaucratic stability [25], this study observed a problematic form of pathological isomorphism – where restrictive leadership communication patterns have become a repeating concern across the nested public Australian HCS. This pattern reinforces that workplace disorder is systemically produced through leadership practices that limit adaptive organisational responses.

The recurrent social configurations evidenced attractor-like states and were entangled with HCWs' experiences of workplace disorder and unaddressed adverse well-being [24]. While leaders hold the formal authority to provide intervention and support [23], the HCWs approached the leaders with scepticism, as prior experiences suggested that the desired support was unlikely to be realised [23]. This finding is consistent with work from Varga, Spehar [26] regarding the link between leadership availability, trust, and competence, suggesting that in the Australian HCS, HCWs' well-being was recursively shaped by relational conditions and prolonged unresolved distress. These findings demonstrate the importance of support-seeking conversations, whereby the outcomes of these interactions shape HCWs' perceptions of leadership competence.

In contrast to work by Losada (27) on functional disequilibrium in productive social systems, our study found that the public HCS was often characterised by periods of functional disequilibrium. In these states, when feedback mechanisms were restrained to promote change, the system could no longer effectively self-regulate or manages increasing internal social disorder [28]. First, this finding is consistent with Holland's concept of boundary conditions that function as control mechanisms between sub-systems within CAS [21]. The analysis revealed that during the attractor-like social configurations, leaders' restrictive communication mechanisms acted as system boundaries to weaken the progression of non-clinical conversations, thereby restraining the escalation of organisational disorder. Contrary to adaptive communication in CAS [29], the leaders exerted authoritative behaviours which attempted to shape top-down control or revert the system to a pre-existing state [30]. These 'information damping mechanisms' suppressed signals of HCWs distress. Given the nature of systemic disequilibrium, our study findings indicated the emergence of behavioural patterns – signalling a shift in system dynamics – and attempts by HCWs to self-manage unaddressed psychosocial and workplace distress [7]. The analysis shows that when HCWs' efforts to seek resolution and support from leaders were constrained, their well-being deteriorated. This, in turn, strengthened systemic disorder rather than diminishing it.

Observations from our study revealed a central paradox: rigid hierarchical communication, that desires to maintain order, is fundamentally incompatible with the complex and nested feedback inherent in public HCS. Our finding is congruent with the work from Jackson [5] regarding leader communication mechanisms that reinforce top-down structures in organisations. However, workforce shortages, workload intensification, and constrained operational capacity are well-established pressures within HCS and align with complexity-informed understandings of the HCS as a CAS, where outcomes emerge through interactions between structural conditions, relational processes, and local adaptation (31, 32). This study therefore does not position leadership communication as a substitute for inadequate HCS resourcing. Rather, leadership communication is interpreted as a sensemaking and dynamic feedback mechanism through which resource pressures are acknowledged and escalated – not normalised or buffered. Consequently, leadership communication appears to shape whether resource scarcity is experienced as a shared system risk or as an individualised burden managed through withdrawal, or attrition. The findings emphasise how the leaders' recurrent restrictive communication approaches with HCWs did not suppress system disorder. Rather, the HCWs appeared to self-organise, adopting survival-based coping mechanisms in response to unresolved, perceived pathological systemic disorder (33). These responses

included resignations, reduced work hours, and disengagement, are all purposeful actions to limit further adverse well-being as a consequence of leader inaction [28].

Our study findings also add to the literature on attractor states in social CAS, particularly the Australian HCS [23] and is congruent with MacIntosh and MacLean (28) demonstrating how leaders have limited control over the informal structures in CAS. Rather than controlling emergent social patterns, leaders can influence the conditions that shape them through communication, feedback, sensemaking, and the reinforcement or disruption of recurring system behaviours. Consistent with Uhl-Bien and Arena [34], our study findings suggest that traditional 'command and control' leadership in healthcare settings suppresses the HCS's ability to leverage information for complex problem-solving, such as HCW well-being and adapting operational requirements.

In addition to workplace disorder, the HCWs' idiosyncratic states of adverse well-being and psychological safety emerged as a variable outcome of the recurrent social patterns [7]. When the HCWs felt their concerns were disregarded, their adverse well-being became exacerbated and was associated with unpredictable psychological states such as burnout and PTSD. Friedman, Resick [35] argue that emotional and psychological states, such as burnout and PTSD, are unpredictable and indicate a progression towards 'edge of chaos' system conditions. The narratives from the study demonstrate that when leaders employ restrictive communication strategies, they fail to mitigate disclosed stressors and instead intensify the occupational harms experienced by HCWs already operating at the limits of their capacity.

IMPLICATIONS AND CONCLUSION

Despite relational-transformational leadership being widely considered the dominant approach in the public sector, findings from this study reveal that Australian public HCS leaders often adopt restrictive communication strategies aimed at containing systemic disorder. Rather than stabilising the workforce, these practices foster environments characterised by low morale, distrust, and worker withdrawal. This disconnect highlights a critical misalignment: leaders attempted to apply linear, cause-and-effect management styles to a complex adaptive system where feedback dynamics are inherently unpredictable. Crucially, the study findings underscore that HCS organisational instability stemmed not just from external pressures, but from a failure to adapt communication mechanisms to the reality of the nested workplace environment-which intensified HCW fragility and feeling unsupported.

To address these systemic vulnerabilities, HCS leaders must transition from generic 'command-and-control' communication toward agile and adaptive practices. This realignment matches the dynamic nature of the HCS, where both frontline managers and leaders transition from top-down information flows to participatory sense-making forums. By fostering psychologically safe environments, leaders enable HCWs to engage in emotionally and contextually uncertain dialogues, allowing real-time feedback to be treated as critical system intelligence rather than a challenge to organisational stability.

Finally, managerial and leadership development programs should prioritise complexity literacy. Rather than relying on standard well-being or psychological safety communication competencies, leaders need a 'complexity and adaptive communication toolkit' that equips them to recognise non-linear patterns, remain transparent under uncertainty, and respond constructively to rising system pressure. This may reduce pathological isomorphism by disrupting the repeated reproduction of restrictive communication practices across HCS levels and strengthening the trust needed to sustain workforce well-being.

LIMITATIONS AND FUTURE RESEARCH

This study's cross-sectional and qualitative design cautions the strength of claims that can be made about attractor dynamics. The findings do not demonstrate attractors as formal dynamical states, nor do they establish temporal stability, basin structure, or observed return following perturbation. Rather, the study applies attractor logic as an interpretive complexity lens to make sense of recurrent behavioural, cultural, and communicative patterns reported by participants. Future research should examine maladaptive system dynamics through longitudinal and mixed-method designs, integrating successive time points of qualitative inquiry and quantitative measures of workload, psychosocial safety,

communication quality, workforce movement, absenteeism, turnover, incident reporting, and workload. This would better identify these recurrent patterns as attractor states and help establish whether adaptive leadership interventions can disrupt maladaptive patterns and support transition toward more functional system states.

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RESEARCH ARTICLE

DECODING DOCTOR DEPARTURE DECISIONS IN REGIONAL QUEENSLAND

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ABSTRACT

BACKGROUND

Medical workforce shortages are a pervasive issue across Australia, with rural and regional hospitals facing particular challenges in maintaining a stable workforce. Frequent turnover of prevocational doctors in these areas can adversely impact service delivery and healthcare outcomes. The primary aim of this study is to investigate the reasons why prevocational doctors leave regional hospitals, and whether these reasons vary across different regional settings.

METHOD

Semi-structured, mixed methods exit interviews were conducted with 83 interns and resident medical officers (RMOs) who resigned from three regional Queensland hospitals (Townsville, Cairns, and Bundaberg) at the end of the 2023 clinical year. Thematic analysis was used to identify common themes, and chi-squared tests assessed quantitative regional differences.

RESULTS

The main reasons for starting at a regional hospital included reputation, familiarity with the hospital or region, and proximity to family or friends. Career progression emerged as the primary reason for leaving. There was no significant difference across regions in the reasons for leaving, retention factors, most valuable attributes, and factors influencing resignation. A significant difference between regions was established in the reasons for starting ($p=0.01$) and areas for improvement ($p=0.02$).

CONCLUSIONS

Strengthening regional hospitals by promoting their unique attributes and enhancing career development opportunities is essential for fostering a sustainable medical workforce. The findings highlight key areas where regional hospitals can focus to enhance prevocational doctor retention. Furthermore, a systemic approach to attracting and retaining prevocational doctors is essential for building a future proof workforce capable of meeting the healthcare demands of regional communities.

KEYWORDS

exit interviews, regional workforce, junior doctor, prevocational, attraction, retention, attrition

BACKGROUND

Geographic maldistribution of prevocational doctors continues to pose a significant challenge for regional hospitals despite the increasing number of medical graduates in Australia [1-3]. National surveys of graduating medical students consistently show a preference for metropolitan practice, with only 31.5% of medical graduates in 2023 expressing a desire to work in regional, rural or remote communities [4]. This has contributed to recruitment and retention challenges for regional hospitals. As a result, these hospitals frequently rely on locum doctors and International Medical Graduates (IMGs) to fill vacancies, which compromises workforce sustainability and continuity of care [2]. In the Australian healthcare system, rotational doctors (interns and resident medical officers) are essential to delivering healthcare in regional and rural communities, which are already disadvantaged by geographical isolation and complex sociodemographic factors [5-6].

A growing body of research has explored the factors influencing healthcare workforce attraction and retention in rural areas. These factors include career opportunities, workplace conditions, rural background, organisational management, social connections and attachment to place [6-8]. A study examining doctors' perceptions of rural practice found work-life balance and social connectedness are advantages of working rurally, but the lack of specialist training and career development opportunities are significant deterrents [9]. Within the Australian setting, retrospective research of James Cook University (JCU) medical graduates found that rural generalist training, attendance at rural clinical schools and completing internships in regional or remote locations were associated with an increased likelihood of practicing in these areas for at least 12 months [10]. Similarly, attending a regional clinical school has been shown to be the strongest predictor of completing an internship in that area, alongside being from a hometown near the clinical school location [11].

The association between rural background, rural medical training and subsequent rural practice is well documented [7, 12-14]. However, fewer studies have focused on attraction and retention factors of early career doctors, despite international evidence that rural exposure during this time is positively associated with subsequent rural practice [15-18].

This study aims to build on the existing knowledge by examining the factors influencing the attraction and retention of prevocational doctors across three regional health services located in Queensland (QLD), Australia. The health services cover a large geographical area with a population each served by a single larger hospital and multiple smaller rural facilities (Table 1). By providing a detailed analysis of the reasons doctors leave regional settings, this study will inform targeted strategies for recruitment and retention.

TABLE 1 - REGIONAL HOSPITAL CHARACTERISTICS

	Townsville	Cairns	Bundaberg
Catchment population	250,000, with a tertiary catchment of 700,000	250, 000	100,000
Geographical area served (square km)	148,000	142,900	6,500
Beds or equivalents	811	771	261
Doctors employed	Over 1000	742 (Cairns Hospital) 853 (HHS)	Over 400
Clinical Service Capability Framework (CSCF) level	6	5	2
Specialist College Training programs	Physician (Adult and subspecialties) Physician (Paediatrics) Anaesthetics Radiology (including radiation oncology)	Physician (Adult) General Medicine and subspecialties Physician (Paediatrics)	Physician (Adult) Physician (Paediatrics) Anaesthetics Emergency medicine

	Emergency medicine Intensive care Surgery (including general, orthopaedics, urology, vascular, paediatric, neurosurgery, otolaryngology head and neck, cardiothoracic) Oral and maxillofacial Dermatology General practice (including rural generalist) Medical administration Obstetrics & gynaecology Psychiatry	Anaesthetics Emergency medicine Intensive Care Surgery (including general, orthopaedics, urology, vascular) Dermatology General practice (including rural generalist) Medical administration Obstetrics & gynaecology Psychiatry Sports medicine	Intensive care Surgery (General) General practice (including rural generalist) Medical administration Obstetrics & gynaecology Psychiatry
Coastal or inland	Coastal city	Coastal city	Coastal city
Access to direct international flights	No	Yes	No
Modified Monash Model (MMM)	MM2	MM2	MM2
Rural health service facilities	8	8	8

Note: Data reference- Queensland Government. Our Performance. [Internet]. [cited 2024 Nov 22]. Available from: www.performance.health.qld.gov.au/view-performance-by-facility/hospitals

METHOD

STUDY AIM, DESIGN AND SETTING

This study aimed to explore the factors influencing the attraction and retention of prevocational doctors in regional Queensland health services, with a focus on understanding why prevocational doctors choose to leave these hospitals. This was a cross-sectional, mixed-methods study conducted across three regional Queensland hospitals: Townsville Hospital and Health Service (THHS), Cairns and Hinterland Hospital and Health Service (CHHHS), and Bundaberg, Wide Bay Hospital and Health Service (WBHHS). The study employed both qualitative and quantitative data collection techniques, utilising semi-structured exit interviews with interns and RMOs who had resigned at the end of the 2023 clinical year. They were conducted between December 2023 to January 2024.

PARTICIPANTS

The participants in this study were prevocational doctors who resigned from their positions at the three regional hospitals during the 2023 clinical year. The inclusion criteria were: (1) doctors in their postgraduate year 1 (interns) or postgraduate year 2+ resident medical officers (RMOs) and (2) those who had officially resigned from the hospital between October 2023 and March 2024. Doctors who were accredited or unaccredited registrars were excluded from the study due to differences in the length of their rotational period. Based on these criteria, a total of 127 participants were deemed eligible across the three hospitals.

DATA COLLECTION

Data were collected through semi-structured exit interviews facilitated by the study investigators, who were each medical education or medical administration registrars from the participants' respective hospital. These interviews were conducted mostly face-to-face, with some via video conferencing if working at a rural facility. Each interview took 15 to 30 minutes.

The questions asked at the outset of the interview captured a range of sociodemographic variables (gender, age, role, relationship status, presence of children, and hometown) and professional details, university attended, and location of current employment. The ensuing questions elicited participants' reasons for starting at the hospital, reasons for leaving, and intentions to return to their current health service.

To ensure relative consistency across the exit interviews, a standardised set of questions was used to guide the interview (Appendix 1). The interview template was developed to ensure consistency in the core questions relevant to this study and in documentation across all interviews. The questions related to factors influencing attraction and attrition were intentionally broad and open-ended, to invite participants to share the experiences and thought processes which contributed to their employment decisions. During the interviews, the interviewers sought feedback on participant answers to elicit examples of specific events the participants experienced and/or observed at their hospital, as well as personal opinions and circumstances affecting their decision to resign. The semi-structured approach allowed for flexibility in exploring participants' reasons for departure, which may be of a sensitive or personal nature [19].

Regular meetings were held among the researchers to discuss emerging themes and ensure alignment in the interpretation of responses. Interviews were recorded and transcribed for qualitative analysis. This process ensured standardised, reliable data collection while allowing flexibility for participant-driven insights.

DATA ANALYSIS

Quantitative data were analysed using Stata version 17 (StataCorp, TX, USA). Descriptive statistics were calculated to summarise the characteristics of the participants and the frequency of responses to key questions. Chi-squared (χ^2) tests were employed to assess differences between the hospitals in terms of factors influencing decisions to leave. The level of significance for all tests was set at $\alpha = 0.05$. Post-hoc analyses with Bonferroni correction were performed to further investigate any statistically significant differences between the hospitals.

For qualitative data, a thematic analysis using Braun & Clarke's approach was conducted to identify recurring themes and factors influencing the attraction and retention of prevocational doctors [20]. Transcripts were coded using a deductive approach, with themes related to reasons for leaving, factors influencing retention, and valuable aspects of the hospital experience being identified and categorised. When theming occurred, the group collectively set the themes through an initial review of the earlier transcribed interviews and then later brought any queries back to the group for theming. Regular meetings were held among the interviewers to discuss emerging themes and ensure alignment in the interpretation of responses and reflexivity.

ETHICAL CONSIDERATIONS

The study was approved by the Townsville Hospital and Health Service Human Research Ethics Committee (HREC approval: THHS EX/2024/QTHS/108407). All participants provided informed and written consent prior to participating in the study, and their responses were anonymised to ensure confidentiality.

STATISTICAL POWER

A power calculation was not performed for this exploratory study, as the primary aim was to conduct an in-depth, qualitative analysis of factors influencing attrition, supplemented by descriptive quantitative analysis. Nonetheless, the sample size of 83 participants provides clear insights across the three regional hospitals, given the relatively small medical workforce in these settings and data saturation.

RESULTS

SOCIODEMOGRAPHICS

A total of 83 doctors participated in the exit interviews, with a response rate of 53%, 64% and 100% across CHHHS, THHS and WBHHS respectively. The sociodemographic characteristics of the participants are summarised in Table 2. The majority of participants were female (61%). The predominant age group was 26-30 years (59%). Most participants were RMOs (73%), with a smaller proportion being interns (27%). Relationship status varied, with 57% being single, 33% having a medical partner and 11% having a non-medical partner. A minority (4%) had children. Just over one third of participants (35%) identified as IMGs. Figure 1 outlines the employment destination for participants leaving these regional health services. Whilst 41% of participants sought roles in a different regional setting, just over half of participants (51%) left the regional hospital to work in a metropolitan area. The remaining 8% of participants expressed intentions to undertake locum work. The majority of participants expressed a willingness to return to their regional health service in the future (83% overall) with CHHHS at 96%, THHS at 79%, and WBHHS at 71% (Table 3).

TABLE 2. PARTICIPANT SOCIODEMOGRAPHICS

Baseline characteristic	THHS		CHHHS		WBHHS		Total sample	
	n	%	*n*	%	*n*	%	*n*	%
Gender								
Male	13	38.24	11	39.29	7	33.33	31	37.35
Female	20	58.82	17	60.71	14	66.67	51	61.45
Nonbinary	1	2.94	0	0.00	0	0.00	1	1.20
Age								
20-25 years	8	23.53	6	21.43	11	52.38	25	30.12
26-30 years	24	70.59	19	67.86	6	28.57	49	59.04
31-35 years	2	5.88	2	7.14	3	14.29	7	8.43
36+ years		0.00	1	3.57	1	4.76	2	2.41
Role								
Intern	8	23.53	5	17.86	9	42.86	22	26.51
RMO	26	76.47	23	82.14	12	57.14	61	73.49
Partner								
Single	17	50.00	12	42.86	18	85.71	47	56.63
Medical partner	13	38.24	12	42.86	2	9.52	27	32.53
Non-medical partner	4	11.76	4	14.29	1	4.76	9	10.84
Children [a]	1	2.94	1	3.57	1	4.76	3	3.61
Hometown								
Local	4	11.76	4	14.29	0	0.00	8	9.64
QLD resident	9	26.47	12	42.86	2	9.52	23	27.71
Interstate resident	11	32.35	10	35.71	1	4.76	22	26.51
Overseas resident	10	29.41	2	7.14	18	85.71	30	36.14
QLD university	18	52.94	20	71.43	2	9.52	40	48.19
Interstate University	5	14.71	7	25.00	2	9.52	14	16.87
IMG	11	32.35	1	3.57	17	80.95	29	34.94

[a] Reflects the number and percentage of participants answering "yes" to this question.

FIGURE 1. LOCATION OF NEXT ROLE AFTER LEAVING THE REGIONAL HOSPITAL

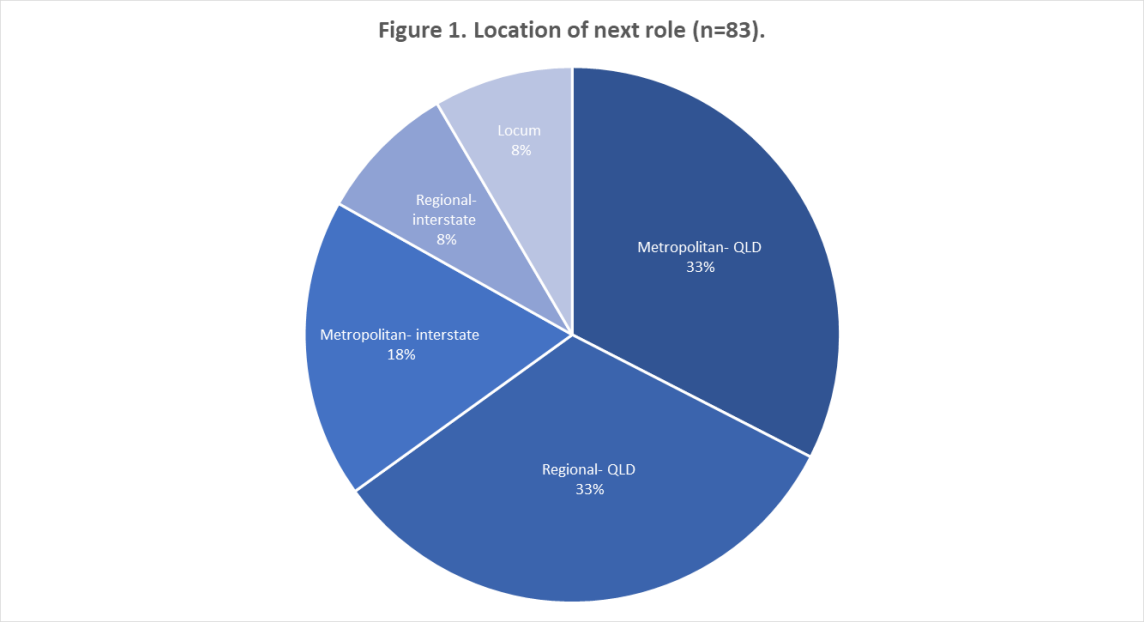


TABLE 3. PARTICIPANT WILLINGNESS TO RETURN TO THE HEALTH SERVICE

Response	THHS		CHHHS		WBHHS		Total sample	
	n	%	*n*	%	*n*	%	*n*	%
Yes	27	79.41	27	96.43	15	71.43	69	83.13
No	6	17.65	1	3.57	3	14.29	10	12.05
Maybe	1	2.94	0	0.00	3	14.29	4	4.82

REASONS FOR STARTING

Table 4 outlines the reasons given by the participants for starting their positions. The most common reason for starting overall cited by participants across the three regions included reputation of the hospital (41%). Participants considered the opinions and recommendations of friends and colleagues as key sources of information when assessing a hospital's reputation:

I asked around about where is a good place to be a junior doctor, and heard reports from multiple different people that [this] hospital has a good environment and supportive system for junior doctors.

I heard really good feedback about […] Hospital whilst in medical school… friendly place to work, well supported, good Intern teaching.

Familiarity with the region was another key factor influencing the decision to seek employment in the regional hospital, with 25% of participants citing prior experience with the hospital or region as a reason for starting. Generally, this sense of local connection originated from having attended university in the region or having completed hospital placements at the regional hospital as a student. In these cases, participants often emphasised their desire to smoothly transition from medical student to doctor. In some cases, participants had grown up or studied in the region:

[…] is my hometown...I was away from home for uni and always wanted to come back here to work. From a personal perspective, I have had family members come to this hospital and felt it was a familiar environment.

I had done 2 years of medical school here... so felt this was a comfortable, familiar place to step up to being a doctor.

I went to the local clinical school, so it just made sense to do internship here.

Social connections were identified as a reason for starting by 20% of participants. Having friends or family in the region encouraged these participants to seek employment with the regional hospital, alluding to the value of social support when transitioning to a new position. One participant described meeting their partner, a local resident with a non-medical career, whilst living in the regional setting and attending the rural clinical school as a medical student. This was a significant factor in their decision to relocate and commence working in the regional hospital as a doctor. Several participants described already having friends, peers or colleagues working at the regional hospital as an incentive to start, whilst others stated they moved to the region with a group of medical friends:

I had a few friends that were also keen on making the move as well, so that was probably a big part of it. Not going alone.

The desire for new experiences and a change of scenery contributed to the decision to start for 17% of participants. Participants often felt compelled to relocate after years of living or studying in one location, particularly when this setting was interstate or metropolitan. These participants articulated an urge to "get away from the big city", "see Australia" or undertake a "personal and professional lifestyle change".

My partner and I were looking for a lifestyle change with warmer weather, more outdoor activities and were not sure what we wanted to do so, so it seemed like a good opportunity to move somewhere else and work in a different environment.

However, the desire for change was not limited to participants from metropolitan locations. One regionally based participant from a geographically distant state of Australia voiced their desire for "different experiences at a different hospital", referencing the diverse patient demographic, medical conditions, and climate the regional hospital had to offer.

Access to desired or required clinical rotations was identified as a reason for starting for 14% of participants. For some participants who identified as International Medical Graduates, the decision to relocate to the regional hospital was based on the availability of specific rotations to fulfil their registration requirements. For other participants, the decision to seek employment was based on the availability of certain rotations to fulfil specialist training requirements:

The main thing that bought me here was I needed a paediatric rotation for RACGP [Royal Australian College of General Practitioners] training. It was difficult to get in {previous hospital} because there are limited spots.

For 13% of participants, a desire for clinical exposure to regional and rural medicine was identified as a reason for commencing employment with the regional hospital. A summary of the most prominent themes and examples of participant quotes can be found in Table 5.

Data analysis revealed that the reasons for starting at the hospital showed significant differences between regions ($\chi2(11) =8.64$, $P=0.013$). For example, for THHS participants, the most prominent attraction factor was familiarity with the region, whereas reputation was the common reason for seeking employment for CHHHS and WBHHS participants. Post-hoc comparison using Chi-Squared tests, adjusted with the Bonferroni correction, highlighted notable differences between THHS and WBHHS (Adjusted $P=0.022$). This finding suggests distinct regional factors influencing initial employment decisions in these regions.

TABLE 4. ATTRACTION FACTORS.

Themes	THHS		CHHHS		WBHHS		Total sample	
	n	%	*n*	%	*n*	%	*n*	%
Reputation of hospital/word of mouth	5	14.71	17	60.71	12	57.14	34	40.96
Familiarity with hospital/region	13	38.24	8	28.57	0	0.00	21	25.30
Moving for family/friends/partners	7	20.59	8	28.57	2	9.52	17	20.48
Looking for a change of scene/new experiences	6	17.65	8	28.57	0	0.00	14	16.87
Access to desired/ required rotations	8	23.53	4	14.29	0	0.00	12	14.46
Interest in regional/rural experience	5	14.71	6	21.43	0	0.00	11	13.25
Partner's career	5	14.71	0	0.00	1	4.76	6	7.23
Community lifestyle factors (culture, food, activities)	0	0.00	6	21.43	0	0.00	6	7.23
Tertiary facility	6	17.65	0	0.00	0	0.00	6	7.23
Availability of job (including bonded or balloted position)	4	11.76	1	3.57	1	4.76	6	7.23
Renumeration/financial incentive (onboarding support)	2	5.88	1	3.57	1	4.76	4	4.82
Exposure to interesting/tropical medicine	0	0.00	2	7.14	0	0.00	2	2.41

TABLE 5. MOTIVATION FOR LEAVING.

Themes	THHS		CHHHS		WBHHS		Total sample	
	n	%	*n*	%	*n*	%	*n*	%
Career opportunity [a]	24	70.59	15	53.57	14	66.67	53	63.86
Community [b]	22	64.71	8	28.57	17	80.95	47	56.63
Social [c]	16	47.06	14	50.00	5	23.81	35	42.17
Seeking change/new experiences	7	20.59	5	17.86	9	42.86	21	25.30
Quality of training/education [d]	6	17.65	0	0.00	1	4.76	7	8.43
Employment conditions [e]	0	0.00	2	7.14	0	0.00	2	2.41

[a] Career progression including lack of specific subspecialty rotations, difficulty accessing rotations, promotion to PHO/registrar, professional connections and exposure, specialty training program not available, networked college training program or college requirement, practice primary care (e.g. GP registrar)

[b] Community lifestyle factors outside of work (culture, food, activities) e.g. closer to city, time off to travel and locum, long flights/limited availability of flights

[c] Moving for family/friends/partner / partners career / lack of socialisation or sense of community in medicine

[d] Quality of training/education including supervisor feedback and research opportunities

[e] Employment conditions including flexibility to work part time and remuneration.

REASONS FOR LEAVING

Data analysis revealed five main themes from the reasons given for leaving a regional hospital. A summary of these themes and examples of participant quotes can be found in Tables 6 and 7.

Career opportunities were the most common reason for leaving described by participants overall across the three regions (64%). Participants described a variety of push and pull factors stemming from a desire for career progression. A lack of specific subspecialty rotations, or difficulty accessing a limited number of highly sought-after rotations, led some participants to seek alternative employment. Other participants left the regional hospital due to a lack of availability of their desired speciality training program, or the inability to fulfil certain speciality training requirements. Opportunities such as promotion to a more senior position, and the desire to develop professional connections in a particular field, were also

described as incentives to relocate. This theme was underscored by more than half of participants (51%) choosing to relocate to metropolitan hospitals (Figure 1).

Bigger department and training opportunities.

I want to experience more diverse rotations and subspecialties that we don't have here.

Community and lifestyle factors were identified by 57% of participants as a reason for leaving. Some participants felt that relocating would provide better access to culture, food and activities outside of work. Participants expressed a preference live closer to the city, or have better access to international or domestic airports. In particular, it was noted that some International Medical Graduates left their regional setting due to a lack of availability of international flights:

Being closer to an international airport makes it easier to travel home to see family more often.

My partner's family are in Sydney, so it will be cheaper and closer to catch a flight there.

Family or partner considerations were cited as a motivating factor for leaving by 42% of participants. Participants spoke of their desire to move closer to family members or their network of friends, with some alluding to the value of strong social support structures whilst undertaking speciality training. For many participants, their medical or non-medical partner's career was the deciding factor in relocating:

My partner had limited job options and was offered a job elsewhere.

I think it is the strong family pull... I can't move my whole family up here.

The desire for change was highlighted as a reason for leaving by 25% of participants. Participants emphasised the value of new professional experiences and exposure to different health services, often after spending years at the regional setting. Some participants articulated the need to step out of their comfort zone to gain new skills or perspectives.

This is the only health service I've experienced as a medical student or doctor, I want to grow and challenge myself as a doctor and try working in a different hospital.

I've spent two years here so have learned all I can from this place.

The quality of training or education was cited as a reason for departure by 8% of participants. Some participants perceived that a metropolitan setting would offer better quality specialty training or research opportunities:

I think I would get better training in Brisbane where the registrars are more experienced.

I had trouble starting research for anaesthetics.

Data analysis revealed no significant differences between the regions in motivations for leaving ($\chi 2=2.72$, $P=0.257$). This finding indicates similar challenges in workforce retention across the three regions, potentially pointing to consistent factors affecting intern and RMO turnover.

MOST VALUABLE ATTRIBUTES, AREAS FOR IMPROVEMENT AND RETENTION FACTORS

Table 8 shows the most valuable attributes, or the greatest strengths of each participant's experience, across the regional hospitals. Positive workplace culture was cited most commonly overall by participants across the three regions, followed by supervision and senior support, high-quality teaching and training, practical clinical experience, and exposure to a broad mix of patient presentations and pathology.

There is a wide variety of presentations including tropical diseases.

Supportive, good work culture with good relationships between doctors and nurses that felt less hierarchical.

[The hospital] has some really good mentors who are patient centred.

The rural experience of stepping up making decisions and opportunities for procedural skills.

There were no significant differences between regions on what doctors found their most valuable during their employment at the hospital. The health service areas for improvement were specific to each region and data was utilised for internal quality improvement processes. Areas for improvement revealed significant differences between regions ($\chi 2=8.64$, $P=0.013$). Further analysis using post hoc Chi-Squared tests, adjusted with the Bonferroni correction, pinpointed significant differences between THHS and WBHHS (Adjusted $P=0.024$). Analysis showed no statistically significant difference between regions with regards to retention factors. This aligns with the findings on motivations for leaving, with similar rationale underlying the decision to leave across regions.

TABLE 6 – THEMES: ATTRACTION FACTORS

Themes	Quote
Hospital reputation	"I asked around about where is a good place to be a junior doctor, and heard reports from multiple different people that {this] hospital has a good environment and supportive system for junior doctors." "... has a great reputation for being a supportive, friendly environment, especially for IMGs" "I know a few people who work here and really like it"
Familiarity with hospital or region	"I had done 2 years of medical school here... so felt this was a comfortable, familiar place to step up to being a doctor." "I already knew people up here, my partner had done Internship here and liked it." "We wanted to spend a year somewhere I was familiar and comfortable... because it would be a smooth transition for internship." "I went to the local clinical school so it just made sense to do internship here"
Moving for friends/family/partner	"I had a few friends that were also keen on making the move as well, so that was probably a big part of it. Not going alone." "It was easy for my partner and I to both get jobs here"
Looking for a change of scenery/new experiences	"My partner and I were looking for a lifestyle change with warmer weather, more outdoor activities, and were not sure what we wanted to do so, so it seemed like a good opportunity to move somewhere else and work in a different environment." "My partner and I wanted to get away from living in a big city and felt like this could work well for our lifestyle... lots of outdoor things to do here"
Access to desire or prerequisite rotations	"I was offered a job with really good terms…I've been doing ACRRM Training... and was given rural, anaesthetics, ED and O&G terms" "The main thing that bought me here was I needed a paediatric rotation for RACGP training. It was difficult to get in {previous hospital} because there are limited spots." "The opportunity for a GP rotation was pretty cool"

TABLE 7 – THEMES: MOTIVATIONS FOR LEAVING

Themes	Quote
Career opportunities	"I can't get more than a 10 week O&G rotation here and I wanted to get more experience in O&G to gauge interest in this as a career pathway. I also want to do a certificate of women's health or the diploma, and I'm not able to do this unless I'm on a longer O&G rotation" "Bigger department and training opportunities." "I want to experience more diverse rotations and subspecialties that we don't have here"
Community lifestyle factors	"My partner's family are in Sydney, so it will be cheaper and closer to catch a flight there." "There's nothing to do outside of work." "For me I wanted to go to a place with more diversity, with Asian stuff, yeah because I get homesick a lot... I wanted to go somewhere a bit more familiar." "Being closer to an international airport makes it easier to travel home to see family more often"
Family or partner considerations	"My partner wants to pursue radiology and has exhausted all the options here." "I think it is the strong family pull... I can't move my whole family up here." "My partner had limited job options and was offered a job elsewhere." "My partner got into specialty training in the city"
Seeking change/new experiences	"I want to have a different year, take time off, travel, see different hospitals." "This is the only health service I've experienced as a medical student or doctor, I want to grow and challenge myself as a doctor and try working in a different hospital." "ACRRM would have been good to do here. But there is also have good training in NSW so why not." "I've spent two years here so have learned all I can from this place"
Quality of training/education	"I had trouble starting research for anaesthetics." "I think I would get better training in Brisbane where the registrars are more experienced"

TABLE 8 – THEMES: MOST VALUABLE ATTRIBUTES

Themes	Quote
Workplace culture	"Supportive, good work culture with good relationships between doctors and nurses that felt less hierarchical."
Supervision and senior support	"[Hospital] has some really good mentors who are patient centred." Supportive senior staff and good supervision."
Quality teaching and training	People respected protected teaching time
Practical clinical experience	"The rural experience of stepping up making decisions and opportunities for procedural skills." 'Good autonomy for junior doctors."
Broad mix of presentations/ pathology	"There is a wide variety of presentations including tropical diseases." "The hospital has provided new and different experiences with uncommon pathologies."

DISCUSSION

The majority of prevocational doctors participating in our exit interview left regional areas for work in metropolitan regions or locum positions. This preference has been consistently shown in other international studies that medical schools produce graduates who strongly prefer to work in metropolitan areas, with urban areas seeing a concentration of the medical workforce [2, 21]. Addressing medical workforce maldistribution and building a sustainable workforce across Australia's vast geographical regions is a longstanding challenge. The problem is not unique to Australia but is also shared by other countries with large geographical coverage, such as the United States, as well as by smaller low-income countries [17-18, 21]. The responsibility for overcoming these challenges should not lie with remote, rural, or regional services but is instead a shared responsibility across the health, social, and political sectors. Accordingly, the World Health Organisation (WHO) in 2010 produced global policy recommendations to assist countries in increasing the attraction and retention of health workers in remote and rural areas [18].

The three participating regional sites in this project vary in terms of hospital size, services, and factors influencing place attractiveness, such as affluence, isolation, amenities, and spousal employment opportunities. The statistically significant difference in the reasons doctors chose to work in these regions echo previous findings that location-related factors, including hospital reputation, family ties, and lifestyle play a role in these decisions [22-24]. This finding highlights the importance of tailored recruitment strategies for prevocational doctors that promote a region's unique strengths. A nuanced understanding of regional attributes and how they align with doctors' personal and professional goals could be pivotal in workforce planning [9, 22-23].

Over half of the doctors who chose to work at CHHHS and WBHHS cited the hospitals' strong reputations as their primary reason for starting, while familiarity with the hospital and region was the most common reason (38%) for THHS participants, likely due to its proximity to and affiliations with a medical school. The association between familiarity with the Townsville region and the decision to start work at THHS concurs with the existing body of literature advocating for recruiting medical students of rural-origin, rural clinical schools and rural health exposure [21, 23, 25-26]. Despite these well-established findings and WHO recommendations, many medical students in Australia, particularly those in metropolitan-based medical schools, do not receive adequate rural exposure, with 29% of final-year students having no rural placement experience in their final two years [4, 18]. Similarly, a study by Meade and colleagues reported only 36% of US medical student survey respondents received any rural practice exposure [21]. When one considers the demonstrated influence of rural healthcare exposure on a medical student's choice to work in rural healthcare after graduation, there appear to be opportunities for policy reform and the implementation of broader support for rural and regional training pathways to begin to address the maldistribution of the medical workforce [11, 17, 27].

Career progression opportunities were the most frequently cited reason for leaving overall across the three regional hospitals. This finding aligns with well-documented barriers to workforce retention, particularly the limited availability of specialist training posts in regional areas [11]. The imbalance in specialist training opportunities between metropolitan and regional sites remains a critical issue in Australia, as highlighted in the 2021-2023 National Medical Workforce Strategy [2]. Current retention initiatives, such as bonding schemes and rural allowances, vary across regions, but long-term solutions require consideration of the life and career stage of the targeted workforce [17, 28]. For prevocational doctors, interventions that focus on career progression, such as collaboration with specialist colleges to establish accredited training posts in regional centres, would be a meaningful step towards improving retention [11].

Lifestyle factors, particularly access to direct flights and metropolitan amenities, were common factors influencing doctors leaving regional areas, despite the attraction of coastal living. This outcome highlights the need for broader stakeholder engagement and regional workforce planning that addresses social, economic, and lifestyle factors to create environments where doctors and their families can thrive [22]. Despite significant differences across the three regions in reasons for starting, no statistical difference was found in the reasons for leaving or retention factors. This consistency, despite regional variations, highlights the potential for system-level retention strategies [2, 29].

The consistency in participants' responses for valued workplace attributes could be explored further in future research and used to inform universal strategies to enhance prevocational doctor workforce engagement and potentially improve retention. Most (83%) of participants across all three regions expressed a willingness to return for future employment, which is an encouraging result for the three regional areas. Of the 12% who would not consider returning, 75% were IMGs and 87.5% had trained or identified their hometown as interstate or overseas. These data support previous research emphasising the need for targeted strategies and investment in career pipelines for locally trained doctors to build a sustainable rural and regional workforce [11, 26].

Australia is heavily reliant on IMGs to address current medical workforce maldistribution [2]. Based on internal medical workforce estimates, the participant demographics suggested an over-representation of IMGs leaving the three sites. Future research could improve understanding of the overall profile of the prevocational medical workforce and any unique characteristics associated with the reasons IMGs leave regional areas, providing important information if this cohort are to be a sustainable solution to Australian's workforce shortages [28]. From an ethical perspective, the use of IMGs to support developed countries such as Australia should be undertaken with an understanding of the WHO Global Code of Practice on the International Recruitment of Health Personnel and conducted in a way that collaborates with developing nations to strengthen all health systems [30].

This study provides valuable insights through semi-structured exit interviews, offering a nuanced understanding of why prevocational doctors leave regional hospitals. While the focus was regional hospitals, a limitation is the lack of comparison with metropolitan hospitals, which could provide a more comprehensive understanding of workforce challenges. Although the study is specific to Queensland, Australia, the findings may be relevant to other developed countries facing similar issues of workforce maldistribution in geographically dispersed areas, such as that experienced in the United States and Canada [17].

LIMITATIONS

Despite robust standardisation efforts, the potential for interviewer bias cannot be eliminated. All four interviewers were Australian-trained doctors working in education or administration fields within the hospitals where interviews were conducted. Reflexivity was managed by interviewers asking the preselected questions prior to prompting participants for a more in-depth answer. The timing of the interviews, conducted during the last month of employment, may also have affected the extent to which participants disclosed reasons for leaving, particularly for those considering returning to the hospital. While the high participation rate is a strength, this timing may have led to less candid responses, despite efforts to reassure participants through de-identification of data. There is further self-selection bias to be considered in interpretation of the results.

The limited sample size of 83 participants across three sites and the dilution of the results through multiple themes and sub-divisions has impacted the power of the results, however the authors wanted to reflect the multitude of factors that influence the decisions of prevocational doctors, to inform future work and quality improvement.

CONCLUSION

While the findings of this study echo the well-established challenges of recruiting and retaining doctors in regional Australia, they also bring to light opportunities for system-level strategies.

While each health service offers distinct attraction factors, the retention barriers in these regions are thematically consistent. A key driver of departures is the pursuit of career progression opportunities in metropolitan hospitals, along with lifestyle factors beyond the control of individual hospitals. Even a regional tertiary referral hospital with specialist training positions experienced a similar trend, underscoring the complex dynamics influencing prevocational doctor retention.

Prevocational doctor workforce shortages need to be addressed by collaborative effort between local and state health services, medical schools, and policy review at federal government level. Expanding opportunities for career progression,

sustained investment in regional infrastructure and optimising the attractive nature of regional areas will be crucial to building and maintaining a sustainable regional medical workforce.

DECLARATIONS

Ethics approval and consent to participate

The study was approved by the Townsville Hospital and Health Service Human Research Ethics Committee (HREC approval: THHS EX/2024/QTHS/108407). In accordance with the Declaration of Helsinki, all participants provided informed consent prior to participating in the study, and their responses were anonymised to ensure confidentiality.

Consent for publication

The authors sought permission from their respective health services to publish.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

EH, AT, LM, LY all worked on the project design, data collection, manuscript write up and editing. EH conducted the data analysis.

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APPENDIX 1

Interviewer: **Date:** **Participant:**

What brought you to this hospital initially?	
What are your plans after leaving?	Hospital: Position: Training:
What is your motivation for leaving?	☐ Family ☐ Rotations ☐ Lifestyle ☐ Specialist training program ☐ Other:
What did you find most valuable about your experience here?	
Are there any factors, if different, that would have kept you here?	
When considering your career and lifestyle factors, what influences your decision to work somewhere?	
Would you consider returning to this health service?	☐ Yes ☐ No Reason:
Any other comments?	

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RESEARCH ARTICLE

ENHANCING PEDIATRIC OUTPATIENT PERFORMANCE THROUGH LEADERSHIP AND CONTINUOUS IMPROVEMENT CULTURE: THE MEDIATING ROLE OF LEAN HEALTHCARE

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ABSTRACT

OBJECTIVE:

This study examines the association of leadership and continuous improvement culture with Lean Healthcare implementation and their subsequent relationship with service performance in a pediatric outpatient clinic.

DESIGN:

A quantitative explanatory study with a cross-sectional design was conducted among 46 healthcare staff selected through stratified random sampling. The hypothesized relationships were tested using Structural Equation Modeling–Partial Least Squares (SEM–PLS).

SETTING:

The study was carried out in the Pediatric Outpatient Clinic of a private hospital in South Sumatra, Indonesia.

MAIN OUTCOME MEASURES:

Self-reported scores for Leadership, Continuous Improvement Culture, Lean Healthcare implementation, and Service Performance, measured using a validated and reliable structured questionnaire with a five-point Likert scale.

RESULTS:

Leadership (β=0.527, $p<0.001$) and Continuous Improvement Culture (β=0.639, $p<0.001$) significantly predicted Lean Healthcare (R^2=0.733). Lean Healthcare (β=0.244, $p=0.021$), Leadership (β=0.477, $p<0.001$), and Continuous Improvement Culture (β=0.507, $p<0.001$) demonstrated direct associations with Service Performance. Furthermore, Lean Healthcare partially mediated the pathways from Leadership (β=0.128, $p=0.039$) and Continuous Improvement Culture (β=0.156, $p=0.031$) to performance.

CONCLUSIONS:

Lean Healthcare was found to partially mediate the relationships between leadership, continuous improvement culture, and service performance. Findings suggest that healthcare managers should integrate leadership development and continuous improvement initiatives to strengthen Lean implementation and service outcomes. However, findings should be interpreted cautiously due to the small sample size and single-site design. The cross-sectional design and reliance on self-reported measures limit causal inference.

KEYWORDS

leadership; continuous improvement culture; Lean Healthcare; service performance; pediatric outpatient clinic; SEM-PLS

INTRODUCTION

Delivering high-quality and efficient health services is a primary priority for healthcare organizations globally to meet community needs and optimize hospital management. High-quality health services must fulfill multiple dimensions, including safety, timeliness, efficiency, effectiveness, patient-centeredness, and equity[1]. A universally recognized performance indicator is outpatient waiting time. Minimizing waiting time is essential to ensure timely and responsive healthcare delivery[1]; however, a persistent gap often exists between these universal quality expectations and actual operational conditions.

In modern healthcare organizations, Lean Healthcare has emerged as a systematic management approach to identify and eliminate non-value-added activities (waste) while improving service quality[2]. Fundamentally, this approach is rooted in the foundational Lean philosophy of maximizing value creation for the end-user by relentlessly banishing waste[3]. This is particularly relevant in pediatric healthcare, where operational inefficiencies are exacerbated by the complexity of services, such as medication compounding[4]. Operational waste and inefficiencies in pediatric clinics frequently manifest as severe service delays, with patient waiting times reaching up to 50 days prior to the implementation of quality improvement interventions[5], with indirect patient care and non-clinical tasks in hospital-based pharmacies accounting for up to 88% of the total time spent[6]. Empirical evidence confirms that Lean models effectively streamline these outpatient processes and reduce non-value-added time by up to 72%[7, 8].

The proposed model is grounded in socio-technical systems theory, which posits that organizational performance emerges from the interaction between managerial practices, organizational culture, and operational processes. This framework was selected over Transformational Leadership or Continuous Quality Improvement (CQI) theories because it uniquely captures the vital interdependence between social elements (leadership and culture) and technical interventions (Lean practices). While alternative theories tend to isolate either human dynamics or process metrics, STS provides a holistic lens to explain how these subsystems must jointly optimize to drive service performance. In modern healthcare settings, operational efficiency and process flow optimization have become strategic issues that significantly influence organizational performance[9]. Leaders who support continuous improvement tend to create a work environment conducive to innovation, staff participation, and waste elimination[10]. Furthermore, establishing a Lean culture relies heavily on daily management systems and Lean leadership to sustain continuous quality improvement efforts[11]. In Indonesian healthcare, waiting-time management remains critical to meeting national quality standards. The rapid expansion of public health insurance coverage in Indonesia has further intensified the demand for efficient outpatient services, underscoring the urgent need for Lean Healthcare applications to optimize hospital operations and improve overall care delivery.

Nevertheless, the successful implementation of Lean Healthcare is not merely a technical initiative; it fundamentally depends on organizational and managerial factors. Weak leadership support has frequently been identified as a major contributor to Lean implementation failure[12]. Furthermore, Lean initiatives often fail when treated as isolated technical tools without deep-rooted top management commitment[13]. Effective leadership is essential for building adaptive, improvement-oriented work environments[10]. Beyond leadership, a culture of continuous improvement, encompassing openness to feedback, structured problem-solving, and a "just culture" encourages learning without fear of punishment, represents another essential foundation[14].

This study was conducted in the Pediatric Outpatient Clinic of a private hospital in South Sumatra, Indonesia. While the clinic serves a steady volume of patients, preliminary findings identified opportunities for optimization in operational and managerial workflows. Observations suggested leadership support could be strengthened, as management must actively serve as a role model to cultivate continuous improvement capabilities in healthcare settings[15]. Additionally, enhancing staff engagement remains crucial, as it is a key pillar of a robust quality culture[16]. Current Lean practices, such as visual management, are still at a developmental stage, providing a pathway for minimizing waste[11]. Consequently, addressing

these gaps is essential, as suboptimal coordination directly impacts waiting time management, which is universally recognized as a critical indicator of perceived service quality in healthcare settings[17].

Although leadership and organizational culture have been individually linked to Lean implementation, empirical studies simultaneously examining their direct and indirect relationships with service performance remain limited, particularly in pediatric outpatient settings within developing countries. Therefore, this study aims to analyze the association of leadership and continuous improvement culture with service performance, both directly and through the mediating role of Lean Healthcare. Based on this framework, the following hypotheses are proposed:

H1: Leadership is positively associated with Lean Healthcare.
H2: Continuous Improvement Culture is positively associated with Lean Healthcare.
H3: Lean Healthcare is positively associated with Service Performance.
H4: Leadership is positively associated with Service Performance.
H5: Continuous Improvement Culture is positively associated with Service Performance.
H6: Leadership has an indirect positive association with Service Performance through Lean Healthcare.
H7: Continuous Improvement Culture has an indirect positive association with Service Performance through Lean Healthcare.

METHODS

STUDY DESIGN AND SETTING

This study employed a quantitative explanatory design with a cross-sectional approach to examine the relationships among leadership, continuous improvement culture, Lean Healthcare implementation, and service performance. Given the cross-sectional nature of this study, the indirect effects were examined using mediation analysis rather than establishing strict causal mediation.

The study was conducted at the Pediatric Outpatient Clinic of a private hospital in South Sumatra, Indonesia. This unit was selected due to the complexity of its service processes, which involve multiple stages, including patient registration, nursing assessment, medical consultation, pharmacy dispensing and compounding, and billing procedures. The multi-stage nature of these processes increases potential operational inefficiencies and non-value-added activities.

PARTICIPANTS AND SAMPLING

The population consisted of 52 professionals and support staff involved in pediatric outpatient service delivery. The study employed a sample size of 46 respondents. While relatively small, PLS-SEM is a nonparametric technique appropriate for exploratory research with limited sample sizes, as model complexity has little influence on the sample size required[18]. A post-hoc power analysis using the Soper calculator (n=46, 3 predictors, R^2=0.878) indicated an observed statistical power of 1.0, exceeding the 80% threshold.

To ensure proportional representation across professional groups, proportionate stratified random sampling was applied. The final sample included pediatricians, nurses, pharmacists, administrative staff, and cashiers, reflecting the multidisciplinary nature of pediatric outpatient services. Participants were required to have at least three months of work experience to ensure sufficient familiarity with operational procedures. Staff who were on leave during the data collection period or who declined to participate were excluded from the study.

DATA COLLECTION AND INSTRUMENTATION

Primary data were collected using a structured self-administered printed questionnaire. The questionnaire was administered in Indonesian to ensure respondents' understanding. The instrument's validity and reliability were evaluated using the Indonesian version. Content validity was qualitatively established via an expert panel review consisting of four experts in healthcare management and pediatrics. Rather than computing quantitative Content Validity Indices (CVI), the panel assessed item relevance, clinical applicability, and contextual clarity. A pilot test involving 15 healthcare staff verified the questionnaire's appropriateness in the local hospital setting, confirming that all items were clearly understood.

Because no substantial modifications to the instrument were required following the pilot test, these initial 15 responses were retained within the final sample (N=46) to maximize statistical power, which is methodologically acceptable in small-population settings. Final empirical validity and reliability were subsequently established through the measurement model evaluation using PLS-SEM. Items presented here were translated into English (Appendix A). The researcher distributed questionnaires directly, providing clarification to ensure accurate completion. Questionnaires were collected immediately upon completion.

The instrument measured four latent constructs: Leadership, Continuous Improvement Culture, Lean Healthcare Implementation, and Service Performance. All items were assessed using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Negatively worded items were reverse coded prior to analysis to ensure consistency in scale direction.

DATA ANALYSIS

Data analysis was conducted using SmartPLS version 4. PLS-SEM was selected due to its suitability for small samples and exploratory models[18, 19], its robustness in handling multiple latent constructs simultaneously, and its appropriateness for predictive research models.

The analysis followed a two-stage approach. First, the measurement model was evaluated to assess construct validity and reliability. Convergent validity was examined using outer loadings and Average Variance Extracted (AVE), while discriminant validity was assessed using the Heterotrait–Monotrait (HTMT) ratio. Internal consistency reliability was evaluated using Cronbach's alpha and Composite Reliability.

Second, the structural model was evaluated to test the hypothesized relationships among constructs. The significance of the path coefficients was determined using a bootstrapping procedure with 5,000 resamples. Statistical significance was determined at a p-value of less than 0.05 and a t-statistic greater than 1.96. The explanatory power of the model was assessed using the coefficient of determination (R^2), while effect size (f^2) and predictive relevance (Q^2) were evaluated to determine the magnitude and predictive capability of the structural relationships.

Finally, given the use of self-reported questionnaires, the potential for Common Method Bias (CMB) was assessed. Harman's single-factor test yielded a variance of 57.2%, slightly exceeding the 50% threshold, indicating the presence of CMB. However, a subsequent assessment of the inner model's collinearity statistics (Full Collinearity VIF) revealed values of 2.043 for Leadership and 2.531 for Continuous Improvement Culture, both of which fall below the strict 3.3 threshold for CMB concern[20]. However, it must be explicitly acknowledged that the VIF for Lean Healthcare (3.740) exceeds Kock's[20] CMB-specific threshold of 3.3. While this value is acceptable under the standard 5.0 threshold for structural collinearity[19], exceeding the 3.3 limit implies that common method variance may partially inflate the variance explained by the Lean Healthcare construct. Consequently, the relationships involving this mediator should be interpreted with caution. These collinearity statistics, combined with the Harman test result, confirm the presence of potential common method bias that must be considered when interpreting the findings.

ETHICAL CONSIDERATIONS

Participation was voluntary. Prior to data collection, respondents were informed about the purpose of the study and assured that their responses would remain confidential and used solely for academic purposes. No personally identifiable information was collected; data were analyzed in aggregate. Formal research permission was granted by the hospital directorate (Reference Number: 2376/DIR/1.4/XI/2025). As a dedicated ethics committee was not available at the site, this directorate approval served as the institutional clearance. An IRB exemption was applied as the study involved minimal risk and no patient-level clinical data.

RESULTS

RESPONDENT CHARACTERISTICS AND DESCRIPTIVE ANALYSIS

A total of 46 staff members directly involved in pediatric outpatient services participated in this study. Table 1 shows the team is predominantly female (87.0%) and mature (71.7% aged 30 or older). Notably, 67.4% possess >3 years of experience, indicating deep understanding of pediatric outpatient workflows and institutional culture, which strengthens the reliability of their assessments. Furthermore, the predominance of pharmacy personnel should be considered when interpreting perceptions of Lean implementation.

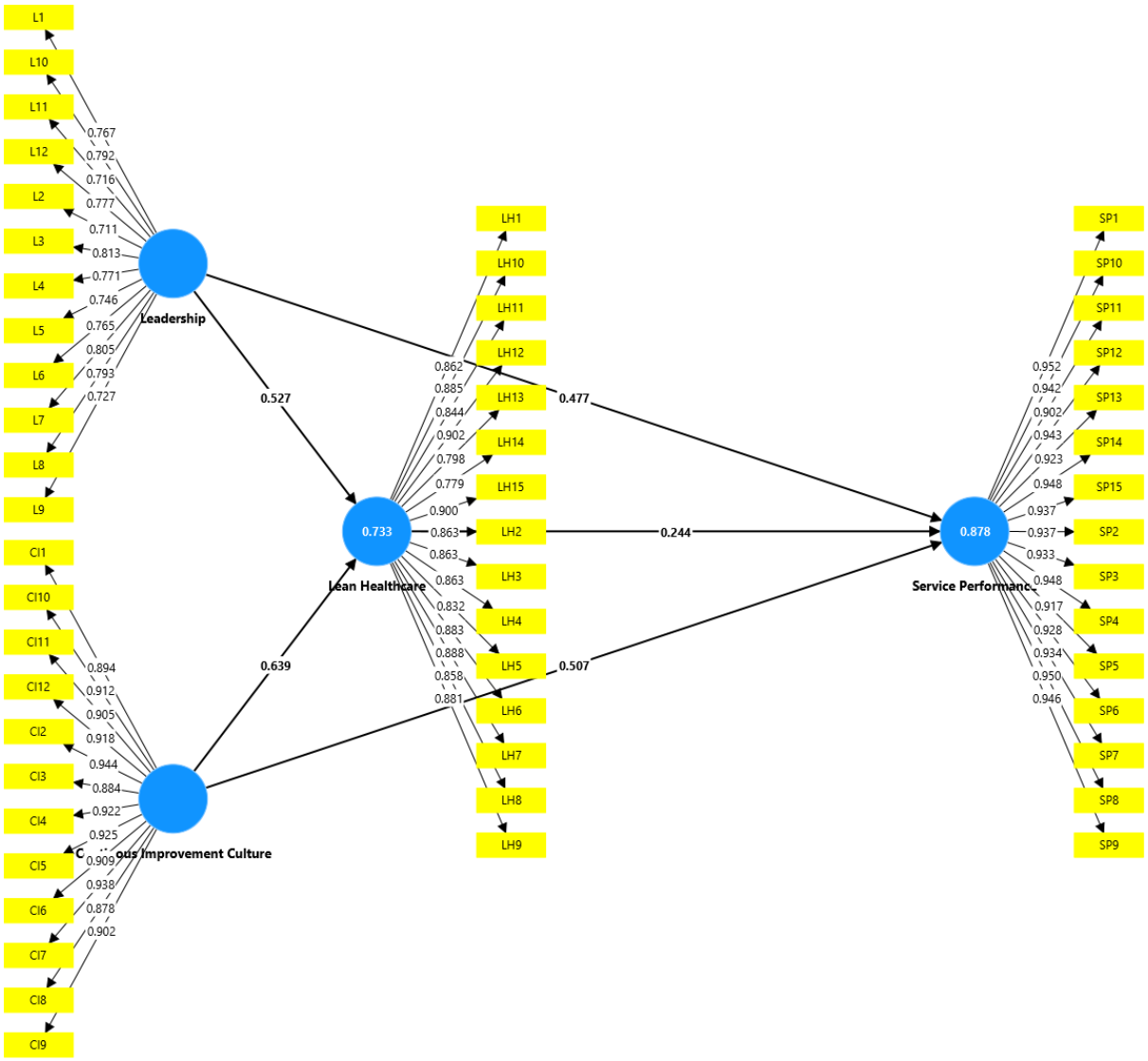
TABLE 1. RESPONDENT CHARACTERISTICS

Characteristics	Category	Frequency (n)	Percentage (%)
Gender	Male	6	13.0
	Female	40	87.0
Age (years)	< 30	13	28.3
	30 – 40	15	32.6
	> 40	18	39.1
Role	Pediatrician	5	10.9
	Pediatric outpatient nurse	4	8.7
	Outpatient administrative staff	8	17.4
	Outpatient cashier	4	8.7
	Outpatient pharmacy staff	25	54.3
Work Experience (years)	< 1	3	6.5
	1 – 3	12	26.1
	> 3	31	67.4

MEASUREMENT MODEL EVALUATION (OUTER MODEL)

Measurement model reliability and validity were evaluated (Figure 1).

FIGURE 1. MEASUREMENT MODEL



This assessment included convergent validity, discriminant validity, and construct reliability using SEM-PLS. As presented in Table 2, all indicators demonstrated strong reliability, with individual loadings exceeding recommended thresholds, confirming the robustness of the measurement model.

TABLE 2. INDIVIDUAL ITEM LOADINGS AND INDICATOR RELIABILITY

Indicator	Loading Factor	Indicator Reliability	Indicator	Loading Factor	Indicator Reliability
Leadership			**Continuous Improvement Culture**		
L1	0.767	0.588	CI1	0.894	0.799
L2	0.711	0.506	CI2	0.944	0.891
L3	0.813	0.661	CI3	0.884	0.781
L4	0.771	0.594	CI4	0.922	0.850
L5	0.746	0.557	CI5	0.925	0.856
L6	0.765	0.585	CI6	0.909	0.826
L7	0.805	0.648	CI7	0.938	0.880
L8	0.793	0.629	CI8	0.878	0.771
L9	0.727	0.529	CI9	0.902	0.814
L10	0.792	0.627	CI10	0.912	0.832
L11	0.716	0.513	CI11	0.905	0.819
L12	0.777	0.604	CI12	0.918	0.843

Indicator	Loading Factor	Indicator Reliability	Indicator	Loading Factor	Indicator Reliability
Lean Healthcare			**Service Performance**		
LH1	0.862	0.743	SP1	0.952	0.906
LH2	0.863	0.745	SP2	0.938	0.880
LH3	0.863	0.745	SP3	0.933	0.870
LH4	0.863	0.745	SP4	0.948	0.899
LH5	0.832	0.692	SP5	0.917	0.841
LH6	0.883	0.780	SP6	0.928	0.861
LH7	0.888	0.789	SP7	0.934	0.872
LH8	0.858	0.736	SP8	0.949	0.901
LH9	0.881	0.776	SP9	0.946	0.895
LH10	0.885	0.783	SP10	0.942	0.887
LH11	0.844	0.712	SP11	0.902	0.814
LH12	0.902	0.814	SP12	0.943	0.889
LH13	0.798	0.637	SP13	0.923	0.852
LH14	0.779	0.607	SP14	0.948	0.899
LH15	0.900	0.810	SP15	0.937	0.878

Furthermore, Table 3 confirms adequate Average Variance Extracted (AVE), while construct reliability was evidenced by high Composite Reliability (CR) scores across all latent variables. While all constructs demonstrated excellent internal consistency, the extremely high reliability coefficients (Cronbach's alpha > 0.97) may indicate potential overlapping item content or redundancy, which should be acknowledged when interpreting the scales. Discriminant validity was rigorously established, as all HTMT values remained below the 0.90 threshold (Appendix B), and all individual item loadings were appropriately higher on their respective constructs than on any competing construct (Appendix C).

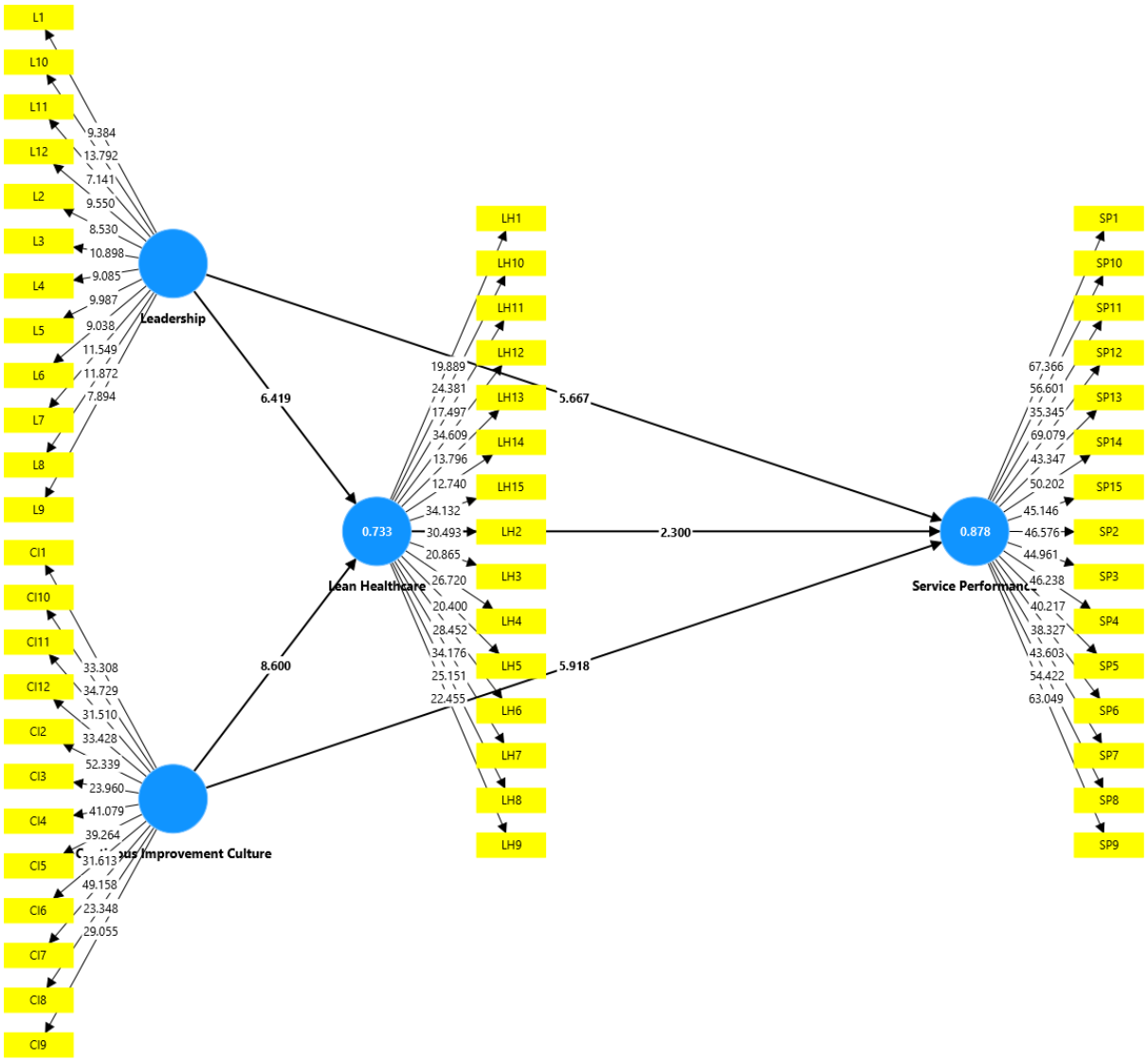
TABLE 3. MEASUREMENT MODEL EVALUATION

Construct	Loading Factor	AVE	Cronbach's Alpha	Composite Reliability
Leadership	0.711 – 0.813	0.587	0.936	0.937
Continuous Improvement Culture	0.878 – 0.944	0.830	0.981	0.983
Lean Healthcare	0.779 – 0.902	0.741	0.975	0.976
Service Performance	0.902 – 0.952	0.876	0.990	0.990

STRUCTURAL MODEL EVALUATION (INNER MODEL)

Following the measurement model validation, the structural model was evaluated to test the research hypotheses. Figure 2 presents path coefficients and R^2 values.

FIGURE 2. STRUCTURAL MODEL



The structural model exhibits substantial predictive capacity and explanatory power (Table 4). The adjusted R^2 values indicate that leadership and continuous improvement culture collectively account for 73.3% of the variance in Lean Healthcare implementation and 87.8% of the variance in Service Performance. The Q^2 values further confirm the model's predictive relevance. The model fit was assessed using the Standardized Root Mean Square Residual (SRMR). The analysis yielded an SRMR value of 0.064, which is well below the recommended threshold of 0.08, indicating a satisfactory model fit[19]. Other fit indices, such as NFI and RMS Theta, were not applicable. Assessment of collinearity (VIF) confirms that the structural relationships are not biased by multicollinearity, as all values remain within acceptable academic limits.

TABLE 4. STRUCTURAL MODEL EVALUATION

Construct	R^2	Q^2
Lean Healthcare	0.733	0.700
Service Performance	0.878	0.849

HYPOTHESIS TESTING

Bootstrapping analysis confirmed that all proposed associations are statistically significant (Table 5). Leadership and continuous improvement culture were identified as powerful predictors of Lean Healthcare implementation. Based on Cohen's[21] benchmarks, where f^2 values of 0.02, 0.15, and 0.35 indicate small, medium, and large effects respectively, the observed effect sizes for H1 (f^2 = 1.033) and H2 (f^2 = 1.518) are exceptionally large. These verified values emphasize

that within this specific pediatric outpatient setting, the deployment of Lean practices is heavily and fundamentally dependent on these two structural pillars, which capture a massive portion of its variance. Importantly, Lean Healthcare was found to positively associate with Service Performance, acting as a vital mechanistic pathway.

The mediation analysis further validates that the associations of leadership and culture with service performance are significantly enhanced when operationalized through Lean practices. Specifically, Lean Healthcare serves as a partial mediator, translating managerial and cultural commitment into measurable operational outcomes.

TABLE 5. HYPOTHESIS TESTING RESULT

Hypothesis	β	t	p	f^2	VIF
H1: Leadership → Lean Healthcare	0.527	6.419	< 0.001	1.033	1.005
H2: Continuous Improvement → Lean Healthcare	0.639	8.600	< 0.001	1.518	1.005
H3: Lean Healthcare → Service Performance	0.244	2.300	0.021	0.130	3.740
H4: Leadership → Service Performance	0.477	5.667	< 0.001	0.911	2.043
H5: Continuous Improvement → Service Performance	0.507	5.918	< 0.001	0.828	2.531
H6: Leadership → Lean → Service Performance	0.128	2.070	0.039	—	—
H7: Continuous Improvement → Lean → Service Performance	0.156	2.164	0.031	—	—

DISCUSSION

STATEMENT OF PRINCIPAL FINDINGS

This study examined the relationships among leadership, continuous improvement culture, Lean Healthcare implementation, and service performance in a pediatric outpatient setting. The findings demonstrate that leadership and continuous improvement culture are significantly associated with Lean Healthcare, both individually and simultaneously. Lean Healthcare, in turn, positively relates to service performance. Additionally, leadership and continuous improvement culture exert direct associations with service performance and indirect associations through Lean Healthcare as a mediating variable.

Descriptive findings indicate that leadership was perceived at a moderate level, with strengths in operational involvement but weaknesses in appreciation and recognition practices. Continuous improvement culture was identified as the highest-rated construct among the variables studied, particularly in organizational commitment and routine discussions; however, the problem reporting system and systematic follow-up mechanisms were perceived as less optimal. Lean Healthcare implementation was categorized as moderate, with challenges in standardization and elimination of non-value-added activities. Service performance was also moderate, with waiting time and repeated processes identified as the main concerns. These findings collectively suggest that service performance is significantly influenced by the synergy between managerial behavior and organizational culture[22, 23], establishing the necessary environment for effective Lean implementation and performance outcomes. This study advances current knowledge by empirically demonstrating that leadership and culture are associated with improved operational outcomes through Lean Healthcare.

STRENGTHS AND WEAKNESSES IN RELATION TO OTHER STUDIES

A primary strength of this study is the integration of leadership, organizational culture, and Lean Healthcare into a single empirical model. Unlike previous studies examining these elements in isolation, this study provides a holistic understanding of how managerial factors are operationalized through Lean practices, specifically demonstrating the vital mediating role of Lean Healthcare in a pediatric setting. This theoretical robustness is further supported by the dominant participation of outpatient pharmacy staff, who are directly involved in medication compounding processes that frequently generate waiting time waste. Because pharmacy personnel constituted the largest respondent group, their specific operational perspectives heavily inform the results. From their standpoint, Lean Healthcare is primarily evaluated based on its ability to resolve compounding bottlenecks, streamline prescription clarifications, and manage inventory workflows. Consequently, this underscores that hospital administrators must prioritize pharmacy-specific workflows to effectively alleviate overall pediatric outpatient delays. Having frontline experts as the majority of respondents enhances the operational validity of the findings, as the evaluation comes from the unit most critical to patient flow. Furthermore, the inclusion of experienced staff enhances the credibility of the organizational evaluation.

The results regarding leadership align with previous findings that effective leadership plays a central role in Lean implementation[24]. Leadership that provides clear direction, operational involvement, and consistent communication facilitates Lean adoption[25]. However, this study identified a critical gap: while leaders are operationally involved, their appreciation and recognition of staff remain relatively weak. This is consistent with research emphasizing that a lack of managerial commitment and inconsistent leadership behavior can serve as significant barriers to organizational change and the sustainability of Lean initiatives[24]. Furthermore, leadership functions as a bridge between top management and frontline staff in mobilizing resources and sustaining improvement initiatives[26]. Additionally, the remarkably low HTMT value (0.116) observed between Leadership and Continuous Improvement Culture warrants specific attention. This highly distinct discriminant validity indicates that frontline staff clearly differentiate between individual managerial actions (leadership) and the collective organizational norms (culture). In practice, this suggests that even if overarching cultural commitments are strong, staff still critically evaluate their leaders' specific operational behaviors and recognition practices as an entirely separate entity.

The positive relationship between continuous improvement culture on Lean Healthcare is also consistent with the Kaizen philosophy, which emphasizes incremental improvements embedded in daily routines[27]. Lean is widely described not merely as a productivity tool but as a socio-technical system grounded in continuous improvement culture[28]. Employee engagement and participatory improvement practices are repeatedly identified as essential components of successful Lean transformation[26]. However, this study highlights a "communication bottleneck" in the problem reporting system. While cultural commitment is high, the lack of structured mechanisms for idea integration suggests that cultural readiness alone is insufficient, a challenge also observed in organizations where improvement efforts remain sporadic rather than standardized[29].

Findings support previous studies showing Lean Healthcare contributes to improved operational performance, including reduced waiting times and coordination[9, 10]. Lean aims to eliminate waste, streamline processes, and enhance patient-centered value creation[25]. Although statistically significant, the magnitude of the Lean-performance relationship was moderate, suggesting that additional organizational factors, such as staffing levels, workload distribution, and available technology, may also contribute to service performance. Nevertheless, the mediation analysis reveals that Lean Healthcare serves as a vital mechanism; managerial factors (leadership and culture) are more effective when channeled through systematic Lean practices. This nuance adds to the existing literature by emphasizing the systemic interaction among leadership, culture, and Lean implementation[24].

PRACTICAL IMPLICATIONS FOR MANAGERS AND POLICY MAKERS

Based on the findings, healthcare organizations should prioritize specific actions to foster Lean implementation. Healthcare managers are encouraged to initiate Lean leadership training, conduct daily huddles, and establish continuous quality improvement teams. Specifically, empowering nursing leadership to act as Lean champions at the unit level is highly recommended. Nurse managers should be equipped to actively lead daily huddles and mentor frontline

nursing staff in identifying workflow inefficiencies, thereby bridging the gap between clinical care and operational improvements. Furthermore, to overcome communication bottlenecks and bridge the gap in problem-reporting, the implementation of visual management boards, staff recognition systems, and electronic incident reporting is highly recommended. These practical interventions can help standardize pediatric outpatient workflows and effectively minimize waiting times.

LIMITATIONS AND FUTURE RESEARCH

Despite its contributions, this study has several limitations that should be critically acknowledged. First, the sample size of 46 respondents is relatively small and originates from a single-site pediatric clinic, which may limit the generalizability of the findings. However, PLS-SEM is methodologically robust and effective for analyzing models with smaller sample sizes[19]. Future research should involve multi-center studies across different hospital types to validate these relationships further. Second, the cross-sectional design of this study captures data at a single point in time, which limits the ability to draw definitive causal inferences between the variables. Longitudinal studies are needed to examine how leadership behavior and improvement culture evolve over time and sustain performance outcomes. Third, service performance was measured using self-reported questionnaires, which inherently carry a risk of response or social desirability bias. To enhance methodological robustness, subsequent studies should incorporate objective performance indicators, such as actual patient waiting time data or clinical outcome metrics. Finally, future studies could explore additional mediating or moderating variables, such as digital health integration, to enrich the understanding of pediatric outpatient efficiency.

CONCLUSION

This study confirms that leadership and continuous improvement culture are critical factors associated with Lean Healthcare implementation and service performance in pediatric outpatient services. Findings demonstrate that Lean Healthcare functions as a partial mediator, bridging the gap between managerial commitment and operational outcomes. While leadership and culture are directly associated with performance, their relationship is notably enhanced when operationalized through systematic Lean practices.

However, the study also reveals that the current implementation level remains moderate. Despite high staff commitment, challenges persist regarding inconsistent leadership appreciation and the lack of user-friendly problem-reporting mechanisms. This suggests that technical Lean tools alone are insufficient without the foundational support of responsive leadership and a structured improvement culture.

For healthcare organizations seeking enhanced performance, Lean initiatives must be integrated with leadership and cultural strategies. Future efforts should focus on institutionalizing bottom-up communication to ensure long-term sustainability. These findings reinforce the importance of aligning leadership, culture, and process innovation to achieve sustainable healthcare performance.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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APPENDIX A

MEASUREMENT ITEMS

Construct	Item Code	Dimension	Measurement Item
Leadership	L1	Role Modelling	Leaders serve as role models in discipline and work ethics.
	L2		Leaders demonstrate genuine commitment to improving service quality.
	L3		Leaders consistently apply more efficient work methods in daily activities
	L4	Support & Empowerment	Leaders provide the necessary time, effort, and facilities to support service improvement.
	L5		Leaders encourage staff to share ideas or suggestions for service improvement.
	L6		Leaders rarely give rewards or appreciation for staff contributions to service improvement.*
	L7	Communication & Vision	Leaders clearly explain the direction and goals of service improvement to the staff.
	L8		Leaders provide opportunities for staff to express their opinions or feedback.
	L9		Leaders communicate information regarding changes in service processes openly and clearly.
	L10	Involvement in Problem Solving	Leaders are directly involved in helping to resolve work obstacles in the service unit.
	L11		Leaders actively monitor the implementation of improvement efforts in the service unit.
	L12		Leaders are routinely involved in work evaluation and improvement activities.
Continuous Improvement Culture	CI1	Staff Engagement	Staff actively propose ideas to improve services.
	CI2		Staff are routinely involved in service improvement activities.
	CI3		Staff feel responsible for the quality of services provided.
	CI4	Organizational Commitment	Management shows tangible support for continuous service improvement efforts.
	CI5		Staff suggestions and feedback are followed up by management.
	CI6		Evaluations of service improvement outcomes are conducted routinely in the service unit.
	CI7	Problem Reporting System	The service problem reporting system is easy for all staff to use.
	CI8		Service problems are handled quickly by superiors.
	CI9		The results of service improvement activities are rarely recorded or documented properly.*
	CI10	Learning & Standardization	Routine discussions or briefings are held to evaluate staff work experiences.

Construct	Item Code	Dimension	Measurement Item
	CI11		Work errors are considered learning opportunities rather than occasions to blame individuals.
	CI12		New work methods are established as standards after process improvements.
Lean Healthcare	LH1	Standardized Work	Existing work procedures are easy for staff to understand.
	LH2		Work procedures are applied consistently in daily services.
	LH3		There are still differences in work methods among staff when performing tasks.*
	LH4	Waste Reduction	Efforts to reduce unnecessary work are carried out continuously.
	LH5		Staff are able to identify parts of the work that waste time or effort.
	LH6		There are tangible efforts to reduce patient waiting times.
	LH7	Value Stream Mapping & Flow Optimization	Service flows are reviewed and improved to be simpler and more efficient.
	LH8		Patient service flow has become smoother after process improvements.
	LH9		Unnecessary movement of patients or staff still occurs frequently.*
	LH10	Visual Management	Information about service flow is displayed clearly and is easy to understand.
	LH11		Visual cues (such as information boards or signs) help staff in their work.
	LH12		Work process non-conformities can be easily identified through visual cues.
	LH13	Continuous Improvement	Performance evaluations are conducted routinely to encourage service improvement.
	LH14		Staff are involved in activities to improve or enhance work methods.
	LH15		Work standards are updated after process improvements are made.
Service Performance	SP1	Waiting Time	Service waiting times meet the established standards.
	SP2		Current patient waiting times are shorter than before.
	SP3		Service delays still occur frequently.*
	SP4	Accuracy & Responsiveness	Services are provided on time according to the designated schedule.
	SP5		Healthcare workers respond to patient needs quickly.
	SP6		Service errors still occur frequently.*
	SP7	Work Efficiency	Work coordination among staff goes well.
	SP8		Patient and staff movements occur efficiently.
	SP9		Repetitive and unnecessary work is reduced.

Construct	Item Code	Dimension	Measurement Item
	SP10	Waste Minimization	Wasted time in the service process is minimized.
	SP11		Equipment and documents are available on time so as not to hinder services.
	SP12		Work errors that cause waste rarely occur.
	SP13	Service Quality	The services provided meet quality standards.
	SP14		Staff provide services in a consistent manner.
	SP15		The clinic quickly adapts its services to meet patient needs.

* Indicates reverse-coded items

APPENDIX B

DISCRIMINANT VALIDITY (HTMT)

Construct	Leadership (X1)	Continuous Improvement Culture (X2)	Lean Healthcare (Y)	Service Performance (Z)
Leadership (X1)				
Continuous Improvement Culture (X2)	0.116			
Lean Healthcare (Y)	0.592	0.687		
Service Performance (Z)	0.673	0.712	0.873	

APPENDIX C

DISCRIMINANT VALIDITY (CROSS-LOADINGS)

Indicator	Leadership	Continuous Improvement Culture	Lean Healthcare	Service Performance
Leadership				
L1	0.767	0.056	0.354	0.539
L2	0.711	0.140	0.499	0.494
L3	0.813	0.000	0.365	0.428
L4	0.771	0.025	0.375	0.501
L5	0.746	0.025	0.506	0.472
L6	0.765	0.092	0.478	0.549
L7	0.805	0.010	0.365	0.528
L8	0.793	0.132	0.480	0.572
L9	0.727	0.132	0.511	0.502
L10	0.792	-0.035	0.467	0.479
L11	0.716	-0.097	0.365	0.405
L12	0.777	0.104	0.428	0.477
Continuous Improvement Culture				
CI1	0.047	0.894	0.568	0.625
CI2	-0.020	0.944	0.578	0.595
CI3	0.036	0.884	0.542	0.601
CI4	0.076	0.922	0.675	0.691
CI5	0.028	0.925	0.601	0.614
CI6	0.088	0.909	0.684	0.650
CI7	0.055	0.938	0.612	0.668
CI8	0.022	0.878	0.575	0.553
CI9	0.107	0.902	0.615	0.652
CI10	0.157	0.912	0.681	0.709
CI11	0.043	0.905	0.608	0.633
CI12	0.099	0.918	0.617	0.684
Lean Healthcare				
LH1	0.476	0.548	0.862	0.734
LH2	0.509	0.599	0.863	0.763
LH3	0.471	0.579	0.863	0.740
LH4	0.419	0.589	0.863	0.681
LH5	0.471	0.549	0.832	0.683
LH6	0.524	0.564	0.883	0.728
LH7	0.567	0.504	0.888	0.740
LH8	0.600	0.475	0.858	0.757
LH9	0.497	0.619	0.881	0.760
LH10	0.422	0.726	0.885	0.785
LH11	0.392	0.656	0.844	0.740
LH12	0.506	0.622	0.902	0.780
LH13	0.508	0.479	0.798	0.734
LH14	0.476	0.575	0.779	0.673
LH15	0.542	0.619	0.900	0.776

Indicator	Leadership	Continuous Improvement Culture	Lean Healthcare	Service Performance
Service Performance				
SP1	0.684	0.667	0.850	0.952
SP2	0.624	0.672	0.828	0.937
SP3	0.593	0.654	0.798	0.933
SP4	0.554	0.694	0.806	0.948
SP5	0.531	0.741	0.841	0.917
SP6	0.646	0.597	0.771	0.928
SP7	0.574	0.664	0.763	0.934
SP8	0.634	0.644	0.779	0.950
SP9	0.612	0.695	0.827	0.946
SP10	0.613	0.651	0.778	0.942
SP11	0.633	0.537	0.812	0.902
SP12	0.635	0.673	0.823	0.943
SP13	0.609	0.654	0.804	0.923
SP14	0.614	0.639	0.805	0.948
SP15	0.599	0.703	0.770	0.937

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RESEARCH ARTICLE

BEYOND HOSPITAL TO COMMUNITY: EXPLORING THE CORE COMPETENCIES OF COMMUNITY HEALTH PROFESSIONALS

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ABSTRACT

OBJECTIVE:

To identify and validate the core competencies required of Community Health Professionals (CHPs) to deliver interprofessional team-based care in Singapore's integrated health services.

METHODS:

An exploratory sequential mixed methods design was used. Four focus groups with CHPs generated initial competency themes and items through thematic analysis. These findings informed a survey in which respondents rated the importance of each item on a five-point Likert scale. Descriptive statistics were used to analyse survey responses.

SETTINGS:

The study was conducted across Singapore's three regional health systems. Participants were health professionals who worked in, or oversaw, community health teams. 36 health professionals participated in the focus groups and 52 responded to the survey.

RESULTS:

Focus groups identified seven themes and 57 competency items. Survey findings showed strong consensus, with 49 items rated as very important or essential. Together with one contextually relevant item on multilingual communication, these informed the final CHP competency framework. Comparison with the World Health Organization health workforce framework supported reorganisation of the 50 core competencies into six clusters: patient advocacy, effective communication, teamwork, people-centred care, continuous learning mindset, and patient assessment and care management. The added competency cluster reflected local expectations for health professionals to perform biopsychosocial screening, basic management, and care escalation in community-based practice.

CONCLUSION:

This study developed a locally relevant CHP competency framework that aligns with international guidance while addressing Singapore's integrated health system context. The framework offers practical guidance for workforce development, interprofessional education, and competency-based training to support the shift from hospital to community care.

KEYWORDS

Community health professionals, Competency framework, Interprofessional teams, Health workforce development, Integrated health services.

INTRODUCTION

Healthcare systems worldwide are facing challenges arising from aging population, increasing chronic diseases, and escalating healthcare costs [1,2,3]. Conventional healthcare systems focusing on hospital-based specialist-led services are no longer able to meet the rising demands for continuity of care effectively [1]. To address the challenges, health systems are shifting focus towards integrated health services, which have proven to benefit individuals and health systems across countries at all income levels [1,2]. **Integrated health services** are defined as: "health services that are managed and delivered so that people receive a continuum of health promotion, disease prevention, diagnosis, treatment, disease-management, rehabilitation and palliative care services, coordinated across the different levels and sites of care within and beyond the health sector, and according to their needs throughout the life course" [4]. Health professionals working in integrated health systems are often expected to work collaboratively across professions to deliver high quality and effective team-based care [3,5].

Interprofessional team-based care models can enhance health service provision and improve work productivity, professional development, job satisfaction and retention of health professionals [6]. Health workforce development thus needs to prioritise cross-professional workforce planning and creation of new, collaborative care models that extend beyond traditional boundaries [6]. However, the uni-professional nature of health professional education, along with its associated profession-specific knowledge and skills, does not adequately prepare health professionals for interprofessional collaborative practice [7, 8]. Furthermore, integrated health systems necessitate that health professionals adopt new roles in prevention and pro-active patient management, focus on managing health and care rather than disease and cure, work along a continuum of care, and develop more than one vertical expertise [9]. Consequently, the transition from hospital-based services towards integrated health services requires health professionals to acquire new clinical and non-clinical competencies and become more open to working in interprofessional teams [3,4]. A tailored, contextualised competency framework is key to developing health professionals to work effectively in teams.

A competency framework provides a guide to enable health professionals to develop and assess their competencies within a broader healthcare team setting and allows mapping of their career progression beyond their current professional roles and functions [8]. **Health workforce competencies** are defined as "the essential complex knowledge-based acts that combine and mobilize knowledge, skills, and attitudes with the existing and available resources to ensure safe and quality outcomes for patients and populations." [9]. In the World Health Organisation Strengthening a competent health workforce for the provision of coordinated/integrated health services paper, the Health Workforce (HWF) framework identifies five fundamental competency clusters for front-line health professionals and lay health workers - ***Patient advocacy, Effective communication, Teamwork, People-centred care and Continuous learning*** [9]. Specific to healthcare professionals in integrated health services, various profession-specific competency frameworks have been developed for physicians, nurses, and pharmacists [10,11,12]. While efforts have been made to align interprofessional competencies, most of these originate from North America and may have limited applicability in other regions [1,13,14]. To ensure relevance to health professionals in integrated health systems, competency frameworks need to be adapted to the local context [7,8].

Singapore, like many developed countries, is experiencing a high prevalence of chronic diseases and multi-morbidity due to an ageing population, placing a significant burden on individuals, families, society, and the healthcare system [15]. To address this, the Ministry of Health introduced the Regional Health System (RHS) model in 2012. Led by public hospitals, each RHS collaborates with healthcare and social care providers to coordinate services across the health continuum for

integrated care delivery and prevent unnecessary hospital admissions [16]. The Ministry of Health introduced the "Three Beyonds" strategy in 2016 to guide long-term transformation of the healthcare system [17]:

- *Beyond Healthcare to Health* through effective health promotion and disease prevention,
- *Beyond Hospital to Community* by shifting focus from acute hospitals to community and primary care settings, and
- *Beyond Quality to Value* by ensuring appropriate and cost-effective care.

In line with shifting care beyond hospital to community, public hospitals in Singapore have initiated various multi-disciplinary hospital-to-home transitional care programmes involving post-discharge community home visits of patients, telephonic reviews to facilitate care co-ordination, and community health posts to facilitate early screening and proactive referral of patients to appropriate community resources [18,19]. However, health professionals traditionally trained in acute care often encounter difficulties in providing holistic care as they lack interdisciplinary training, particularly in the social aspects of care which extend beyond typical health professional curricula [18,20]. There have been local initiatives to develop the Community Nursing Competency framework for community nurses [21], but no similar competency framework exists for other health professionals working in community teams. There is an urgent need to develop a Community Health Professional (CHP) competency framework to guide interprofessional education in shifting care from hospital to community [22].

Therefore, this study aims to explore the core competencies required of CHPs working in regional health systems to provide effective team-based care for patients and caregivers in Singapore. Insights gained can be valuable for other countries seeking to enhance the development of health workforce within integrated health systems.

METHODS

This study used a two-phase exploratory sequential mixed methods design to identify and validate the core competencies for CHPs [23,24]. This approach is in line with study design recommendations to use at least two different data collection methods to increase the credibility and completeness of competency identification [25]. Initial phase involved an exploratory qualitative design in which focus groups were conducted with working CHPs to capture diverse insights of competency requirements. These qualitative data were then synthesised into competency themes and items, which then informed the development of a survey instrument. In the second quantitative phase, the survey was administered to a wider sample of CHPs, who rated the importance of each competency item on a Likert scale. This exploratory sequential mixed methods approach facilitated co-production of the competency framework with experienced practitioners, enhancing contextualisation and ensuring validation of the final competencies by a broader community of health professionals [23,24].

PARTICIPANTS

Purposive and snowball sampling techniques were used for the recruitment of the study participants. The inclusion criteria for the study were any health professional who has worked or oversee a community health team for at least one year at any of the three RHS in Singapore. For the focus groups, individual invitations were sent to a contact list of CHPs who met the inclusion criteria. For the survey, mass invitations were sent to the same contact list, and participants were encouraged to forward the survey to anyone they knew who met the inclusion criteria.

PROCEDURE

Four focus groups were conducted between 8 to 16 December 2020 via teleconference Zoom platform. An open-ended semi-structured interview guide was developed and used by two of the investigators who facilitated the focus groups. The duration of each focus group was between 1 to 1.5 hours. Two key questions in the interview guide were:

1. Describe current work activities which can be interprofessional and list the core competencies required, and
2. Describe any future work activities which could be interprofessional and list the core competencies required.

The focus group interviews were transcribed by the research assistant using Zoom and OTTER Ai transcription software and then coded by two study investigators using NVivo version 12. Thematic analysis was used for the qualitative data analysis [26]. The first focus group transcript was initially coded individually, followed by team coding by the two investigators (HT, LG) to align on the agreed codes and descriptions in the code book. Subsequently, the two investigators continued independent coding of the other three focus groups using the code book. The code book and descriptions were further refined twice during the later team coding process. Finally, the two investigators identified the themes and related competency items, which were then used to develop the survey. After the survey instrument was drafted, the two investigators reviewed all survey items for clarity and face validity. The survey was not externally validated or formally piloted before administration.

The survey was administered from 1 to 16 April 2021 using the FormsSG online platform. Participants were asked to evaluate the importance of each competency item for CHPs to work effectively in a community health team on a five-point Likert scale *(1 = not too important; 2=somewhat important; 3=important; 4=very important; 5 = essential)*. Descriptive statistics were then used to analyse the survey results.

ETHICAL CONSIDERATIONS

Ethics approval was obtained from National Healthcare Group Domain Specific Review Board (NHG DSRB Ref: 2020/00601) prior to conducting the focus groups and survey.

RESULTS

36 out of 67 (54%) invited CHPs from three RHS in Singapore participated in the focus groups. Occupational therapists, nurses and physiotherapists comprised 77% of the total participants. Majority of the participants (69%) had between 1 to 5 years of experience working in community health teams, including home-based community programs, centre-based programs, community health posts and telephonic services. Table 1 shows the participants' characteristics in the focus groups.

TABLE 1. CHARACTERISTICS OF PARTICIPANTS IN THE FOCUS GROUPS (N=36)

	Category	n	Percentage		Category	n	Percentage
Profession	Occupational Therapist	11	30%	**Regional Health Cluster**	National Healthcare Group	25	69%
	Nurse	10	28%		Singhealth	6	17%
	Physiotherapist	7	19%		National University Health System	5	14%
	Administrator	4	11%	**Experience in community health team**	1 to 2 years	12	33%
	Medical Social Worker	2	6%		3 to 5 years	13	36%
	Dietitian	1	3%		6 to 10 years	5	14%
	Doctor	1	1%		11 to 15 years	6	17%

Following thematic analysis of the coded data, seven themes and 57 competency items for CHPs were identified. Table 2 lists the descriptions of the themes and number of competency items in each theme.

TABLE 2. THEME DESCRIPTION AND NUMBER OF COMPETENCY ITEMS PER THEME

Theme	Description	Number of competency items
1	Enabling personal attributes as a CHP	8
2	Enabling professional skills as a CHP	13
3	Collaborating with other CHPs in the inter-professional team	7
4	Assessing the needs of patient and caregiver in the community	7
5	Identifying situations needing escalation of care	5
6	Planning and coordinating care of patient in the community	8
7	Educating and empowering patient and caregiver in self-management	9

52 health professionals from the three RHS responded to the survey. Due to the use of snowball sampling, the response rate could not be estimated. 27 [52%] respondents had previously participated in the focus groups. Nurses, occupational therapists, and physiotherapists continued to account for most of the survey respondents [66%]. Overall, survey respondents had more years of working experience in the community compared to focus group participants. Majority of respondents [56%] had six and more years of experience working in community health teams. Table 3 provides an illustration of respondents' characteristics in the survey.

TABLE 3. CHARACTERISTICS OF RESPONDENTS IN THE SURVEY (N=52]

	Category	n	Percentage		Category	n	Percentage
Profession	Nurse	16	30%	**Regional Health Cluster**	National Healthcare Group	32	61%
	Occupational Therapist	11	21%		Singhealth	14	27%
	Physiotherapist	8	15%		National University Health System	6	12%
	Administrator	6	12%	**Experience in community health teams**	1 to 2 years	12	23%
	Doctor	6	12%		3 to 5 years	11	21%
	Medical Social Worker	2	4%		6 to 10 years	20	39%
	Therapy Assistant	2	4%		11 to 15 years	8	15%
	Care Coordinator	1	2%		16 to 20 years	1	2%

The findings revealed a strong consensus amongst respondents on the importance of most identified competency items from the focus groups. Table 4 shows the median and mean ratings for all 57 competency items. Of the 57 competency items, 49 items had a median of 4 or above, indicating that most respondents considered them as *''very important''* or *''essential''* (ratings of 4 or 5). One item "*Having multilingual skills to improve communication with patient and caregiver*" had a median of 3.5 while the other 7 items had a median of 3.

TABLE 4. MEDIAN AND MEAN RATINGS FOR ALL 57 COMPETENCY ITEMS

Theme	Competency item	Median	Mean	SD
Enabling personal attributes as a CHP	1.1 Being adaptable and flexible	5.00	4.44	0.75
	1.2 Being open minded to changes in roles and practices in the community	4.50	4.40	0.66
	1.3 Being motivated to work in the community	4.00	4.23	0.73
	1.4 Embracing the generalist professional identity in a transdisciplinary team	4.00	3.98	0.85
	1.5 Having a patient-centred mindset over a profession-centred mindset	4.00	4.31	0.76
	1.6 Having the courage to work beyond own professional expertise	4.00	3.92	0.76
	1.7 Willingness to learn from others in the team	4.00	4.17	0.58
	1.8 Willingness to ask for help from others in the team	4.00	4.19	0.72
Enabling professional skills as a CHP	2.1 Ability to manage basic functional mobility needs of patient	4.00	3.92	0.90
	2.2 Ability to manage basic psychosocial issues of patient and caregiver	4.00	4.13	0.79
	2.3 Ability to resolve conflicts amongst multiple stakeholders	4.00	3.62	0.82
	2.4 Ability to negotiate and align care expectations amongst stakeholders	4.00	4.02	0.70
	2.5 Being resilient to manage dynamic situations	4.00	4.19	0.66
	2.6 Facilitating group sessions during community health education programs	3.00	3.33	0.94
	2.7 Having communication skills to build rapport and understand challenges of patient and caregiver	5.00	4.44	0.64
	2.8 Having counselling skills to facilitate patient to cope with challenges	4.00	3.90	0.82
	2.9 Having creativity and problem-solving skills to manage available resources	4.00	4.06	0.80
	2.10 Having multilingual skills to improve communication with patient and caregiver	3.50	3.56	0.83
	2.11 Having self-defence skills for personal safety	3.00	3.13	1.12
	2.12 Using technology-based devices to facilitate health monitoring	3.00	2.85	0.94
	2.13 Using telehealth technologies for e-consultation with patient or staff	3.00	3.02	0.90
Collaborating with other CHPs in the inter-	3.1 Being competent in own professional practice	5.00	4.50	0.64
	3.2 Communicating own professional concerns and ideas effectively	4.00	4.17	0.73

professional team	3.3 Educating other professionals in own professional knowledge and skills	4.00	3.90	0.75
	3.4 Facilitating case discussions in team to develop shared care plan	4.00	4.08	0.84
	3.5 Leading the interprofessional team	3.00	3.37	0.99
	3.6 Maintaining trust and positive relationship with interprofessional team members	4.00	4.23	0.67
	3.7 Respecting interprofessional opinions and expertise	4.00	4.38	0.66
Assessing the needs of patient and caregiver in the community	4.1 Screening for clinical parameters	4.00	4.13	0.91
	4.2 Screening for general health needs	4.00	3.98	0.87
	4.3 Screening for wound and tube care	3.00	3.60	1.07
	4.4 Screening for cognitive and mental health needs	4.00	3.94	0.80
	4.5 Screening for physical and functional health needs	4.00	4.00	0.82
	4.6 Screening for social issues	4.00	4.02	0.80
	4.7 Screening for environmental issues	4.00	3.94	0.78
Identifying situations needing escalation of care	5.1 Having basic medical knowledge of common chronic diseases	4.50	4.25	0.84
	5.2 Identifying risks and red flags which require medical attention symptoms	5.00	4.50	0.73
	5.3 Determining the complexity and urgency of the health needs of patient	4.00	4.31	0.81
	5.4 Recognising own professional competency and when to escalate to other health professionals	5.00	4.54	0.64
	5.5 Applying the available escalation protocols for appropriate care management	4.00	4.27	0.82
Planning and coordinating care of patient in the community	6.1 Maintaining a patient-centered focus during care needs assessment	4.50	4.35	0.71
	6.2 Involving patient and caregiver in collaborative goal setting	4.00	4.33	0.68
	6.3 Identifying and prioritising care needs of patient and caregiver appropriately	4.00	4.31	0.67
	6.4 Knowing the range of community resources [formal and informal] available and accessible to patient and caregiver	4.00	3.98	0.90
	6.5 Knowing the administrative aspects of the community resources to assist patient and caregiver in decision making	4.00	3.67	1.00
	6.6 Matching the health and social care needs of patient and caregiver to relevant services	4.00	3.98	0.83
	6.7 Making appropriate referrals for transition from hospital to community and within the community	4.00	3.98	0.80

	6.8 Establishing networking and partnership with community service providers to facilitate transition of care	4.00	3.77	0.83
Educating and empowering patient and caregiver in self-management	7.1 Educating on behavioural management for patients with various psychosocial issues	4.00	3.81	0.93
	7.2 Educating on different types of exercises for patients with various physical issues	3.00	3.37	1.03
	7.3 Educating on falls prevention at home and in the community	4.00	3.85	0.87
	7.4 Educating on medication administration, compliance and side effects	4.00	3.75	0.97
	7.5 Educating on use of basic assistive devices and environmental modifications	4.00	3.67	0.92
	7.6 Educating on wound care, tube care and prevention of pressure injuries	4.00	3.62	1.01
	7.7 Empowering patient in health promotion for disease prevention	4.00	3.87	0.84
	7.8 Empowering patient in lifestyle modifications for chronic disease management	4.00	3.90	0.87
	7.9 Supporting caregiver to manage own caregiving stress	4.00	4.04	0.71

Table 5 showed the two highest rated themes were *"Identifying situations needing escalation of care"* and *"Enabling personal attributes as a CHP"*.

TABLE 5. MEAN RATINGS FOR EACH THEME, RANKED IN ORDER

Theme	Description	Mean	SD
5	Identifying situations needing escalation of care	4.37	0.77
1	Enabling personal attributes as a CHP	4.21	0.74
3	Collaborating with other CHPs in the inter-professional team	4.09	0.83
6	Planning and coordinating care of patient in the community	4.05	0.84
4	Assessing the needs of patient and caregiver in the community	3.95	0.88
7	Educating and empowering patient and caregiver in self-management	3.76	0.92
2	Enabling professional skills as a CHP	3.71	0.96

DISCUSSION

A locally developed competency framework for CHPs outlines the key roles they play in patient care, promotes collaboration among different professional groups and supports the formation of interprofessional teams in community-based care [8,9]. This study used an exploratory sequential mixed methods design to investigate the core competencies of CHPs working in RHS community health teams in Singapore. Seven themes with 57 competencies were identified through the focus groups. Following analysis of the survey findings, 50 competencies were deemed to be core for CHPs. These included 49 competency items rated as *"very important"* or *"essential" (median=4 to 5)* and the item *"Having multilingual skills to improve communication with patient and caregiver"* (median=3.5), due to the importance of linguistic competence in delivering effective care in Singapore's multi-ethnic context [27].

Comparison of the study findings with the WHO HWF competency framework for coordinated/integrated health services [9] revealed both similarities and differences. The WHO HWF framework outlines five broad competency clusters comprising 42 competencies, developed as a global reference for health professionals and lay health workers delivering integrated care. These clusters emphasised patient advocacy, people-centred care, effective communication, teamwork and continuous learning as fundamental to provision of high-quality health services. Although derived independently in the Singapore community health context, the 50 competency items across seven themes identified for CHPs demonstrated strong alignment with the WHO framework, particularly across four competency clusters - ***Patient advocacy, People-centred care, Effective communication and Teamwork***, highlighting their universal relevance across integrated health systems. Consequently, the WHO HWF framework was used as a reference to align the CHP competency framework with internationally recognised standards, with definitions for the four overlapping competency clusters retained and the 37 corresponding competency items mapped accordingly.

Despite the similarities, two context-specific differences required adaptation of the WHO HWF framework. First, while the WHO ***Continuous learning*** cluster emphasised participation in formal continuing professional development activities, CHPs in this study placed greater emphasis on attitudes towards continuous learning. They highlighted the need for health professionals to transition from a traditional "*profession-led*" to a more "*patient-led*" and team-based model of care, a shift that requires openness to new roles and adaptability in responding to patient and team needs. As such, this competency cluster was renamed as ***Continuous learning mindset*** to emphasise that continuous learning extends beyond participation in professional development activities, to include personal attributes and mindset that are required in CHPs to navigate evolving roles in an interprofessional team. Second, while competencies related to biopsychosocial screening and care escalation emerged strongly in this study, they are absent in the WHO HWF framework. These competencies reflect the practice of Singapore's community-based care model, where CHPs are expected to perform early screening, risk identification, and coordinate escalation across services—roles which are not fully captured by the WHO's generic framework. To address this gap, a new competency cluster - ***Patient assessment and care management***, comprising 13 items, was added to specify the interprofessional clinical capabilities required of CHPs in Singapore.

By retaining the definitions of WHO HWF framework for overlapping competency clusters, renaming continuous learning to reflect mindset-based learning, and introducing a new competency cluster to capture interprofessional clinical competencies, the final CHP competency framework balances international alignment with local relevance. Broadly, the 50 core competencies in six competency clusters can be further grouped into three functional areas, which offers a practice-oriented structure for understanding how the competencies support interprofessional team-based care in the community:

- Competencies reflecting *direct patient and caregiver service provision* - Patient advocacy, People-centred care, Patient assessment and care management,
- Competencies reflecting *interprofessional collaboration* - Effective communication and Teamwork, and
- Competencies reflecting *personal attributes and professional orientation* - Continuous learning mindset.

Table 6 presents the final CHP competency framework derived from this study, illustrating how locally grounded competencies have been systematically aligned with, and extended beyond, the WHO HWF framework to meet the demands of team-based community care in Singapore.

TABLE 6. CORE COMPETENCIES OF COMMUNITY HEALTH PROFESSIONALS IN SINGAPORE

Competency cluster	Core competency item
1. PATIENT ADVOCACY Ability to promote patients' entitlement to ensure the best quality of care and empowering patients to	***Patient education*** • Educating on behavioural management for patients with various psychosocial issues • Educating on falls prevention at home and in the community • Educating on medication administration, compliance and side effects

become active participants of their health	• Educating on use of basic assistive devices and environmental modifications • Educating on wound care, tube care and prevention of pressure injuries ***Patient and caregiver empowerment*** • Empowering patient in health promotion for disease prevention • Empowering patient in lifestyle modifications for chronic disease management • Supporting caregiver to manage own caregiving stress
2. EFFECTIVE COMMUNICATION Ability to quickly establish rapport with patients and their family members in an empathetic and sensitive manner incorporating the patients' perceived and declared culture	***Communication with patient and caregiver*** • Having communication skills to build rapport and understand challenges of patient and caregiver • Having counselling skills to facilitate patient to cope with challenges • Having multilingual skills to improve communication with patient and caregiver ***Communication with stakeholders*** • Ability to negotiate and align care expectations amongst stakeholders • Ability to resolve conflicts amongst multiple stakeholders
3. TEAMWORK Ability to function effectively as a member of an interprofessional team that includes providers, patients and family members in a way that reflects an understanding of team dynamics and group/team processes in building productive working relationships and is focused on health outcome	***Values for interprofessional practice*** • Willingness to learn from others in the team • Willingness to ask for help from others in the team Respecting interprofessional opinions and expertise • Maintaining trust and positive relationship with interprofessional team members ***Team-based practice*** • Being competent in own professional practice • Communicating own professional concerns and ideas effectively • Educating other professionals in own professional knowledge and skills • Facilitating case discussions in team to develop shared care plan
4. PEOPLE-CENTRED CARE Ability to create conditions for providing coordinated /integrated services centred on the patients and their families' needs, values and preferences along a continuum of care and over the life-course	***Care co-ordination*** • Maintaining a patient-centered focus during care needs assessment • Involving patient and caregiver in collaborative goal setting • Identifying and prioritising care needs of patient and caregiver appropriately • Knowing the range of community resources [formal and informal] available and accessible to patient and caregiver • Knowing the administrative aspects of the community resources to assist patient and caregiver in decision making • Matching the health and social care needs of patient and caregiver to relevant services • Making appropriate referrals for transition from hospital to community and within the community

	• Establishing networking and partnership with community service providers to facilitate transition of care
5. CONTINUOUS LEARNING MINDSET Attitude to demonstrate reflective practice, based on the best available evidence and to assess and continually improve the services delivered as an individual provider and as a member of an interprofessional team	***Personal attributes*** • Being adaptable and flexible • Being open minded to changes in roles and practices in the community • Being motivated to work in the community • Embracing the generalist professional identity in a transdisciplinary team • Having a patient-centred mindset over a profession-centred mindset • Having the courage to work beyond own professional expertise • Being resilient to manage dynamic situations • Having creativity and problem-solving skills to manage available resources
6. PATIENT ASSESSMENT AND CARE MANAGEMENT Ability to conduct comprehensive biopsychosocial screening, manage basic functional and psychosocial needs, and identify situations requiring care escalation	***Biopsychosocial screening and management*** • Screening for clinical parameters • Screening for general health needs • Screening for cognitive and mental health needs • Screening for physical and functional health needs • Screening for social issues • Screening for environmental issues • Ability to manage basic functional mobility needs of patient • Ability to manage basic psychosocial issues of patient and caregiver ***Care escalation*** • Having basic medical knowledge of common chronic diseases • Identifying risks and red flags which require medical attention symptoms • Determining the complexity and urgency of the health needs of patient • Recognising own professional competency and when to escalate to other health professionals • Applying the available escalation protocols for appropriate care management

IMPLICATIONS FOR PRACTICE

The findings of this study have significant implications for healthcare administrators and educators in the development of the future health workforce supporting integrated health services.

1. **Competency framework development should be context specific.** As integrated health systems differ across countries, contextually relevant competency frameworks should be developed to address local service gaps and workforce needs. The exploratory sequential mixed methods approach used in this study may be adapted for similar efforts [23,24].
2. **Workforce development should support transition to community care.** In health systems like Singapore, training of hospital-based health professionals moving into community and home-based care roles, should prioritise interprofessional clinical capabilities in patient assessment and care management, with emphasis on care escalation and enabling personal attributes. .

3. **Competency frameworks can guide interprofessional education.** Healthcare organisations and educational institutions can use competency frameworks to design interprofessional training programmes for current and future CHPs [6,10,28]. In this study, the CHP competency framework was translated into three entrustable professional activities and applied in the design of a postgraduate module "Team-based care in the community" at the Singapore Institute of Technology.

STUDY LIMITATIONS

This study had several limitations. The relatively small sample size may limit the transferability of the results across different integrated health service context, while the inclusion of health professionals only may not fully reflect the perspectives and needs of patients and caregivers. In addition, the absence of a separate external review and formal pilot testing may have reduced the survey's content validity, clarity and reliability. Nevertheless, the use of an exploratory sequential mixed methods design ensured the consistency and practical relevance of the findings. Future research on CHP competencies would benefit from larger and more diverse samples, including patients, caregivers, educators, and policymakers, and use of external expert review and pilot testing to further strengthen the robustness and applicability of competency frameworks.

CONCLUSION

This study identified 50 core competencies across six competency clusters for CHPs working in Singapore's integrated health services. Key findings included the high importance placed on competencies related to identifying situations needing escalation of care and enabling personal attributes as a CHP, together with the inclusion of patient assessment and care management, which emphasised the interprofessional clinical capabilities required for effective team-based care in the community.

Addressing a gap in the literature, this study led to a development of a locally relevant interprofessional competency framework for CHPs working in integrated health services. By aligning with the WHO health workforce competency framework while incorporating context-specific competencies, the CHP competency framework offers practical guidance for workforce development, interprofessional education, and competency-based training in Singapore and similar health systems transitioning from hospital-based to community-based care.

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CONFLICTS OF INTEREST

The Authors declare that there is no known conflict of interest that could have influenced the work reported in this paper.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the author(s) used Microsoft Copilot to improve the language and readability of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the publication.

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RESEARCH ARTICLE

NETWORK ANALYSIS OF PHYSICIAN MOBILITY IN ISTANBUL'S PRIVATE HOSPITALS, TÜRKIYE

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ABSTRACT

OBJECTIVE:

To examine whether physician workplace transitions among private hospitals in Istanbul display a systematic network structure and whether this structure varies by district-level socioeconomic development.

DESIGN:

Cross-sectional social network analysis of documented inter-hospital physician transitions using a directed, weighted network framework.

SETTING:

Private hospitals in Istanbul, Türkiye.

MAIN OUTCOME MEASURES:

Hospital-level physician mobility patterns were assessed using a three-layer framework comprising role typology based on inflow structure, flow-based community structure derived from inter-hospital transitions, and district-level socioeconomic development profiles. Network role concentration, inter-community mobility, and socioeconomic differentiation across communities were evaluated.

RESULTS:

The mobility network included 169 private hospitals and 3,834 documented inter-hospital transitions. Physician mobility was not randomly distributed but clustered around identifiable attraction centers and modular communities. Inter-community transitions accounted for 44% of total transition weight, indicating a segmented yet permeable mobility structure. Hospitals classified as centers of attraction were overrepresented in the core mobility community. Community structure also varied significantly by district socioeconomic development, with the core community concentrated in relatively more developed districts. District-level aggregation further suggested that a substantial share of transitions converged on these more advantaged locations.

CONCLUSIONS:

Physician mobility in Istanbul's private hospital sector appears to follow a structured inter-organizational pattern associated with both network position and urban socioeconomic context. These findings suggest that physician mobility can be interpreted not only as individual career movement but also as a measurable workforce governance signal.

Network-based monitoring of documented mobility flows may help managers and policymakers identify attraction pressures, retention asymmetries, and potential service continuity risks across metropolitan private hospital markets.

KEYWORDS

physician mobility; health workforce; social network analysis; directed weighted networks; network role typology; community detection; socioeconomic stratification

INTRODUCTION

Healthcare systems require not only sufficient numbers of health workers but also an adequate distribution of personnel across locations and providers. Recent global assessments indicate that workforce shortages and maldistribution remain major challenges, particularly in settings where private provision is expanding and workforce monitoring is incomplete [1,2]. In metropolitan health systems, these challenges can be intensified by job to job mobility across competing providers, especially where routine data do not consistently capture movements between employers.

In Türkiye, reforms introduced since the early 2000's have increased the scale and visibility of the private hospital sector and broadened physicians' employment options across providers [3,4]. Over time, this expansion may have strengthened competitive recruitment dynamics within the private hospital market. Yet evidence remains limited on how physicians are distributed and how they move between private hospitals within large urban settings.

This question is particularly relevant in Istanbul, Türkiye's largest and most complex healthcare market. The city hosts a dense provider landscape that includes numerous private hospitals and hospital groups operating across districts with marked socioeconomic differences. In such a setting, physician movement between private hospitals may carry managerial relevance for workforce stability, service continuity, and talent competition. However, routine data sources do not always capture these transitions in a way that supports inter-organizational analysis.

Social network analysis offers a useful framework for examining structured patterns of connection in healthcare systems. Although prior studies have often focused on patient-sharing, collaboration, and intra-organizational relationships, this perspective can also be extended to workforce mobility between hospitals [5–7]. Treating hospitals as nodes and physician workplace transitions as ties makes it possible to identify institutions that appear to attract inflows, those that function mainly as sources of outflows, and those occupying more peripheral positions within the mobility structure.

Against this background, the present study examines physician workplace transitions among private hospitals in Istanbul as an inter-hospital mobility network. It aims to describe the structure of documented intra-city physician mobility and to assess whether hospitals' network positions vary in relation to district-level socioeconomic context. The study contributes by integrating three complementary perspectives within a whole-network framework: hospital-level attraction roles, flow-based mobility communities, and district-level socioeconomic context. The study addresses the following research question: *do physician transitions among Istanbul's private hospitals display a systematic network structure, and does this structure vary across districts with different socioeconomic profiles?*

METHODS

STUDY DESIGN, SETTING, AND DATA COLLECTION

We conducted a quantitative, whole-network social network analysis (SNA) to examine inter-organizational physician mobility among private hospitals in Istanbul, Türkiye. The hospital node set represents the full population of active private hospitals operating in Istanbul during the study period (n = 169), preserving institutional-level network completeness.

Between January and May 2024, we systematically reviewed publicly available physician curricula vitae (CVs) on hospital corporate websites and extracted sequential career histories. Consecutive workplace changes were coded as directed transitions. This yielded 3,838 recorded transition entries, of which 3,834 off-diagonal inter-hospital transitions were used in the substantive analyses. To prevent duplicates, physicians were uniquely identified using name, specialty, and profile URL, and identical career sequences appearing across hospital pages were consolidated. Missingness was recorded for key fields, including district, current hospital, and prior hospital.

Because physician rosters and CV-style career histories are institution-maintained and publicly reported, coverage and timeliness likely vary across hospitals and individuals. Accordingly, the observed transitions represent publicly documented career moves rather than a complete census of all physician mobility in the underlying labor market. The analyses therefore model documented mobility flows.

ETHICS STATEMENT

This study is exempt from ethics committee approval under local regulations because it uses exclusively publicly available professional data obtained from institutional websites and involves no direct interaction with human subjects. Data were collected only from publicly accessible institutional pages without circumventing access controls or restricted areas, and were analyzed at aggregate level to minimize re-identification risk. Individual level data were de-identified at source and analyzed only in aggregate. Institutional identities were coded (hospital names are not reported), and district-level visualizations are presented to further reduce re-identification risk.

NETWORK CONSTRUCTION AND MEASURES

Physician mobility was modelled as a directed, weighted network $G = (V, E)$, where nodes **(V)** represent private hospitals and directed edges ($i \rightarrow j$) represent physician transitions between hospitals. Edge weights **(X_{ij})** denote the frequency of transitions.

Analyses were performed using UCINET and Python (NetworkX). We computed standard network connectivity measures, including in-degree (D_i^{in}) and out-degree (D_i^{out}), defined as the number of distinct origin and destination hospitals and interpreted as partner diversity, and in-strength (S_i^{in}) and out-strength (S_i^{out}), defined as the weighted volume of incoming and outgoing physician transitions. We also calculated total activity indicators, including total volume $\left(V_i = S_i^{in} + S_i^{out}\right)$ and total partner diversity ($C_i = D_i^{in} + D_i^{out}$).

To operationalize mobility, we developed an integrated framework [8–10]:

Role typology (T_i):
Hospitals were classified using explicit thresholds for inflow volume (S_in), inflow diversity (D_in), total transition volume (V_i), and total partner diversity (C_i):
T_0 (No Attraction): S_in = 0 and D_in = 0.
T_4 (Low Attraction): 1 ≤ S_in ≤ 8 and 1 ≤ D_in ≤ 8.
T_3 (Attraction Center): S_in ≥ 35 and D_in ≥ 20, with core activity defined as V_i ≥ 57 and C_i ≥ 35.
T_5 (Intermediate): all remaining hospitals.

Flow Communities (C_i):
To identify subgroups with dense internal transitions, that is, "who moves with whom," we applied the Louvain community detection algorithm to the symmetrized weighted matrix ($W_{ij} = X_{ij} + X_{ji}$) [11]. Modularity (Q) was used as the optimization criterion to select the final partition [12], and the procedure was implemented in Python (NetworkX). Symmetrization was used to detect cohesive mobility blocs driven by mutual exchange, while directionality was preserved in role typology and directional flow analyses. Robustness was assessed by repeating the Louvain solution across alternative random seeds and resolution settings and by testing an alternative symmetrization; stability was judged by consistency of C3 membership and persistence of the attraction core.

Contextual layer (SEDI)

The socioeconomic context of mobility was assessed using the Socio-Economic Development Index (SEDI) of the districts in which hospitals are located [13]. We used the Kruskal-Wallis test to compare SEDI profiles across mobility communities and chi-square analysis to test the association between role typology (T_i) and community membership (C_i).

RESULTS

OVERALL NETWORK STRUCTURE

The inter-hospital physician career-transition network for Istanbul's private sector comprised 169 nodes (private hospitals) and 2,660 unique directed edges. Network density was 0.0937, indicating that approximately one in ten possible ordered hospital pairs exhibited at least one observed transition.

Total transition volume (sum of weights) was 3834 when excluding diagonal elements ($i = j$) and 3838 when including them. Because the substantive focus is inter-organizational mobility, results are reported based on the off-diagonal transition structure; inclusion of the diagonal affects totals minimally and does not alter any structural conclusions.

Despite the presence of modular structure (communities), 44.44% of total transition volume occurred between communities (i.e., across community boundaries), indicating that inter-community mobility remains substantial even when within-community clustering is evident.

MODULAR FLOW COMMUNITIES (C_i) AND SEDI PROFILES

Community detection based on the symmetrized weighted matrix yielded four mobility communities (C1 to C4), capturing bidirectional connectivity while ignoring directionality. Across the robustness checks described above, C3 membership remained highly consistent and the C3 attraction core was stable. Table 1 summarizes community-level SEDI rank distributions (rank 1 = most developed). C3 had the most developed profile, whereas C1 and C4 were shifted toward higher ranks consistent with less developed SEDI bands.

TABLE 1. DISTRICT SOCIOECONOMIC PROFILE OF MOBILITY COMMUNITIES BASED ON SEDI RANK

Community (C)	N	Mean SEDI rank	Median [IQR]	SEDI Interpretation
C3	32	6.312	4.0 [2.0, 10.0]	More developed
C2	54	12.148	12.0 [6.75, 15.0]	Middle level
C4	16	16.250	17.0 [4.75, 23.0]	Less developed
C1	67	18.701	21.0 [11.0, 26.0]	Less developed

Note.1 SEDI ranks were computed at the district-level. Lower rank indicate higher socioeconomic development.

Note.2 SEDI differences between Communities:

Kruskal–Wallis: H(3)=33.88, p<0.001

Impact: ε^2=0.195, indicating a moderate magnitude of between-community differences.

Dunn post-hoc: C1–C3 (adj p<0.001); C1–C2 (adj p=0.001); C2–C3 (adj p=0.006); C3–C4 (adj p=0.006)

ASSOCIATION BETWEEN ATTRACTION-ROLE TYPOLOGY (T_i) AND COMMUNITY MEMBERSHIP (C_i)

Table 2 reports the association between attraction-role typology and community membership. Attraction centers (T3), defined by high inflow volume and inflow source diversity, were over-represented in the core community (C3) relative to independence expectations (O=12, E=6.06, O/E≈1.98; standardized residual=2.41). This pattern indicates that hospitals acting as major attractors of physicians tend to cluster within the core mobility community.

TABLE 2. ASSOCIATION BETWEEN ROLE TYPOLOGY AND COMMUNITY MEMBERSHIP

Panel A. *Cross tabulation (n)*					
Community (C)	**T0**	**T3**	**T4**	**T5**	**Row total**
C1	1	8	15	43	67
C2	0	7	14	33	54

C3	0	12	4	16	32
C4	0	5	7	4	16
Column total	1	32	40	96	169

Panel B. *Cells with notable deviation from independence*

Community (C)	Typology	Observed (O)	Expected (E)	O/E	Std. residual
C3	T3	12	6,06	1,98	2,41

Note. Chi Square-$\chi^2(9)=25.06$, p=0.003; Cramer's V: 0.222

INTEGRATED COMMUNITY–SEDI–TYPOLOGY PROFILE

Table 3 integrates community level socioeconomic context with role typology composition. C3 shows the most developed SEDI profile and contains the highest proportion of attraction centers, while also including a large share of intermediate hospitals, indicating that the core community combines attraction with substantial throughflow.

In contrast, C1 and C2 are dominated by intermediate hospitals and align with less developed and mid-level SEDI profiles, consistent with corridor-like segments in the mobility network. C4 aligns with a less developed SEDI profile but still contains a non-trivial share of attraction centers, suggesting heterogeneity; SEDI aligns with community structure overall, but notable exceptions remain.

Table 4 complements this view by showing how each typology distributes across communities. T3 is most concentrated in C3, whereas T4 and T5 are concentrated in C1 and C2, consistent with a core community dominated by attraction centers and corridor communities dominated by intermediate and low-attraction roles.

TABLE 3. INTEGRATED COMMUNITY SEDI AND ROLE TYPOLOGY PROFILE

Community (C)	N	SEDI median (Q25, Q75)	SEDI interpretation	Dominant typology n (%)	Secondary typology n (%)	Remaining typologies n (%)	T3 n (%)
C3	32	4,0 (2,0-10,0)	More developed	T5 16 (50.0)	T3 12 (37.5)	4 (12.5)	12 (37.5)
C2	54	12,0 (6,75-15,0)	Middle level	T5 33 (61.1)	T4 14 (25.9)	7 (13.0)	7 (13.0)
C4	16	17,0 (4,75-23,0)	Less developed	T4 7 (43.8)	T3 5 (31.3)	4 (25.0)	5 (31.3)
C1	67	21,0 (11,0-26,0)	Less developed	T5 43 (64.2)	T4 15 (22.4)	9 (13.4)	8 (11.9)

Note. SEDI ranks are at district level, rank 1 indicates the most developed. Percentages are within community, denominator equals community n. Dominant and secondary typologies are the two most frequent types within each community, remaining aggregates all other types.

TABLE 4. DISTRIBUTION OF TYPOLOGIES ACROSS COMMUNITIES, N (% WITHIN TYPOLOGY)

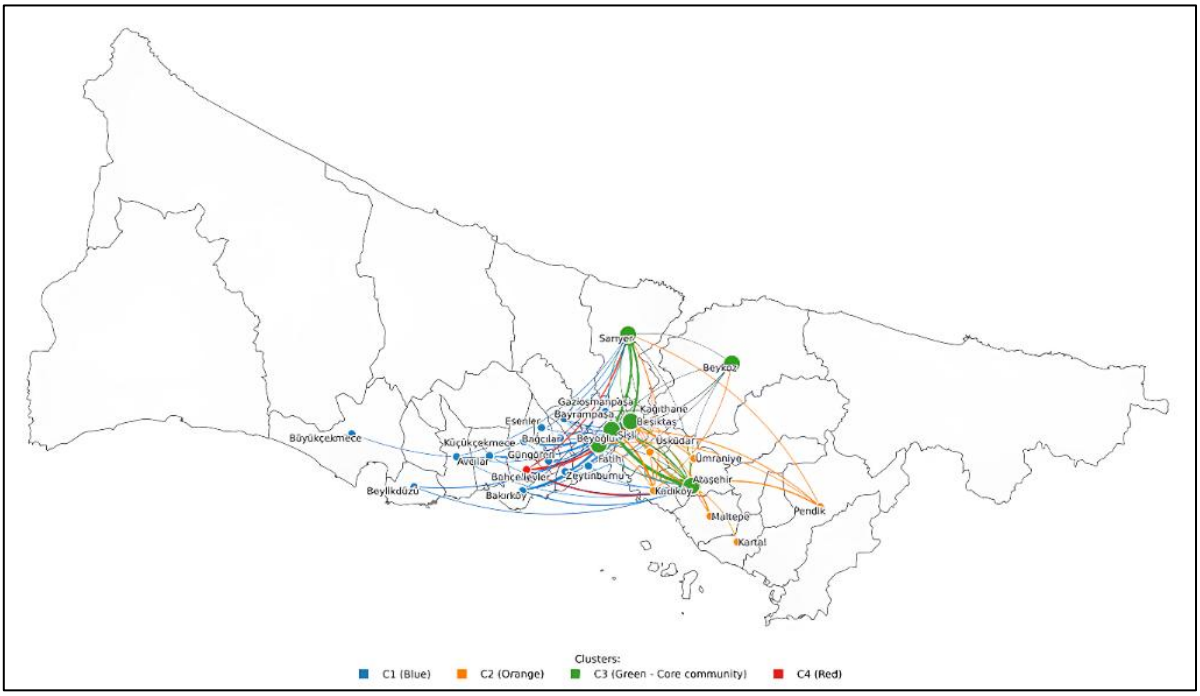
Typology (T)	N	C1 n (%)	C2 n (%)	C3 n (%)	C4 n (%)
T3 (attraction center)	32	8 (25.0)	7 (21.9)	12 (37.5)	5 (15.6)
T4 (low inflow, low diversity)	40	15 (37.5)	14 (35.0)	4 (10.0)	7 (17.5)
T5 (intermediate segment)	96	43 (44.8)	33 (34.4)	16 (16.7)	4 (4.2)

Note. Percentages are within typology, denominator equals typology n.

COMMUNITY, SEDI, AND DISTRICT-TO-DISTRICT FLOWS

Figure 1 summarizes district-level mobility by aggregating hospital-to-hospital transitions (X_ij) to districts and illustrates how the hospital-level C3 "attraction core" corresponds to concentrated inter-district mobility corridors. To improve readability, only the top 80 inter-district flows are displayed, ranked by aggregated transition volume (sum of X_ij across all hospital pairs connecting each origin–destination district pair). Links (origin → destination) represent directed inter-district flows, with line width proportional to total flow volume and color matching the origin district's dominant cluster. Nodes represent districts and are colored by their dominant cluster (C1–C4). Node size reflects district socioeconomic development based on SEDI (lower rank indicates higher development). The strongest flows tend to terminate in districts whose hospital composition is dominated by the core community (C3), consistent with the integrated hospital-level pattern.

FIGURE 1. TOP 80 INTER-DISTRICT PHYSICIAN MOBILITY FLOWS BY AGGREGATED TRANSITION VOLUME AND SEDI



DISCUSSION

STATEMENT OF PRINCIPAL FINDINGS

This study suggests that physician workplace transitions among private hospitals in Istanbul are not randomly distributed but cluster around attraction centers and modular communities. Across 169 hospitals and 3,834 inter-hospital transitions, 44% of total transition weight crossed community boundaries. The resulting pattern is consistent with a segmented yet permeable market: segmentation is reflected in community clustering, while permeability is indicated by substantial cross-community mobility.

District socioeconomic level also varied across communities. SEDI distributions differed significantly (Kruskal Wallis $p<0.001$): C3 showed a more developed profile, whereas C1 and C4 were shifted toward relatively lower profiles. This suggests that mobility patterns may be associated with both institutional dynamics and the socioeconomic context in which hospitals operate. SEDI should be interpreted as a district-level contextual measure and does not represent the socioeconomic characteristics of individual physicians or hospitals. International evidence similarly shows that physician supply can remain socioeconomically uneven even when overall numbers rise [1,14–17].

Typology analyses further showed that socioeconomic differentiation coincided with network roles. Attraction centers (T3) appeared about twice as often as expected in C3 ($O/E\approx1.98$), consistent with a possible core career-node role for hospitals in more developed districts. Prior research identifies income, working conditions, development opportunities, institutional reputation, supportive environments, and professional development as relevant to clinicians' job choices and retention [18–22]. Our results identify relational concentration rather than its causal mechanisms; explaining these patterns would require data on salary, contract terms, specialty, working hours, HR practices, and vacancies.

The high inter-community transition share indicates that physicians do not remain confined to closed mobility loops. The concentration of intermediate hospitals (T5) in C1 and C2 may reflect a possible stepping-stone role, with some organizations connecting physicians to other parts of the market. Such movement may also reflect commuting costs, network ties, and opportunity timing [23]. Network analysis makes this circulation more visible than conventional summaries [7], while prior research suggests that mobility reflects interacting organizational, professional, and contextual factors

[24,25]. This interpretation remains hypothesis-generating because the present study observes movement structure rather than the underlying decision process.

MEANING OF THE STUDY

At the Istanbul level, this structure has managerial relevance because district socioeconomic differences can coincide with disparities in service access and health outcomes [26,27]. If attraction centers cluster in more developed districts, gains in one part of the market may coincide with retention strain elsewhere. Physician mobility networks may therefore provide an intermediate monitoring layer between hospital-level HR indicators and district-level service equity, helping managers and planners identify where workforce concentration and retention pressure are emerging.

In Türkiye, the post-2002 growth of private hospital capacity and physician employment provides a plausible context for stronger inter-institutional competition [28,29]. Hospital groups, brand effects, referral relationships, and localized labor pools may interact with recruitment and retention across metropolitan providers. The contribution of this study is to make such concentration and circulation measurable through the direction and intensity of documented career transitions, without claiming to identify the underlying incentives.

The findings point to two management considerations. First, concentration around the core may create retention pressure in surrounding districts and challenge service continuity. Second, network-based monitoring can identify net attractors, net sources, and concentrated mobility corridors, providing potentially useful signals for workforce planning and targeted retention strategies [19,30].

Taken together, the findings suggest that physician mobility in Istanbul's private hospital ecosystem shows network regularity broadly aligned with district socioeconomic profiles. The framework contributes to health workforce governance by treating mobility as a measurable urban indicator of retention dynamics and inter-organizational competition.

STRENGTHS AND WEAKNESSES OF THE STUDY IN RELATION TO OTHER STUDIES

A key strength is coverage of the full set of 169 active private hospitals, combined with a whole-network, directed and weighted design and integration of hospital-level mobility structure with district-level socioeconomic context. However, CV-based data rely on publicly reported career histories, and the January to May 2024 observation window limits assessment of longer-term network evolution. Missing information on specialty, seniority, salary, contract model, and working hours also limits explanation of the mechanisms underlying observed mobility patterns and precludes causal claims.

UNANSWERED QUESTIONS AND FUTURE RESEARCH

Future research could test the socioeconomic hierarchy hypothesis more directly by combining time-series network analysis, specialty-specific breakdowns, and hospital-level indicators within multilevel designs. Robustness could also be examined using alternative network definitions, including tie weights based on repeated transitions or time intervals.

CONCLUSION

This study shows that physician mobility in Istanbul's private hospital ecosystem can be described through attraction roles, modular flow communities, and district-level socioeconomic stratification. Attraction centers (T3) combine high incoming volume with broad source diversity and strong connectivity, while community structure captures "who moves with whom." Empirically, attraction centers are over-represented in the core mobility community (C3), and this core aligns with more socioeconomically developed destination districts. These findings suggest that intra-urban mobility operates through segmented yet permeable submarkets and may reflect a network-mediated opportunity structure that complements individual-level explanations.

In health sciences, SNA has most often been used to analyse patient-sharing networks or intra-organizational collaboration. Modelling inter-organizational physician career transitions as a network of hospitals and flows offers a

complementary way to monitor attraction and retention dynamics and to detect emerging inequalities in the private sector.

From a policy and managerial perspective, concentration of attraction centers in more developed districts may increase core-periphery vulnerabilities in physician availability and service continuity. Potential responses, including structured rotations, training and clinical pathways, and targeted workforce incentives, may help reduce disparities and support a more balanced workforce distribution.

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RESEARCH ARTICLE

ARTIFICIAL INTELLIGENCE LEADERSHIP IN NURSING MANAGEMENT FOR NURSING ORGANISATIONS: A CONCEPT ANALYSIS

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ABSTRACT

BACKGROUND:

Artificial intelligence (AI) is increasingly embedded in nursing management through workforce modelling, quality surveillance, resource allocation and organisational decision support. However, artificial intelligence leadership in nursing management remains conceptually underdeveloped, particularly regarding governance, accountability and nursing-specific leadership responsibilities.

OBJECTIVE:

To analyse and define artificial intelligence leadership in nursing management and develop a conceptual framework for future empirical research, competency development and responsible AI implementation.

DESIGN:

A concept analysis using Walker and Avant's eight-step methodology, supported by a structured search to identify conceptually relevant interdisciplinary literature.

SETTING:

Peer-reviewed interdisciplinary literature and authoritative policy and professional guidance documents identified through PubMed, Google Scholar, Europe PMC, ProQuest Nursing & Allied Health Database and relevant authoritative sources, published between 2020 and 2025.

MAIN OUTCOME MEASURES:

Defining attributes, antecedents, consequences, model cases and empirical referents.

RESULTS:

Twenty-four substantive sources were retained for conceptual analysis; methodological and theoretical foundations were used separately to guide analysis and support theoretical positioning. Artificial intelligence leadership in nursing management was conceptualised as a governance-specialised extension of nursing leadership comprising five interrelated attributes: strategic AI direction-setting, managerial AI literacy, ethical and regulatory oversight, organisational change leadership and workforce capability development, and systematic integration into nursing management processes. Antecedents were organised as core or contextual conditions; consequences were differentiated into proximal and proposed distal consequences, the latter requiring empirical validation. Empirical referents were identified at individual, workforce and organisational levels.

CONCLUSIONS:

Artificial intelligence leadership in nursing management clarifies the leadership responsibilities required when AI informs nursing managerial decision-making, including algorithmic accountability, human oversight and preservation of professional nursing judgement. The concept provides a foundation for competency development, empirical validation and organisational governance across health and aged care settings, including Asia-Pacific contexts.

KEYWORDS

artificial intelligence; artificial intelligence leadership; nursing management; nursing leadership; concept analysis

INTRODUCTION

Artificial intelligence (AI) is increasingly used in health and aged care organisations for predictive workforce modelling, operational optimisation, quality surveillance and resource allocation [1]. In nursing management, these applications influence staffing, workload, patient safety, service equity and organisational performance, shifting leadership accountability towards the interpretation and oversight of AI-informed decisions.

In nursing and aged care, this shift is particularly important because continuity of care, workforce stability, patient advocacy, safety culture and ethical accountability are central to service delivery. AI applications such as workload forecasting, staffing optimisation and real-time quality monitoring may redistribute informational authority within managerial decision-making [2,3], raising questions about responsibility for AI-informed harm, human override, data validation and preservation of professional judgement.

Although scholarship on AI in nursing and health services is expanding, much of the literature focuses on readiness, professional adaptation, user perceptions and clinical ethics [4,5]. Less attention has been directed towards the leadership capability required to govern AI-informed managerial decisions responsibly. Existing perspectives including digital, informatics, technology and transformational leadership, as well as technology governance provide relevant foundations but do not consistently specify responsibilities for algorithmic accountability, critical interpretation of AI outputs and professional oversight. Digital leadership guides organisation-wide technology change [6,7]; informatics leadership focuses on the use and governance of health information and data in nursing practice [8]; AI leadership additionally requires scrutiny of algorithmic outputs, monitoring of bias and human accountability for AI-informed decisions.

Artificial intelligence leadership in nursing management is therefore conceptualised not as a wholly independent leadership theory or separate construct, but as a governance-specialised extension of nursing leadership. Its additional contribution lies in specifying responsibilities that become particularly salient when AI influences managerial authority and professional accountability, including critical interpretation of algorithmic outputs, human oversight, AI-related risk governance and preservation of professional nursing judgement. Its nursing relevance is evident in decisions affecting staffing adequacy, workload distribution, nursing-sensitive outcomes, workforce wellbeing and safe person-centred care. The concept builds on rather than replaces established leadership perspectives. Transformational, adaptive, complexity, systems and ethical leadership provide foundations for vision, change, uncertainty, interdependence and professional responsibility [9–13], while the focal concept integrates these perspectives with AI-specific accountability and governance responsibilities in nursing management.

Although derived from international and interdisciplinary literature, the framework is intended to be broadly applicable rather than region-specific. Its application may nevertheless be particularly relevant to Asia-Pacific health systems, where population ageing, nursing workforce shortages, uneven digital maturity, resource constraints and regulatory variation may shape AI adoption and governance. Using Walker and Avant's eight-step concept analysis methodology [14], this study aimed to clarify artificial intelligence leadership in nursing management, identify its defining attributes, antecedents,

consequences, model cases and empirical referents, and provide a foundation for competency development, empirical operationalisation and responsible AI governance.

METHODS

DESIGN

This theoretical study used Walker and Avant's eight-step concept analysis methodology [14] to clarify the defining attributes, antecedents, consequences, model cases and empirical referents of artificial intelligence leadership in nursing management. The study was conducted as a concept analysis rather than a systematic or scoping review; the structured literature search identified conceptually relevant sources to support the analytic steps rather than to synthesise evidence, estimate effects or formally appraise study quality. No risk-of-bias assessment, evidence grading or meta-synthesis was undertaken because the search served a concept-identification rather than evidence-synthesis purpose.

DATA SOURCES AND SEARCH STRATEGY

A structured literature search was conducted in PubMed, Google Scholar, Europe PMC and ProQuest Nursing & Allied Health Database. Search terms combined "artificial intelligence" with "nurse manager" or "nurse leader" and with leadership, management or governance, with syntax and limits adapted to each platform. English-language literature published from January 2020 to December 2025 was eligible for inclusion.

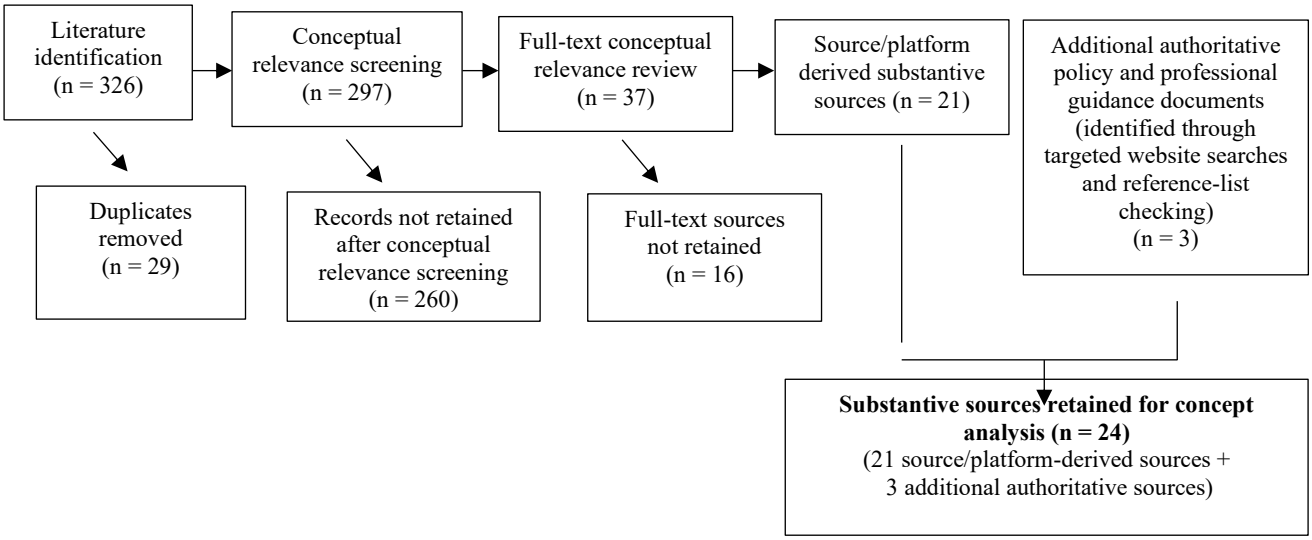
The structured searches across the four sources/platforms identified 326 records. After removal of 29 duplicates, 297 records were screened and 37 full texts were reviewed for conceptual relevance. Of these, 21 source/platform-derived sources were retained. Three additional authoritative policy and professional guidance documents were identified through targeted website searches and reference-list checking. Following assessment for conceptual relevance and contribution to the analysis, a total of 24 substantive sources were retained for concept analysis. Walker and Avant [14] and five established leadership sources [9–13] were used separately as methodological and theoretical foundations and were not included among the 24 substantive sources. Source/platform-specific search strategies, including the search strings as executed, fields and limits, search dates, and the number of records exported for screening, are reported in Supplementary Table S2.

Peer-reviewed conceptual papers, empirical studies and reviews, together with authoritative policy and professional guidance, were retained when they contributed to understanding AI-related leadership, governance or managerial responsibilities in nursing or health services. Sources focused solely on technical AI development, clinical applications without organisational leadership relevance, or non-authoritative material were excluded.

SCREENING AND CONCEPTUAL DATA EXTRACTION

One author conducted screening and conceptual data extraction using a structured matrix aligned with Walker and Avant's analytic steps. The matrix captured concept uses, leadership and governance responsibilities, nursing-specific considerations, candidate attributes, antecedents, consequences and empirical referents. An audit trail documented source-selection, extraction and category-development decisions to enhance analytic transparency and consistency.

FIGURE 1. LITERATURE IDENTIFICATION AND CONCEPTUAL RELEVANCE SCREENING FOR WALKER AND AVANT'S CONCEPT ANALYSIS, INCLUDING SOURCE/PLATFORM-DERIVED AND ADDITIONAL AUTHORITATIVE SOURCES.



ANALYTICAL PROCEDURE

The analysis followed Walker and Avant's eight steps: concept selection, determination of aims, identification of concept uses, determination of defining attributes, construction of a model case, identification of related, borderline and contrary cases, identification of antecedents and consequences, and definition of empirical referents [14].

Conceptual data were iteratively compared across sources. Candidate attributes were retained when they were recurrent, conceptually coherent and necessary to clarify the boundaries of artificial intelligence leadership in nursing management. Antecedents, consequences and empirical referents were subsequently organised to support conceptual clarity and future operationalisation. Leadership sources [9–13] were used for theoretical positioning rather than category generation.

ETHICAL CONSIDERATIONS

As this study involved analysis of published literature and did not include human participants or identifiable data, ethical approval was not required.

RESULTS

STEP 1: SELECTION OF THE CONCEPT

Artificial intelligence leadership in nursing management was selected because AI increasingly informs nursing workforce planning, quality governance, resource allocation and managerial decision-making, expanding nurse leaders' responsibilities for oversight, accountability and ethical stewardship. Related digital, technology and informatics leadership constructs share important features but do not consistently address algorithmic accountability, human oversight and preservation of professional nursing judgement. The focal concept was therefore positioned as a governance-specialised extension of nursing leadership, rather than a wholly independent leadership construct.

STEP 2: DETERMINATION OF THE AIM OF ANALYSIS

The aim of this analysis was to clarify and define artificial intelligence leadership in nursing management by identifying its defining attributes, clarifying its boundaries with related concepts, determining antecedents and consequences, and articulating empirical referents to inform future competency development, measurement and empirical testing.

STEP 3: IDENTIFICATION OF ALL USES OF THE CONCEPT

Interdisciplinary literature described AI-related leadership across several domains. In health service contexts, it was associated with staffing optimisation, predictive workforce modelling, service coordination, resource allocation and quality monitoring [8,15]. Related literature addressed technology implementation and organisational readiness [6,16], alongside ethical accountability, transparency, regulatory oversight and AI governance [17,18]. In nursing-specific literature, additional emphasis was placed on professional judgement, patient advocacy, workforce wellbeing, safety culture and ethical responsibility [19–21]. However, most sources focused on implementation, readiness or technological competence rather than the governance responsibilities of nurse leaders overseeing AI-informed managerial decisions.

STEP 4: DETERMINATION OF DEFINING ATTRIBUTES

Five defining attributes emerged through iterative comparison of conceptual data from the 24 substantive sources. Candidate attributes were retained when they were recurrent, conceptually coherent and contributed to clarifying the boundaries of artificial intelligence leadership in nursing management. Conceptual boundaries and distinguishing focus across the five attributes are summarised in Table 1. Source contributions are mapped in Supplementary Table S1.

Strategic AI direction-setting concerns why, where and for what purposes AI should be adopted in nursing management. It aligns AI initiatives with safe staffing, nursing-sensitive outcomes, workforce sustainability and professional accountability. Managerial AI literacy refers to the nurse leader's capability to understand, interpret and critically question AI outputs, including data quality, uncertainty, bias and potential risks, particularly when these outputs influence staffing, workload, care prioritisation and patient safety.

Ethical and regulatory oversight encompasses transparency, fairness, privacy, data governance, regulatory compliance and human oversight. Its nursing relevance lies in protecting patient advocacy, equitable care, workforce wellbeing and professional nursing judgement.

Organisational change leadership and workforce capability development involves preparing staff and organisations for responsible AI use, addressing resistance and developing workforce capability while preserving professional judgement and autonomy.

Systematic integration into nursing management processes involves embedding AI within governed functions such as staffing, quality surveillance, risk monitoring and resource allocation, linking AI-supported decisions with nursing governance, nursing-sensitive indicators and patient safety.

Collectively, these attributes position artificial intelligence leadership in nursing management as a governance-specialised extension of nursing leadership that integrates strategic direction, critical interpretation, ethical oversight, workforce capability development and systematic AI integration.

TABLE 1. CONCEPTUAL BOUNDARIES AMONG DEFINING ATTRIBUTES OF ARTIFICIAL INTELLIGENCE LEADERSHIP IN NURSING MANAGEMENT

Defining attribute	Distinct conceptual focus	Level of leadership responsibility
Strategic AI direction-setting	Defines the purpose and priorities for AI adoption in nursing management, aligned with safe staffing, workforce sustainability and nursing-sensitive outcomes.	Strategic / policy level
Managerial AI literacy	Enables nurse leaders to critically interpret and question AI outputs affecting staffing, workload and patient safety, including data quality, uncertainty, bias and risk.	Individual managerial capability
Ethical and regulatory oversight	Ensures transparency, fairness, privacy, regulatory compliance and human oversight so that AI-informed	Governance / accountability level

Defining attribute	Distinct conceptual focus	Level of leadership responsibility
	decisions remain explainable, contestable and consistent with professional nursing judgement.	
Organisational change leadership and workforce capability development	Prepares staff and organisational culture for responsible AI use while developing collective capability and preserving professional nursing judgement and autonomy.	Workforce / organisational change level
Systematic integration into nursing management processes	Embeds AI into governed nursing management functions, including staffing, quality surveillance, risk monitoring and resource allocation, linked with nursing governance, nursing-sensitive indicators and patient safety.	Operational / system-integration level

STEP 5: CONSTRUCTION OF A MODEL CASE

A chief nursing officer implements AI-driven predictive workforce analytics, integrated into routine staffing processes, to support strategic staffing and patient safety. The system recommends reducing registered nurse coverage because predicted patient volume is low; however, the nurse manager identifies high patient acuity and safety risks that are not adequately reflected in the model. The chief nursing officer overrides the recommendation, documents the rationale and refers the decision to a multidisciplinary AI governance committee. The committee reviews the model input and performance, and the findings inform staff education, future monitoring and model improvement.

This case demonstrates all five defining attributes: strategic AI direction-setting, managerial AI literacy, ethical and regulatory oversight, organisational change leadership and workforce capability development, and systematic integration into nursing management processes.

STEP 6: CONSTRUCTION OF ADDITIONAL CASES

Borderline case: A nurse manager uses AI scheduling software to optimise shifts but lacks strategic alignment, formal governance oversight, structured risk review and workforce capability development. AI use is present, but only some defining attributes are demonstrated.

Related case: A nurse executive leads digital transformation through electronic health records and reporting systems. Digital leadership is evident, but AI-specific governance, algorithmic accountability and human oversight of AI-informed recommendations are absent.

Contrary case: A nurse administrator rejects AI integration and relies solely on manual systems without strategic AI direction, managerial AI literacy, governance oversight or systematic AI integration. None of the defining attributes are present.

STEP 7: IDENTIFICATION OF ANTECEDENTS AND CONSEQUENCES

Antecedents were classified as core or contextual. Core antecedents comprised adequate digital and data infrastructure, minimum managerial AI literacy, governance and accountability mechanisms, and organisational authority to oversee AI-informed decisions. Contextual antecedents included executive support, financial resources, organisational learning culture, psychological safety, regulatory clarity, workforce readiness and interprofessional collaboration. Together, these conditions shape whether Artificial intelligence leadership in nursing management develops as a sustained governance capability rather than an isolated managerial practice.

Consequences were classified as proximal or proposed distal. Proximal consequences included clearer accountability, more critical interpretation of AI outputs, strengthened governance practices, improved workforce capability and more systematic integration of AI into nursing management. Proposed distal consequences may include patient safety, quality

of care, nurse retention, organisational resilience, legitimacy and public trust [22,23]. These distal consequences are theoretically anticipated rather than established causal effects and require empirical validation.

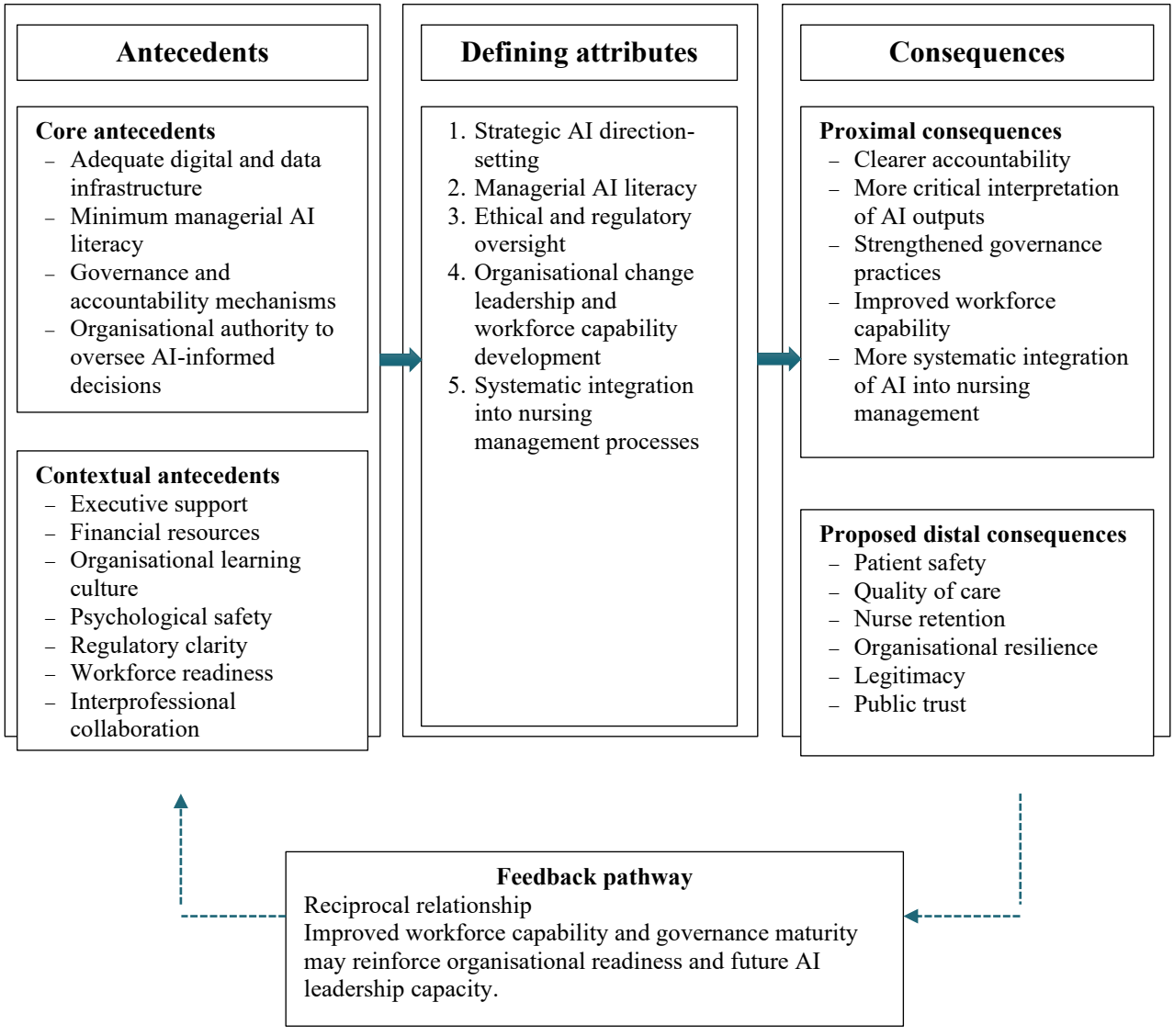
The relationship is dynamic rather than linear: improved workforce capability and governance maturity may reinforce organisational readiness and future AI leadership capacity.

STEP 8: DEFINITION OF EMPIRICAL REFERENTS

Empirical referents for the five defining attributes were organised by level of measurement. Individual-level referents included AI literacy and competency assessment scores, demonstrated ability to interpret algorithmic uncertainty and bias, and documented questioning or override of AI-generated recommendations with professional rationale. Workforce-level referents included AI-readiness scores, training participation rates, psychological-safety scores and mechanisms to prevent deskilling or automation-driven work intensification. Organisational-level referents included AI governance policies, ethics-review mechanisms, bias-monitoring reports, audit frequency, escalation protocols and routine integration of AI-supported evidence into nursing management and governance.

Individual referents reflect nurse-manager leadership capability, whereas workforce and organisational indicators represent the context in which that capability is enacted. Accordingly, a future artificial intelligence leadership competency scale for nurse managers should primarily assess individual-level competencies, with workforce and organisational indicators treated as contextual or complementary measures. A separate organisational AI leadership capability measure may be developed in future research.

FIGURE 2. CONCEPTUAL FRAMEWORK OF ARTIFICIAL INTELLIGENCE LEADERSHIP IN NURSING MANAGEMENT



DISCUSSION

PRINCIPAL FINDINGS

This concept analysis positions artificial intelligence leadership in nursing management as a governance-specialised extension of nursing leadership concerned with the responsibilities that arise when AI informs managerial decision-making. Its contribution lies in clarifying how nurse leaders can retain professional accountability while using AI in decisions affecting staffing, workload, nursing-sensitive outcomes and patient safety.

THEORETICAL POSITIONING OF AI LEADERSHIP

Artificial intelligence leadership in nursing management builds on rather than replaces established leadership perspectives. It shares with digital and informatics leadership a concern with technology-enabled transformation, and with transformational, adaptive, complexity, systems and ethical leadership a concern with vision, change, uncertainty, interdependence and accountability [9–13]. Digital leadership concerns organisation-wide technology-enabled change [6,7], whereas informatics leadership concerns the use and governance of health information and data in nursing practice [8]. Digital and informatics implementation is additionally influenced by usability, training, technical support and organisational support [24]. AI leadership places additional emphasis on critical interpretation of algorithmic outputs, human oversight, bias monitoring and accountability for AI-informed managerial decisions.

Beyond identifying AI-specific responsibilities, this analysis makes two theoretical contributions. First, while transformational leadership [9] provides a foundation for strategic direction and mobilisation, the joint human–algorithm decision process proposed here aligns more directly with adaptive and complexity leadership perspectives [10,11], which emphasise responding to novel challenges and enabling adaptation within complex organisational systems. In AI-informed nursing management, this contribution specifies a distinct decision-governance requirement: determining when algorithmic outputs should inform, be questioned or be overridden by professional nursing judgement. Second, drawing on systems thinking [12] and ethical leadership [13], the analysis links individual nurse-leader capability with organisational governance arrangements and specifies accountability for decisions produced through human–algorithm interaction. Together, these contributions clarify decision authority and accountability when algorithmic recommendations influence managerial judgement, positioning AI leadership in nursing management as a governance-specialised extension of established nursing leadership rather than a separate leadership theory. The proposed relationships among antecedents, defining attributes and consequences (Figure 2) remain conceptual propositions for future empirical testing rather than established causal relationships.

NURSING-SPECIFIC CONTRIBUTION

The five attributes are not exclusive to nursing. Their nursing specificity derives from the professional domain and accountability in which they are enacted, particularly in decisions concerning staffing, workload, nursing-sensitive outcomes, workforce capability, professional judgement and patient safety. Their significance lies in the nurse leader's responsibility to ensure that AI-informed decisions remain consistent with nursing governance, professional standards and safe person-centred care.

COMPARISON WITH EXISTING LITERATURE

Existing studies have primarily examined nurse leaders' AI preparedness, including the relationship between executive nurses' leadership self-efficacy and medical AI readiness [25], broader AI preparedness among hospital nurse leaders [15], and experiences with digital technologies [7], as well as relationships between transformational leadership, perceptions of AI use and innovative work behaviour [26]. The present analysis extends this literature by shifting attention from readiness and adoption towards the governance responsibilities associated with AI-informed nursing management.

RISKS AND GOVERNANCE RESPONSIBILITIES

AI-informed nursing management may introduce algorithmic bias, automation bias, deskilling and workforce resistance [5,27,28]. Responsible leadership therefore requires human oversight, transparent decision processes, mechanisms for questioning or overriding AI recommendations, workforce engagement and ongoing monitoring. Governance

responsibility extends beyond adoption to ensuring that AI-informed decisions remain accountable, context-sensitive and professionally defensible.

STRENGTHS AND LIMITATIONS

Strengths include the structured application of Walker and Avant's eight-step framework [14], use of a structured analytic matrix and maintenance of an audit trail. The governance-oriented framing also addresses an emerging area of nursing management relevant to AI ethics, regulation and health-system accountability [29,30]. Limitations include restriction to English-language sources, which may have excluded relevant Asia-Pacific scholarship, source selection based on conceptual relevance, and screening and conceptual data extraction by one author. In addition, Google Scholar results cannot be fully reproduced, and search limits differed across platforms (Supplementary Table S2). The resulting concept therefore requires empirical validation across diverse settings.

MEANING OF THE STUDY

At the individual level, the concept can inform nurse-manager competency development in AI literacy, critical interpretation and ethical judgement. At the organisational level, responsible implementation requires governance policies, accountability structures, ethics-review mechanisms, audit processes and workforce development. These requirements may warrant particular examination in Asia-Pacific health systems, where variation in workforce capacity, digital maturity and governance contexts may influence implementation.

UNANSWERED QUESTIONS AND FUTURE RESEARCH

Future research should develop and validate an artificial intelligence leadership competency scale for nurse managers focused on individual-level competencies, while organisational AI leadership capability should be examined separately using organisational-level indicators. Psychometric studies should assess content validity, construct validity, factor structure and measurement equivalence. Quantitative, qualitative and mixed-method studies should examine the proposed relationships and proposed distal consequences identified in this analysis. Longitudinal and cross-contextual studies are also needed to determine how organisational readiness, governance maturity and workforce capability shape these relationships across diverse settings, including the Asia-Pacific region.

CONCLUSION

This concept analysis conceptualises artificial intelligence leadership in nursing management as a governance-specialised extension of nursing leadership for contexts in which AI informs managerial decision-making. The concept comprises five interrelated attributes: strategic AI direction-setting, managerial AI literacy, ethical and regulatory oversight, organisational change leadership and workforce capability development, and systematic integration into nursing management processes. Together, these attributes clarify the leadership responsibilities required to govern AI-informed decisions while preserving professional nursing judgement and supporting safe person-centred care. The concept provides a foundation for competency development, empirical validation and responsible AI governance across diverse health and aged care settings, including Asia-Pacific contexts.

DECLARATIONS

Authorship

All authors listed in this manuscript have made substantial contributions to the conception, design, analysis, and interpretation of the work. All authors participated in drafting or critically revising the manuscript for important intellectual content and approved the final version of the manuscript for submission.

Authorship has been determined in accordance with the recommendations of the International Committee of Medical Journal Editors (ICMJE) guidelines. All authors agree to be accountable for all aspects of the work and approve the order of authorship as presented in the manuscript.

Author Contribution Statement (CRediT Taxonomy)

The authors' contributions to this manuscript follow the Contributor Roles Taxonomy (CRediT) to ensure transparency in scholarly authorship.

K O: Conceptualisation, Methodology, Formal analysis, Original draft writing,

N S: Conceptualisation, Data curation, Investigation, Visualisation, Review & editing writing, Supervision.

All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Declaration of Conflicting Interests

The author declares that there is no conflict of interest related to this research, authorship, and/or publication of this article.

Data Availability

Data will be made available on request.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used ChatGPT in order to improve language clarity. The authors reviewed and edited the content and take full responsibility for the final paper.

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SUPPLEMENTARY TABLE

SUPPLEMENTARY TABLE S1. SOURCE-TO-CONCEPT MAPPING OF THE 24 SUBSTANTIVE SOURCES INFORMING ARTIFICIAL INTELLIGENCE LEADERSHIP IN NURSING MANAGEMENT. THEORETICAL FOUNDATIONS (REFS. 9–13) AND THE METHODOLOGICAL FOUNDATION (REF. 14) ARE LISTED IN CITATION ORDER, IDENTIFIED IN THE ROLE COLUMN AND SHOWN IN ITALICS; THESE FOUNDATION SOURCES WERE NOT COUNTED AMONG THE 24 SUBSTANTIVE SOURCES.

Coding: A1 = Strategic AI direction-setting; A2 = Managerial AI literacy; A3 = Ethical and regulatory oversight; A4 = Organisational change leadership and workforce capability development; A5 = Systematic integration into nursing management processes. A check mark (✓) is used only where the source directly or clearly informs the conceptual domain; blank cells indicate that support was not sufficiently explicit.

Ref.	Source	Role	A 1	A 2	A 3	A 4	A 5	Antecedent(s) informed	Proposed consequence(s) informed	Empirical referent(s) / observable contribution
1	Gonzalez-Garcia et al. (2024)	Substantive		✓		✓	✓	Managerial AI capability; training; interdisciplinary collaboration; organisational readiness	Potentially improved decision support, resource management and operational efficiency	AI use in nurse-management functions; decision-support/resource-management indicators; training needs
2	Martinez-Ortigosa et al. (2023)	Substantive					✓	Implementation readiness; technological capability	Potential workflow optimisation and decision support in nursing practice	AI applications in patient monitoring, workflow optimisation and nursing decision support
3	O'Connor et al. (2023)	Substantive		✓	✓		✓	AI expertise; clinical interpretation capability; data quality and governance awareness	Potentially safer and more informed AI use	AI expertise/knowledge needs; clinical interpretation; bias, privacy and trust concerns; administration/management applications
4	Burford et al. (2025)	Substantive	✓	✓	✓	✓	✓	Leadership preparedness; education/training; organisational support; governance capacity	Potentially ethical, strategically guided and workforce-responsive AI integration	Nurse-leader roles; education/training needs; ethical, implementation and work-environment themes
5	Göktepe & Sarıköse (2025)	Substantive	✓			✓	✓	Organisational readiness; infrastructure; workforce planning capability; managerial support	Potential improvements in managerial processes, workforce planning and resource use	Nurse-manager experiences of AI-supported monitoring, bed-occupancy prediction and workforce-planning applications
6	Laukka et al. (2020)	Substantive		✓		✓	✓	Leader understanding of HIT; implementation support; organisational readiness	Potentially more effective technology implementation and organisational change	Healthcare-leader roles in HIT implementation; understanding/competence needs; implementation roles
7	Laukka et al. (2023)	Substantive		✓		✓		Digital competence; organisational support; implementation readiness	Workforce adaptation and more effective use of digital technologies	Nurse-leader digital capability; competence needs; stakeholder collaboration; implementation experiences

Ref.	Source	Role	A 1	A 2	A 3	A 4	A 5	Antecedent(s) informed	Proposed consequence(s) informed	Empirical referent(s) / observable contribution
8	Ronquillo et al. (2021)	Substantive	✓	✓	✓	✓	✓	AI/data knowledge; nursing involvement; interdisciplinary collaboration; leadership engagement	Potentially responsible and nursing-informed AI development and implementation	Consensus priorities for nursing participation across AI design, implementation, evaluation, education and governance
9	*Bass & Riggio (2006)*	*Theoretical foundation*	—	—	—	—	—	*Transformational leadership: vision, inspiration and change*	*Supports theoretical interpretation of strategic direction and workforce change*	*Not used to derive AI-specific categories*
10	*Heifetz et al. (2009)*	*Theoretical foundation*	—	—	—	—	—	*Adaptive leadership under uncertainty*	*Supports interpretation of adaptive leadership and change*	*Not used to derive AI-specific categories*
11	*Uhl-Bien et al. (2007)*	*Theoretical foundation*	—	—	—	—	—	*Complexity, emergence and interdependence*	*Supports interpretation of leadership in complex systems*	*Not used to derive AI-specific categories*
12	*Senge (1990)*	*Theoretical foundation*	—	—	—	—	—	*Systems thinking and organisational learning*	*Supports interpretation of feedback, integration and learning*	*Not used to derive AI-specific categories*
13	*Brown et al. (2005)*	*Theoretical foundation*	—	—	—	—	—	*Ethical leadership, role modelling and fairness*	*Supports interpretation of ethical accountability and responsible leadership*	*Not used to derive AI-specific categories*
14	*Walker & Avant (2019)*	*Methodological foundation*	—	—	—	—	—	*Eight-step concept-analysis methodology*	*Provides the methodological structure for concept clarification*	*Not used as substantive AI evidence*
15	Alnomasy et al. (2025)	Substantive		✓		✓		AI preparedness; education/training; professional readiness	Greater preparedness for AI integration among nurse leaders	SHAIP perception/preparedness scores; validated measurement of nurse-leader preparedness
16	Laukka, Hammarén & Kanste (2022)	Substantive		✓		✓		Nurse-leader AI familiarity; awareness of risks; organisational readiness	Potential support for development of AI-enabled services and workflows	Nurse-leader perceptions of AI effects on work, care/services and organisations; familiarity and risk awareness
17	Stokes & Palmer (2020)	Substantive			✓			Ethical awareness; preservation of caring values and human roles	Preservation of human caring and professional nursing judgement	Ethical appraisal of human-versus-AI task allocation
18	Reddy et al. (2020)	Substantive			✓		✓	Governance structures; regulatory/ethical readiness; organisational authority	More accountable and ethically governed AI application	Governance framework; oversight roles; transparency, bias, privacy, safety and liability controls
19	International Council of Nurses (2021)	Substantive			✓			Professional standards; ethical accountability; advocacy responsibilities	Preservation of professional judgement, patient rights and ethical nursing practice	Professional accountability, advocacy, privacy/confidentiality and ethical-decision standards
20	Ergin et al. (2022)	Substantive		✓		✓		Managerial AI awareness; education/training; readiness to guide staff	Potentially more informed adoption of AI and robotic nursing applications	Nurse-manager awareness/opinions and identified education/guidance needs

Ref.	Source	Role	A 1	A 2	A 3	A 4	A 5	Antecedent(s) informed	Proposed consequence(s) informed	Empirical referent(s) / observable contribution
21	Al Khatib & Ndiaye (2025)	Substantive				✓	✓	Nurse involvement and empowerment in AI implementation	Role change, process automation and decision support associated with AI integration	Nurse involvement in AI deployment; role-change themes; operational-use and implementation examples
22	Fisher & Rosella (2022)	Substantive	✓	✓	✓	✓	✓	Data governance; modern infrastructure; workforce skills; partnerships; equity/bias capability	Potentially more sustainable, transparent and equitable organisational AI use	AI strategy/governance priorities; infrastructure readiness; workforce skill gaps; transparency/reproducibility; equity/bias indicators
23	Morley et al. (2020)	Substantive			✓			Ethical-risk awareness; governance and regulatory attention	Ethically mindful AI deployment and protection of public trust	Epistemic, normative and traceability-related ethical-risk categories; accountability and fairness considerations
24	Corbett et al. (2025)	Substantive				✓	✓	Management support; training; IT support; usability; organisational readiness	Potentially improved EHR acceptance and integration into nursing practice and workflow	EHR acceptance; usability-related facilitators and barriers; documentation burden; management and IT support; training needs
25	Eminoğlu & Çelikkanat (2024)	Substantive		✓		✓		Leadership self-efficacy; AI readiness among executive nurses	Greater readiness of nurse leaders for AI integration	Executive nurses' leadership self-efficacy and medical AI readiness scores; observed relationship between leadership self-efficacy and AI readiness
26	Agaoglu et al. (2025)	Substantive				✓		Transformational leadership; employee happiness; perceptions of AI use	Innovative work behaviour (reported empirical association; not a direct causal consequence of AI leadership)	Transformational-leadership, AI-perception, employee-happiness and innovative-work-behaviour scale scores
27	Johnson et al. (2024)	Substantive		✓	✓	✓		Critical evaluation capability; education/training; legal-policy preparedness	Potentially safer AI-informed nursing decisions and preservation of professional responsibility	Patient-safety risk appraisal; education/training recommendations; legal and policy considerations
28	Bodur et al. (2025)	Substantive		✓	✓	✓		AI knowledge; workforce readiness; ethical reasoning; institutional preparedness	Professional adaptation while preserving human-centred nursing roles	Nurses' AI understanding; ethical/accountability concerns; de-skilling, dehumanisation and training needs
29	World Health Organization (2021)	Substantive			✓		✓	Ethical governance; accountability; human-rights safeguards; data stewardship	Trustworthy, accountable and human-centred AI use	Human oversight; transparency; accountability; privacy; fairness and governance mechanisms
30	World Health Organization (2023)	Substantive			✓		✓	Regulatory clarity; lifecycle governance; risk-management capacity	Safer and more accountable AI deployment	Regulatory compliance, documentation, performance monitoring, risk-benefit assessment and audit mechanisms

SUPPLEMENTARY TABLE S2. SOURCE/PLATFORM-SPECIFIC SEARCH STRATEGIES AND RECORDS EXPORTED FOR SCREENING

Source / platform	Database / collection searched	Search string as executed	Fields and limits	Date searched	Records exported for screening (n)
PubMed	PubMed	("artificial intelligence"[tiab] OR "Artificial Intelligence"[Mesh]) AND ("nurse manager"[tiab] OR "nurse leader"[tiab] OR "nursing management"[tiab] OR "nursing leadership"[tiab] OR (nurs*[tiab] AND (leadership[tiab] OR management[tiab] OR governance[tiab]))) AND ("2020/01/01"[dp] : "2025/12/31"[dp]) AND english[la]	Title/Abstract [tiab] and MeSH Terms [Mesh]; English language; publication date 1 Jan 2020–31 Dec 2025; no publication-type or full-text availability filters	10 Jan 2026	20
Google Scholar	Google Scholar	"artificial intelligence" ("nurse manager" OR "nurse leader") leadership management	General search; publication years 2020–2025; English-language records considered	15 Jan 2026	198
Europe PMC	Europe PMC	"artificial intelligence" AND ("nurse manager" OR "nurse leader") AND leadership AND management AND (HAS_FT:Y) AND (FIRST_PDATE:[2020 TO 2025]) AND ((SRC:MED OR SRC:PMC) NOT (PUB_TYPE:"Review"))	Full text available; first publication date 2020–2025; sources limited to MED or PMC; reviews excluded	13 Jan 2026	104
ProQuest	Nursing & Allied Health Database	TI,AB("artificial intelligence") AND TI,AB("nurse manager*" OR "nurse leader*") AND TI,AB(leadership OR management OR governance)	Title/Abstract (TI,AB); publication date 1 Jan 2025–31 Dec 2025	11 Jan 2026	4
Total					**326**

Note. Records from all sources/platforms were combined before removal of duplicates. Three additional authoritative policy and professional guidance documents from the World Health Organization and International Council of Nurses were identified through targeted website searches and reference-list checking and were not included in the source/platform record counts. Search syntax and limits differed across platforms according to the search procedures applied and are reported as executed. The overall eligibility period was 2020–2025; platform-specific search limits are shown in the table.

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RESEARCH ARTICLE

ROBUST HOSPITAL EFFICIENCY RANKING: A BAYESIAN AND MACHINE LEARNING INTEGRATED DYNAMIC SLACKS-BASED MEASURE DEA APPROACH

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ABSTRACT

Hospitals are complex organizations operating in a dynamic environment, where multiple parameters vary over time. Ranking hospitals by efficiency using traditional methods often overlooks changes in effectiveness and quality. This study proposes a simulation-based Dynamic Slack-Based Measure Data Envelopment Analysis (Dynamic SBM-DEA) framework.

The study is methodological and simulation based, generated using Monte Carlo simulation methods, calibrated from real multispecialty hospital data, healthcare literature, etc. To evaluate intertemporal hospital performance, the methodology incorporates carry-over effects and unwanted outputs and uses bootstrap validation to evaluate the reliability of efficiency estimations. The persistence and transition of performance states across time are examined using Markov chain analysis, and the stability measurements that are obtained are combined with Dynamic SBM efficiency ratings to create a composite performance indicator. Additionally, the framework can capture operational stability, ranking robustness, and predicted efficiency trends inside a single evaluation model thanks to Bayesian forecasting's probabilistic estimations of future performance. The machine learning model attained a testing R^2 of 0.4765 and a cross-validated R^2 of 0.553 ± 0.048, indicating moderate predictive capability and stable performance. Sensitivity research showed that the composite ranking framework was resilient, with Kendall's tau values ranging from 0.716 to 0.926 across different weighting schemes and Spearman's rank correlations ranging from 0.881 to 0.983.

The findings revealed a set of hospitals with continuously excellent efficiency, stable rankings, and promising future performance. Staffing levels, surgical activity, and clinical results are some of the most important factors influencing efficiency, according to the SHAP study. The development of an integrated Dynamic SBM-DEA, Machine Learning, and Bayesian decision-support framework that offers a transparent, stability-adjusted, and forward-looking benchmarking tool for evidence-based hospital management, resource allocation, and healthcare policy decision-making is the study's primary contribution.

KEYWORDS

DEA, Dynamic efficiency, Hospital ranking, Bayesian forecasting

INTRODUCTION

Managing multispecialty hospitals with limited resources is challenging due to competing demands across departments for staff, equipment, and funding. These constraints often affect service quality, coordination of care, and timely decision-making [1]. The research by [2] examined hospital performance broadly, particularly by considering organizational and management factors alongside quantitative efficiency measures. It provides a perspective on how internal culture, leadership, and staff engagement relate to performance outcomes. However, it is not directly aligned with quantitative efficiency measurement methods, like DEA, or AI-based prediction models. Hospitals face significant challenges in balancing patient demand with available resource capacity [3], made more difficult by the unpredictable nature of demand and inherent resource constraints. Among these, physicians are among the most critical and scarce assets, essential for hospital operations. Beyond ensuring their availability, effective allocation of physicians according to the hospital's case mix is crucial for delivering high-quality care. Collectively, these studies show how multifaceted hospital performance is, but they don't offer much advice on how to combine operational efficiency assessment with analytics for prediction and decision support.

According to the World Health Organization's Global Health Observatory data for 2022, the global average density of medical doctors stands at 17.2 per 10,000 population. Healthcare systems globally face mounting pressure to address escalating demand for medical services. Hospitals grapple with balancing this demand against constrained resources, which include physicians, nurses, medications, medical equipment, instruments, beds, operating rooms, and related infrastructure. A dynamic, nonparametric DEA framework was proposed [4] that uses performance persistence and intertemporal links to jointly quantify the efficiency of an institution over time and identify failure risk. Similarly, a hospital's efficiency should not be assessed based on results from a single year. Hospitals that demonstrate higher average DEA efficiency with lower variability over time, indicated by a smaller coefficient of variation, reflect more stable and sustainable performance. According to the study [5], the performance of public hospitals was evaluated using a three-stage DEA approach, in which initial efficiency scores were adjusted for environmental and managerial factors through regression analysis to obtain more accurate measures of technical efficiency.

The studies by [4, 6] demonstrate the utility of DEA models outside of the healthcare industry. Their research on banks shows how efficiency varies over time and how dynamic DEA can keep an eye on stability and anticipate any institutional collapses. To overcome bias and uncertainty in efficiency estimation, studies by [7, 8] combine DEA with Bayesian techniques. By incorporating past data, Bayesian DEA generates probabilistic efficiency scores and credibility intervals that enhance ranking stability and dependability in performance comparisons. These studies demonstrate how crucial it is to take temporal dynamics and uncertainty into account when evaluating efficiency. But especially when it comes to hospital performance evaluation, they are mainly concerned with efficiency measurement and do not concurrently handle ranking persistence, uncertainty quantification, explainable prediction, and future performance forecasting within a coherent framework.

This work uses Dynamic SBM-DEA with unwanted outputs to measure ranking stability and intertemporal efficiency in multispecialty hospitals. Bootstrap resampling and Bayesian forecasting generate probabilistic efficiency estimates, while machine learning with SHAP finds significant drivers. The suggested paradigm combines dynamic efficiency assessment, ranking persistence analysis, uncertainty modeling, explainable machine learning, and Bayesian forecasting into a unified decision-support framework, in contrast to previous research that looks at these methods separately. The suggested method creates reliable, forward-looking hospital rankings by integrating forecasting, interpretability, uncertainty assessment, and slack-based efficiency analysis. It also fills up a number of methodological holes seen in the current DEA and healthcare benchmarking literature.

Table 1 provides a list of articles based on DEA, Dynamic DEA, and other forms of DEA models used for various purposes, mostly hospital-related features. The literature review table reveals a number of methodological limitations. The majority of current research focuses on measuring efficiency using traditional, dynamic, fuzzy, or network DEA models; however,

there is little integration of efficiency evaluation with future performance forecasts and predictive analytics. Few studies concurrently account for intertemporal efficiency dynamics, ranking stability, and uncertainty quantification, despite the fact that some include quality indicators, patient satisfaction, death rates, or operational aspects. Additionally, explainable machine learning techniques for identifying the primary drivers of hospital efficiency receive little attention in the literature, which mostly focuses on retrospective performance review. Additionally, it is uncommon for current DEA programs to integrate Bayesian forecasting, Markov persistence assessment, and bootstrap-based uncertainty analysis into a single framework. To promote more reliable benchmarking and healthcare decision-making, an integrated methodology that simultaneously assesses efficiency, ranking stability, uncertainty, performance drivers, and future hospital performance is still required.

This study's methodological contribution is the incorporation of well-established analytical methods into a cohesive framework for assessing hospital efficiency. In particular, the suggested framework integrates Dynamic SBM-DEA for efficiency measurement, Markov chain analysis for temporal stability evaluation, Random Forest for predictive validation, Bootstrap resampling for statistical validation, Bayesian updating for information fusion, and SHAP for model interpretability. The main methodological contribution of this study is the methodical integration of these well-established techniques into a unified decision-support framework for hospital efficiency evaluation.

The methodology used to determine the final hospital rankings is presented in Section 2. The analysis's empirical findings are presented in Section 3. Additional analysis and synthesis of these results are given in Section 4. A thorough analysis of the findings in light of the goals of the study and the body of current literature is provided in Section 5. The study's key findings and ramifications are finally summed up in Section 6.

TABLE 1 LITERATURE REVIEW OF HEALTHCARE PERFORMANCE ANALYSIS: INPUTS, OUTPUTS, AND KEY INSIGHTS

Reference	Model Used	Doctors	nurses	beds	operating cost	inpatient	outpatient	surgeries	satisfaction	Mortality rate	Findings
[9]	Dynamic Network DEA	√	√	√	-	-	√	-	-	-	Demonstrated that hospital efficiency is better evaluated by looking at internal sub-processes (clinical vs. administrative) rather than a "black box" approach.
[10]	Dynamic Network DEA	-	-	√	-	-	√	-	√	-	Established a longitudinal link between efficiency and quality, suggesting that efficient hospitals often maintain higher quality standards over time.
[11]	DEA with Quality Variables	√	√	√	-	-	-	√	-	-	Found that improvements in operational efficiency generally led to improved quality, though the relationship varies by hospital size.
[12]	CCR DEA	√	-	-	√	-	-	-	-	√	Analyzed regional healthcare in Slovakia, finding that regions with higher spending did not always correlate with better population health outcomes.
[13]	DEA with Environmental Variables	√	√	√	-	√	√	-	-	-	Factors such as the ratio of specialized technicians and the proportion of outpatient visits significantly influenced these efficiency levels.
[14]	Network DEA	√	√	√	√	-	-	-	-	√	quantifies the efficiency of health systems across 37 OECD countries by analyzing internal sub-processes
[15]	Window-DEA	√	√	√	√	-	-	√	-	-	Conducted a longitudinal (Window-DEA) evaluation of the healthcare sector's efficiency in Poland.
[16]	Credibility-based fuzzy window DEA.	√	√	√	√	√	√	-	-	-	Used credibility-based fuzzy window DEA for dynamic performance assessment of hospitals.
[17]	Systematic review of features used	√	√	√	√	√	√	-	-	√	A systematic review that identified common trends and methodological gaps in health system efficiency literature.
[18]	Two-stage DEA approach	√	√	√	√	-	-	-	-	√	Evaluated the efficiency of healthcare systems in Arab countries using a two-stage DEA approach.

[19]	DEA methodology tot.	-	-	-	-	√	√	√	√	-	Provided an empirical analysis of primary healthcare efficiency within a specific district using standard DEA.
[20]	Network-DEA model.	√	√	-	√	-	-	-	√	-	Demonstrated how the quality of care and patient access directly impact overall hospital efficiency.
[21]	Dynamic Network DEA	-	-	√	√	√	√	√	-	-	Applied a Dynamic Network DEA approach to evaluate hospital performance over multiple periods.

METHODOLOGY

DATA AND SAMPLE DESCRIPTION

This study considers multispecialty hospitals in India as the decision-making units for ranking. Hospital-level panel data covering inputs, outputs, undesirable outcomes, and carry-over variables over multiple years are very limitedly available in a consistent and complete form, especially for multispecialty hospitals. To overcome this limitation while preserving realism and methodological rigor, this study employs a hierarchical Monte Carlo simulation approach to generate a synthetic but policy-relevant hospital panel dataset [22]. To capture changes in performance and intertemporal links in hospital operations, the analysis spans an eight-year study period. Operational benchmarks published in Indian healthcare literature, NABH accreditation requirements, National Health Profile reports, and annual reports of top multispecialty hospitals were used to calibrate the synthetic dataset. While service utilization metrics such as outpatient visits, inpatient admissions, surgical volumes, and mortality rates were obtained from published data for tertiary-care hospitals, staffing levels were determined using average doctor-to-bed ratios of roughly 1:8 and nurse-to-bed ratios of 1.5-2.0. The Monte Carlo simulation's probability distributions and parameter ranges were established using these empirical benchmarks, as shown in Table 3. This ensured that the database was appropriate for Dynamic SBM-DEA and the ensuing ranking stability analysis.

DYNAMIC SBM-DEA EFFICIENCY ESTIMATION

Using a Slack-based DEA framework, the investigation begins by calculating annual efficiency scores. Four input factors (Doctors, Nurses, Beds_Input, Operating_Expenditure_Cr) and four output variables (IPD_Admissions, OutpatientsOPD_Visits, Surgeries, Satisfaction_Pct) are used to assess hospitals annually, as shown in Table 2. To maintain temporal variety, efficiency is computed independently for every year.

TABLE 2 DYNAMIC DEA VARIABLES

Type	Components
Inputs	Doctors, Nurses, Beds_Input, Operating_Expenditure_Cr
Outputs	IPD_Admissions, OutpatientsOPD_Visits, Surgeries, Satisfaction_Pct
Carryovers	Beds_Carryover, Technology_Index, Finance_Strength_Index
Undesirables	Mortality_Rate_Pct

The hospital's physical infrastructure and service capacity that will be accessible in later years are represented by Beds_Carryover. The original dynamic SBM framework of Tone K. Tsutsui and Miki Tsutsui, where carry-overs represent resources transferred between periods. This is the reason to keep beds in Input as well as Carryovers. Beds_Carryover, Technology_Index, and Finance_Strength_Index were chosen as desirable carry-over factors because of their long-lasting impact on hospital performance over a number of time periods. These resources endure and continue to impact future operating capacity and efficiency, in contrast to traditional inputs that are depleted within a year.

The Technology Index and Finance Strength Index were incorporated as carry-over variables because their effects extend beyond a single period and influence future hospital performance. The level of medical equipment, digital infrastructure, and technical capabilities that improve patient outcomes, service quality, and operational efficiency over time is represented by the Technology Index. In a similar vein, the hospital's retained financial capacity and investment potential,

which enable future growth, technology adoption, and service enhancements, are reflected in the Finance Strength Index. These strategic resources are appropriate carry-over variables in the Dynamic SBM-DEA framework because they create an intertemporal connection between previous managerial choices and future efficiency outcomes as they are gathered and transferred over time. Mortality Rate was viewed as an undesirable output since it represents patient safety and clinical results; lower levels signify greater operational performance and healthcare quality. A more thorough evaluation of long-term hospital sustainability and efficiency is made possible by taking these factors into account.

Dynamic DEA extends static DEA to evaluate hospital efficiency across multiple periods T, incorporating carry-over criteria such as the number of beds, thereby enabling stable ranking via period-wise and overall scores. Consider n hospitals (DMUs, $j = 1,2,\ldots\ldots n$), over T periods, with m inputs x_{ijt}>0, for example, staff, beds at period t, s outputs y_{rjt} > 0, for example, inpatients, outpatients, revenue, p carry-overs z_{kjt} > 0, such as capital stock, beds, technology, etc.

Let $\lambda_{jt} > 0$ be the intensity (peer weight) of DMU.

The efficiency formulation is appropriate for a dynamic SBM model within the DEA framework and is well-suited to dynamic healthcare efficiency analysis. By removing the evaluated DMU from the reference set, the model minimizes average inefficiency over time and permits efficiency scores to exceed 1, enabling discrimination among efficient units [23].

Slack variables are input slack ($s_{it}^{-} \geq 0$), output slack ($s_{rt}^{+} \geq 0$), carry-over slacks ($s_{kt}^{c-}, s_{kt}^{c+} \geq 0$). The period-wise constraints

(a) for each input *i* and period *t*

$$x_{iot} = \sum_{j=1}^{n} \lambda_{jt}\, x_{ijt} + s_{it}^{-} \quad (1)$$

(b) for each output r and period t:

$$y_{rot} \geq \sum_{j=1}^{n} \lambda_{jt}\, y_{rjt} - s_{rt}^{+} \quad (2)$$

(c) for each carry over (dynamic link) constraints for variable k and period t:

$$y_{rot} \geq \sum_{j=1}^{n} \lambda_{jt}\, y_{rjt} - s_{kt}^{c+} - s_{kt}^{c-} \quad (3)$$

The overall dynamic SBM efficiency score for DMU o is obtained by solving

$$min_{\lambda,s}\, \rho_0$$

$$where \quad \rho^{SE} = \frac{1}{T}\sum_{t=1}^{T}\left[\frac{1 - \frac{1}{m}\sum_{i=1}^{m}\frac{s_{it}^{-}}{x_{iot}}}{1 + \frac{1}{s}\sum_{r=1}^{r}\frac{s_{kt}^{-}}{z_{kot}}}\right] \quad (4)$$

This objective min ρ^{SE} computes ρ^{SE} as a period-averaged SBM score.

Dynamic hospital ranking and stability

Year-wise ranking

$$R_{jt} = \text{rank descending of } \rho_{jt}^{SE} \quad (5)$$

Average rank

$$\bar{R_j} = \frac{1}{T}\sum_t R_{jt} \quad (6)$$

Rank stability (coefficient of variation)

$$CV_j = \frac{\sigma(R_{jt})}{\bar{R_j}} \quad (7)$$

Lower CV implies a more stable ranking.

MACHINE LEARNING MODELS

The study highlights that machine learning models analyze large volumes of historical and real-time data to identify patterns and predict future needs. These predictive capabilities allow firms to plan production, inventory, and resource allocation more accurately. As a result, companies can reduce overproduction, minimize excess inventory, and lower operational costs [24].

Bootstrap uncertainty in efficiency and ranking

This approach enables statistical inference for Dynamis SBM-DEA results, indicating whether observed differences in efficiency and ranking are robust or driven by sampling variation. Consequently, hospitals whose confidence intervals overlap substantially or whose rank distributions are highly dispersed are interpreted as having less certain performance positions. In contrast, narrow intervals and stable ranks indicate reliable efficiency assessments.

For each period t

Resample hospitals with replacement: dataset D^*

Re-estimate SE-DSBM: ρ_{jt}^{SE*}. Repeat the following steps B times.

Bootstrap mean efficiency: $\widehat{\rho_{jt}^{boot}} = \frac{1}{B}\sum_{b=1}^{B}\rho_{jt}^{*(b)}$ (8)

Bias-corrected efficiency: $\rho_{jt}^{BC} = \rho_{jt}^{SE} - (\widehat{\rho_{jt}^{boot}} - \rho_{jt}^{SE})$ (9)

Confidence interval: $CI_{jt} = \left[\rho_{jt}^{*(\propto/2)}, \rho_{jt}^{*(1-\propto/2)}\right]$ (10)

Rank uncertainty: From each bootstrap sample, $R_{jt}^{*(b)}$, rank variance can be obtained

$$var(R_{jt}) = \frac{1}{B}\sum(R_{jt}^{*(b)} - \overline{R_{jt}})^2 \quad (11)$$

Markov rank transition analysis

Markov rank transition analysis uses dynamic efficiency rankings to monitor how hospitals move across performance levels over time. Transitions create a probability matrix, and hospitals are categorized into rank states (such as quartiles). Off-diagonals indicate mobility, while diagonal values indicate persistence. Mobility indices and steady-state distributions show whether rankings are dynamic, convergent, or stable. To examine the temporal dynamics of hospital performance, efficiency scores from the Dynamic super-efficiency SBM model ρ_{jt}^{SE} were converted into annual ranks R_{jt} for each hospital $j = 1, \dots, n$ and year $t = 1, \dots, T$.

Let E_j = Dynamic SBM Efficiency score of hospital j

For each hospital j, remove its own efficiency score from the reference set and determine the maximum efficiency among the remaining hospitals:

$$E_{\max(-j)} = \max\{E_i : j \neq i\}$$

The Super-Efficiency score is then computed as:

$$\rho_{jt}^{SE} = \frac{E_i}{E_{\max(-j)}} \quad (12)$$

where:

ρ_{jt}^{SE} = Super-Efficiency score of hospital j

E_j = Efficiency score of hospital j

$E_{\max(-j)}$ = Maximum efficiency score among all hospitals excluding hospital j

Ranks were then grouped into K ordered performance states, for example, quartiles, using a mapping $s_{jt} = g(R_{jt})$, where $s_{jt} \in \{1, \dots, K\}$. One-period transitions between consecutive years were counted as $N_{ab} = \{j, t : s_{jt} = a, s_{j,t+1} = b\}$, and the Markov transition probability matrix was obtained by row normalization, $P_{ab} = N_{ab} / \sum_{b=1}^{K} N_{ab}$, with $\sum_b P_{ab} = 1$. Diagonal

elements P_{aa}measure rank persistence, while off-diagonal elements capture upward and downward mobility; the long-run distribution of hospitals across rank states was derived from the stationary vector π satisfying $\pi = \pi P$ and $\sum_a \pi_a = 1$.

Composite Ranking

In the present study, with 100 hospitals evaluated across four inputs, four desirable outputs, one undesirable output, and three carry-over link variables, this degeneracy risk is non-trivial. To address it, the study presents a composite scoring framework that adds two orthogonal dimensions, temporal behavioural consistency and statistical rank confidence, to the Dynamic SBM efficiency estimate. These dimensions are theoretically independent of the DEA frontier geometry. The composite score for the hospital i was calculated as:

$$CS_i = 0.5\,E_i + 0.25\,M_i + 0.25\,B_i \quad (13)$$

where the weight of 0.50 assigned to E_i reflects the primacy of technical efficiency as the core DEA construct, while the equal weights of 0.25 on M_i and B_i encode the assumption that temporal consistency and statistical confidence contribute symmetrically to the reliability of a hospital's ranking.

ML validation of DEA and determinants (Random Forest + SHAP)

To validate the structural consistency of the dynamic super-efficiency DEA results and identify key determinants of sustainable hospital performance, a supervised machine learning model was estimated using DEA inputs, desirable outputs, undesirable outputs, and carry-over variables as predictors. In order to gain a deeper understanding of the factors that influence efficiency, many studies combined machine learning with DEA. After efficiency scores are calculated using DEA, ML models, such as RF, are used to forecast efficiency levels and pinpoint the primary operational factors affecting performance. This study also makes use of AI tools like SHAP [25, 26].

The dataset was divided into 640 training samples (80%) and 160 testing samples (20%). To assess model stability and lower the possibility of overfitting, a 10-fold cross-validation technique was used. The coefficient of determination (R^2), root mean square error (RMSE), and mean absolute error (MAE) were used to evaluate the model's performance.

For each hospital j and year t, the feature vector was defined as

$$\mathbf{X}_{jt} = [x_{ijt}, y_{rjt}, b_{pjt}, z_{kjt}], \quad (14)$$

with the DEA super-efficiency score as the target $Y_{jt} = \rho_{jt}^{SE}$.

A Random Forest regression model $\hat{\rho}_{jt}^{RF} = f_{RF}(\mathbf{X}_{jt})$ was trained by minimizing prediction error $\min \sum_{j,t}(\rho_{jt}^{SE} - \hat{\rho}_{jt}^{RF})^2$; agreement between the DEA and ML estimates was assessed via correlation $\mathrm{Corr}(\rho^{SE}, \hat{\rho}^{RF})$ and error metrics. Determinants of efficiency were then interpreted using SHAP values, where the contribution of the variable k to a prediction is

$$\phi_k = \sum_{S \subseteq F \setminus \{k\}} \frac{|S|!(|F| - |S| - 1)!}{|F|!}[f(S \cup \{k\}) - f(S)] \quad (15)$$

and overall importance was summarized by the mean absolute SHAP $I_k = \frac{1}{N}\sum |\phi_k|$, identifying variables most influential for sustained hospital rankings.

BAYESIAN FUSION MECHANISM

The study begins with Dynamic SBM DEA to estimate intertemporal hospital efficiency and slack structures. In subsequent stages, including bootstrap and Bayesian forecasting, the same Dynamic SBM efficiency scores and their uncertainty distributions are propagated forward. To quantify intertemporal hospital efficiency and slack structures, the investigation starts with Dynamic SBM-DEA. The Dynamic SBM efficiency scores and their corresponding uncertainty distributions are carried over into further phases, such as machine learning prediction and bootstrap analysis. Robust future efficiency estimates are then produced by combining predicted data from the Random Forest model with historical efficiency evidence using a Bayesian fusion framework.

Prior Distribution

The DEA bootstrap efficiency estimates serve as the prior distribution for each hospital. Let θ_h denote the latent efficiency of hospital h. The prior is specified as the DEA efficiency defines the prior

$$\theta_h^{prior} \sim \mathcal{N}(\mu_h^{DEA}, \sigma_p^2) \quad (16)$$

where,

μ_h^{DEA}= mean bootstrap SBM efficiency, $\sigma_p = 0.004$,

bounded to feasible DEA range: $\theta_h^{prior} \epsilon [0.95, 1]$

In addition to providing a statistically supported prior distribution, the bootstrap-derived variance captures the uncertainty related to efficiency estimation.

Likelihood Specification

Random Forest predictions are treated as noisy observations of future hospital efficiency. The likelihood function is specified as

$$\theta_h^{like} \sim \mathcal{N}\left(\theta_h^{RF}, \quad \sigma_L^2\right) \quad (17)$$

where θ_h^{RF} is the Random Forest predicted efficiency score and σ_L^2 denotes the prediction error variance estimated from out-of-sample testing performance. The likelihood therefore incorporates information from operational, financial, infrastructure, and clinical variables used in the machine learning model.

Hyperparameter Selection

The hyperparameters σ_p , and σ_L ascertain the relative impact of Random Forest and DEA data throughout the fusion process. The bootstrap confidence intervals of DEA efficiency estimates are used to calculate the prior standard deviation (σ_p), whereas the likelihood standard deviation (σ_L) is calculated using the residuals of the Random Forest forecast. The weighting system was chosen to incorporate predictive data while highlighting past efficiency performance. The relative contributions of the Dynamic SBM-DEA prior and the Random Forest likelihood were systematically varied across five weight combinations (0.5,0.5), (0.6,0.4), (0.7,0.3), (0.8,0.2), and (0.9,0.1) to conduct a sensitivity analysis. All weight combinations produced exceptionally high Spearman rank correlation coefficients (ρ = 0.998099 to 1.000000, $p < 0.001$), as Table 3 illustrates. This suggests that the suggested Bayesian fusion framework is very robust and that the final hospital rankings are essentially unaffected by moderate changes in the weight allocation. This indicates that the model is stable and independent of specific weight selections. The 0.6 (DEA) and 0.4 (Random Forest) weighting was chosen as the baseline because it produced the best agreement with the reference ranking (ρ = 1.000) while preserving a suitable balance between the two information sources. The weighted combination of DEA prior and RF likelihood is

$$\theta_h^{post} = 0.6\theta_h^{prior} + 0.4\theta_h^{like} \quad (18)$$

where the weights 0.6 and 0.4 reflect greater confidence in observed DEA performance while allowing machine learning forecasts to influence future efficiency estimation. The ML component (0.4) acts as a corrective signal from the demand side, while the DEA component (0.6) is given more weight because it directly reflects operational efficiency from realized performance.

TABLE 3 SENSITIVITY EVALUATION OF BAYESIAN FUSION WEIGHTS

Weight pair	Equation	Spearman(ρ)	p-value	Stability
(0.5,0.5)	θ_h^{post}=0.5θ_h^{prior}+0.5θ_h^{like}	0.999828	0	Very High
(0.6,0.4)	θ_h^{post}=0.6θ_h^{prior}+0.4θ_h^{like}	1	0	Baseline
(0.7,0.3)	θ_h^{post}=0.7θ_h^{prior}+0.3θ_h^{like}	0.999801	0	Very High
(0.8,0.2)	θ_h^{post}=0.8θ_h^{prior}+0.2θ_h^{like}	0.999177	0	Very High
(0.9,0.1)	θ_h^{post}=0.9θ_h^{prior}+0.1θ_h^{like}	0.998099	0	Very High

Posterior Estimation Procedure

The Random Forest likelihood and the DEA-based prior are combined to get the posterior efficiency estimate. After taking into account both past performance and predictive analytics, the resulting posterior distribution shows the updated belief of future hospital efficiency. Here, the efficiency is restricted to the range:

$$\theta_h^{future} = min(1, max(0.7, \theta_h^{post})) \quad (19)$$

Thus, the final forecast (mean over samples):

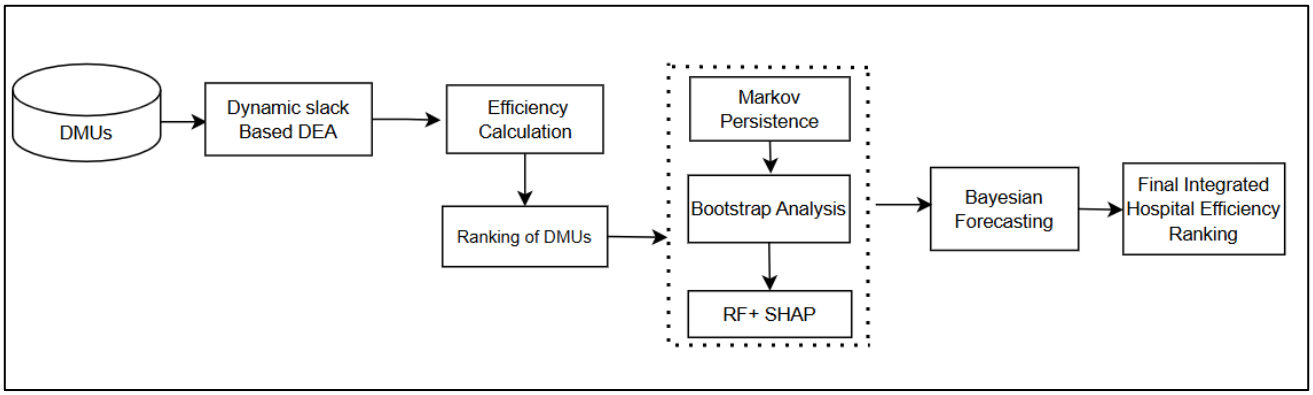
$$\hat{\theta}_h^{future} = E[\theta_h^{future}] \quad (20)$$

Hospitals will be ranked in descending order $\hat{\theta}_h^{future}$.

Uncertainty Quantification

Monte Carlo sampling is used to create posterior distributions from the prior and likelihood distributions in order to assess uncertainty in future efficiency estimates. Posterior means, standard deviations, and 95% credible intervals are computed for every hospital. Wider credible intervals imply more uncertainty in future rankings, while narrow credible intervals show steady and trustworthy efficiency forecasts. This uncertainty assessment offers a probabilistic interpretation of future hospital performance and supplements the bootstrap confidence intervals derived from Dynamic SBM-DEA.

FIGURE 1. INTEGRATED WORKFLOW



RESULTS

A hierarchical Monte Carlo simulation framework was used to create a synthetic panel dataset with 100 hospitals observed every year from 2016 to 2023 (800 hospital-year observations). Baseline characteristics, such as size category, bed capacity, technology index, and financial carryover, were initially sampled for each hospital from empirically calibrated distributions that matched multispecialty hospital standards approved by NABH. Then, based on these baseline characteristics, annual staffing, utilization, spending, satisfaction, and mortality factors were simulated.

Descriptive statistics, distributional analysis, and empirical benchmark (Table 4) comparison were used to evaluate the synthetic dataset's validity. The produced observations showed central tendencies, variability, and realistic ranges that were in line with operational traits documented for multispecialty hospitals in India. The simulated dataset's face validity and practical realism were supported by mean values and dispersion measurements that matched NABH-based staffing norms, hospital use statistics, and published healthcare performance reports. Figure 2 shows the histograms for each of the normal and uniform variables in order to have a better understanding of each variable's distribution and to verify the assumptions stated for the Kolmogorov-Smirnov test visually.

TABLE 4. MONTE CARLO SIMULATION MODEL PARAMETERIZATION USING EMPIRICAL BENCHMARKS AND VALIDATION

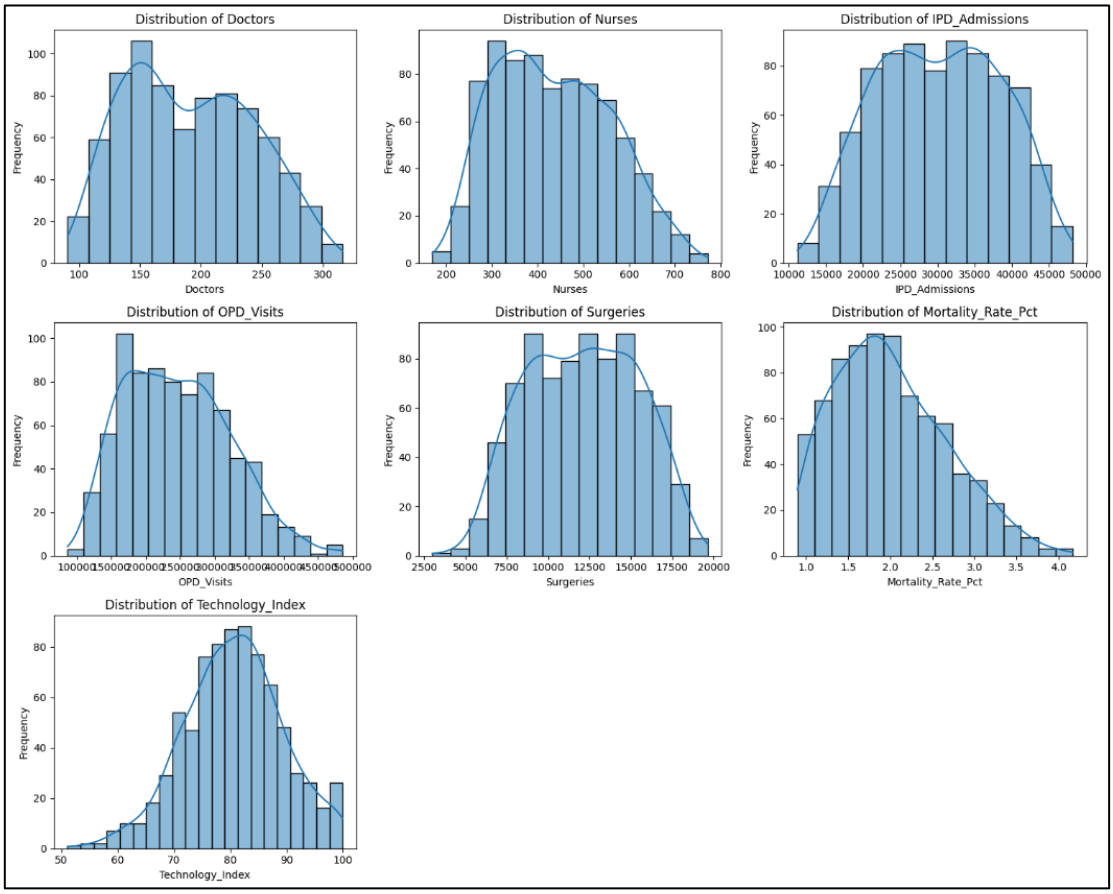
Variable	Initial Simulation Distribution	Literature range	Simulated Mean	Simulated Range	Empirical Source	Validation
Doctors per bed	Normal	0.3-0.5	0.43	0.4-0.59	NABH staffing guidelines; annual reports of multispecialty hospitals	Consistent with staffing levels in large multispecialty hospitals
Nurses per bed	Normal	0.8-1.5	0.99	0.80-1.44	NABH staffing guidelines	Reflects realistic nursing workforce distribution
Operating Expenditure	Uniform	Rs 40- Rs 200 Cr	Rs. 111.5	Rs41.4-Rs202.2	Hospital annual reports; Indian healthcare cost studies	Within expected expenditure levels
Inpatients (IPD Admissions)	Normal	10000-50000	30178	11142-48193	Indian hospital utilization studies; National Health Profile	Consistent with admission volumes reported by medium-to-large multispecialty hospitals
Outpatients (OPD Visits)	Normal	1000-1800	1303	677-2381	National Health Profile; hospital annual reports	Reflects realistic Outpatient service demand and utilization patterns
Patient Satisfaction	Uniform	70-95%	90.80%	71-98%	Published patient satisfaction studies in Indian hospitals	Consistent with accredited hospital performance
Mortality Rate	Uniform	1-4%	2	1-4%	Tertiary-care hospital outcome studies	Within reported clinical outcome ranges
Technology Index	Uniform	50-100	80.65	51-100	NABH infrastructure scoring; calibrated to Capital_Stock_Cr	Reflects progressive technology adoption
Bed Occupancy Rate	Uniform	60-85%	69.38%	37.6-121.6%	WHO & MoHFW target; upper tail >100% reflects day-care turnover	Consistent with occupancy levels observed in efficiently managed multispecialty hospitals

Finance Strength Index	Uniform	40-95	70.1	40-95	Hospital financial performance reports	Indicates realistic financial heterogeneity

MoHFW: Ministry of Health and Family Welfare, Government of India.
NABH: National Accreditation Board for Hospitals & Healthcare Providers
WHO: World Health Organization

Empirical benchmarks from NABH standards, National Health Profile reports, hospital annual reports, and published healthcare studies were used to calibrate and validate the synthetic dataset. The dataset offers a realistic setting for assessing the suggested Dynamic SBM-DEA, machine learning, and Bayesian forecasting framework, according to the congruence between the generated values and reported operational features of Indian multispecialty hospitals, as described in Table 3.

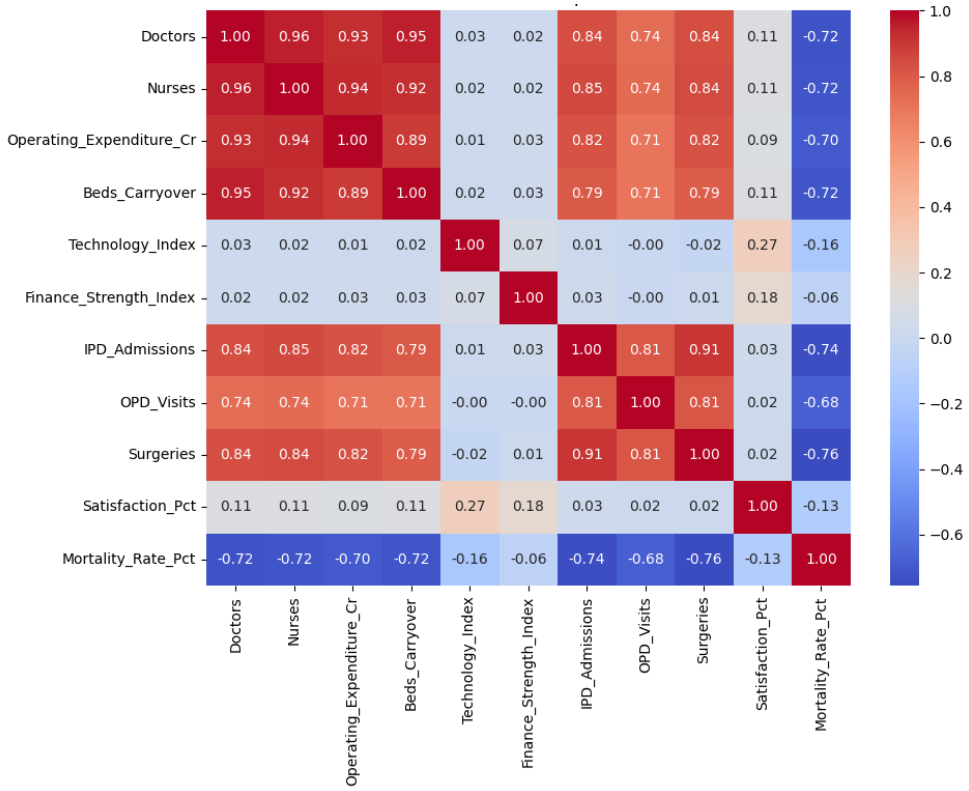
FIGURE 2: VISUALIZING VARIABLE DISTRIBUTIONS



The results of the correlation study in Figure 3 are clinically consistent and validate the DDEA model's structure. The input variables have the largest positive correlations, with Doctors exhibiting substantial connections with Nurses (r = 0.96), Beds_Carryover (r = 0.95), and Operating_Expenditure_Cr (r = 0.93), suggesting bed capacity as the main structural driver of hospital input volume. The volume-outcome hypothesis is supported by the output variables' high internal clustering, with IPD_Admissions, Surgeries, and OPD_Visits intercorrelated at r = 0.81–0.91. Clinical consistency is further confirmed by significant negative correlations between Mortality_Rate_pct and Surgeries (r = −0.76), IPD_Admissions (r = −0.74), and Doctors (r = −0.72), suggesting that higher-capacity hospitals achieve better patient safety results.

Variables were restricted to important operational, clinical, infrastructure, and financial aspects that were backed by NABH standards and healthcare literature in order to allay dimensionality concerns. Technology, finance, satisfaction, and mortality showed lesser correlations, suggesting different performance aspects, but staffing, bed capacity, expenditure, and service volumes showed high positive connections demonstrating hospital scale effects. These connections validate the dataset's eligibility for Dynamic DEA analysis.

FIGURE 3: CORRELATION MATRIX OF HOSPITAL VARIABLES



INTERPRETATION OF KOLMOGOROV-SMIRNOV (KS) GOODNESS-OF-FIT RESULTS

The consistency of the simulated variables with their assumed normal distributions was assessed using the Kolmogorov-Smirnov goodness-of-fit test. The related KS statistics were rather small (0.050–0.078), as shown in Table 5, indicating little deviation from normalcy, even though all variables produced statistically significant p-values ($p < 0.05$). The KS test is extremely sensitive to small distributional changes because of the study's huge sample size. Additionally, a visual analysis of the histograms (Fig. 2) verified that the derived variables closely match the anticipated patterns documented in hospital performance studies and Indian healthcare literature. Consequently, the findings imply that the synthetic dataset maintains genuine variability and heterogeneity among hospitals while fairly approximating the anticipated distributions.

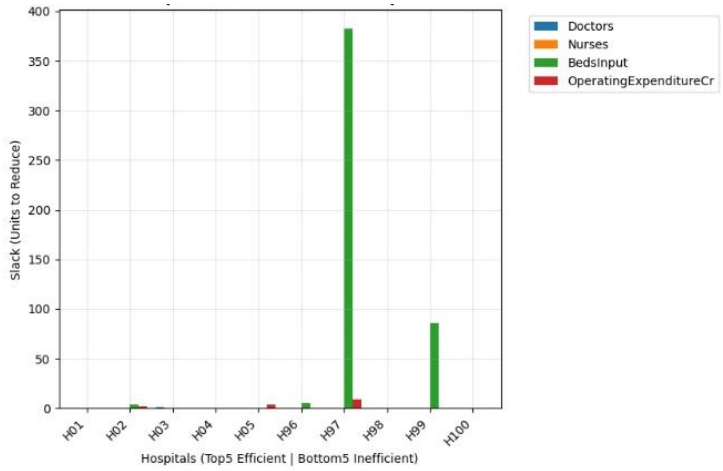
TABLE 5 KOLMOGOROV-SMIRNOV (KS) GOODNESS-OF-FIT RESULTS

Variable	KS Statistic	P-value
Doctors	0.0775	0.0001
Nurses	0.0733	0.0003
IPD Admissions	0.0501	0.035
OPD Visits	0.0586	0.0078
Surgeries	0.0544	0.0168

The synthetic dataset was calibrated using operational benchmarks given in Indian healthcare literature, NABH certification requirements, National Health Profile statistics, and yearly reports of multispecialty hospitals, even though the study is mainly methodological and simulation based. The goal was to create realistic hospital scenarios that maintain the structural relationships, variability, and operational characteristics seen in practice rather than to imitate the performance of particular hospitals. As a result, the synthetic data offer a reliable testing environment for assessing the suggested Dynamic SBM-DEA, bootstrap, Markov transition, machine learning, and Bayesian forecasting framework.

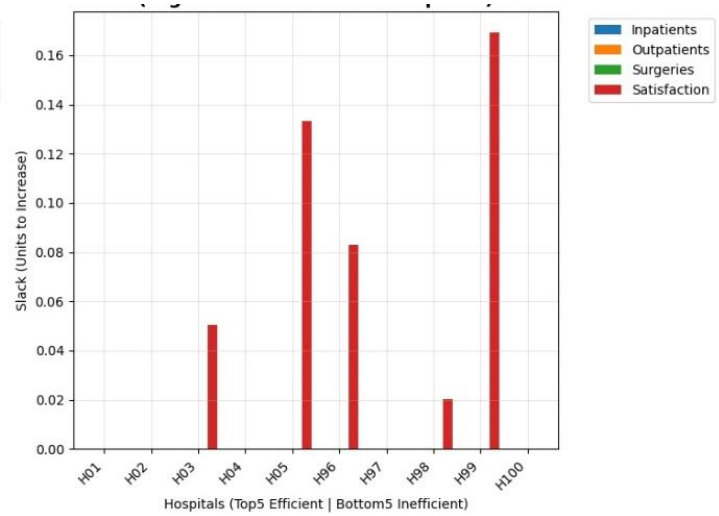
Slacks-Based Measure (SBM) DEA models, introduced by Tone (2002), provide a non-radial efficiency measure that directly minimizes input excesses and output shortfalls relative to the frontier. Unlike radial CCR/BCC models that proportionally adjust inputs or outputs and may leave residual slacks, SBM evaluates inefficiency explicitly. The measure is unit-invariant, monotone in inefficiency, and defined by a DMU's reference set, which supports robust application in network and dynamic extensions such as the Tone–Tsutsui framework.

FIGURE 4: INPUT SLACKS- REDUCTION TARGETS



Based on SBM-DEA, Fig. 4 shows input slack levels that signify excess resource consumption across the top 5 efficient and bottom 5 inefficient hospitals. Across all input categories (Doctors, Nurses, Beds_Input, and Operating_Expenditure_Cr), efficient hospitals (leftmost 5 bars) exhibit almost zero slack values, indicating optimal resource allocation with little waste relative to the efficiency frontier.

FIGURE 5: OUTPUT SLACKS – EXPANSION TARGETS



Output slack levels, which indicate unrealized production potential across hospital groups, are shown in Fig. 5. Near-maximum production in inpatient, outpatient, surgical, and satisfaction results is demonstrated by efficient hospitals, which exhibit very little slack. While greater inpatient and surgical gaps indicate lost revenue potential, moderate outpatient slack shows sufficient use. Maintaining a suitable ratio between the total number of model variables and the number of decision-making units (DMUs) is essential to the discriminatory power of DEA. The current study makes use of a panel dataset that includes 800 hospital-year observations from 100 multispecialty hospitals across eight years. Four inputs, four desired outputs, three carry-over variables, and one unwanted output make up the Dynamic SBM-DEA model. As a result, the number of observations significantly surpasses the model dimensionality, meeting widely recognized DEA sample-size requirements and lowering the possibility that an excessive percentage of hospitals will be categorized as efficient.

TABLE 6 HOSPITAL RANKING ACROSS YEARS

Year Hospital_ID	2016	2017	2018	2019	2020	2021	2022	2023
H009	21	1	10	37	5	11	1	1
H013	23	15	15	12	6	22	38	29
H016	9	2	5	25	10	6	2	2
H021	18	13	30	9	18	16	10	9
H022	16	14	6	18	4	3	9	5
H037	6	8	44	51	7	10	5	65
H039	1	47	1	4	1	2	50	12
H040	28	19	27	2	24	13	11	10
H048	44	3	25	28	14	25	3	3
H050	30	7	21	19	8	12	6	17
H052	14	10	17	8	3	17	33	15
H057	5	9	20	15	13	9	16	11
H062	4	21	22	6	20	15	8	6
H063	7	4	8	14	2	57	7	13
H070	20	49	2	33	23	65	53	16
H072	3	17	11	11	11	21	4	19
H077	15	59	90	3	86	1	79	28
H081	2	5	3	10	41	43	20	4
H084	10	50	12	5	74	4	31	26
H091	8	18	33	7	16	8	15	20

Table 6 explains the variation in hospital rankings over the years. Based on this information, Dynamic SBM efficiency and super-efficiency scores are calculated. The top 20 Hospitals are shown above.

The Dynamic SBM-DEA efficiency scores, super-efficiency scores, and matching hospital rankings based on performance across various time periods are displayed in Table 7 below.

TABLE 7 DYNAMIC SBM DEA RANKING AND SUPER EFFICIENCY

Hospital_ID	Dynamic_SBM_Efficiency	Super_Efficiency	Super_Rank
H039	0.756107	1.061449	1
H009	0.712335	0.942108	2
H016	0.706908	0.934931	3
H022	0.64497	0.853014	4
H063	0.626936	0.829162	5
H081	0.626666	0.828806	6
H062	0.622437	0.823212	7
H072	0.611881	0.809252	8
H057	0.594665	0.786482	9
H040	0.590096	0.78044	10
H052	0.589282	0.779363	11
H021	0.584846	0.773496	12
H091	0.583404	0.771589	13
H048	0.581759	0.769413	14
H050	0.580761	0.768093	15
H037	0.563658	0.745473	16
H084	0.555012	0.734038	17
H013	0.541276	0.715872	18

H077	0.534368	0.706736	19
H070	0.522487	0.691023	20

Table 8 describes the descriptive statistics for Dynamic SBM. The mean efficiency is 0.8337, with a standard deviation of 0.1065, indicating that the Dynamic SBM efficiency scores show moderate variation in hospital performance across the sample. Instead of grouping all hospitals close to the efficiency frontier, the efficiency values ranged from 0.6461 to 1.0000, indicating that the Dynamic SBM-DEA model has sufficient discriminatory ability to differentiate between reasonably efficient and less efficient hospitals.

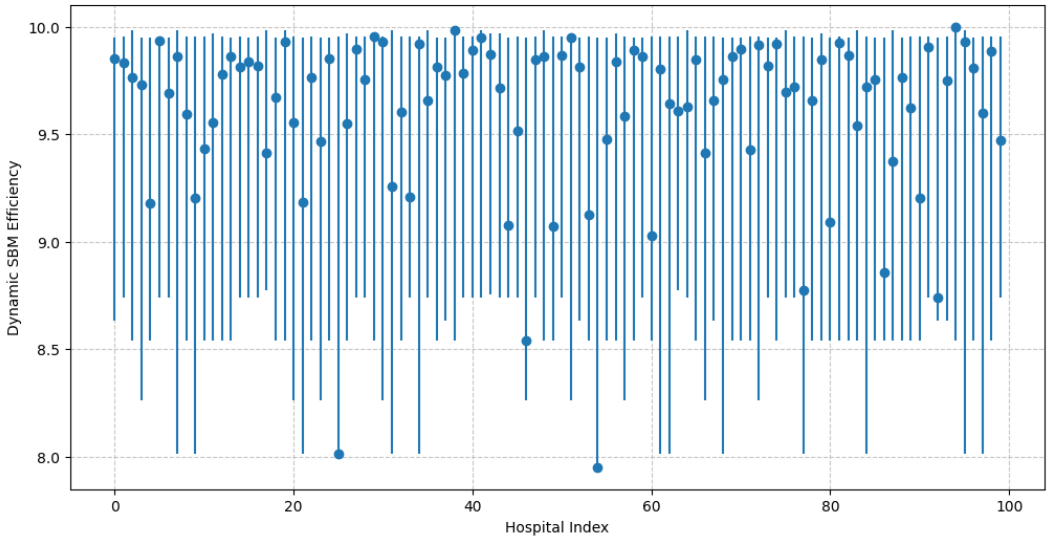
TABLE 8 DESCRIPTIVE STATISTICS FOR DYNAMIC SBM EFFICIENCY

Statistic	Value
Count	100
Mean	0.8337
Standard Deviation	0.1065
Minimum	0.6461
25% (Q1)	0.7372
50% (Median)	0.8265
75% (Q3)	0.9293
Maximum	1

According to the Dynamic SBM-DEA scores, there was moderate fluctuation across hospitals, indicating notable variations in operational effectiveness.

The statistical reliability of the Dynamic SBM-DEA efficiency ratings and ranks was evaluated using bootstrap resampling. Each hospital's rank distributions and confidence intervals were produced by the bootstrap process, allowing for the assessment of whether observed ranking disparities were significant or due to sampling variation. Bootstrap analysis was very helpful in illustrating the uncertainty surrounding hospital rankings and in identifying ranks that were statistically not distinguishable from efficiency ratings. With the mean Bootstrap_SD of 0.045, the bootstrap analysis (B = 500) produced an average 95% confidence interval width of 0.174 for all 100 hospitals. The efficiency rankings have a reasonable level of dependability since the standard errors are consistent across hospitals (SD of Bootstrap_SD = 0.002), indicating that estimation uncertainty is evenly spread throughout the panel rather than concentrated among particular hospitals. Fig. 6 shows bootstrap-based 95% confidence intervals for Dynamic SBM efficiency scores across hospitals.

FIGURE 6 BOOTSTRAP CONFIDENCE INTERVALS FOR DYNAMIC_SBM_EFFICIENCY



The composite score (Table 9) combines three different aspects of hospital performance into a single ranking measure. The formula assigns 50% weight to DEA efficiency, 25% to Markov persistence, and 25% to bootstrap stability. The final enhanced ranking, which is based on a composite score that combines Markov Persistence and Dynamic SBM Efficiency, shows the top 20 hospitals in Table 8 below.

TABLE 9 FINAL ENHANCED RANKINGS

Hospital_ID	Dynamic_SBM_Efficiency	Ei_norm	Mi	Bi	Ci	Final_Rank
H039	0.756107	1	0.818182	1	0.954545	1
H016	0.706908	0.789406	0.818182	0.147805	0.6362	2
H009	0.712335	0.812636	0.818182	0	0.610863	3
H022	0.64497	0.524283	0.818182	0.538843	0.601398	4
H084	0.555012	0.139222	1	0.810166	0.522152	5
H013	0.541276	0.080425	1	0.811694	0.493136	6
H037	0.563658	0.176231	0.693182	0.766574	0.453054	7
H070	0.522487	0	0.897727	0.890051	0.446945	8
H077	0.534368	0.050856	0.772727	0.825385	0.424956	9
H062	0.622437	0.427832	0.511364	0.229523	0.399137	10
H091	0.583404	0.260753	0.693182	0.281566	0.374063	11
H063	0.626936	0.447089	0.215909	0.169953	0.32001	12
H072	0.611881	0.382647	0	0.495514	0.315202	13
H050	0.580761	0.249439	0.261364	0.358416	0.279665	14
H081	0.626666	0.445934	0	0.17559	0.266864	15
H048	0.581759	0.253711	0.159091	0.335029	0.250385	16
H057	0.594665	0.308955	0.125	0.255088	0.249499	17
H040	0.590096	0.289397	0.136364	0.207091	0.230562	18
H021	0.584846	0.266925	0.136364	0.251162	0.230344	19
H052	0.589282	0.285913	0.125	0.206889	0.225929	20

Kendall's tau and Spearman's rank correlation coefficient were used to compare the final ranks with those from four different weighting situations. From Table 10, Kendall's tau values varied from 0.716 to 0.926, and Spearman correlation coefficients ranged from 0.881 to 0.983. These high correlation values show that there is a high degree of agreement between the baseline and alternative rankings, indicating that modest adjustments to the weighting structure do not significantly affect the ranking results. Even though there were minor differences in each hospital's position, the general ranking pattern was essentially the same in all cases. As a result, the suggested composite ranking approach can be regarded as reliable and consistent, offering assurance that the identification of high-performing institutions is independent of a particular weight selection.

TABLE 10 SENSITIVITY ANALYSIS

Scenario	Spearman_Rho	Kendall_Tau
Base	1	1
S1	0.977444	0.894737
S2	0.983459	0.926316
S3	0.914286	0.768421
S4	0.881203	0.715789

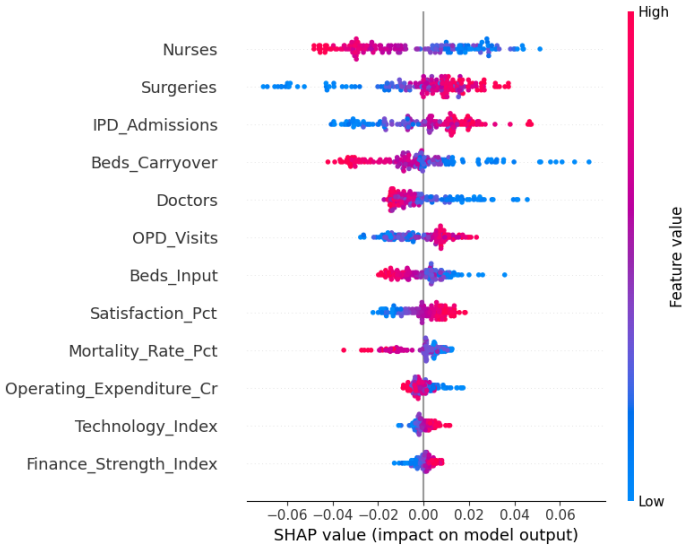
Sensitivity analysis and rank correlation metrics (Table 9) were used to further evaluate the robustness of ranking discrepancies. Strong agreement between the baseline and alternative ranking situations was shown by Spearman correlation coefficients ranging from 0.881 to 0.983 and Kendall's tau values ranging from 0.716 to 0.926. Further proof that

the ranking results are statistically sound and not influenced by small changes in model assumptions comes from these data, which show that the relative ordering of hospitals stayed mostly constant under various weighting systems.

ML MODEL VALIDATION RESULTS

Using 100 decision trees, the Random Forest model was built with a minimum sample split of two, a minimum leaf size of one, and no restrictions on the maximum tree depth. By using 100 trees, the model was able to reduce prediction variance through ensemble averaging and capture intricate nonlinear relationships between hospital performance variables. The trees were able to develop to their full potential because there was no maximum depth constraint, which improved the model's capacity to fit complex patterns in the training set. The discrepancy between the training R2 (0.9407) and testing R2 (0.4765), however, suggests that this flexibility may potentially lead to overfitting. Despite this, the cross-validated performance ($R^2 = 0.553 \pm 0.048$) shows that the model retains reasonable stability and considerable predictive capability across various data divisions. Overall, the chosen Random Forest design strikes a balance between model robustness and predictive accuracy, supporting its use in determining the major factors influencing hospital efficiency and producing projections for future efficiency. The stability and factors influencing hospital efficiency rankings derived from the Dynamic SBM–DEA analysis in conjunction with machine learning and bootstrap methods are summarized in Fig. 7.

FIG. 7 SHAP-BASED IDENTIFICATION OF KEY DRIVERS INFLUENCING HOSPITAL EFFICIENCY RANKINGS



The model obtained an R^2 of 0.4765, an RMSE of 0.5177, and an MAE of 0.4121 on the independent test dataset. According to these findings, the model maintained moderate prediction error levels while explaining roughly 47.65% of the variation in hospital efficiency. A comparison of the testing R^2 (0.4765) and training R^2 (0.9407) indicates that there may be some overfitting, but the consistent cross-validation performance and positive test R^2 show that the model still has significant predictive power on unknown data. Overall, the findings show (Table 11) a moderate level of out-of-sample predictive accuracy and offer enough proof to support hospital efficiency forecasting using the Random Forest model and subsequent SHAP-based interpretation.

TABLE 11 MACHINE LEARNING VALIDATION RESULTS

Metric	Value
Training Samples	640
Testing Samples	160
Training R^2	0.9407
Testing R^2	0.4765
CV R^2 (Mean ± SD)	0.553 ± 0.048

Metric	Value
RMSE	0.5177
MAE	0.4121

BAYESIAN FORECASTING RESULTS

The Bayesian forecasting results provide probabilistic estimates of future hospital efficiency and ranking positions, enabling a forward-looking assessment of performance. Results are given in Table 12 below.

TABLE 12 FORECASTED RANKING OF TOP 20 HOSPITALS

Hospital_ID	Future_Efficiency	Future_Rank
H009	0.689841	1
H039	0.689448	2
H016	0.661782	3
H022	0.629618	4
H062	0.614497	5
H063	0.611187	6
H081	0.610177	7
H072	0.602506	8
H052	0.587584	9
H040	0.586507	10
H057	0.583698	11
H048	0.581608	12
H091	0.578636	13
H050	0.577674	14
H021	0.574417	15
H013	0.539037	16
H037	0.536967	17
H077	0.531657	18
H084	0.530406	19
H070	0.519761	20

The present hospital rankings and the projected future rankings derived from the Bayesian fusion framework are contrasted in the accompanying table. The Rank_Change = Current Rank − Future Rank column shows whether a hospital's status is predicted to improve or deteriorate in the future. Table 13 rank transitions for the top 20 hospitals were predicted using Bayesian efficiency fusion (one period ahead). The Dynamic SBM Composite Score (CSi) provides the basis for Current_Rank. The posterior mean projection is known as the forecasted rank. A projected rank decline is indicated by a negative Rank_Change, whereas an improvement is shown by a positive Rank_Change.

TABLE 13 RANK TRANSITION

Hospital Rank	Hospital_ID	Current_Rank	Future_Rank(Forecasted)	Rank_Change
5	H084	5	19	-14
8	H070	8	20	-12
7	H037	7	17	-10
6	H013	6	16	-10
9	H077	9	18	-9
11	H091	11	13	-2
2	H016	2	3	-1
1	H039	1	2	-1

14	H050	14	14	0
4	H022	4	4	0
3	H009	3	1	2
16	H048	16	12	4
19	H021	19	15	4
13	H072	13	8	5
10	H062	10	5	5
12	H063	12	6	6
17	H057	17	11	6
15	H081	15	7	8
18	H040	18	10	8
20	H052	20	9	11

Each hospital's posterior credible intervals, rank confidence intervals, and Top 5 ranking probabilities were assessed to quantify the uncertainty in the Bayesian future efficiency forecasts and displayed in Table 14. The uncertainty surrounding the Bayesian posterior efficiency estimates after integrating data from the Random Forest forecasts and the DEA bootstrap results is represented by the value Posterior SD = 0.0039. So, the Bayesian fusion framework demonstrated minimal uncertainty in the projected future efficiency. As a result, the 95% Bayesian credible intervals surrounding the posterior efficiency estimates were small, indicating that the predictions are reliable and statistically accurate. Monte Carlo simulation was carried out by periodically sampling from the posterior efficiency distributions and recalculating hospital ranks to further evaluate ranking uncertainty.

TABLE 14 PROBABILITY OF SUSTAINING FUTURE RANKING

Hospital_ID	Posterior_Efficiency	Rank_Mean	Rank_CI_Lower	Rank_CI_Upper	Top5_ Probability	Rank Change
H009	0.689841	1.45405	1	2	1	2
H039	0.689448	1.54595	1	2	1	-1
H016	0.661782	3	3	3	1	-1
H022	0.629618	4.00004	4	4	1	0
H062	0.614497	5.26899	5	7	0.77853	5

The range of ranks that any hospital may reasonably occupy was shown by the rank confidence intervals that were produced, which offered a probabilistic measure of ranking variability. Furthermore, using the simulated rank distributions, the likelihood of being placed in the top five hospitals was calculated. Based on the comparison between current and forecasted rankings, H009, H039, H016, H022, and H062 can be identified as the most sustainable hospitals.

DISCUSSION

PRINCIPAL FINDINGS

This study combined Dynamic SBM DEA, bootstrap validation, Markov chain analysis, machine learning prediction, SHAP explainability, and Bayesian forecasting to create an integrated framework for hospital performance assessment and forecasting. Both consistently high-performing hospitals and those with substantial development potential were identified by the Dynamic SBM DEA results, which showed a great deal of variation in hospital efficiency. The stability of efficiency estimates was validated by bootstrap and Markov chain analyses, which also shed light on the persistence and evolution of hospital performance states across time. The framework produced probabilistic future rankings and identified hospitals likely to maintain or alter their performance positions by combining efficiency, stability, and persistence metrics with Random Forest and Bayesian forecasting.

COMPARATIVE STUDY WITH PREVIOUS WORK

In order to assess efficiency at a particular moment in time, prior hospital benchmarking studies have mostly relied on traditional DEA models. Although these methods offer useful information on relative performance, they frequently overlook ranking stability, temporal dynamics, uncertainty, and future performance expectations. Although dynamic DEA models are being used more and more to capture intertemporal interactions, the majority of research only concentrates on efficiency estimation and do not include uncertainty quantification or predictive analytics. By combining Dynamic SBM DEA with bootstrap validation and Markov chain analysis, the current study expands on previous research by addressing both statistical reliability and longitudinal performance transitions. Additionally, operational, clinical, and infrastructure-related efficiency factors can be identified by combining Random Forest regression and SHAP analysis, and Bayesian forecasting offers probabilistic future performance estimates. Therefore, compared to conventional DEA-based benchmarking frameworks, this integrated methodology represents a substantial methodological leap.

THEORETICAL IMPLICATIONS

By highlighting the benefits of integrating operational research techniques with machine learning and Bayesian inference, the work adds to the body of knowledge on hospital efficiency. The suggested framework takes a dynamic and predictive approach to hospital performance evaluation, going beyond static efficiency measurement. The paradigm offers a more thorough understanding of efficiency evolution over time by combining Bayesian updating, Markov persistence analysis, and bootstrap-based uncertainty evaluation. Although the proposed model demonstrated moderate predictive performance and satisfactory cross-validation stability, its robustness may be further improved through the use of real-world longitudinal hospital datasets. The present study relies on synthetically generated data, which may not fully capture the complexity and variability of actual healthcare environments. Future research incorporating real-time operational, financial, and clinical data may enhance model generalization, improve forecasting accuracy, and strengthen the reliability of machine-learning-based hospital efficiency prediction. The results bolster the claim that hospital performance should not be seen as a static efficiency score but rather as a dynamic process impacted by past performance trends, operational traits, and future uncertainty. The theoretical connection between efficiency assessment and data-driven decision support is further strengthened by the incorporation of explainable artificial intelligence through SHAP analysis.

MANAGERIAL AND POLICY IMPLICATIONS

By facilitating hospital benchmarking, identifying performance gaps, and evaluating performance persistence across time, the suggested approach offers healthcare managers and policymakers useful decision-support tools. By identifying the critical elements affecting efficiency, SHAP-based analysis enables focused enhancements in infrastructure, staffing, patient happiness, and service use. Furthermore, Bayesian forecasting provides probabilistic future rankings with uncertainty measurements, making it easier to make well-informed judgments on capacity planning, long-term performance management, and resource allocation. Furthermore, by identifying hospitals that are anticipated to perform better or worse in the future, the predicted ranking changes offer important managerial and policy insights. While hospitals with notable rank increases serve as developing benchmarks for performance improvement and best-practice adoption, hospitals predicted to have major rank reductions may need proactive operational assessment and resource optimization to minimize future efficiency losses. Additionally, by supplementing conventional cross-sectional assessments with a forward-looking evaluation of performance sustainability, these forecasts can assist accreditation agencies and healthcare regulators, turning efficiency measurement into a dynamic tool for quality monitoring and strategic decision-making.

LIMITATIONS AND FUTURE SCOPE

The following constraints should be noted even if the simulated dataset shows good face validity and statistical agreement with Indian multispecialty hospital benchmarks:

- The interpretation of surgical volumes and fatality rates in highly specialized centers may be impacted by the dataset's failure to capture specialty-level disaggregation (e.g., cardiology vs. oncology numbers). The dataset is primarily typical of pure private multispecialty hospitals.
- Teaching hospital characteristics (resident physicians, research output) are not explicitly modeled. Although the range of hospital sizes implicitly incorporates this diversity, geographic heterogeneity (Tier-1 vs. Tier-2 cities, North vs.

South India) is not explicitly classified. The difference between IT infrastructure, buildings, and medical equipment is not made; instead, capital stock is modeled as an aggregate carry-over variable.

- Although the system allows evidence-based benchmarking and policy decisions, robustness may be impacted by simulated data, assumptions in priors, and RF structure [27,28].
- The actual multivariate correlation structure of the original data is not explicitly preserved in the synthetic dataset. Rather, temporal carryover rules and structural factors at the hospital level create inter-variable dependence.

In order to properly capture measurement error, operational variability, and institutional variation, future research should evaluate the suggested approach using real-world longitudinal hospital datasets. To specifically maintain the original data's empirical multivariate correlation structure, Gaussian Copula-based simulation or other dependency-preserving techniques to produce synthetic data that more closely mimics the observed multivariate dependence; future research may be able to get around this restriction.

To enhance the depiction of clinical complexity, additional quality-of-care indicators, case-mix modifications, and specialty-specific performance metrics may be added. Furthermore, to improve uncertainty modelling and forecast accuracy in hospital performance evaluation, sophisticated techniques such as stochastic DEA, fuzzy DEA, neutrosophic DEA, and Bayesian hierarchical models could be investigated. Numerous service sectors, such as dining establishments, lodging facilities, educational institutions, banking, and transportation, can use the suggested approach. It is especially helpful in settings where resource allocation and strategic planning depend on precise efficiency evaluation, strong ranking systems, uncertainty management, and trustworthy performance predictions.

CONCLUSION

The framework provides more trustworthy insights into hospital performance by producing probabilistic efficiency rankings while considering intertemporal slack uncertainty. The findings show that Bayesian fusion increases predictive accuracy with quantifiable ranking confidence and that slack-based factors have a major impact on efficiency. By assisting administrators in differentiating between fundamental resource limitations and operational inefficiencies, the method will promote well-informed administrative choices. Overall, the integrated framework is useful in any service industry like restaurants, hotels, educational institutes, banking sectors, transportation, etc where strategic planning and resource optimization depend on efficiency measurement, ranking stability, controlling uncertainty, and forecasting future performance.

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RESEARCH ARTICLE

READINESS OF PRIMARY HEALTH CARE FACILITIES TO DELIVER THE IRAN'S PACKAGE OF ESSENTIAL NON-COMMUNICABLE DISEASES (IRAPEN) PROGRAM: A DISTRICT-WIDE CROSS-SECTIONAL STUDY FROM IRAN

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ABSTRACT

BACKGROUND:

Non-communicable diseases (NCDs) are the leading cause of death in Iran, accounting for the vast majority of all fatalities. Strengthening primary health care (PHC) via Iran's adaptation of WHO-PEN (IraPEN) is central to earlier detection and continuity of NCD care. However, evidence regarding the readiness of PHC facilities to implement IraPEN at the district level remains limited. This study aims to assess facility-level readiness to deliver IraPEN in one district health network of Iran.

METHODS:

This study used a cross-sectional design and conducted a census of all PHC facilities in Kerman district health network. In total, 147 facilities, including comprehensive community health centers (CCHCs), health posts (HPs), and health houses (HHs), were assessed. Data were collected with a checklist adapted from WHO-PEN and IraPEN guidance that measured five domains: accessibility, human resources, medical equipment and supplies, information system, and the care system from November 2019 to January 2020. For each domain, scores were categorized using predefined thresholds as poor (≤50% of maximum score), moderate (51–75% of maximum score), or good (≥76 of maximum score). Content validity was confirmed using CVI and CVR measures, and inter-rater reliability was established with Cohen's kappa across twelve facilities (4 CCHCs, 4 HPs, and 4 HHs) before data collection began. Data were analyzed using descriptive statistics in SPSS version 22.

FINDINGS:

Across all 147 facilities, readiness was highest for the care system and lowest for medical equipment and supplies. In CCHCs, the information and care systems were strongest (each 90.6% good) and medical equipment and supplies was weakest (31.2% good; 15.6% poor). In HPs, the care system was strongest (83.0% good) and medical equipment and supplies was weakest (81.5% poor). In HHs, accessibility was strongest (96.0% good) and medical equipment and supplies was weakest (2.0% good; 54.0% poor). Overall, the care system had the highest good ratings (82.3%), whereas medical equipment and supplies had the highest poor ratings (57.8%; 7.4% good).

CONCLUSION:

Facility readiness was strongest in the care system, routine monitoring and feedback from higher levels, referral tracking, and related information-system functions, and weakest in medical equipment and supplies, particularly in HPs and HHs. Priority actions include targeted procurement of essential screening/diagnostic tools, fixing intranet/data-support gaps, and regular team training on referral closure.

KEYWORDS

Non-communicable diseases, Primary Health Care, IraPEN, package of essential non-communicable diseases, Iran

INTRODUCTION

Non-communicable diseases (NCDs), principally cardiovascular diseases, cancers, diabetes and chronic respiratory diseases, drive most premature mortality globally, with these four groups accounting for 80% of all premature NCD deaths [1].

NCDs account for 43.8 million deaths annually and 1.73 billion disability-adjusted life years (DALYs) globally [2]. In 2021, 18 million people died from an NCD before age 70 years, 82% of these premature deaths occurring in low- and middle-income countries (LMICs), and these four groups of diseases account for 80% of all premature NCD deaths [1].
In south Asian countries – which share similar demographic and health system transitions with Iran – the share of all mortality attributed to NCDs ranges from 55% in Pakistan to 82% in Sri Lanka, and the risk of premature death (age 30–70) from the four major NCDs varies between 13% and 29% [3].

In Iran, non-communicable diseases (NCDs) are the leading cause of death, responsible for 82% of all deaths in 2017. The overall burden of NCDs has shifted from premature mortality toward disability over the past three decades, with increasing age-standardized disability rates despite declining death rates [4]. NCDs not only harm health but also hurt the economy. They reduce productivity, increase healthcare costs, and push families into financial trouble, especially in low- and middle-income countries, where people often get sick during their most productive years. This creates a heavy burden on the country's development [5]. In the coming decades, the burden of non-communicable diseases in Iran is anticipated to undergo a marked transition from premature mortality to chronic disability, largely driven by the escalating prevalence of diabetes, the rising tide of obesity among younger cohorts, and the progressive aging of the population [4].

Despite high political commitment to NCD prevention and control across the region, evidence shows poor multisectoral engagement and weak health system preparedness at the primary health care (PHC) level. Common challenges include shortages of skilled human resources, inadequate infrastructure, lack of essential NCD medicines and technologies, and insufficient dedicated financing. Even where innovative community-based or integrated interventions exist, scaling up remains problematic [3].

PHC-based strategies are therefore pivotal to prevention, early detection, risk-factor management, and longitudinal care. The World Health Organization's (WHO) recommends strengthening primary health care (PHC) as the cornerstone of NCDs prevention and control [6]. This package focuses on training healthcare workers and ensuring access to essential

equipment, medications, and diagnostics, thereby strengthening PHC services for NCD [7]. To operationalize WHO's Package of Essential Noncommunicable Disease Interventions (WHO-PEN) in the Iranian context, the Ministry of Health (MoH) launched the Iran Package of Essential NCD Interventions (IraPEN) in 2014, piloted it in four districts, and then scaled elements nationally [8]. The primary goal of IraPEN is to establish a systematic, continuous program for managing NCD risk factors. Within an integrated framework, it gathers, analyzes, and disseminates information critical for developing, implementing, and evaluating individual- and population-level NCD interventions. By actively engaging in policy-making, IraPEN aims to play a significant role in effectively controlling NCDs [6]. It standardizes cardiovascular risk assessment (≥30 years), early detection pathways for cervical, breast, and colorectal cancers, and case-finding for asthma/COPD, with defined referral and follow-up protocols inside PHC.

Given the importance of IraPEN and its potential impact on strengthening preventive care, evaluating the program's readiness requires reliable information to identify its strengths and weaknesses. About one decade has passed since IraPEN's introduction, yet, consistent with the regional evidence that facility readiness for NCD services remains limited, and evidence on facility readiness to deliver IraPEN at scale remains scarce [3]. Moreover, global evidence on the implementation and effectiveness of PEN interventions is limited and conflicting, a knowledge gap that further underscores the need for local assessments [9]. Therefore, this study aims to quantitatively assess the readiness of IraPEN within the PHC system of Kerman, Iran, using a district-wide census of PHC facilities.

METHODS

CONTEXT

Iran's PHC system, established between 1974-1985, provides primary care in both rural and urban areas [10]. This system consists of health houses (HHs) in villages (each staffed by Behvarz as a community health worker, serving around 1,200 people) and rural health centers (with physicians and a team of 5-10 staff for approximately 7000 people). Urban areas are served by health posts (HPs) and urban health centers offering similar services. District health centers supervise these centers under the medical sciences universities in each province [11, 12].

In this context, the Ministry of Health and Medical Education (MoHME) initiated IraPEN in 2014, aiming to seamlessly integrate NCDs services into the PHC framework. The program consists of three core components. First, cardiovascular risk assessments are conducted in rural health houses (HHs) and urban health posts (HPs) for individuals aged 30 and above. These assessments involve measuring blood glucose and total cholesterol levels to estimate the 10-year risk of major cardiovascular events, followed by tailored preventive or therapeutic interventions. Second, the program includes early detection of three common cancers, cervical, breast, and colorectal, through targeted screening protocols such as patient history, Pap smear or HPV testing, clinical breast examinations, and fecal occult blood tests, with appropriate referral pathways. Third, since 2019, community health workers have been assigned to identify individuals showing symptoms of asthma or chronic obstructive pulmonary disease (COPD) and refer them to family physicians for further evaluation and management [1].

STUDY DESIGN AND SETTING

We conducted a cross-sectional study of IraPEN readiness in Kerman district health network as one of main districts of PHC from 2019–2020. IraPEN readiness was assessed at three levels of service delivery: CCHCs, HPs, and HHs.

SAMPLE SIZE AND DATA COLLECTION

The study population comprised all 147 PHC facilities in Kerman, including thirty-two comprehensive community health centers (CCHCs), sixty-five health posts (HPs), and fifty health houses (HHs). These facilities were further categorized by location (urban, rural, and mixed urban–rural) for comparative analysis. In this research, no specific sampling method was considered, as all PHC centers were assessed through a general census.

ASSESSMENT INSTRUMENT

The data collection instrument was a researcher-made checklist, developed based on WHO's global NCD control principles and tailored to Iran's PHC system. This checklist covered five main domains: accessibility (physical and geographical access to PHC services), human resource (staff availability, training, and skills), medical equipment and supplies (availability of medical devices, technologies, and drugs), information system (patient record-keeping, referral processes, data archiving), and care system (monitoring and supervision of NCD services in PHC). Each domain consisted of multiple indicators corresponding to IraPEN guidelines and standards.

VALIDITY AND RELIABILITY MEASURES

To validate the checklist, we used content validity ratio (CVR) and content validity index (CVI) measures. Items with CVR < 0.7 were removed; CVR 0.7–0.77 were revised; CVR ≥ 0.78 were retained. The overall CVI ensured we included the most essential content. For reliability, we assessed inter-rater reliability via Cohen's kappa. Two independent evaluators each rated a subset of twelve facilities (4 CCHCs, 4 HPs, 4 HHs) using the checklist, and we calculated agreement. Kappa values >0.8 were considered ideal (≥0.6 was the minimum acceptable). In our pilot reliability test, kappa values ranged 0.84–0.91 across the checklist domains, indicating excellent agreement. Table 1 summarizes the validity and reliability results by domain.

DATA COLLECTION METHOD

Two trained interviewers of researchers (MG, MJ) collected data by visiting each facility in person. Interviewers were selected based on prior experience and familiarity with the local context of PHC and IraPEN program to facilitate communication. To standardize administration, interviewers were trained in a four-hour online session before fieldwork and used a common protocol for introducing the study, sequencing the interview, locating required documents, and conducting unobtrusive observations. To ensure consistency, all checklists were completed electronically using a secure, web-based form on smart tablets. The electronic instrument was designed with domain-specific sections, built-in skip logic, mandatory fields for critical items, and automated range checks to minimize missing or inconsistent data. Entries were time-stamped and uploaded in real time (or synced at the end of the site visit where connectivity was limited). The primary researcher remotely monitored incoming submissions during the eight-week data-collection period, queried anomalies when needed, and provided feedback to ensure uniform application of the checklist across facilities. The checklist and instructions were developed using an online platform named Porsline so that interviewers could enter responses electronically on-platform using tablets, thereby eliminating paper forms. Before each visit, interviewers coordinated with facility managers and staff of each PHC center. Data were collected on site at each facility using three complementary techniques: 1) a structured interview with the facility's designated focal person (e.g., general physician, Behvarz/community health worker, family healthcare provider) to elicit responses to each checklist item; 2) a targeted review of documentary evidence relevant to every sub-item within each domain (e.g., equipment logs, training records, supervision reports, referral registers, and information-system printouts); and 3) direct field observation to verify the presence, functionality, and use of infrastructure, equipment, and processes described by respondents. Interviewers first confirmed informed consent, then completed the checklist item-by-item while triangulating interview responses against documents and observations; in case of discrepancy, the documentary/observational evidence prevailed and notes were recorded. Data collection spanned an 8-week period (November 2019 – January 2020). The principal investigator supervised all stages of data collection; the uploaded digital forms also were monitored in real time to verify completeness and accuracy.

TABLE 1: VALIDITY AND RELIABILITY OF THE READINESS CHECKLIST BY DOMAIN

Domain	Number of items	CVI*	CVR**	Cohen's κ *** (inter-rater)	Min &max scores	
Accessibility	24	0.79	0.84	0.86	CCHC	0-44
					HP	0-32
					HH	0-32
Human resources	24	1.00	1.00	0.91	CCHC	0-22
					HP	0-10

					HH	0-10
Medical equipment and supplies	61	0.94	0.87	0.87	CCHC	0-10
					HP	0-34
					HH	0-32
Information system	14	0.91	0.83	0.84	CCHC	0-28
					HP	0-16
					HH	0-16
Care system	7	0.95	1.00	0.88	CCHC	0-14
					HP	0-12
					HH	0-12

* CVI: Content Validity Index; ** CVR: Content Validity Ratio; ***κ: Cohen's kappa for inter-rater reliability)

DATA ANALYSIS

We scored each facility on each checklist indicator and then categorized scores into three levels of readiness: "good" (≥ 76% of maximum score), "moderate" (51–75% of maximum score), or "poor" (≤ 50% of maximum score). Indicators not applicable to certain facility types, based on the PHC organizational structure, were recorded as NA and excluded from scoring .We aggregated these scores for each domain and facility type. Descriptive statistics (frequencies, percentages, means) were used to summarize readiness levels. We present results for each domain stratified by facility type (CCHC, HP, HH) and by location (urban vs. rural) as applicable. All analyses were performed using SPSS v.22.

ETHICAL APPROVAL AND CONSENT

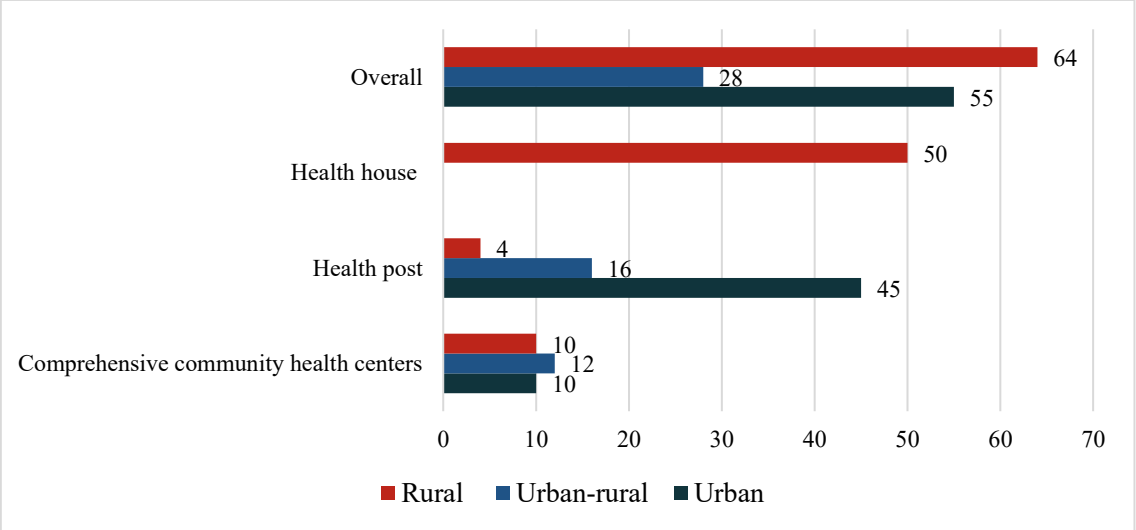
This study received ethical approval from the ethics committee of Kerman University of Medical Sciences with ID number IR.KMU.REC.1398.406. All participants provided written informed consent before participating in the study, ensuring their voluntary and informed participation in accordance with ethical standards.

RESULTS

FACILITY CHARACTERISTICS

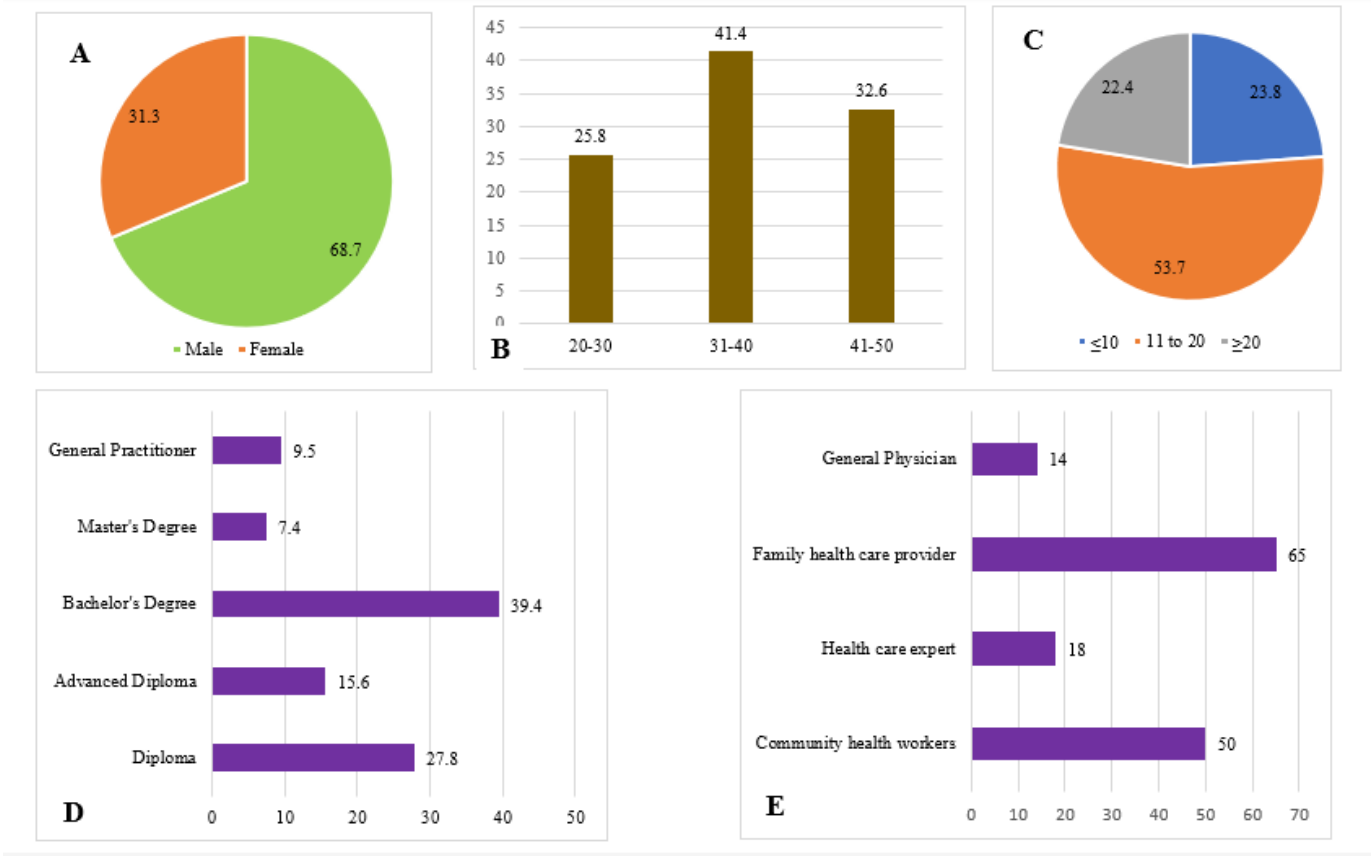
A total of one hundred and forty-seven PHC facilities were evaluated (32 CCHCs, 65 HPs, 50 HHs). The majority of these facilities (about 56%) are located in urban or mixed urban–rural areas, while roughly 44% are in purely rural areas. Here, "urban–rural" denotes centers situated in towns that serve both urban and surrounding rural populations. Details on the number of centers, stratified by the type of population covered (rural, urban, and mixed rural–urban), are presented in Figure 1.

FIGURE 1: CHARACTERISTICS OF HEALTH FACILITIES BY COVERED POPULATION



One focal point employee from each PHC facility center participated as interviewee, comprising family healthcare providers, health care expert, community health worker, and family and general physicians. The majority of the respondents were male, accounting for 67.7%, and the highest proportion of respondents fell into the 31-40 age group, with the majority (39.4%) holding a bachelor's degree. Additionally, nearly half of the respondents (53.7%) had work experience of 11-20 years in the study (Figure 2).

FIGURE 2: DEMOGRAPHIC CHARACTERISTICS OF THE STUDY PARTICIPANTS: A) GENDER B) AGE C) WORK EXPERIENCE D) EDUCATION E) JOB



HEALTH FACILITIES READINESS

Focusing on CCHCs, the information system and care system domains showed the strongest performance, with 29 out of 32 CCHCs (90.6%) in the good range in each domain and none rated poor. The accessibility and human resources domains also performed well, with no facilities receiving a poor score in these areas. In contrast, the medical equipment and supplies domain was the weakest for CCHCs: only 10 out of 32 CCHCs (31.2%) achieved a good score in this domain, while 5 CCHCs (15.6%) were rated poor in terms of medical equipment and supplies availability.

For HPs, the care system domain had the best performance, with 54 out of 65 HPs (83%) in the good range and none in poor. The accessibility and information system domains were also strong (about two-thirds of HPs good). Notably, the medical equipment and supplies domain was very problematic for health posts: none of the 65 HPs achieved a good score in medical equipment and supplies availability, and 53 HPs (81.5%) were rated poor in this domain.

Among HHs, the accessibility domain was excellent– 48 of 50 health houses (96%) had good accessibility (e.g., acceptable travel distance, waiting times) and zero were poor. The human resources domain was also high, with 44 HHs (88%) scoring good (largely because each health house had its trained Behvarz in place). However, similar to HPs, the medical equipment and supplies domain was the weakest area for health houses: 27 out of 50 HHs (54%) were rated poor in medical equipment and supplies, indicating that over half of the rural health houses lacked necessary medical devices or diagnostics. (Table 2)

TABLE 2: HEALTH FACILITIES READINESS SCORES BY CENTERS TYPES

Healthcare centers	Dimensions	Health facilities scores								
		≤50			50-75			≥75		
		Mean	Frequency	Percent	Mean	Frequency	Percent	Mean	Frequency	Percent
Comprehensive community health centers	Accessibility	0	0	0	24.7	9.0	28.1	33.2	23.0	71.8
	Human resource	0	0	0	10.9	12.0	37.5	15.3	20.0	62.5
	Medical equipment and supplies	37.6	5.0	15.6	69.6	17.0	53.1	97.6	10.0	31.2
	Information system	0	0	0	16.3	3.0	9.3	22.2	29.0	90.6
	Care system	0	0	0	8.6	3.0	9.3	13.8	29.0	90.6
Health post	Accessibility	14.0	2.0	3.0	20.0	20.0	30.7	28.8	43.0	66.1
	Human resource	0	0	0	2.6	25.0	38.4	4.0	40.0	61.5
	Medical equipment and supplies	11.6	53.0	81.5	19.0	12.0	18.4	0	0	0
	Information system	6.0	2.0	3.0	10.7	20.0	30.7	14.6	43.0	66.1
	Care system	0	0	0	7.4	11.0	16.9	11.5	54.0	83.0
Health house	Accessibility	0	0	0	20.0	2.0	4.0	30.2	48.0	96.0
	Human resource	0	0	0	2.6	6.0	12.0	4.0	44.0	88.0
	Medical equipment and supplies	12.6	27.0	54.0	17.9	22.0	44.0	26.0	1.0	2.0
	Information system	0	0	0	10.4	22.0	44.0	14.8	28.0	56.0
	Care system	5.0	2.0	4.0	7.0	10.0	20.0	11.8	38.0	76.0
Overall	Accessibility	14.0	2.0	1.3	21.4	31.0	21.0	30.3	114.0	77.5
	Human resource	0	0	0	4.9	43.0	29.2	6.1	104.0	70.7
	Medical equipment and supplies	13.5	85.0	57.8	35.4	51.0	34.6	91.0	11.0	7.4
	Information system	6.0	2.0	1.3	10.9	45.0	30.6	16.9	100.0	68.0
	Care system	5.0	2.0	1.3	7.4	24.0	16.3	12.1	121.0	82.3

DETAILED INDICATOR PERFORMANCE

We further examined specific indicators within each domain (Table 3–5 present these for accessibility, human resources, medical equipment and supplies, and Information & Care systems, respectively).

Regarding accessibility, the waiting time for services received a "good" rating in the vast majority of facilities. A breakdown shows that 100% of CCHCs, 84.6% of HPs, and 94% of HHs attained high scores for prompt service delivery. (Table 3)

TABLE 3: ACCESSIBILITY INDICATORS SCORES BY CENTERS TYPES

Accessibility indicators	Comprehensive community health centers			Health post			Health house			Overall		
	≤50	50-75	≥75	≤50	50-75	≥75	≤50	50-75	≥75	≤50	50-75	≥75
Services provision	0	6(18.7)	26(81.2)	5(7.6)	19(29.2)	41(63)	0	2(4)	48(96)	5(3.4)	27(18.3)	115(78.2)
Identification and patients Care	1(3.1)	14(43.7)	17(53.1)	5(7.6)	33(50.7)	27(41.5)	0	19(38)	31(62)	6(4)	66(44.8)	75(51)
Accessibility of individuals aged over thirty to PEN	0	4(12.5)	28(87.5)	0	24(36.9)	41(63)	0	10(20)	40(80)	0	38(25.8)	109(74.1)
Availability of a facility for laboratory services	6(18.7)	4(12.5)	22(68.7)	NA	NA	NA	NA	NA	NA	6(18.7)	4(12.5)	22(68.7)
Availability of a dedicated injection room for emergencies	1(3.1)	10(31.2)	21(65.6)	NA	NA	NA	NA	NA	NA	1(3.1)	10(31.2)	21(65.6)
Medical check-ups for hypertensive and diabetic patients	0	8(25)	24(75)	0	16(24.6)	49(75.3)	0	6(12)	44(88)	0	30(20.4)	117(79.5)
No difference in service delivery between urban and rural areas	0	10(31.2)	22(68.7)	1(1.5)	17(26.1)	47(72.3)	0	4(8)	46(90)	1(1.5)	31(21)	115(78.2)
Convenient access for the population to service locations	2(6.2)	5(15.6)	25(78.1)	4(6.1)	12(18.4)	49(75.3)	0	0	50(100)	6(4)	17(11.5)	125(85)
The desirability of waiting time for service reception	0	0	32(100)	0	10(15.3)	55(84.6)	0	3(6)	47(94)	0	13(8.8)	134(91.1)

*NA = Not applicable

In the human resources domain, physician training received a "good" or higher rating in 23 out of 32 CCHCs (71.8%). Similarly, community health worker training was rated well in 21 out of 32 CCHCs (65.6%). The majority of HPs and HHs also achieved good scores in this area, with (83%) and (96%) respectively. However, in CCHCs, only 50% of centers received a "good" or higher rating for personnel presence according to the development plan, indicating a significant gap in this area. (Table 4, upper section)

In the medical equipment and supplies domain (Table 4, bottom section), the availability of basic screening equipment was good in most centers. Specifically, 21 Comprehensive Health Centers (34.6%) and 10 Health Posts (15.3%) achieved a high score of 75, indicating good availability. Regarding conducting essential tests, more poor scores were observed in CCHCs, with 12 centers (37.5%) receiving poor ratings. In contrast, within HHS and HPs, the "Availability of medical and diagnostic devices" domain garnered the poorest scores, with 48 (73.8%) and 49 (98) respectively.

TABLE 4: SCORES OF HARDWARE DIMENSION INDICATORS BY CENTERS TYPES

Human resource indicators	Comprehensive community health centers			Health post			Health house			Overall		
	≤50	50-75	≥75	≤50	50-75	≥75	≤50	50-75	≥75	≤50	50-75	≥75
Physician training	2(6.2)	7(21.8)	23(71.8)	NA	NA	NA	NA	NA	NA	2(6.2)	7(21.8)	23(71.8)
Community health worker training	0	11(34.3)	21(65.6)	0	11(16.9)	54(83)	0	2(4)	48(96)	0	24(16.3)	123(83.6)
Midwife training	2(6.2)	4(12.5)	26(81.2)	NA	NA	NA	NA	NA	NA	2(6.2)	4(12.5)	26(81.2)
Other staff member training	2(6.2)	9(28.1)	21(65.6)	NA	NA	NA	NA	NA	NA	2(6.2)	9(28.1)	21(65.6)
Development of training programs	0	2(6.2)	30(93.7)	2(3)	18(27.6)	45(69.2)	0	6(12)	44(88)	2(1.3)	26(17.6)	119(80.9)
Seasonal training	0	3(9.3)	29(90.6)	NA	NA	NA	NA	NA	NA	0	3(9.3)	29(90.6)
Training committees' formation	0	7(21.8)	25(78.1)	NA	NA	NA	NA	NA	NA	0	7(21.8)	25(78.1)
Personnel presence according to development plan	3(9.3)	13(40.6)	16(50)	NA	NA	NA	NA	NA	NA	3(9.3)	13(40.6)	16(50)
Medical equipment and supplies indicators	**Comprehensive community health centers**			**Health post**			**Health house**			**Overall**		
	≤50	**50-75**	**≥75**	**≤50**	**50-75**	**≥75**	**≤50**	**50-75**	**≥75**	**≤50**	**50-75**	**≥75**
Basic screening equipment	0	11(34.3)	21(65.6)	5(7.6)	50(76.9)	10(15.3)	0	30(60)	20(40)	5(3.4)	91(61.9)	51(34.6)
Availability of medical and diagnostic devices	1(3.1)	1(3.1)	30(93.7)	48(73.8)	12(18.4)	5(7.6)	49(98)	1(2)	0	98(66.6)	14(9.5)	35(23.8)
Conducting essential tests	12(37.5)	8(25)	12(37.5)	32(49.2)	27(41.5)	6(9.2)	11(22)	36(72)	3(6)	55(37.4)	71(48.2)	21(14.2)
Availability of essential medications	11(34.3)	10(31.2)	11(34.3)	NA	NA	NA	NA	NA	NA	11(34.3)	10(31.2)	11(34.3)

In the information system domain (Table 5, upper section), provision of individual computers for each team member was nearly universal in CCHCs and high in HPs. Specifically, 96.8% of CCHCs and 81.5% of HPs had a dedicated computer for every healthcare team member. In Patient data collection and support, we had the lowest good scores across all centers.

In the care system domain (Table 5, bottom section), systematic supervision of health centers by higher levels was excellent, particularly in CCHCs. For example, 93.7% of CCHCs received good scores on supervision and regular monitoring, and even among the more peripheral health houses, about 82% were rated good in this aspect. Conversely, Operational program updates and monitoring at health center command displays had the lowest performance scores in this domain.

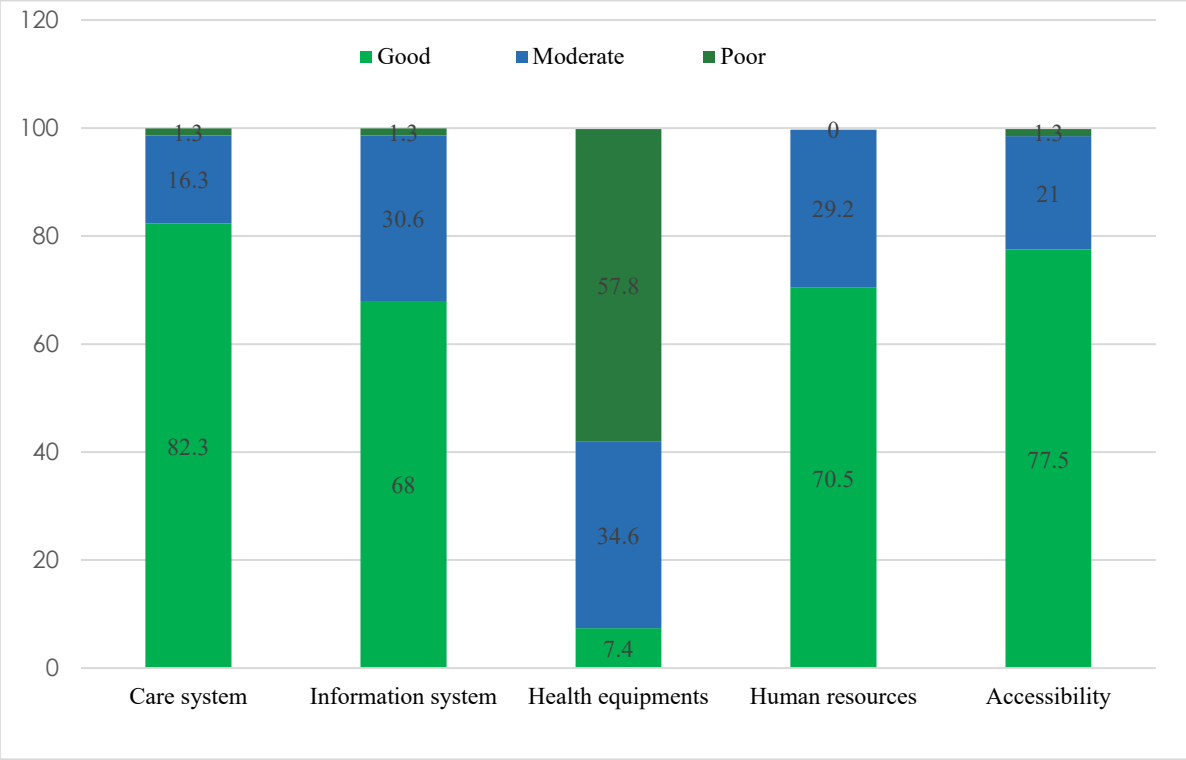
TABLE 5: SCORES OF SOFTWARE DIMENSION INDICATORS BY CENTERS TYPES

Information system indicators	Comprehensive community health centers			Health post			Health house			Overall		
	≤50	50-75	≥75	≤50	50-75	≥75	≤50	50-75	≥75	≤50	50-75	≥75
Electronic patient referrals within the SIB system to higher levels	0	5(15.6)	27(84.3)	2(3)	22(33.8)	41(63)	2(4)	18(36)	30(60)	4(2.7)	45(30.6)	98(66.6)
Individual computers for each healthcare team member	0	1(3.1)	31(96.8)	2(3)	10(15.3)	53(81.5)	4(8)	25(50)	21(42)	6(4)	36(24.4)	105(71.4)
Interanet connectivity establishment	0	10(31.2)	22(68.7)	5(7.6)	17(26.1)	42(64.6)	6(12)	20(40)	24(48)	11(7.4)	47(31.9)	88(59.8)
Patient data collection and support	1(3.1)	11(34.3)	20(62.5)	2(3)	23(49.2)	31(47.6)	0	21(42)	29(58)	3(2)	64(43.5)	80(54.4)
Care system indicators	**Comprehensive community health centers**			**Health post**			**Health house**			**Overall**		
	≤50	50-75	≥75	≤50	50-75	≥75	≤50	50-75	≥75	≤50	50-75	≥75
Regular monitoring program for health centers	0	2(6.2)	30(93.7)	NA	NA	NA	NA	NA	NA	0	2(6.2)	30(93.7)
Systematic supervision of health centers by higher levels	0	2(6.2)	30(93.7)	0	7(10.7)	58(89.2)	0	9(18)	41(82)	0	18(12.2)	131(89.1)
Submission of inspection reports from higher levels to health centers	0	3(9.3)	30(93.7)	0	8(12.3)	57(87.6)	0	10(20)	40(80)	0	21(14.1)	126(85.7)
Validation of data accuracy in systems by evaluation teams	0	4(12.5)	29(90.6)	0	11(16.9)	54(83)	0	12(24)	38(76)	0	27(18.3)	12.(81.6)
Timely follow-up and referral of patients	0	2(6.2)	28(87.5)	0	13(20)	52(80)	2(4)	8(16)	40(80)	2(1.3)	21(14.2)	122(82.9)
Operational program updates and	0	4(12.5)	30(93.7)	0	23(35.3)	42(64.6)	0	14(28)	36(72)	0	41(27.8)	106(72.1)

monitoring at health center command displays												
Submission of monitoring feedback by health centers to higher levels	0	2(6.2)	28(87.5)	0	12(18.4)	53(81.5)	0	14(28)	36(72)	0	28(19)	119(80.9)

Overall, considering all facilities in Kerman, the care system domain had the greatest proportion of facilities with good readiness (82.3% of all centers scored good in care coordination and supervision). Following care system, accessibility (77.5% good), human resources (70.7% good), and information system (68.0% good) were strong areas across the network. The domain with the most significant shortfall was medical equipment and supplies, with only 34.6% of facilities scoring good and 57.8% of all facilities scoring poor in this domain. This highlights a widespread lack of medical equipment and supplies in the PHC network. (figure 3)

FIGURE 3: OVERALL SCORES OF HEALTH FACILITIES READINESS



DISCUSSION

This study aimed to investigate healthcare facilities' readiness to deliver IraPEN services in Kerman, highlighting both strengths and weaknesses in the current system and pinpointing areas for improvement in NCD management.

Based on our findings, in Kerman's PHC network the strongest dimensions were the *care system* and *information system*, while the *medical equipment and supplies* dimension was the weakest. Notably, the *human resources* dimension also had relatively few facilities in the "poor" category (only 0–4% poor across all centers), indicating that basic staffing and training have been addressed to some extent. These results mirror concerns raised in several countries about equipment shortages in PHC. Studies from Myanmar, the West Pacific, and Kyrgyzstan have similarly reported insufficient medical equipment and supplies as a major barrier in PEN implementation [13–17] Our data provide local evidence of this issue: more than

half of the facilities had suboptimal equipment availability, which could impede effective NCD screening and management.

In terms of access to NCD services, our facilities performed well overall – for example, waiting times for patients were rated satisfactory in almost all centers. This finding is encouraging and aligns with outcomes from the Occupied Palestinian Territory's PEN pilot, where reduced patient waiting time was noted as a significant improvement [18]. Furthermore, in the accessibility domain, most indicators were rated good, suggesting that Iran's PHC system offers generally good accessibility to NCD care. However, a study in Nepal by Gyawali et al. found that many individuals lacked access to NCD prevention and control services, in contrast to our findings [19]. The Nepalese experience attributed this gap to insufficient government budgeting for primary healthcare NCD programs and a higher priority given to curative services over preventive care. These differences underline how sustained investment and prioritization of PHC (as in Iran's Health Transformation Plan) can improve accessibility, whereas neglecting PHC funding (as reported in Nepal) can lead to service shortfalls. It is worth noting that Iran's PHC infrastructure, with its extensive rural network of health houses, likely contributes to better access, whereas in Nepal the lack of such an extensive network was a limiting factor.

Our study's findings show that *patient visits for managing blood pressure and diabetes* were being conducted and recorded properly at all levels (CCHCs, HPs, HHs) – these indicators received "good" readiness scores across the board. This suggests that the care protocols for common NCDs (hypertension, diabetes) are largely being followed. A similar positive outcome was observed in Tajikistan, where an evaluation noted improved blood pressure screening and control in primary care centers after implementing essential NCD interventions, echoing our results [20]. Likewise, in Moldova, PEN implementation centers saw better blood pressure control after one year [21]. Our findings reinforce these experiences: when PEN protocols (like regular BP checks and follow-ups) are put into practice, measurable improvements in chronic disease management can occur even within a year.

In the human resources dimension, *community health worker training* stood out with the highest good score (virtually all health houses had adequately trained Behvarz). This reflects the strength of Iran's PHC system in training and deploying community health workers. However, other HR indicators revealed gaps: for instance, many centers did not have the full complement of physicians or nurses as per the staffing norms, and ongoing in-service training for clinical staff (physicians, midwives, etc.) was lacking in a significant number of facilities (these were the indicators with highest "poor" scores in HR). From these results, we infer that human resource management in the IraPEN program has room for improvement. These findings indicate that further attention to workforce planning and staff development may improve readiness for IraPEN implementation. This conclusion aligns with findings from Nigeria's PEN implementation, where *Okpetu et al.* identified human resource shortages as a critical issue hindering NCD preventive services, urging policymakers to develop fundamental solutions [22]. Tripathy et al. likewise noted that insufficient training of staff is a major challenge in PEN effectiveness [7]. Our context is similar: despite having a strong PHC workforce base (Behvarz), there is a need to ensure adequate numbers of skilled clinicians in rural centers and to plan regular training to update staff on NCD care protocols. Policymakers might need to consider incentives for rural service and stronger workforce planning to fill these gaps.

The equipment domain was clearly the weakest link in facility readiness. Key equipment indicators – such as availability of advanced diagnostic devices (like lipid testing or ECG machines) – had very low scores in many facilities. Even essential drug availability was inconsistent, with half of centers lacking one or more medications for managing diabetes, hypertension, or other NCDs. These shortages point to systemic issues in supply chain and resource allocation. Our findings suggest that reorienting the health system to prioritize NCD supplies is urgently needed. This includes not only procurement of equipment but also maintenance and continuous supply of consumables (test strips, reagents, etc.). A reallocation of budget to PHC NCD care, improving inventory management, and perhaps leveraging technology (e.g., telemedicine to extend services where equipment is lacking) could be part of the solution. A qualitative study from Ethiopia similarly indicated gaps between different levels of PHC in terms of capacity and readiness, emphasizing that policymakers need to commit resources and leadership to address such weaknesses [23].

Within the information system domain, our facilities scored well on having basic computer infrastructure for health teams, which is encouraging. This indicates that the Health Transformation Plan's investments in health information technology (like the SIB electronic health record system) are paying off at least in hardware deployment. However, the stark finding was the lack of internet connectivity, particularly in rural and remote posts and houses. Only about one-third of facilities overall had internet connections established, and many health houses had none. This hinders real-time data entry, teleconsultation, and accessing updated guidelines. It also resonates with the experiences reported by Samuel et al. in Kenya, where insufficient digitalization was common, and with an Iranian study by Jafari et al. which pointed out that weak internet infrastructure is a serious barrier to e-health services [24, 25]. Our data underscore that to fully realize the benefits of digital health (which is a component of PEN), Iran must invest in infrastructure – extending broadband or other connectivity solutions to rural clinics. Encouragingly, aside from connectivity, other aspects like electronic record-keeping seemed to be adopted (as indicated by high scores in data collection and support). Therefore, if connectivity issues are solved, the PHC network is poised to effectively use digital tools to enhance NCD care (for example, electronic referrals and telemedicine, which only a minority of centers could currently do).

The care system domain highlights the programmatic aspects of NCD care – supervision, feedback, patient follow-up, and quality improvement. We found that systematic supervision (regular monitoring visits and reporting from higher levels to the centers) was occurring quite well in our study setting. Over 85% of facilities overall reported good practices in receiving supervisory visits and feedback. This is a positive finding, as effective supervision is linked to higher productivity and better identification of service delivery gaps. Our study likely benefited from the fact that Kerman University of Medical Sciences actively oversees the health network, reflecting a strong governance component. On the other hand, timely patient follow-up and referral was the lowest-scoring indicator in the care system. This suggests that once patients are referred (for example, from a health post to a specialist at a higher-level facility), the tracking of whether they went and whether they returned for follow-up is weak. Strengthening this aspect might involve establishing clearer referral pathways and follow-up registers, possibly aided by the information system (if connectivity improves).

Interestingly, the urban-rural gap was also evident here: urban CCHCs, which are closer to specialized services, had better follow-up rates than rural HHs, where patients may need to travel farther and are harder to track. Introducing a family physician program more robustly in urban and rural areas – as Iran has started for rural areas – could help improve follow-up, since each family physician would be responsible for the continuum of care of enrolled individuals. Studies have shown that when health workers actively follow up with patients (through phone or community visits), compliance and outcomes improve. Our findings on supervision correlate with those from an Iranian military health system study, which found that strong monitoring leads to early identification and resolution of service weaknesses [26]. Thus, reinforcing supportive supervision (already relatively good) and adding patient follow-up mechanisms are recommended steps to enhance the care system dimension.

STRENGTHS AND LIMITATIONS OF THE STUDY

A strength of this study is that it covered all PHC service delivery points in the district, providing a comprehensive picture rather than a sample. This lends confidence that our results are representative of the PHC system's status in our context and possibly similar contexts nationwide. We also adapted a standard WHO-PEN questionnaire, which means our findings can be benchmarked against other regions or countries implementing PEN. The timing of the study, however, coincided with the COVID-19 pandemic onset, which posed challenges for data collection and might have temporarily affected service readiness (e.g., some resources diverted to COVID response). We mitigated this by supplementing on-site observation with document review when direct observation was limited. Additionally, our study is descriptive and cross-sectional – it identifies readiness gaps but cannot ascertain causes or long-term outcomes. We did not include outcome measures like NCD control rates (that would require a longer follow-up or separate study). Another limitation is that our readiness scoring, while systematic, relied in part on self-reported information (e.g., staff reports of training received), which could introduce bias. We attempted to validate such information through records where possible.

Despite these limitations, our study provides valuable insights into the implementation gaps (especially equipment and workforce issues) in a real-world primary care NCD program. It highlights how a seemingly well-designed program can be

hampered by logistic issues, and conversely, how certain foundations (like a strong PHC network and good supervision) can facilitate program success. The findings point to important *gaps* – such as the need for better equipment and connectivity – and illustrate how a fragmented approach (where some components are strong and others weak) can impede overall progress in NCD services. Policymakers can use this information to target investments (e.g., equip rural clinics, hire/train staff) and to refine strategies (e.g., strengthen the referral loop via family physicians and digital health) to ensure that an integrated NCD program like IraPEN achieves its full potential in strengthening Iran's PHC.

CONCLUSION

This study provides a comprehensive assessment of IraPEN readiness across PHC facilities in Kerman district and identifies both strengths and areas requiring further improvement. Overall, readiness was highest in the care system and information system domains, reflecting relatively strong performance in monitoring, supervision, referral tracking, and routine program implementation. In contrast, the medical equipment and supplies domain demonstrated the lowest readiness levels, particularly among health posts and health houses, indicating important gaps in the availability of essential equipment and diagnostic resources required for effective NCD service delivery.

The findings suggest that strengthening IraPEN implementation should prioritize investment in essential medical equipment and supplies, enhancement of referral and follow-up mechanisms, and continued capacity-building of the PHC workforce through regular training and supportive supervision. Addressing these readiness gaps may improve the quality, continuity, and effectiveness of NCD prevention and management services within the PHC system.
A coordinated approach targeting infrastructure, workforce capacity, and service-delivery resources is essential to further strengthen facility readiness and support the sustainable implementation of IraPEN in PHC settings.

ETHICAL APPROVAL AND CONSENT:

This study received ethical approval from the ethics committee of Kerman University of Medical Sciences with ID number IR.KMU.REC.1398.406. All participants provided written informed consent before participating in the study, ensuring their voluntary and informed participation in accordance with ethical standards.

AUTHORS' CONTRIBUTIONS

Conceptualization: VYF, MGH, ZZ
Data curation: MJ, MGH
Formal analysis: VYF, MGH
Investigation: MGH, ZZ
Methodology: MGH
Software: MGH
Project administration: VYF
Supervision: VYF, MHM, MSH
Validation: VYF
Visualization: VYF, MGH, ZZ
Writing – original draft: VYF, MGH, ZZ
Writing – review & editing: VYF, ZZ, MHM, MSH, MJ, MGH

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AVAILABILITY OF DATA AND MATERIALS:

All data generated or analyzed during this study are included in this published article.

COMPETING INTERESTS

The authors declare that they have no competing interests

ABBREVIATION

NCD: Non-communicable Diseases
WHO-PEN: WHO package of essential non-communicable diseases
IraPEN: Iran package of essential non-communicable diseases
PHC: Primary Health Care
WHO: World Health Organization
CCHC: Comprehensive Community Health Center
HP: Health Post
HH: Health House
MoHME: Ministry of Health and Medical Education
CVI: Content Validity Index
CVR: Content Validity Ratio

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RESEARCH ARTICLE

AUDIT ON COMPLETENESS OF OPERATIVE NOTES DOCUMENTATION AT A TEACHING HOSPITAL IN LAHORE PAKISTAN

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ABSTRACT

OBJECTIVE:

This study employed a baseline internal audit design to assess completeness of operative notes documentation at a teaching hospital in Lahore Pakistan.

METHODS:

This observational cross-sectional retrospective audit study utilized a standardized checklist to assess completeness of operative notes, drawing on guidelines from the Islamabad Healthcare Regulatory Authority, Punjab Healthcare Commission and the Royal College of Surgeons, after ethical approval from Institutional Ethical Review Committee of Azra Naheed Medical College, Superior University Lahore Pakistan. The audit reviewed all medical records of Department of Surgery and allied specialties from April to June 2025. A total of 227 records were retrieved; however, 24 records were excluded due to missing or damaged operative notes. The audit was conducted on 203 operative notes. The results were analyzed using SPSS version 23.

RESULTS:

A total of 203 records were assessed. Key findings included high compliance in date (191, 94.1%) and time of procedure (188, 92.6%) but patient identification was documented in only 28 (13.8%). Names of surgeon and assistant (203, 100%), operative finding (201, 99.0%), doctor signature (197, 97.0%), name of operative procedure (196, 96.6%), operative diagnosis (186, 91.6%) and details of tissue removed, added or altered (183, 90.1%) were reasonably well documented. There were gaps in type of elective/emergency procedure (54, 26.6%), prosthesis use (44, 21.9%), any extra procedure performed with reason (36, 17.7%), anticipated blood loss (32, 15.8%), complications encountered (19, 9.4%) and DVT prophylaxis (07, 3.4%).

CONCLUSIONS:

While some components of operative notes were well-documented, deficiencies persist in areas critical to patient safety and quality care. Continued measures such as revising the operative notes form, training sessions, regular audits and feedback are needed to uphold and enhance documentation practices.

KEYWORDS:
audit, operative notes, patient care, medical documentation, hospital records, Pakistan.

INTRODUCTION

Operative notes are vital records in any surgical unit and are the professional responsibility of the operating surgeon [1]. A well-documented note supports coordinated care by providing key details for the post-operative and critical care teams. These notes help guide essential decisions such as antibiotic use and thromboprophylaxis, which are often made by the surgeon during the procedure [2]. As such, the quality of operative documentation has a direct impact on patient outcomes and effective post-surgical management. Medical records serve both clinical and legal purposes, documenting the patient's interaction with healthcare services, facilitating communication among providers and support continuity of care in both hospital and community settings [2,3]. Clear documentation becomes especially critical during handovers, where poor-quality notes can lead to delays and errors [3,4]. Properly maintained records help ensure comprehensive care, provide legal protection, and are often used in research, resource planning, and quality improvement.

To recognize deficiencies in our documentation practices, we undertook a clinical audit to evaluate the quality of operative notes at our hospital. Clinical audits are a well-established tool for ensuring adherence to standards and driving improvements in healthcare delivery [5,6]. Our focus was on assessing the completeness of operative notes to identify critical areas for improvement and implement targeted interventions. Accurate and comprehensive operative notes documentation is essential for maintaining continuity of care, preventing medical errors and enhancing patient safety. Incomplete or inaccurate notes can lead to post-operative complications, medication errors and compromised patient outcomes. The rationale for our study was to transform operative notes documentation from a potential liability into a cornerstone of clinical excellence and patient-centered care.

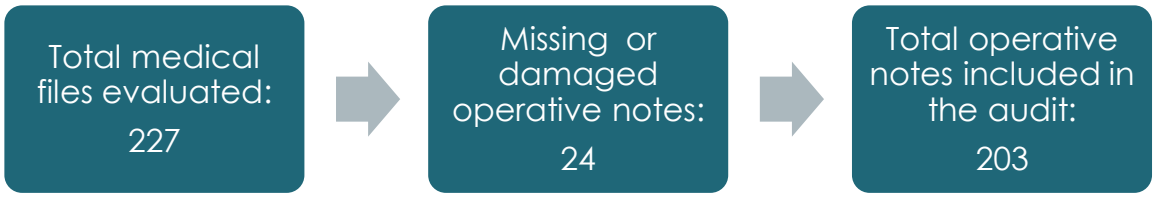
METHODOLOGY

This observational cross-sectional retrospective audit study was conducted in the Department of Surgery and Allied Specialties at Chaudhary Muhammad Akram Teaching and Research Hospital, Azra Naheed Medical College, Superior University, Lahore, Pakistan. A baseline internal audit design was employed to evaluate the completeness of operative notes documentation. Medical records that were incomplete due to missing or physically damaged operative notes were excluded from the analysis. This study was conducted after ethical approval from Institutional Ethical Review Committee of Azra Naheed Medical College, Superior University Lahore Pakistan prior to data collection, approval certificate dated April 30th, 2025. The study adhered to the ethical principles outlined in the Declaration of Helsinki (1964), as revised in 2000. Patient confidentiality and data privacy were rigorously maintained throughout the audit. No patient-identifiable information was included in the analysis and all procedures conformed to established ethical standards for healthcare research.

A standardized checklist was utilized to assess the completeness of various components of the operative notes, drawing on guidelines from both the Islamabad Healthcare Regulatory Authority (IHRA), Punjab Healthcare Commission (PHC) and the Royal College of Surgeons (RCS) [7,8,9]. The checklist consisted of 21 items, including patient identification, date and time of procedure, type of procedure (elective or emergency), names of the surgeon and assistant, name of the theater anesthetist, name of the operative procedure, type of incision, operative diagnosis, operative findings, any complications encountered, any additional procedure performed with reasons, identification of any prosthesis used along with serial numbers of implanted devices, details of tissue removed, added, or altered, details of the closure technique, anticipated blood loss, antibiotic prophylaxis, DVT prophylaxis, detailed post-operative care instructions, doctor's signature, and overall legibility of the documentation. Each item was evaluated as either 'documented' or 'not documented' for every operative note reviewed.

The audit reviewed all medical records of Department of Surgery and allied specialties from April 2025 to June 2025, employing a non-probability consecutive sampling technique. Operative notes within the study organization were mainly handwritten, with an operative note proforma available at the time of audit. The operative notes were written by the surgical residents under supervision of the consultant surgeons, in accordance with practices of the department. A total of 227 records were retrieved; however, 24 records were excluded due to missing or damaged operative notes, as illustrated in Figure 1. Consequently, the audit was conducted on a sample of 203 operative notes. The results were analyzed using SPSS version 23 by calculating the percentage completeness for each checklist item. This percentage was derived by dividing the number of operative notes that fulfilled the documentation criteria by the total number of records (203) included in the audit. Ninety-five percent confidence intervals (CIs) for proportions were calculated using the standard formula for the binomial distribution. All analyses were purely descriptive as the study was designed as a descriptive assessment of documentation completeness rather than a hypothesis-testing analysis.

FIGURE 1: AUDIT INCLUSION PROCESS



RESULTS

The audit included 203 operative notes and revealed varying levels of completeness as shown in Table 1. Key findings included high compliance in documenting date of procedure (191, 94.1%) and time of procedure (188, 92.6%) but patient identification was documented in only 28 (13.8%) of the cases. Other areas such as names of surgeon and assistant (203, 100%), operative finding (201, 99.0%), doctor signature (197, 97.0%), name of operative procedure (196, 96.6%), operative diagnosis (186, 91.6%) and details of tissue removed, added or altered (183, 90.1%) were reasonably well documented.

Moderate compliance was seen with type of incision (139, 68.5%), detailed post-operative care instructions (134, 66.0%), details of closure technique (111, 54.7%), antibiotic prophylaxis (94, 46.3%) and name of theater assistant (97, 47.8%). However, there were gaps in areas such as type of elective/emergency procedure (54, 26.6%), identification of any prosthesis used, including the serial numbers of prosthesis and other implanted devices (44, 21.9%), any extra procedure performed with reason (36, 17.7%), anticipated blood loss (32, 15.8%), complications encountered (19, 9.4%) and DVT prophylaxis (07, 3.4%).

TABLE 1: RESULTS OF AUDIT FOR COMPLETENESS OF OPERATIVE NOTES (N=203)

Checklist Item	Audit Completeness	95% Confidence Interval
Patient identification	28 (13.8%)	9.2 – 19.0
Date of procedure	191 (94.1%)	90.4 – 96.7
Time of procedure	188 (92.6%)	88.5 – 95.6
Type of procedure (Elective/Emergency)	54 (26.6%)	20.7 –33.1
Names of surgeon and assistant	203 (100%)	98.2 – 100
Name of theater anesthetist	97 (47.8%)	41.0 – 54.6
Name of the operative procedure	196 (96.6%)	93.1 – 98.5
Type of incision	139 (68.5%)	61.6 – 74.7

Operative diagnosis	186 (91.6%)	87.2 – 94.9
Operative finding	201 (99.0%)	96.5 – 99.9
Complications encountered	19 (9.4%)	5.4 – 13.4
Any extra procedure performed with reason	36 (17.7%)	12.8 – 22.6
Identification of any prosthesis used, including the serial numbers of prosthesis and other implanted devices	44 (21.9%)	16.2 – 27.2
Details of tissue removed, added or altered	183 (90.1%)	85.9 – 93.3
Details of closure technique	111 (54.7%)	47.9 – 61.5
Anticipated blood loss	32 (15.8%)	11.0 – 20.6
Antibiotic Prophylaxis	94 (46.3%)	39.5 – 53.1
DVT prophylaxis	07 (3.4%)	0.9 – 6.0
Detailed post-operative care instructions	134 (66.0%)	59.4 – 72.6
Doctor signature	197 (97.0%)	94.1 – 98.9
Legibility	187 (92.1%)	87.9 – 95.1

DISCUSSION

The present study aimed to evaluate the completeness of operative notes documentation by conducting an initial audit so that areas of improvements may be identified. The findings of this audit underscore significant variability in the quality and completeness of operative note documentation in a tertiary care teaching hospital. While some aspects, such as the names of the surgeon and assistant (100%), operative findings (99.0%), and doctor's signature (97.0%), demonstrated high compliance, other essential components were notably underreported. Patient identification, for instance, was recorded in only 13.8% of the notes, raising serious concerns about common gaps in documentation that could impact clinical communication, traceability and medico-legal accountability. In Karachi Pakistan, Khan et al. carried out a comparable study to report that the operating surgeon's name, the procedure performed and post-operative instructions were documented in 99%, 99%, and 89% of cases, respectively [10].

Accurate and comprehensive operative notes serve as a critical communication tool between surgical teams, anesthetists, and post-operative care providers. This audit reveals that several key documentation areas are frequently overlooked, particularly those concerning risk mitigation such as DVT prophylaxis (3.4%) and documentation of complications (9.4%). Moderate compliance was observed in items like type of incision (68.5%) and post-operative care instructions (66.0%). While these figures are not alarmingly low, they still indicate room for improvement. A particularly concerning observation was the limited documentation of prosthesis details and serial numbers (21.9%), which is essential for patient safety, especially in the context of implant recalls or post-operative complications. Our results align with findings of previous studies which have reported similar deficiencies [11,12,13].

The audit by Khalid et al. highlighted the need for systemic changes in surgical documentation practices in another teaching hospital from Lahore Pakistan [2]. These findings are echoed in our audit, suggesting that poor documentation is a widespread issue rather than an isolated occurrence. Lorenzetti et al. highlighted audit/feedback, regular reminders, templates and multi-faceted education as effective strategies to improve clinical documentation, especially where electronic medical records (EMRs) are lacking [14]. Similar audits outside the operative room setting have found active approaches including audit/feedback and templates to be more effective than passive ones such as printed materials in engaging clinicians [15,16,17]. Callen et al. also emphasized the importance of adaptability, system integration and stakeholder buy-in for successful implementation [18]. While many hospitals now use EMRs with clear benefits [19,20], paper-based documentation remains common in numerous hospitals, underscoring the relevance of our audit.

The lack of completeness in certain areas may be attributed to several factors including system-related reasons. Firstly, the absence of a fully enforced structured operative note template with mandatory fields may allow omission of critical

clinical details such as patient identification, thromboprophylaxis and implant information. Secondly, since most of the operative notes were made by surgical residents, there could be an issue of them not being trained adequately on the medico-legal and other medical documentation aspects. Time pressure in the busy operating theaters could also add up to incomplete documentation, especially for items perceived as non-critical or routine. From a system perspective, reliance on handwritten documentation may also contribute to variability in completeness and legibility, limiting standardization and increasing the risk of omission errors [21,22]. It is also important to note that incomplete operative reports have serious medico-legal implications. In fact, the operative report is the legal document of the surgical operation; thus, lack of certain crucial information such as patient identification, intra-operative problems, prosthesis information and prophylaxis could put the health professionals in jeopardy, especially in the event of adverse events arising from the operation [23,24].

Furthermore, the lack of completeness in certain components of operative notes is likely multifactorial and reflects both individual and systemic challenges. Contributing factors include lack of proper attention to the process of documenting during the surgical training of residents, poor enforcement of documentation principles during practice and high workload burden in the operation theatres. Failure to use structured templates with compulsory items in documentation may also lead to incompleteness since the process was mostly handwritten. Inconsistency in the supervision and provision of feedback to junior surgical residents who are mainly in charge of documentation may also contribute to it. There is need to improve the documentation process through such methods as revision of operative note proformas, incorporation of mandatory fields for critical patient safety elements, structured training programs for surgical trainees, implementation of regular audit and feedback cycles within surgical departments. Additionally, the use of EMRs with mandatory fields for critical items may also improve compliance [25,26].

There are certain limitations which should be acknowledged. Since this study was based on a retrospective analysis of documented files, our findings would be limited by any inaccuracies in the documentation, thus creating an element of information bias. Furthermore, there was a risk of observer bias when extracting information from documents; however, the use of a standardized checklist mitigated variability. This audit was carried out in one teaching tertiary hospital, and thus the findings might not necessarily be generalized to other healthcare facilities that use a different documentation process or workflow. Also, the study could have suffered from temporal limitations due to the short data collection period, which may have limited the ability to capture broader trends or variations in documentation practices over time. Future efforts could explore integrating mandatory fields into electronic health records or other systemic solutions to improve compliance. Future research should explore these aspects and consider including a wider range of healthcare facilities. Based on our findings, ongoing monitoring of documentation is recommended, with targeted efforts to improve documentation practices. Implementing more comprehensive training for healthcare professionals on detailed documentation could help address these deficiencies.

CONCLUSIONS

While some components of operative notes were well-documented in our study, major deficiencies persist in areas critical to patient safety and quality care such as patient identification, thromboprophylaxis, antibiotic information and implants/prostheses documentation. There is need for certain measures to be put in place, which include revising the form used for documenting operative notes by making sure that there are fields which are mandatory to fill for critical items; training sessions for surgeons and their trainees to ensure that documentation standards are met; and regular audits and feedback to ensure compliance. Continued efforts, targeted interventions and possibly systemic changes are needed to uphold and further enhance documentation practices, thereby supporting better clinical care and medico-legal standards.

AUTHORS' CONTRIBUTION:

AA: Conception and design; literature research; data collection, assembly and patient record assessment; final critical review and corrections.

NIB: Conception and design; data analysis and interpretation; manuscript writing; final critical review and corrections.
HN: Data collection, assembly and patient record assessment; final critical review and corrections.
IK: Literature research; data collection, assembly and patient record assessment; manuscript writing.
BW: Conception and design; literature research; data collection, assembly and patient record assessment; data analysis and interpretation; manuscript writing.
AA: Literature research; data collection, assembly and patient record assessment; manuscript writing.
MSS: Conception and design; data analysis and interpretation; final critical review and corrections.

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ETHICS STATEMENT:

This study was conducted after ethical approval from Institutional Ethical Review Committee of Azra Naheed Medical College, Superior University Lahore Pakistan prior to data collection. The study followed standards laid down in the 1964 Declaration of Helsinki, revised in the year 2000. The audit assessed medical records only, with no direct exposure to patients. Patient confidentiality and data privacy were strictly maintained throughout the study. No patient-identifiable information was used in the analysis, and the study adhered to ethical guidelines for healthcare research.

STATEMENT ON DATA AVAILABILITY:

Data generated or analysed during this study are available from the corresponding author upon reasonable request.

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RESEARCH ARTICLE

EXAMINING THE PERSPECTIVES OF NEPALESE SENIOR PUBLIC HOSPITAL MANGERS ON PROFESSIONAL CAPABILITY AND CAPACITY DEVELOPMENT: A DESCRIPTIVE QUALITATIVE STUDY

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ABSTRACT

The purpose of this paper is to identify the strategies for developing and unlocking the professional capability and capacity of senior hospital managers in Nepal. This research is the first published study outlining the self-perspectives of Nepalese senior hospital managers on their capability and capacity development.

The study utilised a qualitative descriptive design as the second phase of a larger sequential mixed methods research project. Data were collected from 11 senior hospital managers through semi-structured interviews conducted online via the Zoom online videoconferencing platform between August to October 2024.

Four key themes identified were: Stability, continuity and coherence; Practical and logistical constraints; Interference, conflict and control; and managing the mismatch between ability and expectations. Findings highlight breakages in work roles and pervasiveness of political and opportunistic individual actions alongside complex and lengthy bureaucratic processes that stifled senior public hospital managers working roles. Along with well-organised administrative procedures, appropriate compliance training for senior hospital managers is thought essential. Findings from this study may be broadly applicable to other under resourced countries in the Asia Pacific region.

KEYWORDS

Senior hospital managers; capability development; capacity development; Nepal

BACKGROUND

Well-functioning health systems enable countries to deliver the essential health care services required to maintain and improve population [1]. However, health systems do not operate effectively in isolation; they depend on a competent health management workforce to drive continuous improvement and ensure effective organisational performance [2]. In practice, many clinical practitioners, highly skilled in their clinical domains are promoted into managerial positions because of their career achievements rather than demonstrated managerial capability [3,4]. Without formal management training, these clinicians often enter leadership roles as novices, lacking the specialised competencies required for effective management practices. The scope of managerial responsibilities is extensive and in a rapidly evolving health sector, future clinical managers must demonstrate proficiency in management alongside their clinical expertise [5,6]. Yet, efforts to cultivate a competent health management workforce have been fragmented and largely insufficient, constrained by the absence of a coherent and strategically aligned framework [5,7]. Moreover, capability and capacity building initiatives across countries have been inconsistent, resulting in substantial variation in health management development and uneven progress in strengthening health management systems [5]. Such shortcomings are highly evident in under-resourced countries facing entrenched social and economic adversities, such as Nepal [7,8].

Nepalese hospital management roles have been operating without formal regulation, lacking specific registration or credentialing standards [4]. Additionally, clear competency criteria for hospital managers have yet to be properly defined as management positions are well occupied by senior doctors [4,8]. A lack of structured guidance in designing and developing training programs for hospital managers has contributed to reduced confidence in performing managerial roles. Without clear training frameworks, managers may struggle to build the necessary skills required to effectively do their job [9].

Senior hospital managers (SHMs) in this research refers to all department heads/ chiefs or managers who are at senior level and responsible for managerial functions. SHMs further reports to the hospital director, while the hospital director reports to the hospital management committee or directly to the Ministry of Health and Population, Government of Nepal [10,11]. A cross-sectional study using a survey questionnaire aimed at Nepalese SHMs was undertaken in Phase I of the study [9]. This built an understanding of the current competency levels and competency gaps identified by Nepalese SHMs in central level public hospitals in Nepal. To gain a deeper understanding regarding the barriers and enablers for SHMs to develop and demonstrate their managerial roles a follow up qualitative study was completed.

METHODS

The study utilised a qualitative descriptive design as the second phase of a larger sequential mixed methods research project aiming to identify strategies for development and unlocking of professional capability and capacity among SHMs in Nepal. Participants for this qualitative study were recruited purposively [12]. The target population was SHMs in four central level public hospitals in Nepal. Recruitment was restricted to those who completed the cross-sectional survey in the first part of the larger project. A total of eleven participants expressed interest in undertaking a research interview. After the eleventh interview the research team agreed that thematic saturation had been achieved [13].

DATA COLLECTION

Data were collected through semi-structured interviews to allow flexibility in the interview process and enable participants to freely share their experiences and perspectives [14]. The interview questions were developed based on initial findings from the previous cross-sectional survey with the aim of exploring participants' perspectives on challenges and solutions at individual, team and organisational levels. The interviews were conducted online via the Zoom online videoconferencing platform between August to October 2024 and digitally recorded to aid transcribing. Consent was received from each participant before beginning the interview and revisited on completion of the interview process. Interviews lengths ranged from 30 to 45 minutes.

DATA ANALYSIS

The interviews were transcribed verbatim in Nepalese and then translated into English. NVivo version 20 was used to for data organisation and management during the analytical process. The interview data were analysed inductively using the six phases of reflexive thematic analysis as described by Braun and Clarke (2021) [15].

[1st Author] and [3rd Author] read the interview transcripts several times to familiarise themselves with the data. [1st & 3rd Author] independently coded the first three transcripts and then met to refine and consolidate these codes. The initial codes were then shared with all members of the research team and further refined following feedback. [1st Author] completed coding of the remaining eight interviews. [1st & 3rd Author] then met to discuss and collate these codes to generate initial themes and sub-themes. These initial themes were sent for review and feedback to the broader research team [2nd, 4th, & 5th Author] with minor amendments made. The themes were then named, and key illustrative quotes or passages of text were collated to support the explanation of themes during the writing phase.

RESULTS

The explanatory qualitative study including semi-structure interviews with SHMs comprised 11 participants (six females and five males). The participants' experience across various organisations ranged from up to five years (n=1), five to 10 years (n=6) and 11-20 (n=4) years.

Four key themes and 15 associated sub-themes were identified from the analysis of transcripts. The four themes highlight structural and procedural factors that the SHMs reported to influence their capacity to effectively fulfil their roles. For brevity and flow, the results presented in this paper have been outlined at the level of the overarching themes.

STABILITY, CONTINUITY AND COHERENCE

The theme of stability, continuity and coherence centres on a belief among SHMs that their capacity to perform their role effectively was compromised by interruptions and breakages in their roles. These interruptions took several forms. The most discussed factor, that of compromised stability, was the high rate of staff turnover within the teams led by the managers. The SHMs argued that this loss of continuity and stability inhibited their capacity to promote productivity within their service.

The available manpower is frequently changed so new manpower comes. The manpower who has learned some works are transferred elsewhere... As our hospital is a government hospital, none of the employees are permanent here…. New employees must be taught about everything … this causes difficulties. (SHM2)

The SHMs indicated that the establishment of permanent positions within the healthcare system assisted in promoting continuity and stability in their organisations. Whilst a permanent position for staff members guarantees ongoing employment in the Nepalese health system, it does not ensure ongoing stability within a particular working role. The participants stated that, typically staff members in middle or senior management roles are transferred to a different institution after a period of no more than two years. One participant (SHM8) discussed an approach they take to try and ensure stability in staffing by assisting their staff members to remain within their roles for a full two years.

In our department, the duration for transfer is set for two years. For two years, no one either comes or goes by transferring someone. I also do not propose to remove someone before he reaches two years in that post in the organisation and others will not come either. (SHM8)

Instability in working roles was not only encountered with team members but also by senior managers themselves. Most participants discussed challenges and frustrations brought about by the short-term nature of their appointment to a position. This was made worse where handover processes, to ensure continuity and coherence, have not been followed.

It's because there is no hand over system or there is no such thing to show the record that the department has done this

much till now …. If one asks, then I will say but there is no documented system mentioning that what I have done. Because of that, new staff need to go from zero again and when he/she reaches hundred percent then again, the management changes. (SHM7)

This frustration reflected concerns regarding both the quality and continuity of communication during times of handover. However, the importance and, at times, poor quality of communication was also discussed by participants in relation to the normal day-to-day working of their teams. For example, when communication was lacking, negative outcomes were described as occurring more frequently.

Conversely, in situations where effective communication processes were established, coherence, continuity of care and positive team dynamics were much more likely to be assured.

Initially, there used to be conflicts because the communication was not clear. Now we all discuss the issue in the group. Those who have conflict would forward their thoughts which would make things clear. … We discuss [these conflicts]*in our daily morning session for 15 minutes with all the responsible people …. Because of this our dynamics has improved, and harmony has maximised among the staff. (SHM1)*

PRACTICAL AND LOGISTICAL CONSTRAINTS

Several practical and logistical challenges were discussed by SHMs, expressing concerns that these obstacles undermined their ability to perform their roles effectively. One of the most frequently discussed constraints was the availability and assuredness of resources. Issues with insufficient budget allocations were highlighted as a key concern that could impact upon all elements of service provision.

We also lack the budget. It is a government institution. In one financial year, our budget was short. At that time, the budget was only for salary. Apart from that, tenders were to be made to buy goods, but that could not be done. For one year, we ran the hospital despite the scarcity. (SHM10)

Examples were discussed by SHMs in which they worked proactively with their hospital directors to address issues around budget shortfalls, recognising that this approach required a degree of compromise.

If there is crucial need, we usually talk to the director or head of the hospital through an application [for increased funding]. *They listen to us about our needs. Now we should be able to prioritise the requirement as per the need. It is not necessary that we get all the things as we say but they listen to us. (SHM4)*

One of the impacts of restricted budgets was difficulties in recruiting staff, leading to an overreliance on casual employees. This was problematic because the combination of staff turnover and casual workers means that staff lack the experience or the corporate knowledge necessary to perform the job well.

Concerns with the process for resource acquisition were also identified by several participants and compounded the challenges associated with insufficient budget allocations. Participants discussed a variety of strategies that they use to manage difficulties associated with resources acquisition. For example, one participant (SHM3) spoke about the importance of ensuring cooperation between the different levels and sections of the organisation, whereas another (SHM10) indicated that initiating tendering processes in a timely manner was key maintaining enough stocks of essential resources.

To run and manage an organisation the major thing is availability of authority [authorisation] *and resources. To provide the resources, all the concerned agencies must cooperate. Only giving the instructions to implement this and that but not giving any resources does not allow us (managers) to accomplish the task effectively. We cannot fulfill our objective. (SHM3)*

Once after facing lack of budget, we planned and opened tenders timely. If we open tenders in such a timely manner, there will be no shortage of goods. (SHM10)

Three SHMs described stockpiling strategies that they employed to guarantee availability of essential resources that might be needed urgently. Two of these SHMs worked in a rural context in which receipt of resources was not always guaranteed. Interestingly one of the SMHs (SHM9) discussed the importance of stockpiling as a critical resource management strategy in rural contexts but also recognised that this approach did not necessarily reflect the most efficient use of allocated resources.

Stocks are maintained for emergency drugs, and reagents … so we are maintaining a minimum stock of 3 months in the store for diagnosis. We are managing these things that way. Now it's efficacy and efficiency have created a little problem for us. But we are managing it in some ways. (SHM9)

Indeed, several geographical barriers associated with service provision specific to rural contexts were discussed. Participants described challenges associated with transport, infrastructure, logistics and staffing, highlighting the multiplicity of factors that complicate service coordination for SHMs in remote settings.

There is great difficulty. This hospital is in the entire hilly remote area of Nepal. Sometimes we are threatened by the public in the services we provide. When there is no logistic supply at the time and sometimes there is no internet, there are no lights, such things are many. We have faced many problems when equipment machines are broken, not maintained on time. (SHM11)

INTERFERENCE, CONFLICT AND CONTROL

The theme of interference, conflict and control focuses on a belief among SHMs that their ability to perform their roles effectively are sometimes compromised by internal interference, conflict, and restrictive hierarchical structures.
Some SHM's discussed concerns that interference in their working roles was often driven by self-interest among colleagues who had political or financial motivations.

If I try to do something, another person will stop me with political interest... If I take any proposal …, let's say it has a budget of around 10 lakhs [about 1.4 times the average SHM salary]. *If there is someone else with potential financial interest, they will manipulate the person above the director. … Due to politics, it will get manipulated and diverted by the higher authorities and do not allow to work... Because there is the economic interest – this is the problem. (SHM11)*

Challenges to being able to undertake their role as well as effective teamwork were also reported to arise due to opportunistic efforts from some individuals to enhance their chances of future promotion.

Although these forms of interference were considered both unhelpful and unnecessary, SMHs who reported them also discussed employing a range of strategies to try to improve the situation, prior to an escalation to more senior levels of the organisation if required.

I try to talk face to face with the person with whom I have a conflict. But sometimes there will be such a negative perception that it is not possible to talk face to face. In that situation, I communicate on paper and sit quietly. Sometimes, if there are too many problems, I will inform the ministry above me. I inform that I have a problem because of this reason and sometimes I have tried to solve it by organising a meeting in the team. (SHM1)

Several SHMs discussed that top-down decision making, and bureaucracy stifled their creativity and autonomy. One SHM (SHM6) stated that their recommendations relating to staffing and training within their own department were often ignored or overridden by the Directors who are in a position a level above them. Given that these decisions would have a considerable bearing on the function of their team, the SMHs felt that their recommendations and preferences should have been given greater consideration.

If one has worked well in my unit and want to send them to the training as a motivation then, the director should say yes. Or if one didn't work so well and has damaged the position of the unit, if I recommend not to add this contract, the director should not add the contract. If he adds then, it will get worse…. If I recommended for their contract extension, it's not like that it will be surely implemented. I recommend it, but practically what top level wants that will only happen. (SHM6)

These SHMs argued that in instances where their recommendations were not accepted, they should be informed of the reasons underpinning the decision. When this did not occur, SHMs felt undervalued and disempowered. Beyond this, however, some SHM asserted that broader changes to organisational processes are warranted to enable greater emphasis on bottom-up planning to ensure responsiveness to specific departmental needs and greater autonomy in the fulfillment of their roles.

Some SHMs reported feeling hamstrung in their working roles due to lengthy and non-negotiable procedural requirements. One example related to the process of procurement whereby the timely purchase of required commodities products was delayed due to the lengthy bureaucratic processes.

Another SHM raised similar concerns regarding a continued reliance on slow and multi-layered bureaucratic processes and advocated for a shift towards more output focused approaches targeted at creating greater efficiency and effectiveness. SHM6 argued that the greater the number of hierarchical approval levels that are required, the greater the risk of diversion or dilution of resources eventually received.

Process must be less focused, and output should be more focused …. When I want to add some service then I need to raise a comment … I need to take it to the head of the department. The head of the department brings it to the hospital director, the hospital director brings it to the development committee, the development committee will see if it is a priority or not. The more channel is there, the more interests will be mixed. That interest can be diluted when it gets to the decision makers. (SHM6)

MANAGING THE MISMATCH BETWEEN ABILITY AND EXPECTATIONS

Several SHMs discussed frustrations with a mismatch between their abilities and the expectations in their roles. In some instances, this mismatch related to underuse of their potential when they had specific knowledge and skills that were not required in the organisation they had been transferred to. This appeared to be a by-product of the process of rotating SHMs every two to three years. One example of this was reported by SHM1, who described a diminished role scope after being transferred from a major specialist hospital to a different organisation where her extensive skill set wasn't required.

It seems that I cannot utilise the capability that I have. … Because I think that I could utilise my previous experience and the knowledge I had acquired in a bigger area …. But I cannot utilise my capacity. I believe I could work in more areas. The present space is too small. I have not been able to use my potential. (SHM1)

Conversely, SHMs discussed numerous situations in which they were expected to work beyond their professional skill sets. SHMs suggested that they are routinely expected to perform tasks that extend beyond their stated job descriptions resulting in uncertainty and anxiety as well as compromising the time required to undertake the stated managerial duties.

Regarding the job description, … it has not been disclosed clearly whether or how much even: we do not understand it well. There are times when we work beyond our responsibilities. There is not the same skilled manpower everywhere …. And it has been challenging when we need to work apart from our skills outside of our subject. It is difficult but there are situations where we must do it. (SHM5)

Even in their stated day-to-day managerial roles some SHMs reported being responsible for duties that they did not feel able to perform well.

Since we are technical people, we may be experts in technical field, but we are not experts in other things. Now, from maintenance to infrastructure, all these things we are not perfect. (SHM5)

Some SHMs pointed to the importance of education and support to grow and unlock their managerial and leadership capacity as needed to perform the variety of roles expected of them. SHMs believed, however, that opportunities for education in managerial and leadership development have been limited in Nepal, impacting negatively on their capacity to perform well.

Interestingly, SHMs suggested that the education and training provided to them are typically oriented toward disease management or technical features of their roles, rather than managerial skills development, which is often underfunded. *The budget is reduced; many needs and expectations of the organisation must be covered from a small budget. Mainly our budget allocation is based in the core function. Other non-core functions are not considered. Now there is no situation to develop our own skills. (SHM8)*

One participant identified an example of hospital management-related education provided by the Nepalese government but highlighted the limited access to and long waitlists for this education and a tendency for it to be offered to individuals in higher level of management.

SHM4 discussed a different management related training opportunity that had been undertaken and positively reviewed by a few colleagues. SHM4 believed that this training should be prioritised and provided to all SHMs in hospitals.

I have heard that the management training of the staff college is a must. Some of our colleagues have also joined that training. That should be prioritised and given to all the senior managers of the hospital. (SHM4)

The need to be provided with education to support technical updates was also identified as a priority for some participants. SHM3, for example, stated that their technical and leadership knowledge had become outdated and suggested that periodic updates were required to enhance their potential.

We have certain limitations in recent technical system. We are not updated to it … it's all about online/virtual thing and I am little lacking to such things, …. So, if the organisation could provide me with some trainings and exposure then I can be more competent … Trainings and knowledges related to current affairs and digital things could help me to better land in the leadership role. (SHM3)

There was some difference of opinion among SHMs as to the way in which ongoing education should be provided. Some expressed a view that training should be mandated and built into organisational processes, pointing to the additional burden of having to seek training for oneself.

The organisation can support by giving trainings time to time. But here we must search for it ourselves, we must make an effort. (SHM5)

Others indicated that it would be better to be able to self-select education appropriate to their own needs and allocated roles but emphasised the need for organisational support with this.

It would be helpful if the organisation could facilitate in participating at national and international conference, we could take the initiative ourselves. And if the organisation could nominate the name of staff for training, then it would be better. (SHM10)

A few SHMs stated that the absence of educational opportunities contributed to a loss of professional motivation, suggesting that it reflected a broader lack of recognition of the hard work that is put into the SHM roles.

Importantly, one participant highlighted the risks to individual mental health that can occur because of SHMs performing their role. This concern reflects a need for greater personal and pastoral support for SHMs due to the challenging and dynamic nature of their working roles.

Emotional matters and mental health also need to be focused …. How do a manager feel and his thinking also should be considered. … The manager is also under stress, now what is the reason why this happened to him... It's important to identify the cause behind it. I feel that mental health and emotional issues need to be addressed. (SHM10)

DISCUSSION

This qualitative descriptive study explored the barriers for SHMs in central level public hospitals in Nepal in demonstrating their managerial competencies and capabilities. The findings highlighted several structural and procedural factors that SHMs reported to influence their capacity to effectively fulfil their managerial roles.

This study revealed that the instability of SHMs and their working team has undermined SHMs productivity and jeopardised their ability to accomplish their managerial tasks. The short-term nature of hospital management appointments resulted in high staff turnover, unpredictability, lost productivity, shifting responsibilities and lack of handovers. The approach taken by one SHM through advocating his team member to remain in their working roles for designated period, has been helpful in ensuring stability and continuity in staffing. These findings suggest a need for a degree of predictability in the working roles of SHMs and their teams along with arrangements for structured promotion. Turato et al. (2024) reinforce this by stating that provision of structured progression opportunities reduces uncertainty and improves retention of health professionals [16].

Challenges and frustrations brought about by the short-term nature of SHMs own appointments were made worse due to the non-adherence to the existing handover processes. The lack of formal handovers reported by SHMs, needs immediate attention to implement and adhere to the existing handover protocols. As supported by the Australian Commission on Safety and Quality in Health Care [ACSQHC] (2025) executing structured handover protocols along with clear documentation systems is essential for ensuring the transmission of consistent and accurate information [17]. McCarthy (2025) also emphasises organised handover approaches can mitigate risks associated with fragmented information exchange thus strengthening patient safety [18]. Whilst Nepal Health Service Regulations, 1988 requires proper documentation of duties, responsibilities and assets during managerial transitions, [19] the actual problem is its implementation. Similarly, Nepal Public Health Service Regulations, 2020 mandates that the institutions maintain service continuity during leadership changes [20] but lack of adherence to policies and procedures have led to frustration and inefficiencies with inferior communication strategies resulting in unfavourable outcomes and decreased morale of SHMs. To assist SHMs through transition, mentorship and peer networks should be encouraged thus fostering adaptive leadership skills [21]. Kreps (2016), reinforces the importance of a collaborative work culture for empowering team members to communicate, share their thoughts, and reduce misunderstandings whilst improving patient outcomes and organisational coherence [22]. Complementing this, structured workshops on communication skills focussing on conveying crucial information confidently and precisely needs to be implemented.

Senior hospital managers' report that budget related issues have impacted their management role with the need to compromise with hospital directors. Suggestions for overcoming lack of funding include optimising resource allocation, acquiring government grants, and exploring public-private partnerships [23]. As well as this, systematic budgeting approaches and tailored allocation mechanisms are crucial in sustaining health service delivery [24]. SHMs discussed their concerns with the processes associated with resource acquisitions and viewed it to compound the challenges associated with insufficient budget allocations. Different strategies have been employed by SHMs to overcome these challenges, such as ensuring cooperation between the different levels and sections of the organisation, initiating tendering processes in a timely manner for maintaining enough stock of essential resources.

This study identified that rural location impacted management practice since the timely receipt of resources was not always guaranteed. SHMs discussed the importance of stockpiling as a critical resource management strategy in rural contexts but also recognised that this approach may not adequately reflect the most efficient use of allocated resources. This research has demonstrated that geographical difficulties, restricted transport facilities and low staff numbers impact service provision. These context-specific difficulties highlight the importance of government strategies including prioritisation of transport infrastructure, regional collaboration and targeted resource issuance to enhance healthcare [25]. The need for prioritisation of strategic investment in logistical support systems in rural and underserved areas along with multi-sectoral collaborative approaches [25] would help to address infrastructure barriers and assist SHMs in their managerial role.

The study identified that the casual staffs, competing interests and power struggles stifled autonomy of SHMs and hindered institutional coherence. Such challenges require SHMs to have critical leadership skills to navigate these challengers as well as remain proactive and resilient. This is a similar finding to Clarke et al. (2021) who emphasised political skills for aiding health managers in engaging stakeholder negotiation, utilising contextual knowledge and having impact on policy processes [26]. Similarly, Agostini et al. (2023) also identified that resilient hospital mangers are well prepared for handling both acute disturbances and chronic stressors including politically intensified situations whilst maintaining service standards [27]. The identification of strategies proactively employed by SHMs during handling difficult situations prior to needing to escalate issues to senior directors further supports the importance of developing resilient and proactive SHMs.

SHMs felt undervalued and disempowered when their recommendations regarding their department were overridden or ignored by senior directors. The lack of transparency and respect for SHM knowledge has undermined SHMs confidence eroding trust as well as reducing team morale. Psychologically safe environments are places where professional input is encouraged and respected. Such approaches are important for promoting participatory governance whilst strengthening accountability and improving cohesion of the health workforce in dynamic and resource-sensitive circumstances [28].

SHMs identified multi-layered bureaucratic processes as an impediment to effective and efficient management advocating for transition toward output-oriented and adaptive approaches. SHMs also discussed that broader changes to organisational processes are warranted to enable greater emphasis on bottom-up planning to ensure responsiveness to specific departmental needs and greater autonomy in the fulfillment of their roles. These findings highlight the significance of empowering SHMs through government reforms, prioritising transparency and flexibility in the interests of productive and accountable service delivery through the dynamic hospital system.

Broad dissatisfaction and diminished motivation among SHMs were identified due to misalignment between their professional capabilities and role expectations. Similar to previous research [4,29] access to training was limited and predominantly oriented toward clinical and technical competencies development. The need for organisational leadership development reinforces findings by Chadwell et al., 2012 [4] and Pokhrel et al., 2025 [9] who recommend a multidimensional approach, targeting management competencies, specific to the context and roles required of SHMs. Research evidence suggests mentorship, peer collaboration, and the opportunity for expert consultation are other strategies for increasing manager competency [30]. These mechanisms strengthen managerial skill acquisition, reinforcing the ability of health managers to negotiate complex health systems. At an organisational level work is required to define SHMs roles, responsibilities and expectations. Thus, policy makers, and SHMs need to develop adaptable, context-specific role descriptors as well as training and mentorship opportunities to support SHMs in their managerial role.

SHMs identified that stress when undertaking their role can impact mental health. Previous research [31] has highlighted that managers experience stress in their roles due to expectations placed on them, the level of responsibility to meet high standards with limited resources and additional bureaucracy when trying to implement change. This study did not aim to investigate psychological safety and future research in this area is recommended.

STRENGTHS AND LIMITATIONS

This study provides a rich understanding of an under-researched context related to SHMs in central level public hospitals in Nepal. The incorporation of current SHMs perspectives assures that the explored topic is connected to current real-world practice. Practical suggestions for improving the hospital management system and workforce policy development, may aid in hospital management reform. While this study does not propose detailed policy solution, a follow up study involving national-level policy makers is planned to examine the system-wide strategies and feasible interventions. This sequential approach ensures that any proposed solution s are grounded in both managerial experience and policy authority, rather than relying on generic or superficial recommendations.

Results may be impacted by personal bias. Utilising reflexivity in data interpretation along with identifying consistent patterns by comparing evolving themes, the research process reduces potential individual bias [32].

The focused scope on central level public hospitals in Nepal sets the findings within the bounds of a defined cultural and operational circumstance. Findings from this study may be broadly applicable to other under resourced countries in the Asia Pacific region. However, challenges identified in this study, including limited budgets, staff turnover, reliance on casual staff, burnout and rural service delivery issues are not exclusive to under resourced countries or LMICs, rather the distinguishing feature is the degree of resource constraint, managerial autonomy, and system capacity within LMIC settings. The intention is not to identify LMIC challenges as unique, but to provide context specific insight into how these widely recognised issues manifest within the Nepalese hospital system and how they shape the managerial capabilities of SHMs.

CONCLUSION

The findings highlight the nuanced barriers for the development and demonstration of managerial competencies and capabilities required for SHMs roles. Managerial effectiveness is multidimensional and influenced by workforce instability, practical and logistical constraints, interference and conflict and the mismatch between ability and expectations. Breakages in work roles and sabotage of formal handover processes contributes to undermining SHMs managerial performance, with a need for predictability in SHMs and their team dynamics and role accountabilities. Operational capacity of SHMs can be significantly constrained because of geographical and logistical challenges particularly those arising in rural and underserved regions. Overall government investment in infrastructure, transport, and the health management workforce is required to enable appropriate service provision.

Moreover, the pervasiveness of political and opportunistic individual actions alongside complex and lengthy bureaucratic processes requires development of well-organised administrative procedures, defined promotional pathways and appropriate compliance training. Discrepancy between organisational expectations and managerial ability lead to professional frustration, warranting documented role expectations, targeted skill development, system level support. Given the multidimensional, complex and stressful nature of SHMs roles, pastoral and personal support mechanisms are required for long-term hospital management workforce resilience.

Ethics Statement:

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RESEARCH ARTICLE

FAMILY NEEDS OF TRAUMA PATIENTS IN EMERGENCY DEPARTMENTS: A COMPARATIVE STUDY OF FAMILIES' AND NURSES' PERSPECTIVES

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ABSTRACT

OBJECTIVE:

This study aimed to compare the needs of the families of trauma patients admitted to the emergency departments (EDs) from the perspective of families and nurses.

DESIGN:

This study is a descriptive-analytical, cross-sectional study.

SETTING:

The study was conducted on trauma patients with non-acute injury with triage level 3, 4 and 5 in the EDs of seven Medical and Educational hospitals in Mazandaran (North of Iran).

MAIN OUTCOME MEASURES:

The data collection instruments included a demographic information questionnaire and the Critical Care Family Needs Inventory Emergency Department (CCFNIED). Data analysis was performed using descriptive and inferential statistics (chi-square, independent t-test, and Mann-Whitney U test).

RESULTS:

The average age is 37.90 ± 11.76 for the family members of trauma patients and 33.20 ± 6.27 for the nurses. The needs related to the communication and participation dimensions, such as talking to the physician (Mean= 3.42) and knowing about the expertise of staff caring for your relative (Mean= 3.41) received the highest scores from the perspective of family members. In addition, the needs related to the communication and comfort dimensions such as talking to the physician (Mean= 3.41), to be treated as an individual (Mean= 3.40) received the highest score from the perspective of the nurses. The mean scores of the family members' needs from the perspectives of family members and nurses do not differ significantly, although the scores of the needs of family members from the perspective of family members are higher (p = 0.336).

CONCLUSIONS:

Considering that the needs related to the communication dimension are considered important from the perspective of both families and nurses, therefore, it is suggested to do the necessary planning in this regard.

KEYWORDS

needs assessment, family, trauma, emergency service, hospital, perception, wounds and injuries

BACKGROUND

The emergency department (ED) is a challenging and stressful environment for patients, their families, and healthcare staff, causing anxiety for patients and their families [1]. The unfamiliarity of the environment and conditions make it more stressful for family members [2]. Many emergency department patients have experienced traumatic events, which are a leading cause of disability and mortality in both modern and developing societies [3].

Patient care, especially in the emergency setting, is not only about meeting the needs of the patient, but also the needs of their family [4]. Because patients need more support from their families to overcome the health turmoil, the likelihood of emotional problems for family's increases following the physical and mental crisis of hospitalized patients [5]. Some believe that families of hospitalized patients may suffer more anxiety than the patients, however physicians and nurses often focus on treatment and have limited time to address the family members and their needs [6, 7]. Identifying the needs of patients' families should be part of nursing care, which is recommended to be addressed in hospital emergency departments [8].

Meeting the needs of the patient's family in emergency departments can result in reduced stress, increased family performance in patient care, improved quality of healthcare, and facilitated patient recovery [9]. It also increases the trust of patients and their families in the ED staff and creates a healthy environment so that staff can focus on the patient. Moreover, it prevents harmful and violent behaviors of patients and their families [10].

One review study of the needs of families of adult trauma ICU patients reported needs such as information, understanding, hope, support, participation, and protection. However, this review study was limited by the lack of research focused on families of trauma patients and its reliance on subgroups of traumatic brain injury and burn injuries, suggesting further investigation of the needs of other trauma patients' families' especially in ED in future studies [11].

Additionally, in one study, the perception of family needs was different from the perspectives of emergency department staff and family members. Family members placed more importance on the need for effective communication than emergency nurses [12]. However, in another study, which examined the perception of family needs from the perspectives of emergency department staff and family members, it was observed that nurses did not consider family needs [13], which indicates that different studies have reached different results regarding the needs of families of hospitalized patients.

In general, a review of available databases showed that scant studies have been conducted on the needs of families of trauma patients admitted to the ED, especially in Iran. Most have focused on the needs of families of patients hospitalized in ICUs or not considered the type of injury or illness. It should be noted that the ED is inherently different from other departments and the needs of the families of trauma patients are different from those of other patients. Besides, the focus of the conducted studies has been more on the perspective of the families, and the nurse's perspectives still need to be fully addressed. Nurses play an important role in addressing these needs, but their perceptions of the priorities and importance of these needs may differ from those of families. Comparing perspectives and identifying agreement or disagreement between families and nurses can help nurses more consciously identify and prioritize families' real needs in their care plans. Additionally, sociocultural and geographical contexts that contribute to the diversity of needs among patients' families, can be important factors. Therefore, evidence from different cultures around the world is crucial [14].

Therefore, this study aimed to assess the needs of Iranian families of trauma patients admitted to the ED of hospitals from the perspective of families and nurses.

METHODS

STUDY DESIGN AND SETTINGS

This descriptive-analytical cross-sectional study was conducted on 441 Iranian participants (222 family members of trauma patients referred to the EDs & 219 nurses working in the EDs) from July 2022 to July 2023. The study was conducted in the EDs of seven Medical and Educational hospitals in Mazandaran (North of Iran).

INCLUSION CRITERIA

The inclusion criteria for the families of trauma patients were age ≥18, being literate, being able to speak Persian, having no physical or mental disability, two hours after the patient's admission to the ward, and accompanying trauma patients with non-acute injury with triage level 3, 4, 5 (oriented patient, aware of time and place with no need for care in the ICU). The inclusion criteria for nurses included having a bachelor's degree or higher, at least 6 months of work experience in the ED [8], and the experience of caring for trauma patients. Incomplete completion of questionnaires and withdrawal or unwillingness to participate at any stage of the study were among the exclusion criteria.

DATA COLLECTION

The instruments used in this study included a demographic information questionnaire and the Critical Care Family Needs Inventory Emergency Department (CCFNIED).

The demographic information form for family members included age, gender, marital status, education level, occupation, financial ability, relationship with the patient, residence, and living with the patient, and demographic information for nurses were their age, gender, marital status, education level, and work experience.

The CCFNIED is a questionnaire for assessing the needs of families of patients hospitalized in the ED. It consists of 40 items and four subscales: support, comfort, communication, and participation. Items are rated on a four-point Likert scale from 1 (not important) to 4 (very important). The score for each item ranges from 1 to 4. The support subscale, which has six items, addresses the needs of families for support in the ED. The score for this subscale ranges from 6 to 24. The comfort subscale with 11 items reflects the emotional, physical, and personal comfort needs of families in the ED. The score for this dimension ranges from 11 to 44. The communication subscale with 10 items focuses on mutual understanding and information exchange between family members and healthcare providers. The score for this dimension ranges from 10 to 40. Finally, the participation subscale with 13 items addresses the family members' desire to participate in the care and companionship of their patient. The score for this dimension ranges from 13 to 52. The total score for the questionnaire ranges from 40 to 160 [2, 15]. Molter (1979) first designed the Critical Care Family Needs Assessment (CCFNI) questionnaire [16]. Then, Redley (2004) modified and adapted this instrument to EDs, and developed the CCFNIED [17]. This questionnaire has an acceptable reliability and validity [5, 17]. In a study by Adineh Menbar et al. (2019) [8] in Iran, the CCFNIED was assessed and translated. Also, validity and reliability of the Persian version of the CCFNIED was confirmed satisfactorily. The Cronbach's alpha coefficient was found to be 0.86 [8].

SAMPLE SIZE & SAMPLING

To determine the sample size, data from the study by Demirtas et al. (2020) were utilized [1]. Based on the proportion of trauma patients' needs (p = 0.477), 95% confidence level (a = 0.05, Z = 1.96), and margin of error equal to 10% of p (d = 0.0477), the required sample size (441 participants, including family members of trauma patients and nurses working in the emergency department) was calculated using the following formula.

$$n = \frac{Z^2 \cdot p \cdot (1-p)}{d^2}$$

The number of nurses working in the EDs of the investigated hospitals was 260, of which 219 nurses were eligible to include the study; therefore, 219 nurses working in the EDs participated in this study. Also, the number of patients' families available was 240, of which 2 did not meet the inclusion criteria and 16 did not want to cooperate; therefore, finally 222 patients' families participated in this study.

The sampling method in this study was convenience sampling for families of trauma patients and census sampling for emergency department nurses if they met the inclusion criteria. In this way, the researcher was constantly present in the emergency departments and personally distributed and collected the questionnaires. The questionnaires were often given to the patients 2-3 hours after admission, after the patient's condition had stabilized and the family was relatively calm. This timing (2-3 hours after admission) was chosen to improve participants' ability to understand the study information, provide informed responses, and complete the questionnaire with greater accuracy and reliability. It also helped minimize the influence of the initial shock and anxiety that often occur immediately after trauma admission. The questionnaires were completed in private, without the presence of nurses. The nurses' questionnaires were also given to them during the same period of time as the researcher was present in the emergency department.

STATISTICAL ANALYSIS

After collecting the completed questionnaires, the data were fed into SPSS version 22. The findings were reported using mean ± standard deviation and frequency (percentage). Data analysis was performed using descriptive and inferential statistics (chi-square, independent t-test, and Mann-Whitney U test). The results for the needs of trauma patients were separately reported qualitatively (prevalence with 95% confidence intervals) and quantitatively (based on the questionnaire as mean with 95% confidence intervals). Since there was no normal distribution in the age variable, the nonparametric Mann-Whitney U test was used to compare the mean age between the two groups of family members and nurses. Additionally, the independent t-test was used to assess the statistical significance of the results in the age difference between the family members and nurses. Finally, the association of the reported needs of family members of trauma patients with the demographic variables of gender, age, marital status, education level, occupation, financial ability, residence, and employment were examined. The subgroup analysis was performed based on trauma patients referred to the hospitals. A p-value < 0.05 was defined as statistically significant.

ETHICAL CONSIDERATIONS

The Ethics Committee of Mazandaran University of Medical Sciences approved the study with the ethics code IR.MAZUMS.REC.1401.202. Participation was voluntary, with written informed consent obtained from all participants by main researcher (L.A), and it was explained that the information would be kept confidential. Participants were informed that they could skip any question or withdraw from the study at any time without consequence. Surveys were self-administered, with no time constraints, and support was available if needed. The families of the trauma patients were assured that withdrawal from the study would not adversely affect the treatment procedure or care. The nurses were also assured that not participating in the study would not affect their evaluation or work conditions.

RESULTS

The present study involved 222 family members of trauma patients referred to the EDs and 219 nurses working in the EDs of seven hospitals. The mean and standard deviation of the age are 37.90 ± 11.76 for the family members of trauma patients and 33.20 ± 6.27 for the nurses. Meanwhile, most of the participants from the family members were male (120 men), while there were 154 female nurses. In most cases (81.18%), the patient's sister was present as an accompaniment. Details are provided in Table 1.

TABLE 1. DEMOGRAPHIC INFORMATION OF THE FAMILIES OF TRAUMA PATIENTS AND NURSES WORKING IN THE EMERGENCY DEPARTMENTS OF TEACHING AND THERAPEUTIC HOSPITALS

Variables	Subgroups	Families of patients		Nurses		p value
Gender No. (%)	Males	120	54.05	65	29.36	<0.001
	Females	102	49.95	154	70.64	<0.001
Age (Mean±SD)		11.76±37.90		6.20±33.27		<0.001
Marital status No. (%)		151	68.02	139	63.47	0.27
Experience(Mean ±SD)	In the emergency department (month)			67.57±52.07		
Occupation No. (%)	Employee	38.81				
Relationship between the patient and the companion	Father	39	17.89			
	Mother	26	11.93			
	Sister	41	18.81			
	Brother	35	16.06			
	Child	29	13.30			
	Spouse	24	11.01			
Financial ability No. (%)	Moderate	58.37				
Residence	Urban	163	73.42			
	Rural	59	26.58			
Living in the same house as the patient (%)	Yes	142	64.55			

The results showed that the following needs received the highest scores from the perspective of family members, with the majority belonging to the communication dimension: to talk to the physician (communication dimension), to know about the expertise of staff caring for your relative (participation dimension), to be assured that the best care possible has been given to your relative (communication dimension), to feel hospital staff care about your relative (communication dimension), and to have questions answered honestly (communication dimension). In addition, the following needs received the highest scores from the perspective of nurses, with the majority belonging to the communication dimension: to talk to the physician (communication dimension), to be treated as an individual (comfort dimension), to talk to a nurse (participation dimension), to have questions answered honestly (communication dimension), and to have explanations given in understandable terms (communication dimension). It was found that the needs of the communication dimension were considered more important by both groups of family members and nurses (Table 2).

TABLE 2. THE MEAN SCORE OF NEEDS OF FAMILIES OF TRAUMA PATIENTS IN THE EMERGENCY DEPARTMENTS OF TEACHING AND THERAPEUTIC HOSPITALS FROM FAMILIES' AND NURSES' PERSPECTIVES

Needs	Item No.	Families of patients' perspectives	Mean	Item No.	Nurses" perspectives	Mean
Highest score	11	To talk to a doctor	3.42	11	To talk to a doctor	3.41
	13	To know about the expertise of staff caring for your relative	3.41	29	To be treated as an individual	3.40
	17	To be assured that the best care possible has been given to your relative	3.40	12	To talk to a nurse	3.38
	30	To feel hospital staff care about your relative	3.38	15	To have questions answered honestly	3.36

	15	To have questions answered honestly	3.38	16	To be told about transfer plans while they are being made	3.32
Lowest score	32	To be encouraged to express emotions	2.91	36	To be told about religious services	2.86
	33	To be reassured as to what normal emotional responses should be	2.90	4	To have friends and relatives with you while in the emergency department	2.77
	34	To share emotions with staff	2.87	18	To stay out of the way during your relative's care	2.76
	37	To have food and refreshments nearby	2.83	23	To be with your relative at any time	2.73
	36	To be told about religious services	2.76	21	To have a staff member with you while visiting your relative	2.57

An independent t-test was used to compare the mean scores of the family members' needs from the perspectives of family members and nurses. Table 3 shows that the mean scores of the family members' needs from the perspectives of family members and nurses do not differ significantly, although the scores of the needs of family members from the perspective of family members are higher (p = 0.33). Moreover, comparing the mean scores of the needs of patients' families in the emergency departments of teaching and medical hospitals from the perspectives of families and nurses after adjusting for age and gender variables showed that there was no significant difference (Tables 4 and 5).

TABLE 3. COMPARISON OF THE MEAN SCORES OF THE NEEDS OF FAMILIES OF PATIENTS IN THE EMERGENCY DEPARTMENTS OF TEACHING AND THERAPEUTIC HOSPITALS FROM THE PERSPECTIVES OF FAMILIES AND NURSES

Variable	Patients' families' perspective	Nurses' perspectives	p value
	Mean ± SD, 95% Confidence Intervals	Mean ± SD, 95% Confidence Intervals	0.33
The total score of the family needs	126.44±1.44, (CI: 123.59-129.29)	124.64±1.21, (CI: 122.25-127.03)	

TABLE 4. COMPARISON OF THE MEAN SCORES OF THE NEEDS OF FAMILIES OF PATIENTS IN THE EMERGENCY DEPARTMENTS OF TEACHING AND THERAPEUTIC HOSPITALS FROM THE PERSPECTIVES OF FAMILIES AND NURSES AFTER ADJUSTING THE AGE VARIABLE

Variable	Patients' families' perspective	Nurses' perspectives	p value
	Mean ± SD, 95% Confidence Intervals	Mean ± SD, 95% Confidence Intervals	0.69
Age	125.79±1.39, (CI: 123.05-128.52)	125.02±1.28, (CI: 122.48-127.55)	

TABLE 5. COMPARISON OF THE MEAN SCORES OF THE NEEDS OF FAMILIES OF PATIENTS IN THE EMERGENCY DEPARTMENTS OF TEACHING AND THERAPEUTIC HOSPITALS FROM THE PERSPECTIVES OF FAMILIES AND NURSES AFTER ADJUSTING THE GENDER VARIABLE

Variable	Patients' families' perspective	Nurses' perspectives	p value
	Mean ± SD, 95% Confidence Intervals	Mean ± SD, 95% Confidence Intervals	
Male	127.2±57.06, (CI: 123.46-131.67)	122.03±2.44, (CI: 117.13-126.93)	0.089
Female	125.25±2.01, (CI: 121.23-129.27)	125.63±1.39, (CI: 122.88-128.39)	0.87

DISCUSSION

The results of the current study and analyzing the dimensions and needs made it evident that communication, participation, support, and comfort dimensions were prioritized from the perspective of families of trauma patients hospitalized in the ED. Similarly, from the perspective of nurses, communication, comfort, participation, and support dimensions were prioritized.

Specifically, in the present study, the communication dimension (ability to talk to a physician) ranked first from both the nurses' and the families of trauma patients' perspectives, indicating its highest priority. In studies conducted to investigate the needs of patients' families from the perspectives of families and nurses in the EDs, family members reported higher scores for the communication dimension compared to nurses, indicating that they prioritized effective communication more than nurses did [12, 18]. Adineh Menbar et al. (2019) analyzed the needs of hospitalized patients' families in the EDs of hospitals in Zanjan and reported communication, participation, support, and comfort needs, respectively, as the needs of the participants [8]. Similarly, studies conducted in Turkey that examined the needs of patients' families in the EDs concluded that the communication dimension was the most prominent need expressed by families [1, 5]. By the same token, a study conducted by Fortunatti et al. (2018) showed that the greatest need of families was to establish effective communication with staff and to have hope for desirable outcomes [18]. The consistency of results from previous studies with the current study regarding the priority of the communication dimension indicates that nurses' ability to establish effective communication with patients and their families is essential for utilizing the nursing process effectively. Knowledge related to the communication process and effective communication methods is fundamental and necessary in all stages of the nursing process that provides nurses with the necessary leadership and guidance to establish effective communication with patients and their families.

In the present study, comfort needs ranked second from the perspective of nurses and fourth from the perspective of families of trauma patients, indicating their lower priority. In this regard, Büyükçoban et al. (2021) showed that families in Turkey expressed comfort needs as the lowest priority [14]. In a study conducted in Palestine, comfort needs were ranked fourth in priority [19]. This difference in the perspective of nurses and families, as well as the low priority of the comfort dimension for families, could be due to differences in the perception and direct experience of care; nurses in daily contact with patients perceive the need for comfort as an integral part of effective care, while families usually focus more on urgent and vital needs. It could also indicate that families neglect personal issues and show that they prioritize patients and their medical issues [20]. In contrast to the results of the present study and previous studies, Hasandoost et al. (2018) in a study in Qazvin concluded that comfort needs were one of the top three priorities [21]. Possible reasons for this difference include that the present study was conducted in the emergency department, while the study by Hasandoost et al. (2018) was conducted in the intensive care unit. In the emergency department, it is possible that the acute anxiety caused by trauma leads families to prioritize medical needs over personal comfort. However, recognizing and meeting personal daily needs and creating a safe and comfortable environment for rest undoubtedly reduces their anxiety and distress.

In the present study, the support dimension ranked third from the perspective of families and fourth from the perspective of nurses. The results of a study in Egypt also showed that support needs were given the lowest priority [22]. Contrary to the results in the present study, studies by Gundo et al. (2014) [23] and Abbaszadeh et al. (2024) [24] reported that the most important need from the perspective of nurses was the support dimension. Humanitarian feelings vary significantly across cultures and ethnicities, leading to differences in prioritization. Also, various factors such as the time and place of the study, compliance with hospital standards, facilities and equipment, and even different personalities of nurses could be involved in this regard. However, in both family and nurse groups, "talking to a doctor or nurse upon entering the hospital" was a component that was identified as the main need for the support dimension.

In the present study, the participation dimension ranked second from the families' perspective and third from the nurses' perspective. A study conducted in Tabriz revealed that the least expressed needs were related to the participation

dimension [24]. Family members play a significant role in the patient's well-being in the hospital through meaningful interaction with the patient and collaboration with the treatment team. Due to their access to patients and frequent contact with families, nurses can play a crucial supportive role both physically and emotionally [25]. Redley et al. (2019) conducted a study to examine similarities and differences in the fundamental needs of patients' families in the ED in three countries: Australia, South Africa, and Taiwan. The study results indicated that everyday needs in all three countries were related to the participation and communication dimensions [2]. The sensitivity of care in the ED can be mentioned as a justification for the difference between nurses' and patients' families' perspectives. Patients referring to this department often have severe conditions, and even the slightest mistake can have irreparable consequences. Therefore, nurses may have expressed participation needs as less important compared to patients' families.

LIMITATIONS

Among the limitations of this study, the reliance on self-reported data may have caused recall bias or social desirability bias. In addition, since this study was conducted in Iranian hospitals, the findings may not be generalizable to settings with different cultural, organizational, or healthcare system contexts. Also, due to the exclusion of critically ill participants (triage 1–2 and ICU-requiring patients), the findings may not be generalizable to critically ill trauma patients.

CONCLUSION

In conclusion, both groups of families of trauma patients and nurses gave more priority to the communication dimension than other dimensions. Therefore, it is necessary to focus more on improving communication between nurses and the families of patients admitted to the ED in planning nursing care. To translate this finding into practice, the following specific actions are recommended:

- Implement a structured family communication protocol in the emergency department.
- Conduct skills-based training workshops for all emergency department nursing and medical staff, focusing on family communication skills.
- Create a standard family information board in each emergency department waiting area, displaying real-time updates (e.g., “patient in triage”) to reduce uncertainty for families.

Future studies should evaluate the effectiveness of communication-focused interventions in improving family satisfaction and care outcomes.

COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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RESEARCH ARTICLE

ETHICAL NON-COMPLIANCE IN NURSING PRACTICE AS AN ORGANIZATIONAL RISK: A GOVERNANCE-ORIENTED ANALYSIS OF SUPERVISORY STRUCTURES

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ABSTRACT

OBJECTIVE:

This study aims to analyse ethical non-compliance in nursing practice through a governance-oriented perspective, focusing on how supervisory structures and organizational arrangements shape ethical conduct within health service organizations.

DESIGN:

A qualitative, document-based study employing an interpretive content analysis approach.

SETTING:

The study was conducted in a tertiary hospital, examining formal supervisory, governance, and policy documents related to nursing practice.

MAIN OUTCOME MEASURES:

Governance-related patterns associated with ethical non-compliance, including supervisory accountability, workload management, credentialing arrangements, and ethical oversight mechanisms.

RESULTS:

Four interrelated themes were identified. Ethical non-compliance was normalized under sustained workload pressure and operational demands. Supervisory accountability was fragmented across organizational units, resulting in unclear ethical oversight. Gaps between formal credentialing requirements and actual task allocation weakened professional accountability. In addition, ethical standards were often symbolically emphasized but weakly enforced in routine supervisory practice. These governance conditions collectively contributed to the routinization of ethically problematic practices in everyday nursing work.

CONCLUSIONS:

Ethical non-compliance in nursing practice is best understood as a governance-related phenomenon embedded within supervisory structures and organizational routines rather than as an individual moral failure. Addressing this issue requires strengthening supervisory accountability, integrating credentialing and clinical oversight, and embedding ethical evaluation within routine governance processes to prevent the normalization of ethical deviations in healthcare practice.

KEYWORDS

ethical non-compliance; nursing practice; supervisory governance; ethical climate; health service governance

INTRODUCTION

Ethical compliance represents a fundamental dimension of professional nursing practice and is closely associated with patient safety, dignity, and public trust in healthcare institutions. As the largest professional group within hospital systems, nurses engage in continuous ethical decision-making that shapes not only individual patient experiences but also organizational credibility and clinical outcomes [1]. International professional frameworks, such as the International Council of Nurses Code of Ethics, emphasize accountability, respect for patient autonomy, confidentiality, and professional responsibility as core ethical obligations in nursing practice [2].

Despite the widespread institutionalization of ethical codes and regulatory standards, ethical non-compliance remains a recurrent issue in hospital settings. Empirical studies have documented that ethical lapses often manifest in routine clinical activities, including inadequate communication, incomplete documentation, breaches of confidentiality, and non-adherence to professional regulations [3]. Such deviations have been linked to adverse patient outcomes, increased medico-legal risk, and erosion of trust in healthcare organizations [4].

Much of the existing literature has conceptualized ethical non-compliance primarily as an individual-level phenomenon, focusing on nurses' moral sensitivity, ethical awareness, and personal coping mechanisms. Research on moral distress and moral courage, for instance, has highlighted the psychological and emotional challenges faced by nurses when ethical values conflict with clinical realities [5,6]. While these perspectives offer important insights into individual experiences, they tend to underemphasize the organizational and governance contexts within which ethical behavior is enacted and sustained.

Increasingly, scholars have argued that ethical practice in healthcare is embedded within the broader ethical climate and governance structures of organizations. Ethical climate—defined as shared perceptions of ethically appropriate behavior and institutional support for ethical decision-making—has been shown to influence nurses' professional conduct, job satisfaction, and moral distress [7,8]. Leadership and supervision play a central role in shaping this climate, as supervisors translate institutional policies into everyday practice through monitoring, feedback, and role modeling [9].
In complex hospital environments, particularly tertiary care settings, ethical non-compliance often emerges not from deliberate misconduct but from systemic pressures. High patient acuity, staffing shortages, time constraints, and emotional fatigue can normalize deviations from ethical standards, gradually embedding them into routine clinical practice [10,11]. These conditions may weaken accountability mechanisms and blur professional boundaries, especially when supervisory oversight is inconsistent or fragmented.

Supervisory governance constitutes a critical yet underexplored mechanism in the maintenance of ethical nursing practice. Supervisors act as intermediaries between organizational policies and frontline care, shaping ethical expectations and reinforcing professional norms. Evidence suggests that weak supervisory structures and inconsistent enforcement of standards contribute to the normalization of ethical deviations, whereas structured and supportive supervision strengthens accountability and ethical compliance [12,13].

Quality improvement approaches, such as the Plan–Do–Study–Act (PDSA) cycle, have been widely applied to address clinical and organizational performance gaps, including communication failures and documentation quality. While such frameworks can support behavioral change, scholars caution that technical improvement tools alone are insufficient if they are not embedded within robust governance and ethical oversight structures [14,15]. Without attention to supervisory accountability and organizational context, improvement initiatives risk addressing symptoms rather than underlying ethical vulnerabilities.

In low- and middle-income country settings, challenges related to ethical governance may be further compounded by resource limitations, administrative fragmentation, and uneven supervisory capacity. Previous studies indicate that gaps in credentialing oversight, regulatory compliance, and monitoring systems can undermine ethical practice even when

formal policies are in place [16]. Nevertheless, empirical research examining ethical non-compliance through a governance-oriented qualitative lens remains limited, particularly in tertiary hospital contexts.

This study addresses this gap by examining ethical non-compliance in nursing practice as a supervisory governance phenomenon rather than as isolated individual failure. Using a qualitative descriptive approach based on document analysis, the study explores patterns of ethical non-compliance and the supervisory structures that shape these practices within a tertiary hospital setting. By foregrounding organizational context and governance dynamics, this research aims to contribute a nuanced and contextually grounded perspective to the international literature on nursing ethics and ethical governance.

MATERIALS AND METHODS

STUDY DESIGN AND RESEARCH PARADIGM

This study employed a qualitative research design grounded in an interpretivist paradigm to explore ethical non-compliance as an organizational phenomenon embedded within supervisory governance structures. A document-based qualitative approach was adopted to examine how ethical expectations, supervisory responsibilities, and accountability mechanisms are formally articulated and operationalized within hospital governance frameworks. This design was selected to capture institutional logics and governance practices that shape ethical conduct in nursing practice beyond individual perceptions or experiences.

STUDY SETTING

The study was conducted in a tertiary referral hospital providing comprehensive inpatient and outpatient services, including high-acuity clinical units such as emergency care, intensive care, surgical wards, oncology, pediatrics, and obstetrics. Tertiary hospitals represent complex organizational environments where high patient turnover, regulatory demands, and hierarchical supervision structures may intensify ethical governance challenges [4,10]. To reduce unnecessary localization and enhance analytical relevance, the hospital is described at an organizational level rather than by name.

DATA SOURCES AND UNIT OF ANALYSIS

The primary data sources consisted of formal supervisory and governance documents used within a tertiary hospital, including supervisory guidelines, standard operating procedures, internal policies, and ethical oversight documents relevant to nursing practice. These documents were selected because they represent authoritative organizational texts that structure supervisory practices and define ethical expectations within the institution.

The unit of analysis was the content of supervisory governance as reflected in these documents, with particular attention to how ethical responsibilities, reporting mechanisms, and supervisory roles were framed. Documents were included based on their relevance to nursing supervision, ethical oversight, and organizational accountability.

DATA COLLECTION PROCEDURES

All eligible documents were retrieved through formal permission from hospital management and the nursing supervisory unit. Prior to analysis, documents were fully de-identified to remove personal identifiers of nurses, patients, and supervisors. Each document was assigned a unique code to facilitate organization and traceability during analysis. Data collection focused on capturing the breadth of ethical issues recorded through routine governance mechanisms rather than generating new observational or interview data.

DATA ANALYSIS

Data were analyzed using a qualitative content analysis approach. Documents were read repeatedly to achieve familiarization, followed by systematic coding to identify patterns related to ethical expectations, supervisory practices, and governance mechanisms. Codes were then grouped into broader analytical categories that captured recurring governance-related themes associated with ethical non-compliance.

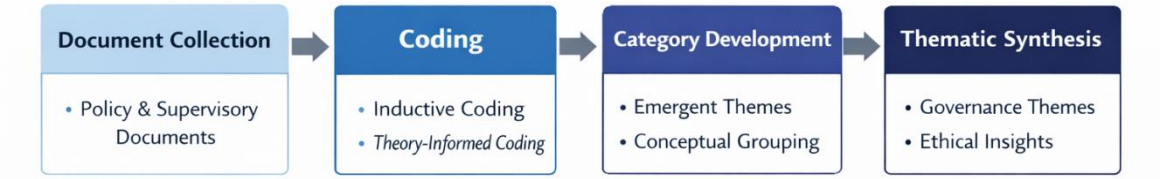
Coding was conducted using a hybrid approach that combined inductive and theory-informed strategies. Initial open coding was performed to identify recurrent patterns emerging directly from the documents, while sensitizing concepts from governance and ethical climate literature guided the interpretation of ethically relevant content. These initial codes were then compared, refined, and grouped into higher-order categories based on conceptual similarity.

Through an iterative process of abstraction and constant comparison, these categories were further synthesized into four overarching themes that represent governance-related dimensions of ethical non-compliance. This process ensured that themes were grounded in the data while also analytically aligned with the study's conceptual focus on supervisory governance.

The analytical process followed a structured sequence: document collection, data familiarization, open coding, category development, and thematic synthesis. This stepwise progression enhanced transparency and allowed traceability between raw document content and final thematic interpretations.

The analytical process was iterative, moving between the data and emerging interpretations to refine categories and ensure conceptual coherence. Throughout the analysis, attention was given to how supervisory structures and organizational routines may contribute to the normalization or regulation of ethically questionable practices within nursing work. Analytical decisions were documented in an audit trail to support transparency and dependability.

FIGURE 1. ANALYTICAL PROCESS OF DOCUMENT-BASED THEMATIC SYNTHESIS



TRUSTWORTHINESS

Several strategies were employed to enhance the trustworthiness of the study. Credibility was supported through prolonged engagement with the document corpus and iterative analytical review. Dependability was addressed by maintaining a transparent audit trail documenting analytical decisions and category development. Reflexivity was incorporated through ongoing critical reflection on the researchers' assumptions and interpretive positioning.

Peer validation was conducted with supervisory personnel to verify the factual accuracy of document interpretation. This process was limited to confirming the contextual accuracy of organizational procedures and did not involve modification of analytical categories, themes, or interpretive conclusions. Supervisory personnel had no role in shaping the analytical framework or influencing the interpretation of findings.

ETHICAL CONSIDERATIONS

The study involved analysis of existing institutional documents and did not include direct interaction with human participants. All materials were anonymized prior to analysis, and no patient identifiers were accessed. Consistent with ethical guidelines for document-based qualitative research and quality governance evaluation, the study was classified as minimal risk [16]. Formal authorization to access and analyze documents was obtained from hospital management, and confidentiality was maintained throughout the research process.

RESULTS

The findings presented in this section are derived from analysis of formal supervisory and governance documents within the hospital setting. Analysis of supervisory and governance documents indicated that ethical non-compliance in nursing practice was not incidental or isolated. Instead, it appeared as a patterned phenomenon shaped by organizational conditions, supervisory arrangements, and routine clinical pressures. Four interrelated analytical themes were identified, reflecting how ethical standards were interpreted, enacted, and, at times, compromised in daily nursing practice.

TABLE 1. ANALYTICAL THEMES OF ETHICAL NON-COMPLIANCE IN NURSING PRACTICE

Theme	Core description	Illustrative focus
Normalization of ethical deviations	Ethical non-compliance becomes routine under sustained workload pressure and operational demands.	Workload-driven prioritization, time constraints, task-oriented supervision
Fragmented supervisory accountability	Supervisory responsibilities are dispersed across units, resulting in unclear ethical oversight.	Ambiguous reporting lines, inconsistent supervisory enforcement
Credentialing and competency gaps	Discrepancies between formal credentials and actual task assignments weaken ethical accountability.	Informal task delegation, limited competency verification
Symbolic professionalism	Ethical standards are formally emphasized but weakly enforced in everyday practice.	Compliance-oriented documentation, symbolic audits

THEME 1: NORMALIZATION OF ETHICAL DEVIATIONS UNDER SUSTAINED WORKLOAD PRESSURE

Across multiple clinical units, supervisory records consistently documented ethical deviations occurring during periods of high workload and service intensity. Practices such as abbreviated patient explanations, delayed or incomplete documentation, and reduced interpersonal engagement were frequently noted. These deviations were often framed as practical adaptations to time constraints rather than as ethical concerns requiring corrective action.

Over time, repeated exposure to such conditions appeared to normalize these practices. Supervisory notes suggested that deviations were increasingly perceived as routine and unavoidable aspects of clinical work, particularly in high-acuity units. This normalization blurred the distinction between acceptable situational adjustment and ethical compromise, allowing deviations to persist without sustained reflection or intervention. Supervisory records indicated that patient communication was frequently abbreviated during high workload periods (Supervisory Report SR-03), suggesting that reduced interaction was implicitly tolerated as an operational adjustment rather than addressed as an ethical concern.

THEME 2: FRAGMENTED SUPERVISORY ACCOUNTABILITY

A second theme concerned variation in supervisory oversight and accountability mechanisms across clinical units. Documents revealed inconsistencies in the frequency, depth, and follow-up of ethical supervision. In some units, supervisors conducted regular monitoring and provided immediate feedback, while in others, supervision was sporadic and largely reactive.

This fragmentation resulted in uneven expectations regarding ethical compliance. Nurses working in different units received divergent signals about the importance of ethical standards, depending on supervisory practices. Where follow-up was inconsistent, ethical deviations were less likely to be addressed systematically, weakening accountability and reinforcing selective compliance. Documents highlighted that follow-up actions on ethical issues were inconsistent, with some units lacking documented feedback mechanisms (Audit Record AR-02), indicating variability in supervisory enforcement.

THEME 3: ADMINISTRATIVE–CLINICAL DISCONNECTION IN CREDENTIALING AND LEGAL COMPLIANCE

Supervisory documentation frequently identified gaps in credentialing and legal compliance, including expired professional licenses and incomplete clinical authorization records. These issues were rarely associated with deliberate neglect. Instead, they reflected unclear responsibility and limited coordination between administrative systems and clinical supervision.

Credentialing compliance was often treated as an administrative requirement rather than an integral component of ethical nursing practice. Supervisors noted that nurses were frequently unaware of documentation lapses until audits or external reviews occurred. This administrative–clinical disconnection reduced the visibility of legal compliance within everyday supervisory processes and weakened its integration into ethical oversight. Administrative records noted instances of expired professional licenses that were only identified during periodic audits (HR Compliance Log HR-01), reflecting weak integration between administrative and clinical oversight.

THEME 4: SYMBOLIC PROFESSIONALISM AND SUPERFICIAL COMPLIANCE

The final theme highlighted a tendency toward symbolic expressions of professionalism. Supervisory notes frequently emphasized visible indicators such as uniform adherence, punctuality, and formal appearance. While these elements were consistently monitored, deeper ethical dimensions such as respectful communication, confidentiality, and patient-centered explanation received less systematic attention.

Corrective actions often focused on surface-level compliance, reinforcing observable behaviors without addressing underlying ethical reasoning or professional judgment. This emphasis on symbolic professionalism risked reducing ethical practice to a checklist of appearances rather than fostering reflective and substantive ethical engagement. Supervisory notes emphasized visible compliance indicators such as punctuality and uniform adherence (Policy Monitoring Record PM-04), while limited documentation addressed deeper ethical dimensions such as patient communication or confidentiality.

TABLE 2: MAPPING THEMES TO REPRESENTATIVE CODES AND DOCUMENT SOURCES

Theme	Representative Codes	Document Source	Document Reference
Normalization of ethical deviations	Workload pressure, delayed documentation	Supervisory reports	SR-03
Fragmented supervisory accountability	Inconsistent monitoring, unclear roles	SOP & audit reports	AR-02
Credentialing and competency gaps	Expired licenses, incomplete authorization	HR & compliance records	HR-01
Symbolic professionalism	Appearance compliance, checklist audits	Policy documents	PM-04

SYNTHESIS OF FINDINGS

Taken together, these themes illustrate that ethical non-compliance in nursing practice was shaped primarily by organizational and supervisory dynamics rather than by individual moral failure. Sustained workload pressure normalized deviations, fragmented supervision weakened accountability, administrative gaps undermined legal compliance, and symbolic professionalism displaced deeper ethical reflection. The interaction of these factors created conditions in which ethical standards were unevenly enacted and inconsistently reinforced across clinical units.

DISCUSSION

This study advances understanding of ethical non-compliance in nursing practice by framing it as a governance-related phenomenon embedded within supervisory structures and organizational routines, rather than as isolated individual shortcomings. The findings, derived from formal supervisory and governance documents within a single tertiary hospital, demonstrate that ethical conduct is collectively shaped through everyday supervision, leadership signals, and institutional priorities. This reinforces the view that ethics is not solely an individual responsibility but an organizational outcome grounded in ethical climate and governance arrangements [7,9,12].

The normalization of ethical deviations under sustained workload pressure illustrates how organizational constraints recalibrate ethical boundaries. In high-acuity settings, time scarcity and competing demands appeared to legitimize abbreviated communication and delayed documentation as pragmatic responses. While previous studies have linked such patterns to moral distress and ethical accommodation [5,6,10], this study shows that normalization is reinforced through supervisory tolerance and inconsistent feedback, contributing to the routinization of ethical drift within governance processes.

Fragmented supervisory accountability emerged as a key structural vulnerability. Variability in monitoring and follow-up practices weakened the authority of ethical standards and produced uneven expectations regarding compliance. This aligns with evidence that ethical climate depends on leadership consistency and the visibility of ethical priorities in routine supervision [7,9,12]. Where supervisory structures lack clarity, ethical norms become negotiable, diminishing accountability and increasing selective compliance [4,17].

The administrative–clinical disconnection observed in credentialing and legal compliance underscores the importance of integrated governance systems. When oversight responsibilities are fragmented, compliance may be perceived as a bureaucratic requirement rather than an ethical obligation. Consistent with prior research [15,16,18], weak integration reduces the visibility of legal compliance within everyday supervisory practices.
The tension between symbolic professionalism and substantive ethical practice reflects broader organizational ethics concerns. Emphasis on visible indicators may create an appearance of professionalism while diverting attention from deeper ethical dimensions such as communication, autonomy, and confidentiality. Similar patterns have been reported in checklist-oriented oversight systems [3,8].

Ethical practice may also be shaped by cultural norms, interpersonal relationships, and hierarchical dynamics, although these were not examined in this study. Future research using observational or interview-based methods may provide a more comprehensive understanding.

This study has strengths in its document-based qualitative approach and governance-oriented lens, but is limited to formal documents within a single tertiary hospital. Informal practices and real-time interactions were not captured, and findings should be interpreted as contextspecific.

From a governance perspective, strengthening ethical practice requires more than periodic ethics training. Practical interventions include structured supervisory audits, integrated credentialing dashboards, and routine ethical review checkpoints within performance monitoring systems [20]. These findings suggest that quality improvement approaches such as the Plan–Do–Study–Act (PDSA) cycle require strong integration with governance structures and supervisory accountability to effectively address ethical non-compliance.

Future research should examine how different governance models influence ethical practice across settings and how reforms affect the sustainability of ethical standards over time.

CONCLUSION

Based on the analysis of formal governance and supervisory documents, this study demonstrates that ethical non-compliance in nursing practice is not merely an individual moral issue but a governance-related phenomenon embedded within supervisory structures and organizational routines. The findings show that sustained workload pressure, fragmented supervisory accountability, administrative–clinical disconnection in credentialing, and the emphasis on symbolic professionalism collectively contribute to the normalization of ethically problematic practices in everyday clinical work.

These results highlight that ethical practice in healthcare organizations is shaped by system-level conditions rather than solely by individual ethical awareness. Weak integration between supervisory, administrative, and regulatory functions

reduces the visibility and enforcement of ethical standards, allowing deviations to become routine and implicitly accepted within clinical environments.

From a governance perspective, addressing ethical non-compliance requires more than reinforcing professional codes or providing periodic ethics training. Practical interventions should include strengthening supervisory accountability through structured audit mechanisms, integrating credentialing and clinical oversight via digital governance systems, and embedding routine ethical evaluation within performance monitoring processes. These measures are essential to prevent the normalization of ethical deviations and to ensure that ethical standards are consistently enacted in daily nursing practice.

Overall, this study underscores the importance of governance-oriented approaches in sustaining ethical practice within complex healthcare systems. Strengthening supervisory structures and aligning organizational processes with ethical oversight are critical steps toward building a more accountable, transparent, and ethically resilient healthcare environment.

CONFLICT OF INTEREST

The author declares that this research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AI STATEMENT

AI-assisted tools were used solely for language editing and did not contribute to data analysis, interpretation, or the generation of findings.

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RESEARCH ARTICLE

HEALTHCARE SYSTEM CAPACITY, EFFICIENCY AND OBSTACLES SINCE CHINA'S 2009 REFORM: AN INTEGRATED TIME-SERIES ASSESSMENT OF REGIONAL DISPARITIES

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ABSTRACT

BACKGROUND

In 2009 China launched a new round of healthcare reform. This study aims to comprehensively evaluate the service capacity and efficiency of the Chinese healthcare system at both the national and regional levels since the reform's inception.

METHODS

We collected ten indicators of healthcare service capacity and efficiency from the China Health and Family Planning Statistical Yearbook and the China Health Statistical Yearbook for the period 2009-2023. This study employs the entropy weight method and the obstacle degree model in an integrated approach to comprehensively evaluate performance and diagnose the specific obstacles that constrain it.

RESULTS

Over the 16 years since the healthcare reform, the levels of healthcare service capacity and efficiency have generally shown an upward trend at the national level and across the eastern, central, and western regions. Specifically, the highest performance was observed in 2023, while the lowest was recorded in 2009. The main factors influencing healthcare service capacity and efficiency in China were identified as Inpatient Surgeries, Health Personnel, Hospital Beds, Medical Institutions, Average Length of Stay, and Total Patient Visits. However, the specific obstacle factors varied marginally among the national, eastern, central, and western regions.

CONCLUSIONS

Based on our comprehensive evaluation, it has been confirmed that healthcare service capacity and efficiency in China have demonstrated a pattern of gradual improvement since the 2009 healthcare reform. However, against the backdrop of ongoing socioeconomic development, demographic shifts, and other influencing factors, the Chinese government should continue to enhance healthcare capacity and efficiency nationwide to address the trend of diversifying future healthcare demands.

KEYWORDS

healthcare system; capacity and efficiency; obstacles; time-series

BACKGROUND

The Chinese Government has always prioritized the reform of the healthcare system [1]. In 2009, China launched its landmark healthcare reform through the Opinions of the Central Committee of the Communist Party of China and the State Council on Deepening the Reform of the Medical and Health System (Zhongfa [2009] No. 6). This ten-year plan aimed for universal basic healthcare coverage by 2020, with key efforts focused on expanding insurance, strengthening primary care, establishing an essential medicines system, improving public health services, and advancing public hospital reforms [2,3]. Over the past ten years, the reform has achieved remarkable outcomes [3,4]: China's healthcare service system has been steadily improved, universal health insurance coverage has been nearly fully achieved, the capacity of primary healthcare services has been consistently strengthened, and the equity in basic public health services has been further enhanced.

Despite the remarkable achievements in China's healthcare reform, significant challenges persist, driven by evolving socioeconomic conditions [5], demographic shifts [6], deteriorating environmental factors [7], changes in the disease spectrum [8], accelerated urbanization, rapid advances in medical technology, and the population's growing multi-tiered health demands. First, China's population aging is intensifying [9-11]. Projections indicate that by 2050, the population aged 60 and above will reach 522 million, while those aged 80 and above will total 133 million [12]. This profound demographic shift toward an older population structure is exacerbating pressure on the health insurance system and driving increased demand for healthcare and long-term care services.

Second, China's rapid socioeconomic development has been accompanied by a marked shift in its disease spectrum, evolving from a predominance of communicable diseases to a dual burden of both communicable and non-communicable diseases (NCDs) [13]. This transition presents substantial challenges to the healthcare system, necessitating long-term management strategies for NCDs and integrated approaches for the prevention and treatment of communicable diseases.

Third, China's ongoing urbanization has accelerated the demand for healthcare services and insurance coverage among rural and migrant populations [14]. This necessitates an integrated urban-rural and regionally coordinated healthcare system that ensures equitable access to basic medical security and continuous health services for these groups. Fourth, although the Chinese government has long been committed to optimizing the structure of healthcare resource allocation across the country and has implemented multiple initiatives to promote a more balanced distribution, significant regional disparities persist [15-18]. Gaps in the allocation of medical resources and variations in healthcare service capacity between regions still need to be further narrowed [19-20].

Confronted with these challenges, China's healthcare reform remains an ongoing and challenging endeavor, requiring the government and relevant authorities to implement comprehensive, systematic, and sustained reforms. Therefore, scientifically evaluating and analyzing the capacity and efficiency of China's healthcare services since the 2009 reform is crucial for health planners and policymakers. Such analysis will help health administrations adopt targeted measures to address existing issues and further optimize the national health system. To this end, this study collects data on healthcare service capacity and efficiency at both national and regional levels following the 2009 reform, longitudinally assesses the performance of China's health system from 2009 to 2023, and explores potential strategies for enhancing healthcare capacity and efficiency.

METHODS

DATA SOURCES

China's new healthcare reform was launched nationwide in 2009. Accordingly, this study collected indicator data for evaluating medical service capacity and efficiency in China from the period following 2009. The data for the years 2010-2012 were obtained from the China Health Statistical Yearbook; data for 2013-2017 were sourced from the China Health

and Family Planning Statistical Yearbook; and data for 2018-2024 came from the China Health Statistics Yearbook. These are the same yearbook, with the name changes due to the restructuring of national health institutions. Since the yearbooks compile statistical data from the preceding year, the study ultimately covers and analyzes indicator data for the period 2009-2023. The data encompass 31 provincial-level regions in mainland China, excluding Hong Kong, Macao, and Taiwan Province. The China Health Statistical Yearbook adopts the following regional classification: Eastern China comprises 11 provincial-level divisions, including Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan. Central China consists of 8 provinces: Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan. Western China encompasses 12 provincial-level divisions, namely the Inner Mongolia Autonomous Region, Guangxi Zhuang Autonomous Region, Chongqing, Sichuan, Guizhou, Yunnan, Tibet Autonomous Region, Shaanxi, Gansu, Qinghai, Ningxia Hui Autonomous Region, and Xinjiang Uygur Autonomous Region.

In accordance with the China National Health Statistics Survey System, all healthcare institutions at all levels and of all types, including hospitals, primary healthcare institutions, specialized public health institutions, and other healthcare institutions, are required to submit data related to medical services. These institutions report data through the National Health Statistics Network Direct Reporting System. The state mandates that the submitted data must be truthful, accurate, complete, and timely. After hierarchical review by health administrative departments at various levels, the National Health Commission is responsible for the final review and release of the national health statistics data.

INDICATOR SELECTION

The selection of scientific and rational indicators is crucial for evaluating medical service capacity and efficiency in China. The indicators in this study were chosen based on the following key considerations [21,22]: First, the representativeness and sensitivity of the indicators were taken into account. Drawing on the indicator selection practices used in similar studies on medical service capacity and efficiency evaluation in China, the choice of indicators in this research is guided by evidence-based approaches. Second, the selection adheres to fundamental principles such as scientific soundness, comprehensiveness, and data accessibility. Specific indicators were chosen from the medical service capacity and efficiency sections of the China Health Statistical Yearbook, China Health and Family Planning Statistical Yearbook, and China Health Statistics Yearbook. Based on the above principles and rationale, a comprehensive indicator system for evaluating medical service capacity and efficiency in China was constructed. This system consists of three hierarchical levels: the objective layer, the criterion layer, and the indicator layer (Table 1).

TABLE 1. A COMPREHENSIVE INDICATOR SYSTEM FOR EVALUATING MEDICAL SERVICE CAPACITY AND EFFICIENCY IN CHINA.

Objective layer	Criterion layer	Indicator layer	Indicator Naming	Attribute
Evaluating medical service capacity and efficiency	Healthcare Resources	Number of Medical Institutions	X1	Positive
		Number of Hospital Beds	X2	Positive
		Number of Health Personnel	X3	Positive
	Healthcare Services	Total Patient Visits	X4	Positive
		Outpatient and Emergency Visits	X5	Positive
		Hospital Discharges	X6	Positive
		Inpatient Surgeries	X7	Positive
	Healthcare Efficiency	Average Length of Stay	X8	Negative
		Bed Occupancy Rate	X9	Positive
		Daily Patient Load per Physician	X10	Positive

THE ENTROPY METHOD

The Entropy Method is an objective weighting approach originally proposed by Shannon and Weaver (1947) and later advanced by Zeleny (1982) [23]. Its fundamental principle involves evaluating the dispersion degree of indicators through the calculation of their entropy values. Specifically, a smaller entropy value for an indicator reflects greater data variability, which in turn conveys more useful information and carries greater significance in comprehensive evaluation systems. The specific calculation steps of the entropy weight method are as follows [24-27]:

Step 1: Data Standardization

Assuming there are n evaluation indicators and m evaluation years, the original data is first subjected to normalization and forward processing according to Equations (1) and (2).

For positive indicators:

$$Y_{ij} = \left\{ \frac{M_{ij} - min M_{ij}}{max M_{ij} - min M_{ij}} \right. \quad (1)$$

For negative indicators:

$$Y_{ij} = \left\{ \frac{maxM_{ij} - M_{ij}}{max M_{ij} - min M_{ij}} \right. \quad (2)$$

Among them, M_{ij} represents the value of year (i) for indicator M_j, $maxM_{ij}$ denotes the maximum value of indicator M_j across all years (i), $minM_{ij}$ denotes the minimum value of indicator M_j across all years (i), and Y_{ij} represents the standardized indicator value after processing.

Step 2: Calculation of Characteristic Proportions:

Calculate the relative proportion P_{ij} of the *i-th* indicator value under the *j-th* indicator.

$$P_{ij} = \frac{Y_{ij}}{\sum_{j=1}^{n} Y_{ij}} \quad (3)$$

Step 3: Calculation of the Entropy Value e_j for the *j-th* Indicator

$$e_j = -k \sum_{i=1}^{m} P_{ij} \ln(P_{ij}), k = 1/\ln m \quad (4)$$

Where k=1/lnm>0 is a normalization constant ensuring [0, 1].

Step 4: Calculation of the Divergence Coefficient g_j for the *j-th* Indicator

$$g_j = 1 - e_j \quad (5)$$

Step 5: Determination of Indicator Weights

$$w_j = g_j / \sum_{j=1}^{n} g_j \quad (6)$$

WEIGHTED TOPSIS METHOD

As a classical multi-attribute decision-making approach, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was initially proposed by Hwang and Yoon in 1981[28]. The fundamental principle of this method involves identifying the optimal and worst solutions from a finite set of alternatives based on a normalized original data matrix, followed by calculating the relative closeness of each evaluation object to these ideal solutions for comprehensive assessment. The specific procedural steps are outlined as follows [29-30]:

Step 1: Construction of the Initial Evaluation Matrix

Assume there are *m* alternatives to be evaluated against *n* criteria, forming an initial evaluation matrix $X=(x_{ij})m\times n$, where represents the performance value of alternative *i* with respect to criterion *j*.

Step 2: Normalization of the Decision Matrix

The normalized matrix is constructed using Equation (7).

$$Z_{ij}=\frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}{}^{2}}} \quad (7)$$

Step 3: Construction of the Weighted Normalized Matrix

The normalized matrix is weighted using the entropy weight method(w_j). Assuming the weighted matrix is denoted as V_{ij}, it is calculated as follows:

$$V_{ij}=w_j X_{ij} \quad (8)$$

Step 4: Determination of the Ideal and Negative-Ideal Solutions

$$v_j^{+}=\left(max\, v_{ij}\,/\,i=1,2,3,\ldots,n\right)=\left(v_1^{+},v_2^{+},v_3^{+},\ldots,v_n^{+}\right) \quad (9)$$

$$v_j^{-}=\left(min\, v_{ij}\,/\,i=1,2,3,\ldots,n\right)=\left(v_1^{-},v_2^{-},v_3^{-},\ldots,v_n^{-}\right) \quad (10)$$

Step 5: Calculation of Separation Measures

The Euclidean distances of each alternative from the ideal and negative-ideal solutions are calculated:

$$D_i^{+}=\sqrt{\sum_{j=1}^{m}\left(v_{ij}-v_j^{+}\right)^2} \qquad i=1,2,3,\ldots,n \quad (11)$$

$$D_i^{-}=\sqrt{\sum_{j=1}^{m}\left(v_{ij}-v_j^{-}\right)^2} \qquad i=1,2,3,\ldots,n \quad (12)$$

Step 6: Calculation of Relative Closeness to the Ideal Solution

$$C=\frac{D^{-}}{D^{+}+D^{-}} \quad (13)$$

The C-value indicates the relative closeness of each annual Euclidean distance to both the positive and negative ideal solutions, with its value ranging between 0 and 1. A higher numerical value signifies better performance.

OBSTACLE DEGREE MODEL

The Obstacle Degree Model (ODM) constitutes a methodological framework for assessing impediment effects through systematic deconstruction at the system level [31]. Developed upon comprehensive evaluation architectures, this model enables the identification of critical elements constraining system functionality. The core theoretical premise of ODM involves quantifying the obstructive impact of individual indicators on system development through precise measurement of deviation between observed values and ideal benchmarks. The main procedural formulas of the model are as follows [32-34]:

Step 1: Calculate Factor Contribution

$$F_j=w_j\times W_j \quad (14)$$

Where w_j represents the weight obtained through the entropy weight method, while W_j denotes the weight of the criterion layer.

Step 2: Compute Deviation Degree

Calculate the deviation degree of the *j-th* indicator in the *i-th* year.

$$I_{ij} = 1 - X_{ij} \quad (15)$$

Step 3: Determine Obstacle Degree

Compute the obstacle degree (Oij) for each evaluation indicator.

$$Q_{ij} = \frac{F_j I_{ij}}{\sum_j F_j I_{ij}} \times 100\% \quad (16)$$

The obstacle degree is calculated by integrating the factor contribution and the deviation degree, reflecting the extent to which each indicator hinders system development.

DATA ANALYSIS

MATLAB (Version R2020b; MathWorks, Natick, MA, USA) was employed to conduct analyses based on the Entropy Weight Method, Weighted TOPSIS, and the Obstacle Degree Model. The significance threshold was established at $p < 0.05$.

RESULTS

THE ENTROPY WEIGHT METHOD

The entropy weight method was applied to calculate the weight values of the ten evaluation indicators (X1-X10) under Healthcare Capacity and Efficiency for the national level as well as for the eastern, central, and western regions. We observe discernible regional variations in the assigned weights of the ten evaluation indicators (X1–X10) under Healthcare Capacity and Efficiency. For instance, at the national level, indicator X7 carries the highest weight (w = 0.1518), while X10 is assigned the lowest (w = 0.0527). In contrast, although X7 remains the most heavily weighted indicator in the western region (w = 0.1130), X1 receives the least weight (w = 0.0417). The complete set of entropy values (e), utility values (g), and weights (w) for all 10 indicators across the national, eastern, central, and western regions is reported in Table 2, with corresponding visualizations in Figure 1.

TABLE 2. ENTROPY WEIGHT METHOD CALCULATIONS FOR INDICATOR WEIGHTS OF HEALTHCARE CAPACITY AND EFFICIENCY.

Country/Region		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
National	e	0.9351	0.9148	0.9070	0.9376	0.9376	0.9396	0.8879	0.9173	0.9377	0.9473
	g	0.0649	0.0852	0.0930	0.0624	0.0624	0.0604	0.1121	0.0827	0.0623	0.0527
	w	0.0879	0.1154	0.1260	0.0846	0.0846	0.0819	0.1518	0.1120	0.0844	0.0714
Eastern Region	e	0.8909	0.9177	0.9078	0.9402	0.9402	0.9304	0.8851	0.9204	0.9375	0.9449
	g	0.1091	0.0823	0.0922	0.0598	0.0598	0.0696	0.1149	0.0796	0.0625	0.0551
	w	0.1390	0.1048	0.1175	0.0761	0.0762	0.0887	0.1464	0.1014	0.0797	0.0702
Central Region	e	0.9227	0.9112	0.9031	0.9379	0.9379	0.9436	0.8932	0.9082	0.9353	0.9332
	g	0.0773	0.0888	0.0969	0.0621	0.0621	0.0564	0.1068	0.0918	0.0647	0.0668
	w	0.0999	0.1148	0.1253	0.0802	0.0802	0.0729	0.1380	0.1187	0.0836	0.0864
Western Regions	e	0.9583	0.9150	0.9072	0.9278	0.9279	0.9429	0.8870	0.9187	0.9374	0.9487
	g	0.0417	0.0850	0.0928	0.0722	0.0721	0.0571	0.1130	0.0813	0.0626	0.0513
	w	0.0572	0.1166	0.1273	0.0990	0.0988	0.0784	0.1550	0.1115	0.0858	0.0703

FIGURE 1: PIE CHARTS OF TEN EVALUATION INDICATORS' WEIGHTS ACROSS THE NATIONAL, EASTERN, CENTRAL, AND WESTERN REGIONS.

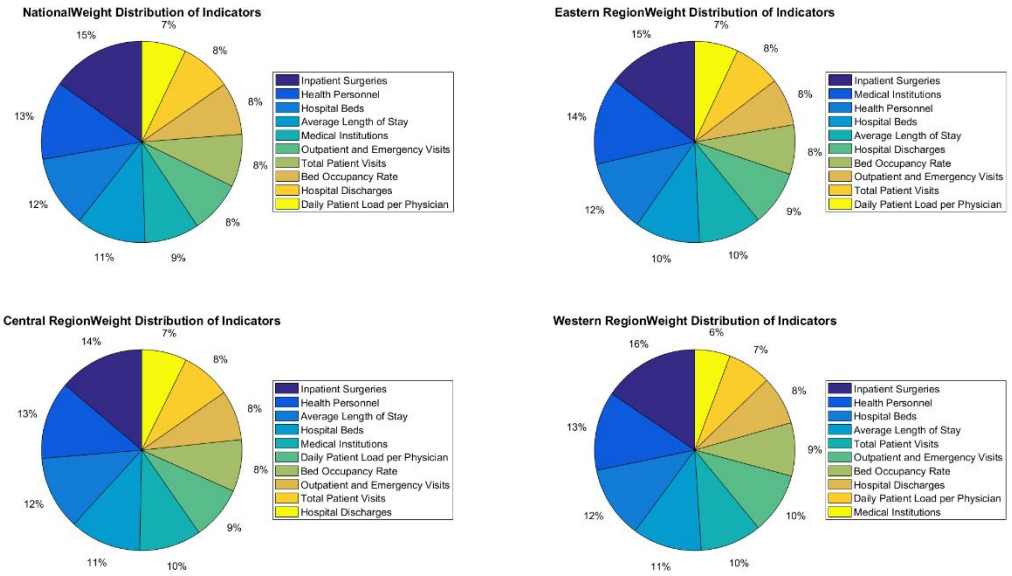


Figure 1 presents a series of pie charts illustrating the weight distributions of ten evaluation indicators (X1-X10) across the nation, eastern, central, and western regions. Each chart uses distinct colors to represent the proportional weights of different indicators. For instance, in the "National Weight Distribution of Indicators" chart, yellow corresponds to "Daily Patient Load per Physician," blue to "Health Personnel," and green to "Outpatient and Emergency Visits." Similar color schemes and interpretations apply to the regional charts for the eastern, central, and western areas.

The analysis reveals that the weight distributions of the ten evaluation indicators vary across regions, indicating that each indicator contributes different levels of meaningful information depending on the geographic context. These region-specific weight structures provide a valuable foundation for conducting comprehensive evaluations with enhanced accuracy and relevance.

WEIGHTED TOPSIS METHOD

In accordance with the steps of the weighted TOPSIS method, we computed the comprehensive evaluation scores (C-values) for the national, eastern, central, and western regions, and subsequently performed a ranking based on these values. While some differences exist in Healthcare Capacity and Efficiency across regions, their ranking trends remain largely similar. The detailed results are presented in Table 3 and Figure 2.

TABLE 3. EVALUATION OF HEALTHCARE CAPACITY AND EFFICIENCY IN CHINA SINCE THE 2009 HEALTHCARE REFORM USING THE WEIGHTED TOPSIS METHOD.

Year	National		Eastern Region		Central Region		Western Regions	
	C	*Rank*	*C*	*Rank*	*C*	*Rank*	*C*	*Rank*
2009	0.1825	15	0.1996	15	0.1483	15	0.1684	15
2010	0.2186	14	0.2294	14	0.1891	14	0.2037	14
2011	0.2695	13	0.2690	13	0.2596	13	0.2564	13
2012	0.3470	12	0.3353	12	0.3394	12	0.3339	12
2013	0.4007	11	0.3783	11	0.3946	11	0.4040	11
2014	0.4543	10	0.4290	10	0.4496	10	0.4518	10

2015	0.4791	9	0.4494	9	0.4877	9	0.4912	9
2016	0.5239	8	0.4925	8	0.5196	8	0.5248	8
2017	0.5771	6	0.5489	7	0.5667	6	0.5866	7
2018	0.6238	5	0.6021	5	0.5996	5	0.6373	5
2019	0.7023	2	0.6733	2	0.6646	4	0.7196	2
2020	0.5697	7	0.5703	6	0.5357	7	0.5982	6
2021	0.6648	4	0.6625	4	0.6674	3	0.6694	4
2022	0.6712	3	0.6729	3	0.6907	2	0.6838	3
2023	0.8255	1	0.8284	1	0.8366	1	0.8236	1

FIGURE 2. MEDICAL SERVICE CAPACITY EVALUATION (2009-2023) FOR THE NATIONAL, EASTERN, CENTRAL, AND WESTERN REGIONS.

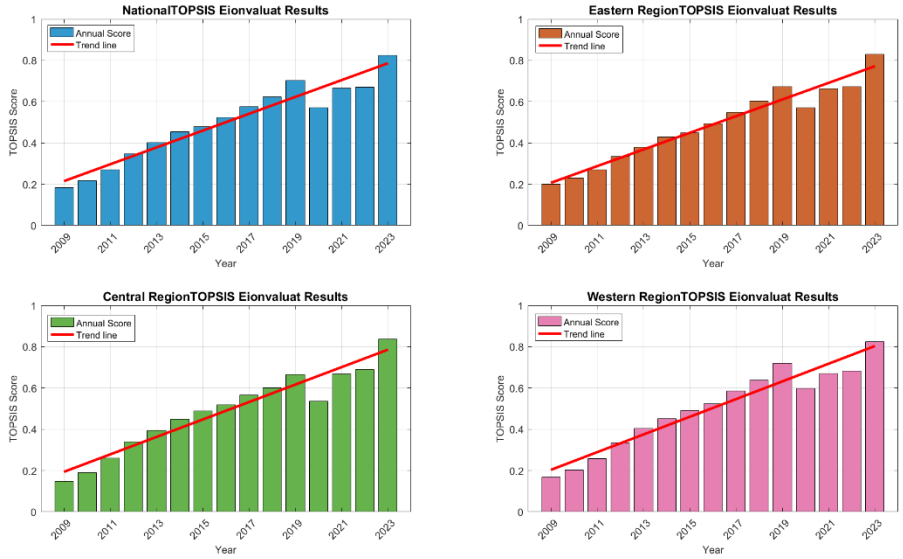
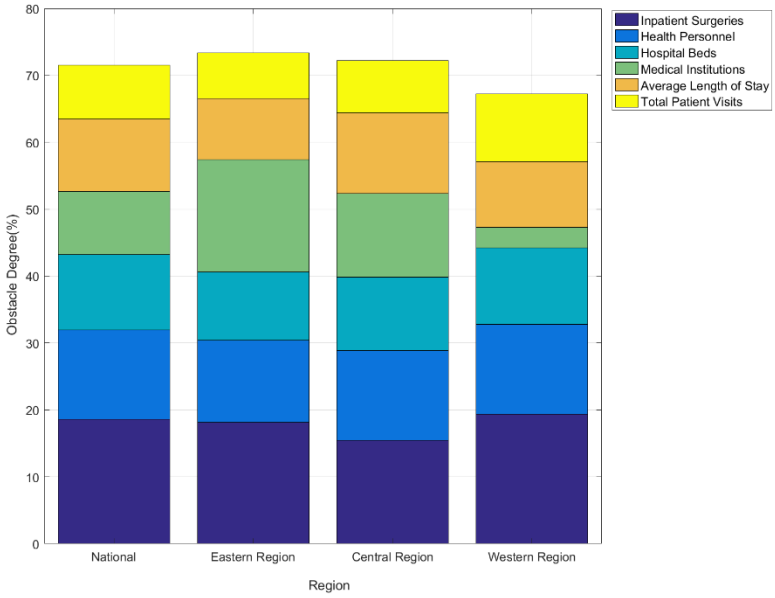


Figure 2 illustrates the comprehensive evaluation results of medical service capacity across the national, eastern, central, and western regions since the initiation of the new healthcare reform in 2009. Distinct colors represent the different regions, and the addition of trend lines allows for a clear discernment of the overall trajectory.

OBSTACLE DEGREE MODEL

Based on calculations from the Obstacle Degree Model, we identified the six indicators with an obstacle degree value as the primary obstacle factors. These factors are: Inpatient Surgeries, Health Personnel, Hospital Beds, Medical Institutions, Average Length of Stay, and Total Patient Visits (Figure 3-4).

FIGURE 3. MAIN OBSTACLE INDICATORS FOR MEDICAL SERVICE CAPACITY ACROSS REGIONS.



In Figure 3, the color scheme represents the obstacle degree values for each indicator. Based on the values represented by this color scheme, the six indicators from each region were identified as the primary obstacle factors.

To further the analysis, we present the specific obstacle degrees of all ten indicators for each region. This allows for a visual comparison that immediately reveals the primary constraining factors of the Medical Service Capacity evaluation in different areas. The detailed results are shown in Figure 4.

FIGURE 4. DETAILED PRESENTATION OF OBSTACLE DEGREES FOR THE TEN INDICATORS ACROSS REGIONS.

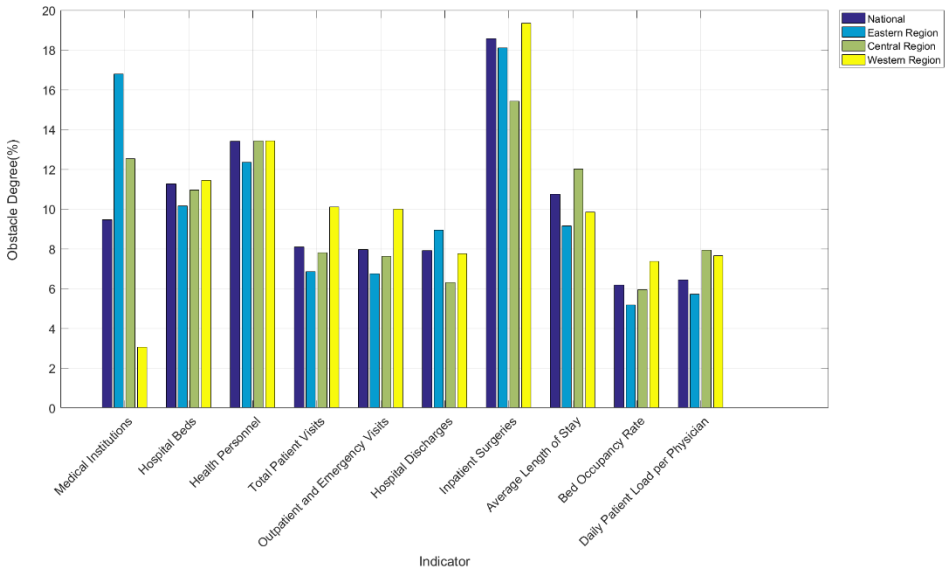


Figure 4 employs a color code to represent the different regions. The results clearly illustrate that the constraining effects of the various indicators on the Medical Service Capacity evaluation differ across these regions.

DISCUSSION

To our knowledge, this is the first study to conduct a longitudinal, comprehensive assessment of China's healthcare service capacity and efficiency following the implementation of the new medical reform. The insights gained are crucial for informing evidence-based policies aimed at enhancing service delivery and overall system effectiveness.

In this study, a rigorous screening process prioritizing representativeness, sensitivity, and data availability was first conducted, leading to the selection of ten key indicators. Subsequently, the entropy weight method was applied to objectively determine the relative importance and calculate the weights for these indicators. These calculated weights were then integrated into the TOPSIS model to perform a comprehensive time-series evaluation of healthcare capacity and efficiency at the national, eastern, and western regional levels. Furthermore, to pinpoint the specific factors impeding performance, the obstacle degree model was employed to identify the primary obstacles across these different regions. Based on the methodological analysis, the entropy weight method was first employed as an objective approach to calculate indicator weights. By determining weights through information entropy, this method effectively minimizes subjective bias, thereby ensuring the objectivity of the weighting process and avoiding the arbitrariness inherent in subjective assignment [35-37]. Subsequently, the TOPSIS method was applied due to its notable advantages, including computational simplicity, strong applicability, and objective results. It imposes minimal restrictions on data distribution and sample size [38-40]. Through data normalization and vector scaling, it eliminates the effects of different measurement units, which significantly enhances the accuracy of the comprehensive evaluation. The weights derived from the entropy weight method were directly integrated into this step to calculate the evaluation results. Thus, the entropy-weighted TOPSIS method can fully leverage the respective advantages of each model to yield a more robust and objective assessment [41, 42]. Furthermore, to diagnose the specific factors limiting system development, the obstacle degree model was introduced [43]. This tool quantifies key obstacles, allowing for the identification of the primary factors affecting healthcare capacity and efficiency. Finally, the sequential and combined application of these three methods formed a comprehensive analytical framework. This integrated approach provided a systematic analysis of both the longitudinal evolution and the key obstacles in China's healthcare capacity and efficiency following the new medical reform.

Our findings indicate an overall upward trend in healthcare capacity and efficiency rankings since the inception of China's new healthcare reform in 2009. This trend was observed despite slight variations among the national, eastern, central, and western regions. In China, the eastern, central, and western regions exhibit distinct healthcare supply and demand patterns: supply is dense in the east, moderate in the center, and sparse in the west [44]. On the supply side, the eastern region benefits from higher population density and stronger socioeconomic development, ensuring better resource availability [45]. The western region, in contrast, is sparsely populated and under-resourced relative to the central and eastern regions. On the demand side, the east's advanced medical technology and capacity generate strong demand for complex, severe, and life-cycle care. Meanwhile, patients with complex conditions from the central and western regions frequently seek cross-regional referrals to the east, exacerbating supply-demand imbalances [46, 47].

We analyze the specific reasons as follows. On one hand, since the inception of the new healthcare reform in 2009, China has undertaken a systematic restructuring of its medical and health system through top-level national design. This integrated approach has not only enhanced the overall capacity of the national healthcare service but has also improved medical service efficiency, thereby driving high-quality development in the sector [3,4]. On the other hand, following the new healthcare reform, China has actively promoted the coordinated reform of pharmaceuticals, medical insurance, and healthcare delivery, a mechanism known as the "Triple Linkage." The government has consistently increased healthcare investment, with total health expenditure rising from 4.85% of GDP in 2010 to 7.19% in 2023 [48]. Concurrently, continuous expansion of insurance coverage and improvements in the medical service system have effectively stimulated the growing healthcare demands of the population. This is evidenced by China's Medical Insurance Information Systems (MIISs), which now connect over 700,000 medical institutions across all levels and cover more than 1.35 billion people [49]. Collectively, these factors have driven the enhancement of China's healthcare capacity and efficiency.

In addition, digital health, technological advancements, and modern health service management have emerged as key drivers of improvement in China's healthcare system [50, 51]. For example, with the development of telemedicine in China, healthcare service supply has expanded, inter-regional and inter-city service efficiency has significantly improved, and healthcare accessibility for rural populations has therefore been markedly enhanced [52, 53]. Meanwhile, the application of electronic health records and artificial intelligence in healthcare services has further driven and enhanced medical service efficiency in China [54]. For instance, AI-assisted diagnostic technologies have strengthened both the capacity

and efficiency of primary healthcare services [55]. Furthermore, modern management practices, including hospital accreditation, lean hospital management, and national performance-based assessments of public hospitals, have been progressively implemented across the country, thereby strengthening healthcare service capacity, quality, and efficiency [56, 57]. The implementation of these measures has jointly contributed to the improvement of China's healthcare service capacity, efficiency, and quality.

However, our observation using the obstacle degree model was that the obstacles to improving healthcare capacity and efficiency were universal across the national, eastern, central, and western regions. These primary obstacles are: Inpatient Surgeries, Health Personnel, Hospital Beds, Medical Institutions, Average Length of Stay, and Total Patient Visits. Among these obstacles, the resource-based indicators of Health Personnel, Hospital Beds, and Medical Institutions can be more directly addressed through governmental resource reallocation. In contrast, improvements in the service-oriented indicators, Inpatient Surgeries and Average Length of Stay, depend on nationwide advancements in medical technology, service delivery, and consistent quality enhancement, representing a longer-term endeavor. In optimizing health resource allocation, China's key challenge lies in the inequitable distribution across regions, with the western region being less equitable than the central and eastern regions, and rural areas less equitable than urban areas. Therefore, priority must be given to improving resource allocation levels in the western region and rural areas [16, 17]. In advancing medical technology and service quality, China's key initiative was the 2019 "Pilot Program for Regional Medical Center Construction" jointly launched by national authorities, involving the establishment of 125 national and 114 provincial regional medical centers aimed at standardizing service quality and elevating care standards. However, this program represents a complex, multi-domain systemic project whose implementation faces challenges primarily in management systems, human resources, and clinical capabilities [58]. Therefore, focused efforts to address these issues are crucial for enhancing China's medical technology and service levels. In strengthening medical quality, China has established medical quality control centers at the national, provincial, and municipal levels, forming a three-tier quality control network. However, the monitoring and evaluation of medical quality still lack effective integration and supplementation, with insufficient dynamic monitoring and assessment of the healthcare service process [59]. Therefore, enhancing the dynamic monitoring of clinical care processes should be the highest priority in future medical quality improvement efforts. Our study has certain limitations. First, while the selection of indicators was based on representativeness, sensitivity, and availability, these indicators cannot fully reflect healthcare capacity and efficiency. For example, the number of Diagnosis-Related Groups is a crucial metric in evaluating healthcare capacity but could not be included in the analysis due to data unavailability. Similarly, indicators reflecting healthcare quality and safety, such as medical adverse events and unplanned readmissions or reoperations, were also excluded. Second, although the entropy weight method applied in this study produced valuable findings in assessing healthcare capacity and efficiency across national, eastern, central, and western regions, the method itself has inherent drawbacks. For instance, it calculates weights based solely on data statistics and cannot incorporate prior knowledge or expert judgment. Therefore, in future research, we will first attempt to collect data on indicators such as DRG numbers, medical adverse events, and unplanned readmissions or surgeries to improve the healthcare capacity and efficiency indicator system and achieve a more comprehensive evaluation. Furthermore, we will explore integrating the Delphi method and the Analytic Hierarchy Process to determine indicator weights, thereby incorporating prior knowledge and expert experience into the analytical framework. Third, regarding the limitations of data analysis, this study focused more on data at the regional level in China. However, the China Health Statistics Yearbook also provides facility-level data disaggregated by type of health care institution (e.g., hospitals, community health centers), which could offer more granular insights. These data were not included in this study due to concerns about longitudinal consistency. Future research should explore these disaggregated indicators as data availability improves.

CONCLUSIONS

In this study, we evaluate the evolution of healthcare service capacity and efficiency in China since the 2009 healthcare reform and identify the key constraints influencing their development. The findings offer valuable insights for informing future healthcare reform policies. While the results indicate an overall improvement in healthcare service efficiency since

the reform, China continues to face multiple challenges. These include accelerated population aging, which is expected to drive sustained growth in medical service demand, as well as persistent disparities in healthcare service levels and resource allocation across regions. Looking ahead, China should focus on enhancing the healthcare service system, optimizing the distribution of medical resources among regions, improving medical technology and quality management, advancing the Healthy China Initiative, and ultimately elevating the overall health status of the population.

CONFLICT OF INTERESTS

We declare that we have no conflict of interest.

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None.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable. Data were obtained from publicly accessible sources. Formal ethical approval was not required for this study.

AUTHOR CONTRIBUTIONS

Conceptualization: DZ and SCP
Data curation: DZ
Formal analysis: DZ
Writing–original draft: DZ and SCP
Writing-review & editing: DZ and SCP

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RESEARCH ARTICLE

A HYBRID APPROACH TO IDENTIFYING FACTORS ASSOCIATED WITH RADIATION SAFETY KNOWLEDGE AMONG HEALTHCARE PROFESSIONALS

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ABSTRACT

OBJECTIVE:

Radiation safety knowledge is fundamental to protecting both healthcare workers and patients. Yet, persistent knowledge gaps continue to compromise safe clinical practice. This study aimed to evaluate radiation safety knowledge among healthcare professionals in central Vietnam and to identify key factors associated with higher competency.

METHODOLOGY:

In this cross-sectional study, healthcare professionals from a national general hospital in central Vietnam were surveyed using a standardized instrument developed in accordance with national radiation safety guidelines endorsed by the Vietnamese Ministry of Health, the Ministry of Labour, Invalids and Social Affairs, and the Ministry of Science and Technology. A hybrid analytical framework integrating Bayesian Model Averaging (BMA), Lasso, and Ridge regression was applied to identify independent predictors. Model robustness was further validated through standard regression and bootstrapping analyses.

RESULTS:

The overall radiation safety knowledge was suboptimal, with an average score of 35%. Knowledge of preventive measures was higher (69.3%), while awareness of radiation risks and radiographic room safety was notably limited. Key predictors of higher radiation safety knowledge included direct involvement with X-rays (β=16.85, P<0.001), higher educational attainment (β=15.72, P<0.001), older age (β=13.99, P <0.001), participation in radiation-related training courses (β=9.08, P<0.001), and access to multiple information resources (β=6.27, P<0.05). The hybrid statistical approach provided robust insights, with results consistent across different models. Both standard regression and bootstrapping analyses confirmed the stability of these findings.

CONCLUSIONS:

This study highlights a significant gap in radiation safety knowledge among healthcare professionals in central Vietnam. Significant knowledge gaps underscore the need for targeted training, curriculum integration, and enhanced access to radiation safety resources at healthcare settings. The study also recommends the usage of hybrid statistical approaches in robust inference generation.

KEYWORDS

Radiation safety knowledge, Healthcare professionals, Bayesian model averaging (BMA), Lasso Regression, Ridge regression

INTRODUCTION

Radiation technology is indispensable in modern healthcare, enabling precise diagnostics and effective treatments across multiple disciplines [1]. While its benefits are well-documented, improper or excessive exposure poses serious risks to both patients and healthcare professionals. Prolonged occupational radiation exposure has been associated with increased risks of cancer, genetic mutations, and other adverse health effects, as demonstrated by epidemiological studies [2, 3]. The International Commission on Radiological Protection (ICRP) and the World Health Organization (WHO) emphasize the critical importance of strict adherence to radiation safety protocols to mitigate unnecessary exposure and protect occupational health [2, 4]. Ensuring healthcare professionals – particularly those in radiology and related specialties – possess adequate radiation safety knowledge is fundamental to implementing protective measures effectively.

Despite established guidelines, recent evidence highlights suboptimal awareness, attitudes, and practices regarding radiation protection among healthcare workers, with mixed findings across studies [5]. Most research has centred on assessing general knowledge of radiation safety standards [5], while relatively few studies have examined knowledge of facility safety requirements or the specific health risks associated with prolonged exposure. Determinants of radiation safety knowledge remain inconsistent across contexts. Han et al. in South Korea identified gender, age, marital status, education, and work experience as significant factors [6], whereas Farajollah et al. in Iran emphasized age, education level, and participation in refresher courses [7]. Studies in Turkey [8] and Iran [9] also reported differing determinants, such as professional level and educational background, with limited consensus. Notably, research in low- and middle-income countries (LMICs) remains sparse, despite the rapid expansion of medical imaging infrastructure in regions such as Vietnam [10]. Addressing these knowledge gaps is essential for improving occupational health practices and ensuring safe radiation use in resource-limited settings.

Vietnam has invested significantly in healthcare infrastructure over the past decade, leading to the establishment of new radiology departments equipped with advanced imaging technology [11]. National regulatory bodies have introduced comprehensive policies and training programs to promote radiation safety [11-13]. Yet, the extent to which healthcare professionals in Vietnam are adequately prepared to manage radiation exposure remains unclear. Evaluating current

knowledge levels and identifying key determinants are crucial steps toward strengthening occupational safety and optimizing policy implementation [14].

To address these gaps, the present study assesses radiation safety knowledge and its associated factors among healthcare professionals in central Vietnam. Given the limitations of standard regression in handling model uncertainty, multicollinearity, and high-dimensional data, especially with small sample sizes [15], we adopt a hybrid analytical approach, integrating Bayesian Model Averaging (BMA), Least Absolute Shrinkage and Selection Operator (Lasso), and Ridge regression to identify key predictors. This complementary strategy ensures robust inference, with cross-validation optimizing regularization parameters and performance metrics guiding model selection. Upon model selection, a standard regression framework is applied for model inference on associated factors. By combining these methods, this study provides critical insights for policymakers, educators, healthcare administrators, and practitioners to improve radiation safety practices.

Although the data for this study were collected several years ago, the findings remain relevant to current healthcare practice and policy because radiation safety knowledge, training gaps, and adherence to radiation protection principles continue to be ongoing concerns in healthcare systems, particularly in resource-constrained and rapidly developing clinical settings. Furthermore, baseline evidence from earlier periods remains important for understanding persistent workforce educational needs, informing institutional training strategies, and evaluating progress in radiation safety awareness over time.

METHODS

STUDY DESIGN AND SETTING

A cross-sectional study was conducted from late 2018 to 2019 across three hospitals in central Vietnam: Quang Nam Provincial General Hospital, Quang Nam National General Hospital, and Quang Nam Mountainous Northern Provincial General Hospital. A structured questionnaire was used for data collection.

DATA SAMPLE AND SAMPLING

Healthcare professionals working in radiation-related departments – including diagnostic imaging, interventional radiology, cardiovascular intervention, trauma surgery, neurosurgery, and general surgery – were eligible. These included medical doctors, associate medical doctors, technicians, and nurses. Sample size estimation was based on a power of 0.80, a significance level of 0.05, and a medium effect size (Cohen's $f^2 = 0.20$) for a regression model with nine predictors, yielding a minimum requirement of 88 participants. To account for anticipated non-response, the minimum sample was inflated using a two-component adjustment: a 20% allowance for incomplete or unusable questionnaires (e.g., missing data, refusal to complete all items), which is consistent with rates recommended in similar survey-based studies among healthcare professionals or in clinical settings [16], and an additional 30% allowance for non-participation and recruitment difficulties due to the demanding schedules of clinical staff across three hospital sites during routine working hours [17]. This combined adjustment yielded a target sample of 137. Ultimately, 153 healthcare workers completed the survey.

MEASUREMENTS

The questionnaire was developed and validated following national radiation safety guidelines issued by the Ministry of Health, the Ministry of Labour, Invalids and Social Affairs, and the Ministry of Science and Technology [11-13, 18]. It comprised two sections. The first collected data on data on gender, age group (20–29, 30–39, ≥40 years), education level (vocational, university, postgraduate), professional role (medical doctor, technician, nurse), years of experience, daily working hours, and sources of radiation safety knowledge (formal training, hospital-based training, media, and peer discussions). These variables were analyzed as predictors of radiation safety knowledge.

The second section consisted of 19 items covering three knowledge domains: (i) radiographic room safety (7 items) [4, 5], (ii) radiation exposure risks (6 items) [2, 4, 5], and (iii) radiological protection measures (6 items) [2, 5, 19]. Each correct

response was scored as 1 point, with a maximum score of 19. The total score, expressed as a percentage, was the primary dependent variable.

The questionnaire underwent pilot testing with ~10 participants to assess feasibility. Internal reliability was high (Cronbach's $\alpha = 0.88$), and no major issues regarding comprehension or feasibility were identified.

DATA COLLECTION

Data collection was conducted following ethical approval from Hanoi Medical University and the three participating hospitals. Prior to recruitment, the principal investigator liaised with department heads to present study objectives and obtain institutional support. Eligible participants, identified from hospital records, were invited to private interview sessions. A structured, face-to-face interview was conducted after obtaining written informed consent. Participants could seek clarification on any item, and responses were reviewed for completeness.

STATISTICAL APPROACHES AND ANALYSIS

Descriptive statistics summarized demographic characteristics and radiation safety knowledge scores (Table 1, Table 2, Figure 1). The dependent variable, knowledge score (%), normally distributed was summarized (Table 2).

To enhance model selection and address multicollinearity in high-dimensional data, we employed a hybrid approach integrating Bayesian Model Averaging (BMA; Table 3), Least Absolute Shrinkage and Selection Operator (Lasso), and Ridge regression (Table 4). This complementary strategy ensures robust inference, with cross-validation optimizing regularization parameters. Further methodological details are provided in the supplement. Final model inference was conducted using standard regression and bootstrapping, ensuring result stability (Figure 2). Multiple testing adjustments were performed using the Benjamini-Hochberg procedure, with an adjusted false discovery rate (FDR) threshold of <0.05 [20].

All statistical analyses were conducted using Stata version 18.5 [21] and R version 4.4.1 [22].

SENSITIVITY ANALYSIS

To ensure robust findings, a hybrid approach was employed for model selection, incorporating BMA, Lasso, and Ridge regression to identify factors associated with the outcome. The results were consistent across models (Tables 3 and 4). For model inference, both standard regression and bootstrapping analyses yielded stable regression coefficients and *p*-values (Figure 2).

ETHICAL APPROVAL

The research approval was granted by the Institute for Preventive Medicine and Public Health and Hanoi Medical University (No. 5425/QD-DHYHN dated 09/10/2018). Participants provided informed consent to participate in the survey and agreed for data usage in the research.

RESULTS

In table 1 of the 153 participants, they were predominantly male (86.3%), mostly aged 30–39 years (43.8%). Most had vocational or school-level education (34.0%) and worked as technicians (45.8%), primarily in diagnostic imaging (57.6%) and handling X-ray procedures (57.5%). A majority (71.9%) worked 6–8 hours daily, 58.8% had ≥5 years' experience, 47.1% received Ministry training, and 77.1% obtained information from colleagues.

TABLE 1. GENERAL CHARACTERISTICS OF THE STUDY PARTICIPANTS

Variables (N=153)	n (%)
Gender	
Men	132 (86.3)
Women	21 (13.7)
Age (years)	
20-29	51 (33.3)
30-39	67 (43.8)
≥40	35 (22.9)
Education level	
University graduate	18 (11.8)
University	41 (26.8)
College	42 (27.5)
Vocational/school education	52 (34.0)
Professional level	
Doctor	38 (24.8)
Technician	70 (45.8)
Nurse/assistant doctor	45 (29.4)
Radiation departments	
Diagnosis imaging	88 (57.6)
Cardiovascular/cardiovascular intervention	30 (19.6)
Other radiation departments	35 (28.8)
Working with X-rays (Direct vs. indirect)	
Direct	88 (57.5)
Indirect	65 (42.5)
Average duration of working with X-ray radiation per day	
< 6 hours	33 (21.6)
6-8 hours	110 (71.9)
> 8 hours	10 (6.5)
Working years in X-ray setting	
< 5 years	63 (41.2)
≥ 5 years	90 (58.8)
Attending training courses by the Ministry of Science and Technology	
Yes	72 (47.1)
No	81 (52.9)
Access to information resources	
Colleagues	118 (77.1)
Media	71 (46.4)
Schools	75 (49.0)
Hospital-based training	40 (26.1)
Number of information resources	
1-2 resources	73 (47.7)
≥ 3 resources	80 (52.3)

Table 2 summarizes participants' knowledge of radiation safety. Correct responses regarding radiographic room safety ranged from around 19% for radiation source facility requirements to 47% for standard room dimensions. Knowledge of radiation exposure risks was generally limited, with 22.2% identifying the properties of X-rays, 21.6% recognizing early symptoms of radiation-related diseases, and 13.1% knowing the consequences of radiological contamination. In contrast, knowledge of radiological protection measures was generally higher, with 69.3% aware of preventive measures and over half correctly answering questions on annual dose limits for health workers (50.3%) and frequency of individual dose assessments (56.9%). The overall level of radiation safety knowledge was ~35 (SD = 22.05).

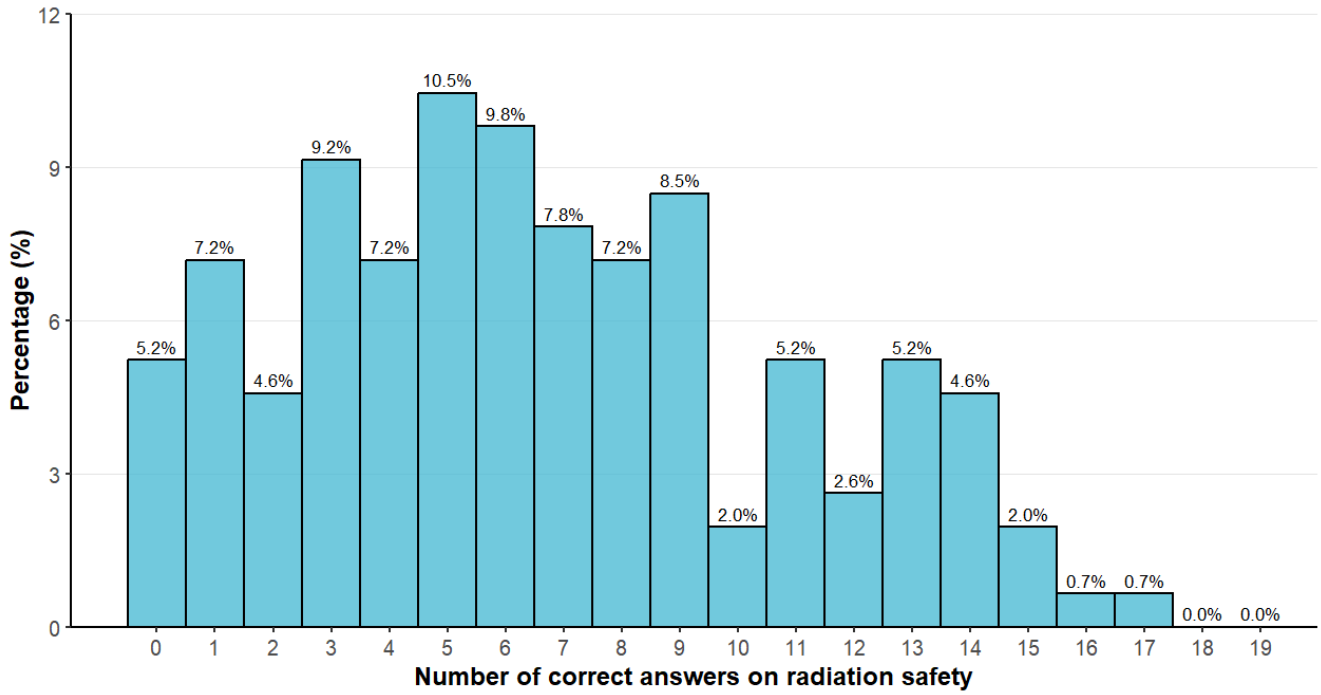
TABLE 2. GENERAL KNOWLEDGE ABOUT RADIATION SAFETY AMONG THE STUDY PARTICIPANTS (N=153)

No.	Knowledge questions	Answer correctly n (%)
	Safety requirements of a radiographic room	
1	Radiographic room design and construction	62 (40.5)
2	Layout of radio-diagnostic facilities: room walls, warning signs, warning lights, safety regulation notice	41 (26.8)
3	Standard room dimensions	72 (47.1)
4	Requirements for standard radiation source facilities	29 (18.9)
5	Requirements for radiological equipment such as DSA and C-Arms	47 (30.7)
6	Minimum safe distance between the radiation source and the operator	32 (20.9)
	Risks of radiation exposure	
7	Properties of X-rays	34 (22.2)
8	Cell damage related to X-rays	45 (29.4)
9	Factors affecting the radiation dose	48 (31.5)
10	Active ingredients help reduce oxidation and neutralize free radicals caused by X-rays	41 (26.8)
11	Types of diseases caused by X-rays	54 (35.3)
12	Early symptoms of radiation-related diseases	33 (21.6)
13	Consequences of radiological contamination (cancer, gene mutation, infertility)	20 (13.1)
	Radiological protection measures	
14	Preventive measures for individuals from radiation exposure: reducing exposure duration, using protection equipment, keeping a safe distance, lead lining on door	106 (69.3)
15	Dose limit of radiation/ year for the health worker	77 (50.3)
16	Dose limit of radiation/ year for the patient	62 (40.8)
17	Frequency of individual dose assessment for radiation workers in one year	87 (56.9)
18	Frequency of screening for radiation workers in one year	99 (64.7)
19	Frequency of checking radiological equipment	72 (47.1)
	Radiation safety knowledge level (mean (SD))	34.95 (22.05)

Figure 1 visualizes the distribution of the total number of correct answers to X-ray-related questions. The data demonstrates a bimodal distribution, with a primary peak (10.5%) at 5 correct answers and a secondary peak (5.2%) at 13 correct

answers. The majority of respondents answered fewer than 10 questions correctly, and no participant achieved a perfect score (19 correct answers), indicating a general lack of comprehensive knowledge across all items assessed.

FIGURE 1. DISTRIBUTION OF RESPONDENT PERCENTAGE BY THE TOTAL NUMBER OF CORRECT ANSWERS



Alt text: Bar chart depicting the distribution of correct answers on radiation safety knowledge among healthcare professionals. The horizontal axis represents the number of correct answers, while the vertical axis shows the corresponding percentage of participants.

The BMA analysis results (Table 3) indicate that among the seven possible models generated, the three most probable models are presented. Model 1 demonstrated the best overall fit, as reflected by the highest posterior model probability (PMP = 56%), the lowest Bayesian information criterion (BIC = -182.37), and the lowest root mean squared error (RMSE = 13.52) and R2 value comparable or higher than the other models (0.74 vs. 0.75 and 0.73). This model retained five key predictors: direct involvement with X-rays, educational level, age group, participation in radiation-related training courses, and access to multiple radiation-related information resources. Each of these factors showed a posterior inclusion probability (PIP) of 100%, indicating their consistency across all best models. In contrast, variables such as years of exposure, professional level, working and exposure hours per day, and gender did not meet the threshold for inclusion in Model 1.

TABLE 3. BAYESIAN MODEL AVERAGING ANALYSIS FOR IDENTIFYING FACTORS ASSOCIATED WITH RADIATION SAFETY KNOWLEDGE

Variables	PIP[A]	Post. Mean (Beta)[A]	Post. SD (SE)[A]	Model 1	Model 2	Model 3
Working with X-rays (Direct vs. indirect)	1.00	17.13	2.58	1.00	1.00	1.00
Educational level (University vs. lower)	1.00	16.50	2.10	1.00	1.00	1.00
Age group (≥40, 30-39, vs. 20-29 years old))	1.00	6.53	1.49	1.00	1.00	1.00
Training courses (yes vs. no)	1.00	8.67	2.63	1.00	1.00	1.00
Number of information resources (≥3 vs. <3 resources)	1.00	5.89	3.42	1.00	1.00	0.00

Working and exposing years (≥5 vs. <5 years)	0.84	0.55	1.57	0.00	1.00	0.00
Professional level (Others vs medical doctor degree)	0.06	-0.14	0.90	0.00	0.00	0.00
Working and exposed hours per day (>=6 vs. <6 hours)	0.06	0.09	0.69	0.00	0.00	0.00
Gender (male vs. female)	0.05	-0.06	0.68	0.00	0.00	0.00
Model fit						
Posterior model probability (PMP)				0.56	0.12	0.11
R^2				0.74	0.75	0.73
BIC				-182.37	-179.24	-179.14
RMSE				13.52	21.08	13.63

Post.: Posterior; PIP: Posterior inclusion probabilities; BIC: Bayesian information criterion; RMSE: Root mean-squared error

[A]Average values of 7 models selected by the BMA

Table 4 presents the results of Lasso and Ridge regression analyses for selecting factors associated with radiation safety knowledge. Both models achieved good fit (R^2 = 0.74; RMSE ≈ 11.1), with coefficients estimated using optimal lambda values (λ = 0.78 for Lasso; λ = 0.23 for Ridge) and 95% confidence intervals (CIs) obtained through bootstrapping with 1,000 resamples. Five key predictors consistently showed significant positive associations in both models: direct involvement with X-rays, higher educational attainment, older age, attendance at radiation-related training courses, and access to three or more information resources. Direct involvement with X-rays had the strongest association (Lasso β = 15.78, 95% CI: 10.28 to 21.28; Ridge β = 14.72, 95% CI: 10.72 to 18.73), followed by higher education and older age. In contrast, variables such as working and exposure years, professional level, working hours per day, and gender did not show significant associations, with their confidence intervals including zero. Lasso and Ridge regression reveals the results in consistency with the BMA.

TABLE 4. LASSO AND RIDGE REGRESSION ANALYSIS FOR IDENTIFYING FACTORS ASSOCIATED WITH RADIATION SAFETY KNOWLEDGE

Variables	Lasso model	Ridge model
	Beta[A1] (95%CI)[A2]	Beta[B1] (95%CI)[B2]
Working with X-rays (Direct vs. indirect)	15.78 (10.28, 21.28)	14.72 (10.72, 18.73)
Educational level (University vs. college or lower degree)	15.06 (9.24, 20.88)	13.44 (8.57, 18.32)
Age group (≥40, 30-39, vs. 20-29 years old))	5.26 (1.97, 8.54)	4.94 (2.44, 7.43)
Training course attendance (yes vs. no)	8.03 (2.40, 13.66)	8.61 (4.47, 12.74)
Number of information resources (≥3 vs. <3 resources)	6.41 (1.01, 11.82)	7.14 (3.08, 11.19)
Working and exposing years (≥5 vs. <5 years)	2.00 (-2.19, 6.19)	3.62 (-0.10, 7.34)
Professional level (Others vs medical doctor degree)	-1.16 (-5.80, 3.48)	-3.94 (-8.72, 0.84)
Working and exposed hours per day (>=6 vs. <6 hours)	0.00 (-1.96, 1.96)	0.35 (-3.39, 4.10)
Gender (male vs. female)	0.00 (-1.33, 1.33)	-1.22 (-4.90, 2.47)
Model fit		
R^2	0.74	0.74
RMSE	11.13	11.11

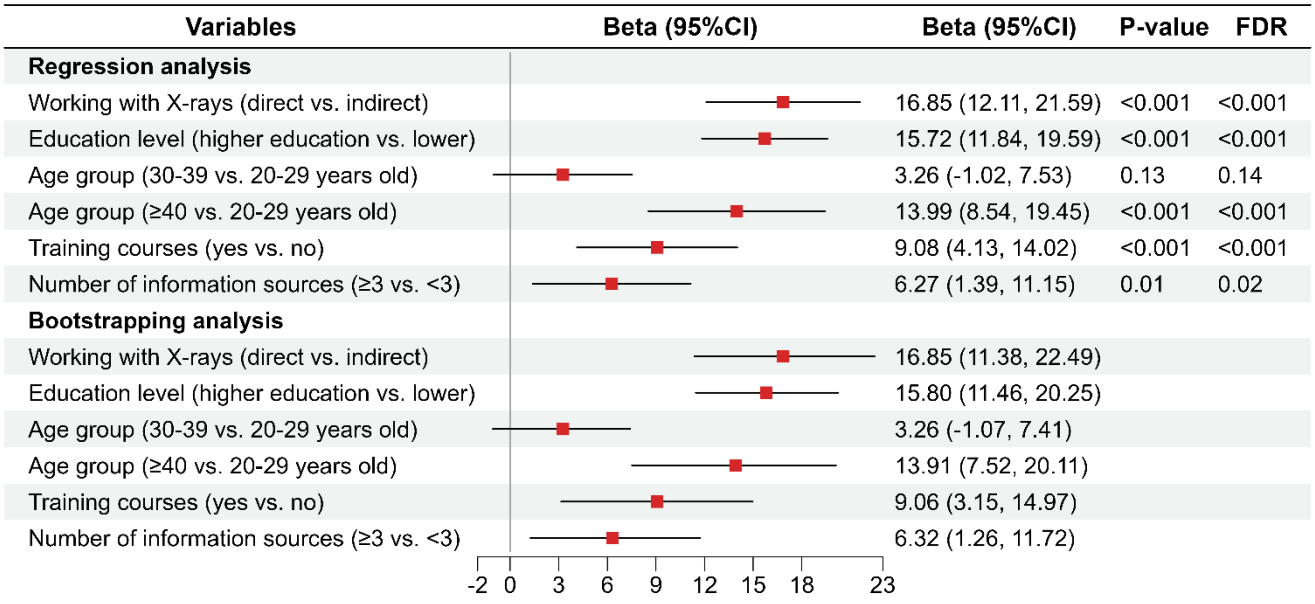
A1 and B1: Regression coefficients estimated using the optimal lambdas (λ = 0.78 for Lasso and λ = 0.23 for Ridge regression) obtained through 10-fold cross-validation.

A2 and B2: 95% confidence intervals (CIs) for the regression coefficients estimated using bootstrapping techniques with 1,000 resamples, based on the optimal lambdas from Lasso and Ridge regression.

Figure 2 presents the results of the linear regression and bootstrapping analysis evaluating the association between various independent variables and radiation safety knowledge. The analysis indicates that direct involvement with X-rays, higher educational attainment, age ≥40 years, participation in training courses, and access to three or more information sources are significantly and positively associated with higher knowledge scores. Specifically, health professionals working directly with X-rays scored 16.85% higher in radiation safety knowledge compared to those with indirect exposure. Similarly, having

a university-level education, being in the age group ≥40 years, attending training courses, and accessing three or more information sources were associated with significantly higher scores of 15.72%, 13.99%, 9.08%, and 6.17%, respectively. The bootstrapping analysis corroborated the findings of the standard regression model.

FIGURE 2. STANDARD REGRESSION AND BOOTSTRAPPING ANALYSIS OF FACTORS ASSOCIATED WITH RADIATION SAFETY KNOWLEDGE



Alt text: Forest plot displaying regression coefficients (Beta) with 95% confidence intervals for various factors associated with radiation safety knowledge, based on regression and bootstrapping analyses

DISCUSSION

MAIN FINDINGS OF THIS STUDY

This study assessed radiation safety knowledge among healthcare professionals in central Vietnam and identified key associated factors using a hybrid analytical approach that combined BMA, Lasso, and Ridge regression. The findings highlight significant predictors: direct involvement with X-rays, higher education, older age, participation in radiation-related training, and access to multiple information resources. These results underscore the need for targeted training and improved information dissemination to enhance radiation safety competency.

WHAT IS ALREADY KNOWN ON THIS TOPIC

Previous studies have consistently reported suboptimal awareness, attitudes, and practices concerning radiation safety among healthcare workers [5]. However, findings on key determinants remain inconsistent across different settings, with most research focusing narrowly on general knowledge of radiation safety standards rather than facility-specific safety requirements or health risks associated with prolonged exposure. Furthermore, standard regression approaches commonly employed in these studies may introduce biases due to model selection limitations. Research in LMICs remains particularly scarce, leaving significant knowledge gaps regarding context-specific predictors of radiation safety competency.

WHAT THIS STUDY ADDS

The overall level of radiation safety knowledge among healthcare professionals was not adequate, with an average score of approximately 35% correct responses. Knowledge of radiological protection measures was relatively higher, with 69.3% of participants aware of preventive measures. However, knowledge of the risks of radiation exposure and safety requirements for radiographic rooms was notably limited. Only 22.2% of participants correctly identified the properties of X-rays, and a mere 13.1% were aware of the consequences of radiological contamination. The bimodal distribution of correct answers, with peaks at 5 and 13 correct responses out of 19, further highlights the uneven distribution of knowledge,

with the majority of participants scoring below 50%. These findings are consistent with previous studies in LMICs [5, 14, 23, 24]. revealing persistent gaps that may compromise the safety of both healthcare workers and patients. Targeted educational interventions and continuous professional development programs are needed to address this knowledge deficit and promote safer practices.

The hybrid analytical approach employed in this study, integrating BMA, Lasso, and Ridge regression, provided robust insights into the factors associated with radiation safety knowledge. BMA, with its ability to account for model uncertainty, identified five key predictors with high posterior inclusion probabilities (PIP = 100%): direct involvement with X-rays, higher educational attainment, older age, participation in radiation-related training courses, and access to multiple information resources. These findings were corroborated by Lasso and Ridge regression, which consistently highlighted the same factors as significant predictors of radiation safety knowledge. The consistency across these models underscores the reliability of the identified predictors. The hybrid approach validated the robustness of the selected predictors and demonstrated the utility of combining multiple statistical methods to address the challenges of multicollinearity [25, 26], and small sample sizes [15], which are common in healthcare research.

The standard regression and bootstrapping analyses further validated the findings from the hybrid models, supporting that direct involvement with X-rays, higher educational attainment, older age, participation in training courses, and access to multiple information resources are significantly associated with higher radiation safety knowledge scores. Healthcare professionals who worked directly with X-rays, had a university-level education, attended radiation-related training, and had access to diverse information resources demonstrated notably higher knowledge scores than their counterparts. Older age was also positively correlated with higher scores, likely reflecting the cumulative experience and greater exposure to safety protocols over time. These results underscore the importance of a combination of formal education [2, 27, 28], continuous training [2, 28], and access to varied information sources [2] in enhancing radiation safety knowledge. The stability of results across bootstrapping analyses strengthens their validity and reliability [2].

Despite the age of the dataset, the present findings continue to have practical relevance for current healthcare systems. Radiation safety remains a critical component of clinical governance and occupational health policy, particularly as the use of diagnostic imaging technologies continues to expand globally. The identified associations between professional role, training exposure, and radiation safety knowledge may still inform contemporary workforce education strategies, especially in regional and resource-limited hospital settings where access to continuous professional development may vary. In this context, the study provides useful baseline evidence for evaluating ongoing improvements in radiation safety training and policy implementation.

LIMITATIONS OF THIS STUDY

Despite its robust methodology, this study has several limitations. First, there is the temporal gap between data collection and publication. Radiation safety policies and hospital practices in Vietnam may have evolved during this period. However, baseline assessments of this nature remain valuable as reference points for evaluating the effectiveness of subsequent policy and training interventions. Future studies should assess whether the knowledge gaps identified here have been addressed under current regulatory frameworks. Second, the cross-sectional design restricts causal inference between predictors and radiation safety knowledge. Third, reliance on self-reported data introduces potential response bias. Future studies should incorporate objective knowledge assessments and observational validation. Nevertheless, these limitations do not diminish the study's practical significance. The findings emphasize the need for targeted interventions—mandatory radiation safety training, continuous professional development, and improved access to educational resources. They also highlight the importance of embedding radiation safety education within formal medical and technical curricula.

In conclusion, this study reveals a substantial gap in radiation safety knowledge among healthcare professionals in central Vietnam. The integration of Bayesian Model Averaging, Lasso, and Ridge regression robustly identified key predictors of

higher competency: direct X-ray involvement, higher education, older age, participation in radiation training, and access to multiple information sources. These findings illustrate the value of hybrid statistical frameworks for deriving reliable inferences. The results underscore an urgent need for focused educational interventions, strengthened training programs, and the systematic integration of radiation safety into medical curricula to safeguard both healthcare workers and patients from preventable radiation exposure.

CONFLICT OF INTEREST

The authors have no conflicts of interest associated with the material presented in this paper.

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SUPPLEMENT

MODELLING APPROACHES TO MODEL SELECTIONS

To enhance model selection and address the inherent challenges of small sample sizes and multicollinearity in high-dimensional data, we employed a hybrid modelling approach integrating BMA (Table 3), Lasso regression, and Ridge regression (Table 4).

BMA was chosen to mitigate model uncertainty, which is a well-recognized issue in frequentist approaches, particularly when multiple potential predictors are involved and sample sizes are limited [1]. BMA estimates all possible combinations of predictors and constructs a weighted average over these models based on their posterior probabilities. This allows for more robust inference by accounting for model uncertainty. Specifically, if *K* variables are considered, BMA evaluates 2^K combinations and assigns weights to each model according to their posterior model probability (PMP) derived from Bayes' theorem.[1]

$$p(M_\gamma|y,X) = \frac{p(y|M_\gamma,X)p(M_\gamma)}{p(y|X)} = \frac{p(y|M_\gamma,X)p(M_\gamma)}{\sum_{s=1}^{2^K} p(y|M_s,X)p(M_s)} \quad (1)$$

Where $p(y|X)$ denotes the incorporated likelihood, which is constant over all models and is simply a multiplicative effect. The posterior model probability (PMP) $p(M\gamma|y, X)$ is proportional to the marginal likelihood of the model $p(y|M\gamma, X)$, the probability of the data *y* given the model $M\gamma$, times a prior model probability $p(M\gamma)$. The process of renormalization leads to the PMPs, and thus the model weighted posterior distribution for any statistic θ (for example β):

$$p(\theta|y,X) = \sum_{\gamma=1}^{2^K} p(\theta|M_\gamma,y,X)p(M_\gamma|X,y) \quad (2)$$

The model prior to $p(M\gamma)$ can be defined by the researcher such that it should reflect prior beliefs. A popular choice is to set a uniform prior probability for each model $p(M\gamma) \propto 1$ to represent the lack of prior knowledge [1].

In addition, Lasso regression and Ridge regression were used to ensure robust variable selection and coefficient stability. Lasso regression applies an L_1-penalty, which forces some coefficients to exactly zero, effectively performing variable selection while simultaneously shrinking other coefficients.[2] This method is especially suitable for sparse models where only a subset of predictors is relevant. In contrast, Ridge regression applies an L_1-penalty, shrinking all coefficients toward zero without setting any to exactly zero, thereby stabilizing the model and reducing the impact of multicollinearity [3, 4]. The objective functions for Lasso and Ridge, respectively, minimizes the residual sum of squares subject to a constraint on the sum of the absolute values of the coefficients are presented below:

$$\sum_{i=1}^{n}\left|y_i - \sum_{j=1}^{p}\beta_j\, x_{i\,j}\right|^2 + \lambda\sum_{j=1}^{p}|\beta_j| \quad (3)$$

$$\sum_{i=1}^{n}\left(y_i - \sum_{j=1}^{p}\beta_j\, x_{i\,j}\right)^2 + \lambda\sqrt{\sum_{j=1}^{p}\beta_j^2} \quad (4)$$

Here, n, p and λ represent the number of observations, the number of variables and the tuning parameter controlling the degree of shrinkage, respectively, with λ selected using cross-validation to minimize prediction error. x_{ij} denotes the value of variable j for individual i, and β_j represents the regression coefficient for variable j.

The rationale for combining these methods was to capitalize on the strengths of each: BMA for comprehensive model selection with uncertainty quantification,[1] Lasso for identifying key predictors, and Ridge for improving coefficient stability and prediction accuracy.[3] Performance metrics, including root mean squared error (RMSE), adjusted R^2, and Bayesian Information Criterion (BIC), were used to evaluate and compare models for model selection. The optimal regularization parameter λ for Lasso and Ridge was chosen using cross-validation to minimize prediction error.[3] Upon completing model selection, we performed standard linear regression analyses to estimate parameters and derive statistical inferences, ensuring robust and interpretable results (Figure 2).

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RESEARCH ARTICLE

CHARACTERIZATION OF COUNTRIES WITH HIGH HAPPINESS INDEX: A CLUSTER ANALYSIS

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ABSTRACT

OBJECTIVE:

This study investigates the common characteristics of countries with high happiness index scores using a cluster analysis of 20 nations.

DESIGN:

The study is an ecological study where the unit of observation is the population in a country.

SETTING:

Data were drawn from the World Happiness Report, World Bank, WHO, and World Population Review (2023–2025).

MAIN OUTCOME MEASURES:

The study focused on five variables: social support, GDP per capita, healthy life expectancy, crude death rate, and health expenditure.

RESULTS:

Results revealed that countries in higher-performing clusters exhibited consistently strong social support systems, moderate to high GDP per capita, high healthy life expectancy, moderate crude death rates, and substantial public health spending. Among these factors, social support emerged as the most influential determinant, aligning with recent literature emphasizing the psychological and societal benefits of strong interpersonal networks. GDP alone was not a sufficient predictor of happiness; countries with high economic output but lower investment in health and social infrastructure ranked lower in overall well-being.

CONCLUSIONS:

This study demonstrates that countries with high happiness cannot be characterized by economic prosperity alone. The cluster analysis showed that high happiness may coexist with different combinations of economic, social, and health conditions. The study therefore characterizes countries with high Happiness Index scores as heterogeneous rather than uniform.

KEYWORDS

happiness index, social support, GDP, life expectancy, health expenditure, cluster analysis.

INTRODUCTION

Happiness has long been recognized as a central component of human well-being. In Nicomachean Ethics, Aristotle described happiness as the ultimate human good, something pursued for its own sake. Similarly, Freud emphasized happiness as a lifelong pursuit - a goal that individuals continually strive to attain and maintain [1]. Contemporary research supports these classical perspectives, indicating that happier individuals tend to live longer, healthier lives [2]. The relationship between happiness and life expectancy is influenced by various factors, including social relationships, socioeconomic status, geographic context, and religious participation, suggesting that happiness may both influence and be influenced by these variables.

In recent decades, the study of happiness, also referred to as subjective well-being, has gained considerable attention in academia, policy, and public discourse. This field began developing in the 1970s and significantly expanded after 2000, when the subjective quality of life became a widely accepted topic across disciplines such as psychology, sociology, and economics. Measures of subjective well-being typically rely on survey questions such as, "Taking all things together, how happy would you say you are?" or "All things considered, how satisfied are you with your life as a whole these days?" [3]. To assess happiness and its broader societal implications, researchers frequently use tools like the Happiness Index, developed by the Happiness Alliance. This instrument measures happiness, well-being, sustainability, and resilience across nations, offering a multifaceted view of how countries support the well-being of their populations [4, 5]. The Happiness Index has become a valuable resource for community organizers, researchers, and policymakers seeking data-driven approaches to improving quality of life.

In an increasingly dynamic global landscape, understanding the determinants of happiness is essential for promoting societal well-being and guiding public policy. The prosperity of a nation is closely linked to the quality of life it offers its citizens [6]. This study seeks to characterize countries with high levels of happiness through a cluster analysis, identifying common patterns among nations that report high subjective well-being.

METHODS

The study is an ecological study where the unit of observation is the population in a country. Often, in an ecological study, the information is abstracted from published statistics and therefore does not require expensive or time-consuming data collection. The populations compared may be defined in various ways [7].

In this study, existing data and statistics on happiness index, social support, GDP per capita, and healthy life expectancy were taken from the World Happiness Report. The Happiness Index was operationalized using the average life evaluation score reported for 2022–2024, measured on a 0–10 scale. The World Happiness Report identifies life evaluation as the basis of its country ranking and uses a three-year average to improve the stability of country-level comparisons. [8]. Social support is the national average of the binary responses (0=no, 1=yes) to the Gallup World Poll (GWP) question "If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them, or not?" GDP per capita is in terms of Purchasing Power Parity (PPP) adjusted to constant 2017 international dollars, taken from the World Development Indicators (WDI) by the World Bank (version 17, metadata last updated on January 22, 2023). The time series for healthy life expectancy at birth is constructed based on data from the World Health Organization (WHO) Global Health Observatory data repository, with data available for 2005, 2010, 2015, 2016, and 2019 [9]. The death rate is an important factor for the happiness index because it reflects broader aspects of a country's health, healthcare quality, safety, and overall living conditions. This is taken from the World Population Review 2024 report. Death rate, also known as mortality rate, is the number of deaths that occur in a particular population during a particular period. Typically, the death rate is expressed as the number of deaths per one thousand people per year [10]. Increased health expenditure can positively impact a country's happiness index by improving citizens' health, well-being, and overall quality of life. Country health expenditure is calculated by summing all financial resources, both public and private, used to purchase health goods

and services [11]. The nature of the data used qualified it for exemption from ethical review, and the researchers ensured compliance with ethical guidelines in the use of this publicly available data for research purposes.

After the process of harmonization, the researchers utilized data from 20 countries to include Finland, Denmark, Iceland, Sweden, Netherlands, Costa Rica, Norway, Israel, Mexico, Australia, New Zealand, Switzerland, Belgium, Ireland, Lithuania, Austria, Canada, Slovenia, Czechia, and United Arab Emirates. The selected countries represented different geographic regions and levels of economic development, allowing the study to examine whether countries with relatively high happiness shared common socioeconomic and health characteristics. The data were analyzed using cluster analysis utilizing Statistics Kingdom, an online calculator. Clustering is used to identify groups of similar objects in datasets with two or more variable quantities. In practice, this data may be collected from marketing, biomedical, or geospatial databases, among many other places. The k-means cluster algorithm classifies information based on the similarities of the data points.

RESULTS

The cluster analysis presents a compelling view of how national happiness is shaped by interconnected socioeconomic and health-related factors. The most prominent determinant among high-performing clusters is social support, followed closely by healthy life expectancy and health spending. Interestingly, gross domestic product per capita, while important, is not a sufficient predictor of happiness when considered in isolation.

TABLE 1. CLUSTER ANALYSIS

Cluster	Social Support	GDP per Capita	Healthy Life Expectancy	Crude Death Rate	Health Expenditure
0	0.915	-0.066	0.269	0.750	0.307
1	0.904	-0.191	0.780	-0.792	-0.367
2	-1.473	-1.892	-3.027	-0.717	-1.604
3	0.091	2.001	0.583	-0.378	-0.939
4	-0.099	0.258	0.292	0.550	0.855
5	-0.353	-1.649	-0.594	-1.055	-0.866
6	0.714	-0.667	-1.438	1.672	-0.494
7	-3.227	0.399	-0.712	-2.409	-2.131
8	-0.163	0.057	0.560	-0.144	0.944

Denmark and Iceland formed Cluster 0. Both countries demonstrated very high social support, relatively high GDP per capita, favorable healthy life expectancy, and moderate crude death rates. Their Happiness Index scores were also among the highest in the dataset. The clustering of these two countries suggests a profile in which strong social connectedness, economic resources, and favorable population health occur together. This profile illustrates that high happiness may be associated with the interaction of social and health conditions rather than with economic resources alone.

The United Arab Emirates (UAE) formed a distinct single-country cluster (Cluster 1). It had relatively high GDP per capita but the lowest social support in the dataset, together with below-average healthy life expectancy and health expenditure. Its crude death rate was also substantially lower than those of the other countries. The UAE's distinct clustering demonstrates that economic prosperity can coexist with a substantially different social and health profile from that observed among other high-happiness countries. Its inclusion highlights the heterogeneity of countries with relatively high Happiness Index scores.

Australia, New Zealand, and Canada formed Cluster 2. These countries shared relatively favorable healthy life expectancy and comparatively high health expenditure, while maintaining relatively strong social-support levels and moderate-to-

high GDP per capita. Their clustering indicates a profile characterized by favorable population health and substantial investment in healthcare. This suggests that health-related conditions and health-system investment constitute important dimensions in understanding high national well-being.

Mexico formed a single-country cluster (Cluster 3) characterized by substantially lower GDP per capita, social support, healthy life expectancy, and health expenditure than most of the countries included in the study. Despite these comparatively less favorable socioeconomic and health indicators, Mexico recorded a Happiness Index of 6.979. This finding is particularly relevant because it demonstrates that high happiness does not necessarily require uniformly high economic and health resources. Factors not included in the present analysis, such as family and community relationships, cultural characteristics, and other dimensions of subjective well-being, may also contribute to national happiness.

Lithuania formed a separate cluster (Cluster 4). It was characterized by very high social support but comparatively low healthy life expectancy and the highest crude death rate among the countries analyzed. GDP per capita and health expenditure were also below the overall average. Lithuania therefore represents a profile in which strong social support coexists with substantial population-health challenges. The finding reinforces the importance of examining social and health characteristics together when characterizing countries with high happiness.

Norway and Ireland formed Cluster 5 and were distinguished primarily by exceptionally high GDP per capita. They also demonstrated favorable healthy life expectancy and relatively low crude death rates. Interestingly, their health expenditure was not among the highest in the dataset. This cluster illustrates that high economic capacity is an important but not sufficient characteristic of countries with high happiness. The findings suggest that national income should be considered alongside social and health conditions rather than treated as a standalone explanation of national well-being.

Cluster 6 was the largest cluster and included Sweden, the Netherlands, Switzerland, Belgium, and Austria. These countries shared relatively high GDP per capita, favorable healthy life expectancy, and the highest average health expenditure among the clusters. Their social-support levels were also relatively strong, although not as pronounced as those observed in Denmark, Iceland, Finland, or Lithuania. The clustering of these five countries indicates a profile characterized by economic development accompanied by substantial investment in health. Their grouping suggests that health expenditure and population health may be important contextual characteristics of high-happiness countries, even when countries differ in their absolute Happiness Index scores.

Costa Rica and Israel formed Cluster 7. Both countries exhibited relatively high social support, favorable healthy life expectancy, and relatively low crude death rates. However, their GDP per capita differed considerably, with Costa Rica having substantially fewer economic resources than Israel. Their grouping is therefore particularly informative. It demonstrates that countries can share favorable social and health characteristics despite substantial differences in economic capacity. Costa Rica, in particular, provides evidence that relatively high happiness can coexist with considerably lower GDP per capita than that observed in many of the high-income countries in the study.

Finland, Slovenia, and Czechia formed Cluster 8. The three countries shared relatively high social-support levels, although their economic and health indicators differed. Finland had the highest Happiness Index in the dataset, while Slovenia and Czechia recorded lower scores. Nevertheless, their common clustering indicates similarities in the multidimensional characteristics used in the analysis, particularly social support. The inclusion of Finland in this cluster is noteworthy because it demonstrates that the country with the highest Happiness Index does not necessarily form a cluster by itself. Rather, clustering identifies similarities across multiple socioeconomic and health dimensions that may not correspond directly to the rank order of happiness.

Overall, the cluster analysis demonstrates that countries with high Happiness Index scores are not characterized by a single socioeconomic or health profile. The nine clusters identified distinct combinations of social support, economic resources, population health, mortality, and health expenditure.

Denmark and Iceland represented a profile combining strong social support with favorable health conditions, while Norway and Ireland were distinguished primarily by very high economic capacity. Sweden, the Netherlands, Switzerland, Belgium, and Austria shared a profile of relatively strong economic resources and health investment, whereas Australia, New Zealand, and Canada were characterized by favorable health outcomes and substantial health expenditure. At the same time, Costa Rica and Israel demonstrated that favorable happiness, social support, and health conditions may occur across substantially different levels of economic resources. Mexico and Lithuania further illustrated that high happiness may coexist with comparatively challenging economic or health indicators. The distinct profile of the United Arab Emirates similarly demonstrates that high income does not necessarily correspond to the social-support characteristics observed in other high-happiness countries. Taken together, these findings support a multidimensional characterization of national happiness, in which economic prosperity, social connectedness, and population health interact rather than operate as independent determinants.

The findings also have differentiated implications for countries across levels of economic development. For countries with comparatively fewer economic resources, such as Mexico and Costa Rica, improving population well-being may require strengthening basic health-system capacity, preventive healthcare, education, social protection, and economic opportunities while recognizing that material resources alone do not determine happiness. For countries with moderate economic capacity, the experiences reflected in clusters involving Lithuania, Slovenia, and Czechia suggest the importance of combining economic development with investments in population health and social support. For high-income countries such as Denmark, Iceland, Norway, Ireland, Sweden, the Netherlands, Switzerland, Belgium, Austria, Australia, New Zealand, and Canada, the findings indicate that continued economic prosperity should be accompanied by sustained attention to social connectedness, healthy life expectancy, and effective health-system investment. The distinct profile of the United Arab Emirates further demonstrates that high national income may coexist with a different pattern of social and health characteristics.

Across economic contexts, therefore, the findings support context-specific and multidimensional approaches to national well-being, integrating economic development with social support and population health rather than relying on income as the principal indicator of happiness.

DISCUSSION

These patterns are strongly supported by contemporary empirical research. A multinational longitudinal study covering 155 countries found that high levels of social support and perceived freedom of life choice consistently predicted greater positive affect and lower negative emotional states across time [12]. This reinforces the central role of social cohesion in shaping both individual and collective well-being. Parallel findings from a European panel study demonstrated that individuals embedded in strong friendship networks reported significantly higher levels of life satisfaction, independent of economic status. These interpersonal relationships not only enhance subjective well-being but also buffer against stressors that often erode quality of life [13].

Community-level social capital has also emerged as a key determinant of psychological flourishing. Social cohesion at the neighborhood level improves life satisfaction, especially among individuals with lower educational attainment [14]. This suggests that social support can moderate the negative effects of socioeconomic disadvantage, reinforcing its role as a structural asset in promoting national happiness. Similarly, longitudinal evidence from Indonesia showed that older adults who experienced higher levels of both structural and cognitive social capital reported fewer depressive symptoms and greater overall happiness, highlighting the protective function of community engagement in later life [15].

Health system strength and investment further differentiate higher-performing clusters. Equitable access to quality primary and preventive care significantly contributes to societal well-being. Countries with limited health spending, such as Mexico, continue to face persistent gaps in healthcare delivery, which hinder improvements in life expectancy and diminish happiness outcomes. In contrast, nations with substantial investment in public health infrastructure demonstrate

stronger outcomes in both health and subjective well-being, supporting the idea that public spending is a necessary condition for translating national wealth into citizen satisfaction [16].

Recent findings from the Harvard Study of Adult Development also affirm the critical role of relationships in determining long-term health and happiness. Quality social connections, rather than income or occupational success, are the strongest predictors of both longevity and psychological well-being. These results underscore why economic indicators such as GDP per capita must be understood within the broader context of social support and health access. High national income, as observed in countries like Norway and Ireland, does not automatically yield high happiness if health investment or social cohesion is lacking [17, 18].

Countries that rank high on the happiness index consistently demonstrate a convergence of interrelated strengths. These include strong and accessible social support systems, sustained investment in public health infrastructure, high life expectancy, moderate crude death rates, and stable economic conditions marked by moderate to high gross domestic product per capita. Such nations often uphold values of equity and cohesion, supported by democratic institutions that facilitate trust and civic engagement. Moreover, the capacity to convert economic wealth into tangible well-being outcomes—through inclusive healthcare, strong community ties, and widespread public services—is what sets these countries apart. It is not the presence of wealth alone, but how that wealth is utilized to enhance social and health capital, that most significantly influences national happiness [19].

The present study contributes to the literature by shifting the analysis from simply identifying countries with high happiness scores toward characterizing the socioeconomic and health profiles that distinguish groups of highly happy countries. Rather than treating happiness as a phenomenon explained by a single factor, the cluster analysis demonstrates that countries with high happiness can possess substantially different combinations of economic resources, social support, population health, mortality, and healthcare expenditure.

The analysis also contributes to understanding health as a component of happiness. Healthy life expectancy and healthcare expenditure vary considerably across clusters, demonstrating that countries with similar levels of happiness may arrive at that outcome through different combinations of health and socioeconomic conditions. The findings therefore support a multidimensional conceptualization of national well-being.

LIMITATIONS

The researchers accept that the study focuses on a relatively small and purposively selected group of countries with high Happiness Index scores. The clustering variables are based on country-level indicators and therefore represent national averages, which should not be interpreted as evidence that the same relationships necessarily exist at the individual level.

CONCLUSION

This study demonstrates that countries with high happiness cannot be characterized by economic prosperity alone. The cluster analysis showed that high happiness may coexist with different combinations of economic, social, and health conditions. The findings indicate three broad insights. First, social support is an important characteristic of several high-happiness country profiles, demonstrating the relevance of social connectedness to national well-being. Second, economic prosperity does not automatically translate into higher happiness, as countries with substantial GDP can still exhibit relatively weaker social or health characteristics. Third, health investment and healthy life expectancy distinguish several country profiles, suggesting that population health is an important component of the broader conditions associated with happiness.

The study therefore characterizes countries with high Happiness Index scores as heterogeneous rather than uniform. Countries may achieve high levels of life evaluation through different combinations of social, economic, and health resources. This finding adds to the literature by demonstrating the value of a cluster-based approach in identifying distinct

patterns among highly happy countries rather than assuming that all high-happiness nations share the same characteristics.

RECOMMENDATIONS

Governments should prioritize the development of social capital networks, investment in universal health infrastructure, and inclusive governance as the foundation for sustainable national well-being. Researchers should look into the other aspects of health and well-being that contribute to the increase in happiness and conduct qualitative studies on individual views on factors affecting happiness.

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RESEARCH ARTICLE

POTENTIAL OF UTILISING WEB-GIS TECHNOLOGY IN LOCAL HEALTH SERVICE PLANNING: A DESCRIPTIVE CASE STUDY FOR MENTAL HEALTH SERVICES PLANNING

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ABSTRACT

BACKGROUND

The integration of Web-Based Geographical Information Systems (Web-GIS) presents a significant enhancement to current health and social services planning methods, particularly in the overly complex context of mental health service planning.

AIM

To improve accessibility to health service information and enhance situational analysis using Web-GIS.

METHODS

The study involved the collection of publicly accessible data of mental health and mental health related services. The data was collected, collated and analysed using a 6-stage cross-sectional method.

FINDINGS

Web-GIS demonstrates potential to support individual service navigation, health service planning, and overcome access issues that are often highlighted as a barrier to recovery for individuals with a lived experience of mental illness.

CONCLUSION

Web-GIS provides many opportunities for health and social service planning, specifically for health and social services in a complex situational mental health environment. This descriptive case study provides lessons learnt, opportunities for further integration and enhancement as well as the potential for interaction of Web-GIS with generative artificial intelligence.

KEYWORDS

mental health, health services planning, health service navigation

INTRODUCTION

The integration of Web-Based Geographical Information Systems (Web-GIS) presents a potential for significant enhancement to current health and social services planning methods. The service context of Mental Health intersects traditional healthcare settings (hospitals, health services), social service environments (employment support, service navigation), telehealth environment (online crisis support, text illness monitoring), psycho-social supports (recreation, men's/women's/youth specific health supports, religious organisations) as well as more novel recovery services (stepped care, psycho-social peer support, recovery colleges). Planning for new mental health services presents a significant challenge with many traditional planning techniques ideal for one service context but not the complex combination of services that exist within mental health. Within the current fast paced changes in technology there is opportunities to explore new methodologies such as Web-GIS, and the use of these technologies in providing navigational and service planning tools.

BACKGROUND

The Central Coast region of New South Wales is comprised of 180 suburbs and a population of approximately 350,000 residents within the local government area of the Central Coast Council. Prior to 2016, it was divided into two subregions North, Wyong Shire, and South, Gosford City [1-2] . Mental health (MH) issues in this region exceed the state prevalence by 3%, highlighting the critical need for developing additional mental health services [1,3].

Despite existing service directories, health service managers in this region face major challenges, such as, limited access to up to date and accurate information regarding mental health, psychosocial and mental health support services. This is a common issue identified across geographically dispersed health services [4]. Additionally, health service managers have limited information regarding the quantity and spread of mental health services (psychosocial/vocational and alike), at the local/state/national level, resulting in a significant contextual gap for service planning [5].

This approach explores the potential of Web-Based Geographical Information Systems (Web-GIS) in compiling and mapping health service data. It examines how these systems can support service navigation and provide contextual information for health service planning, particularly in implementing a Recovery College Model of Care aimed at enhancing mental health and psychosocial support.

Recovery College Models of Care take an education-based approach to support people on a MH recovery journey and overall wellbeing [6]. These services are co-designed with people with a lived experience of MH issues, or with those who care for a person with a MH issue [6]. To implement a Recovery College model that improves MH, meets the needs of the community and decreases pressure on the local health system, effective service planning is essential. Situational analysis is vital in effective service planning and involves identifying the number and locations of currently operating services, and service gaps within a region [7-10].

Web-GIS is often used to visualise spatial data in the form of interactive maps [7,11,12]. This technology is documented to be an effective tool within healthcare settings in planning the location of health infrastructure and disease surveillance [8, 14-16]. Despite this effectiveness, a gap in scientific knowledge exists when utilising Web-GIS in local-level planning, such as the planning for the type and location of health services [9]. This gap in knowledge extends to public health services managers, with limited information accessible regarding non-government MH supports, focused psychosocial supports, and novel MH support services that may be operating across a region. The existing knowledge gap and limited situational analysis data, reduces health managers and service planners capacity to implement informed decisions. The repercussions of this lack of knowledge, leads health managers to develop MH services that potentially fail to meet current and future health demands or replicate existing service offerings in a geographical region. This highlights the need for further research and emphasises the significance of this study.

PURPOSE

The purpose of this study is to explore the use of Web-GIS technology via the development of an Interactive Service Map (ISM) to improve the accessibility of health service information and enhance situational analysis. This study aims to explore if a Web-GIS technology supporting a service directory map can empower health service managers by providing a decision-making tool for designing and implementing health services.

LITERATURE REVIEW

GIS technologies are widely recognised for their capability to collect, organise, analyse, and visualize large datasets of geographical and health information [10,12,15,18-19]. They have been extensively used in identifying service gaps within health systems, optimizing health infrastructure planning to ensure equitable access to health services [12,18]. These technologies also support the identification of shortfalls, or gaps, within a region's health system including health facility supply and demand gaps, and associated health disparities [10,15]. Identifying shortfalls enables health managers and planners to optimise the planning and resourcing of health infrastructure locations to ensure populations are not geographically marginalised or disadvantaged in accessing essential health services [15,18,19]. Maina et al's study outlines a viable method for the utilisation of GIS technologies in strategic level health service planning [19]. The proposed method comprises data source identification, collection, abstraction, cleaning, and evaluation. However, a significant gap exists in utilising Web-GIS for local service level planning, specifically to inform the types and delivery methods of health services within regions, particularly in mental health contexts.

METHODS

This study involved six key stages adapted from Maina et al. [19]; data source identification, collection, extraction, Web-GIS ISM development, data evaluation, and cleaning. Data was publicly available and obtained from the secondary sources of Google and Microsoft Bing Maps. With data publicly accessible, no ethical clearance was required for this study. However, approval for the use of relevant organisational technologies and the distribution of findings was attained from the Local Health District.

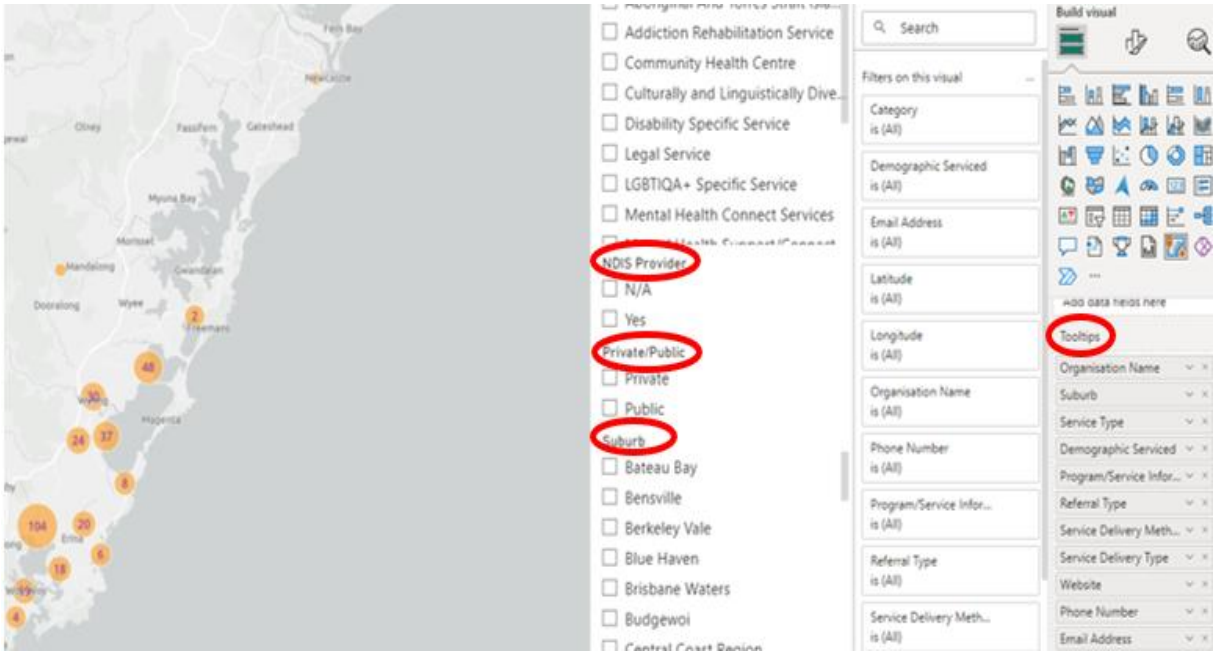
TABLE 1. METHOD FOR DEVELOPING A WEB-GIS ISM

Stages	Description
1 - Data Source Identification	Google and Microsoft Bing search engines utilised to obtain local health service information.
2 - Data Collection	Microsoft Sharepoint Application utilised to collect local health service information into a WEB-GIS database.
3 - Data Extraction	Database information categorised into overall service category, service suburb, demographic able to access service, service type, referral type, NDIS provider status, service delivery method, service delivery type, and if a publicly or privately funded.
4 - Web-GIS ISM Development	ARC-GIS mapping software within the Microsoft PowerBI application was utilised to create an ISM which enables filtering functions for service type, NDIS provider status, suburb, and services that are private or publicly funded.
5 - Data Evaluation	An automated email system was utilised, incorporating a Microsoft Forms application to verify with health service organisations and ensure the accuracy of WEB-GIS ISM data.
6 - Data Cleaning	Completed Microsoft Forms integrated into the WEB-GIS database and ISM to correct data inconsistencies and remove health services no longer operating within the Central Coast.

'Google Maps' and 'Microsoft Bing Maps' search engines were identified as primary data sources for this study. The search strings of 'Mental Health Service Central Coast', 'Psychosocial Service Central Coast', and 'Mental Health Support Service Central Coast' were input into these search engines. Data collection and extraction occurred simultaneously, with the relevant health service information obtained from search engines stored in the Microsoft Sharepoint Application. Data extraction saw stored data organised and classified into the following categories: 'overall service category', 'service suburb', 'demographic able to access service', 'service type', 'referral type', 'NDIS provider status', 'service delivery method', 'service delivery type', and if a service was 'publicly or privately funded'. Abstracted data resulted in the establishment of a Web-GIS database.

This database was connected to ARC-GIS mapping software through the Microsoft Power BI Application to produce an interactive service map (ISM). Functions, such as tooltips and slicers, were embedded into the ISM to integrated data to relevant database abstraction categories and allow end-users to filter service locations based on service type, NDIS provider status, suburb, and services that are privately or publicly funded.

FIGURE 1. TOOLTIPS AND SLICER FUNCTIONS UTILISED WITHIN THE ARC-GIS POWERBI SOFTWARE.



Data evaluation and cleaning improved the accuracy and validity of database information and the ISM. This consisted of three rounds of emails sent to services logged on the database using an automated email verification system. Emails included a Microsoft Forms link that contained abstracted database information specific to each MH, psychosocial, and MH support service. Services either verified or updated the database information via this form. Completion of the Microsoft Form enabled data-cleaning, as services corrected data inconsistencies, and services which were non-longer operating were removed from the database. Services that completed the forms were logged on the database as 'verified'.

RESULTS

The Web-GIS ISM developed in this study successfully visualised situational analysis data, highlighting 433 MH, psychosocial, and MH support service locations across the Central Coast. Of these 433 services, 323 operated in or from a physical location on the Central Coast, while the remaining 110 operated remotely via online or phone service delivery methods. Of the 433 services identified in 2022, 229 services had email addresses with 65% (148) of these services verifying the data collected from the public domain was accurate and valid.

TABLE 2. SERVICE GAPS ACROSS CENTRAL COAST IN 2022

	North District	South District	Total	Service Gap
2021 Population (ABS, 2021)	168,171	178,427	346,598 people 17,047 First Nations people	• Physically located Mental Health Support services • Psychiatry services, additional deficit in the North district • Legal services • Aboriginal Specific services • CALD services • LGBTQIA+ specific services
Mental Health Services	35 (8%)	48 (11%)	83 service locations	
	• 32 psychology & counselling services • 3 psychiatry	• 43 psychology & counselling services • 5 psychiatry		
Psychosocial Services	114 (26%)	105 (24%)	219 service locations	
	• 9 Aboriginal Specific • 14 Addiction Rehabilitation • 4 Legal • 1 CALD specific • 3 LGBTQIA+	• 6 Aboriginal Specific • 11 Addiction Rehabilitation • 1 Legal • 1 CALD specific • 3 LGBTQIA+		
Mental Health Support Services	9 (2%)	12 (2%)	21 service locations	
Operating Remotely	110 services (25%)			
Total	158 (36%)	165 (38%)	**433**	

Publicly funded services were reported to account for more than 81% (351) of services physically located within and operating remotely across the Central Coast. This study also reveals a significant difference in the distribution of privately funded services, with the South, Gosford Shire (47), home to 1.5 times more private services than the North, Wyong shire (29).

This study and the ISM identified significant service gaps, particularly in specific service types and geographic regions within the North and South districts. The ISM reveals psychosocial services account for the largest proportion (69%) of services across the Central Coast. With psychosocial services 3.5 times, and 6 times greater than the number of MH and MH support services on the Central Coast, respectively.

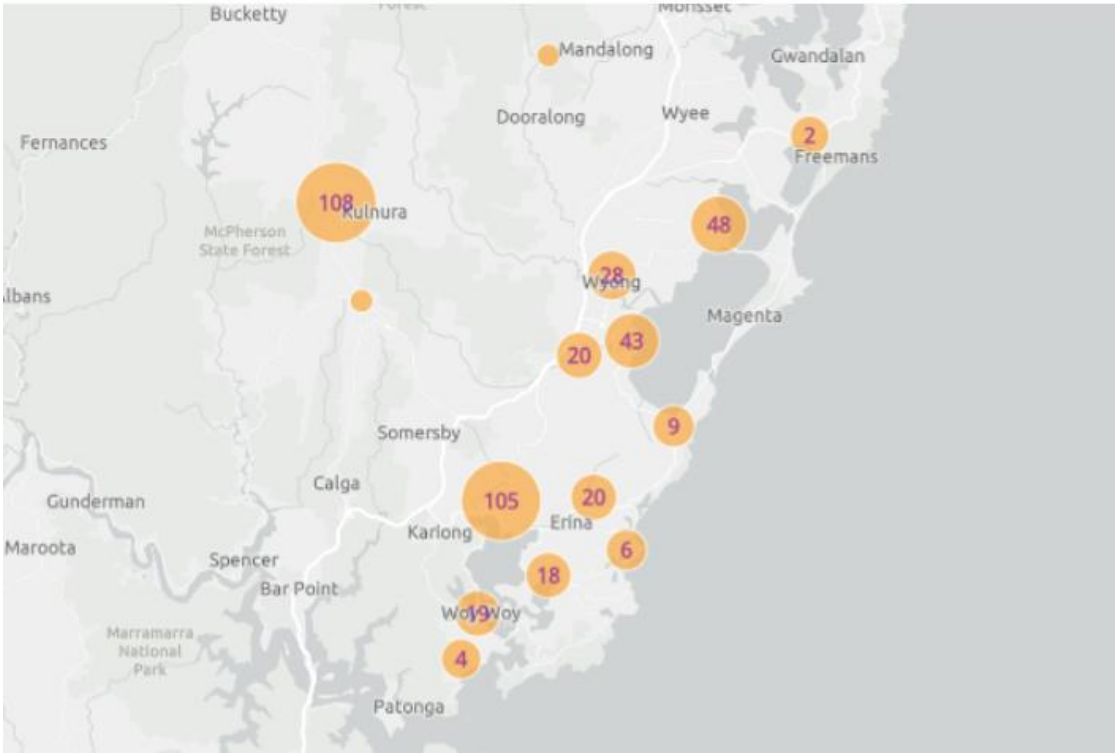
The ISM identified a significant overall gap in services physically located on the Central Coast with psychiatric (8), Culturally and Linguistically Diverse (CALD) (2), and legal services (5). Furthermore, the ISM highlights significant service gaps when comparing the northern (Wyong) and southern (Gosford) districts, with psychiatric services in the south double of those in the north. Additionally, the number of psychology and counselling services was 1.3 times greater in the South than in the North.

TABLE 3. GEOGRAPHIC DISTRIBUTION OF HEALTH SERVICE LOCATIONS ACROSS THE CENTRAL COAST.

	North District	South District	Total
Highest Suburban Density	46 (14%) of physically located services operate in Wyong	87 (27%) of physically located services operate in Gosford	133 (41%) of physically located services operate within 2 suburbs.
Lowest Suburban Density	21% of suburbs with services have only 1 physical service location.	19% of suburbs with services have only 1 physical service location.	17 (40%) Central Coast suburbs with services have only 1 service location.

A lack of physically located MH Support services was also found in this study, with 60% of MH support services on the Central Coast operating remotely via telephone or online. Additionally, the ISM visualised an uneven distribution of service locations across suburbs, with 72% of suburbs lacking a single physical MH, psychosocial or MH support service. Visualised data from the ISM reveals the highest densities of services to be in the central suburbs of Gosford and Wyong, with these 2 suburbs containing 41% (133) of MH, psychosocial, and MH support services physically located on the Central Coast. The ISM reveals an uneven distribution of services between the suburbs of Gosford and Wyong, with 87 services reported in the Gosford suburb and 46 services in Wyong.

FIGURE 2. NORTH AND SOUTH SERVICE LOCATION AND SERVICES OPERATING REMOTELY ACROSS THE CENTRAL COAST ILLUSTRATED USING WEB-GIS TECHNOLOGY.



DISCUSSION

WEB-GIS ISM: A HEALTH PLANNING TOOL

The ISM visualised MH, psychosocial and MH support service distribution and types, enabling health managers to identify disparities in the type and location of services available to Central Coast residents. By highlighting these disparities, the ISM has enhanced informed decision making for health managers regarding the equitable and effective distribution of health services and resource allocation. The Web-GIS ISM proved to be a crucial tool for health service planning across

the region, with this technology playing a pivotal role in supporting health managers to design a Central Coast Recovery College Model of Care. This technology has facilitated strategic data driven decision-making, allowing health managers to identify service partnerships for the implementation of a Recovery College Model of Care.

WEB-GIS ISM: IMPLEMENTATION OF A SERVICE DIRECTORY

One major challenge for mental health consumers is service navigation [20] with web based digital service navigation tools showing significant potential in the mental health environment [14]. A potentially added benefit of this technology would be the seeming ease of making this data publicly accessible by promoting the ISM as a web-based service directory. An unexpected outcome of a publicly accessible interactive service directory is improved service navigation for Central Coast service providers and community members. With previous health service directories utilising static methods, such as Excel Spreadsheets or paper directories, to visualise service information, data within these directories are often outdated from the point of publication [5]. The automated email verification system within this study highlights the capability of Web-GIS in overcoming the challenges faced by traditional service directories with the data validation and database feedback mechanisms improving service directory data accuracy and validity. These mechanisms emphasise the sustainability of Web-GIS technologies in the applications of service planning and service navigation tools.

STRENGTHS

Key strengths of the Web-GIS ISM included its dynamic data visualisation capabilities, which illustrates significant value when compared to traditional static data visualisation methods that are prone to quickly becoming outdated. This study highlights the potential of integrating Web-GIS technology with automated systems to support ongoing data updates and ensure accurate and valid data is available to support health managers in service planning.

LIMITATIONS

Despite its benefits, using Web-GIS requires investment for access and maintenance and training. Furthermore, integrating this technology into existing systems requires specialised technical knowledge, which can limit its widespread implementation. Additionally, reliance on public domain sources and data verification challenges posed limitations on data comprehensiveness and accuracy, as those MH, psychosocial, and MH support services without an email address were unable to be verified using the study's method. Furthermore, a challenge for the application of these technologies includes certain services requiring varying levels of confidentiality, such as domestic violence refuges and support services. Information available to health services planners, service providers, and the broader community must be at these services' discretion and a key consideration when utilising these technologies for service planning and navigation tools.

ENHANCEMENTS

For addressing the confidentiality challenge, there is potential to establish three separate fit-for-purpose Web-GIS ISM tools. The first of these with a wider scope of confidential service information to meet the needs of health managers. Additionally, this ISM tool could explore the potentials in integrating population and health demographic data via heatmap functions to aid in the planning of health services and models. A potential solution for overcoming challenges relating to publicly accessible data and service information confidentiality includes establishing two separate service directories: a service provider directory, and a community member directory. To meet differing needs, the service provider directory could contain more confidential and detailed service information, than the community member directory. These directories have the potential to be built from the same backend database, enabling sustainable data validation. Further enhancements may be to include additional national services that offer remote support such as Lifeline, Kids helpline, Suicide Callback Service, whilst these are not specific to service planning, they are essential inclusions to service directory/navigation if the scope of the tool is to be expanded.

FUTURE SCOPE

In addition to supporting future health service planning, Web-GIS has also shown potential to support individual service navigation, overcoming access issues that are often highlighted as a barrier to recovery for individuals with a lived experience of mental illness. As technology further enhances there is potential for the integration of Web-GIS with generative artificial intelligence such as; AI chat-bots to provide contact details to consumers in need, AI virtual assistance to support regular data validation, and the integration of AI tools to improve user-face portal navigation. Exploration of

the integration of these technologies offers new innovations for the health landscape such as changes to the digital health space and existing models of care.

CONCLUSION

In conclusion, this study addresses the gap in knowledge regarding the use of Web-GIS in local health service planning. The Web-GIS ISM developed supported the service planning of a Central Coast Recovery College Model of Care. This technology provided critical insights into service distribution and gaps, thereby enhancing situational analysis and decision-making for health service planners, highlighting Web-GIS technologies value in enhancing local level mental health service planning. This study explores the immense potential Web-GIS technologies have in transforming approaches to health planning and service navigation. With the potential to adapt these technologies to meet the evolving needs of communities and health planners, adoption of these technologies' puts forth a sustainable solution to providing current and valid health service information. Moving forward, the potential integration of Web-GIS with adapting AI technologies further emphasises the capabilities and sustainability of this technology within the health landscape.

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RESEARCH ARTICLE

THE IMPACT OF TECHNOSTRESS RESOURCES ON SUBJECTIVE CAREER SUCCESS AMONG HEALTHCARE PROFESSIONALS IN HEALTH INSTITUTIONS

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ABSTRACT

OBJECTIVE:

Employee satisfaction is a critical factor in the success of healthcare organizations. As digital technologies become more prevalent in healthcare settings, understanding their psychological impact on employees is increasingly important. This study investigates the effect of technostress resources on the subjective career success of healthcare professionals.

METHODS:

The study was conducted with 400 healthcare professionals at a university hospital in Konya Province. Data were collected using the 23-item, 5-factor Technostress Creators Scale and the 24-item, 8-factor Subjective Career Success Inventory through face-to-face surveys and convenience sampling. Participants included health technicians, nurses and midwives, physicians, and medical secretaries. SPSS software was used for statistical analysis, including t-tests, ANOVA, correlation, and regression analyses.

RESULTS:

ANOVA and t-tests results showed no significant differences in technostress scores based on education level, marital status, or professional experience. However, significant differences were found in relation to gender, income level, occupation. Correlation analysis revealed a positive and significant relationship between technostress resources and subjective career success.

COCLUSION:

The findings suggest that technostress resources have a measurable impact on healthcare professionals' career satisfaction. Addressing technostress through supportive organizational strategies may enhance employees' sense of career success and well-being in the workplace.

KEYWORDS

technostress, career satisfaction, healthcare professionals, psychological stress, job performance, workplace well-being

INTRODUCTION

Employee satisfaction within the healthcare sector has become a crucial determinant of organizational success. As the healthcare sector continues to evolve, identifying the factors influencing employee satisfaction has gained increasing importance [1]. However, research examining the impact of healthcare organizations on both healthcare providers and patients often produces conflicting findings [2]. In this context, the impact of technology use in organizational settings emerges as a critical issue. Similarly, career success serves as a significant motivator for both employees and organizations, warranting further investigation. Technostress is defined as the negative psychological and physiological strain individuals experience as a result of technology use [3]. Factors such as the inability to keep up with rapidly evolving technological innovations and an increasing workload are among the primary causes of technostress [4]. Technostress is a multifaceted phenomenon encompassing physical, emotional, behavioral, and psychological dimensions [5]. Research on technostress typically focuses on various factors that assess the negative impacts of technology use on individuals [6]. These factors include: the increased workload imposed by technology (techno-overload), the constant connectivity pressure that disrupts personal life (techno-invasion), the complexity of technologies that induces feelings of inadequacy (techno-complexity), concerns about occupational safety arising from new technologies (techno-insecurity), and the uncertainty created by technological changes (techno-uncertainty) [6,7]. Salanova et al. (2013) identified elements of technostress such as skepticism, fatigue, anxiety, and ineffectiveness [8]. In this context, it is believed that the negative impacts of technostress on employees could hinder their career success.

Career success refers to positive outcomes that contribute to an individual's sense of psychological accomplishment in their professional life [9,10]. It can also be defined as the positive outcomes and achievements an individual attains through their work experiences [11,12]. Initially conceptualized through the lens of job satisfaction, career success has since been categorized into two main dimensions as objective and subjective career success. Career success can be assessed through objective factors, such as salary and hierarchical position, as well as through individuals' subjective evaluation of their careers [12,13]. In particular, subjective career success has emerged as a form of success that provides psychological fulfillment, rooted in individuals' personal experiences [14,15]. Conversely, objective career success refers to tangible and psychological outcomes derived from work experiences, which hold significant importance for both individuals and organizations [16,17]. In this context, how individuals perceive their work environments, how they evaluate career development opportunities, and how they cope with stressors have become a fundamental research topic in the field of organizational behavior in today's dynamic and competitive business world.

How individuals perceive their work environments, how they evaluate career development opportunities, and how they cope with stressors have become fundamental research topics in the field of organizational behavior in today's dynamic and competitive business world. In this context, Conservation of Resources (COR) theory offers an important theoretical framework explaining the behaviors and psychological responses of individuals under the threat of resource loss [18,19]. According to COR theory, individuals tend to conserve and increase their resources; some types of stress encountered in this process can be considered not only as threats but also opportunities. From this perspective, challenge stressors represent a potentially valuable resource for individuals [20]. This is because such stressors are often associated with individual development, learning, and career advancement. When individuals perceive these demands as supportive elements in achieving their goals, they tend to view these situations as opportunities for growth rather than as hindering pressure [21,22]. Therefore, it is thought that challenging stressors can strengthen individuals' positive attitudes towards work and encourage innovative behaviors. However, task crafting, a process in which individuals actively reorganize and improve their work, stands out as an important mediating mechanism in transforming challenging stress into innovative outcomes [23]. The task crafting process allows individuals to make their work more meaningful and manageable while coping with stress, and in this respect, it plays a critical role in transforming stress into innovative behaviors.

In a study conducted by Karaşin and Öztırak (2023), it was found that the career dedication of healthcare professionals positively influences their subjective well-being [24]. Similarly, Karadirek (2022) reported that prosocial motivation significantly predicts the career success of academic staff employed at a public university in Türkiye [25]. In addition,

research by Kopuz and Aydın (2020) revealed that healthcare professionals experience a moderate level of technostress [26]. The correlation between career success and technostress is a critical consideration for healthcare institutions striving to establish more efficient and effective work environments. In this context, the present study aims to examine the impact of technostress resources on the subjective career success of healthcare professionals. By contributing to the development of strategies designed to enhance career satisfaction among healthcare professionals, this research seeks to offer a valuable addition to existing literature.

METHODS

PARTICIPANTS

The study sample consisted of physicians, nurses, midwives, health technicians, and medical secretaries employed at a university hospital. Only data from participants who completed all items in the survey were included in the analysis. The sample size was determined using the G*Power 3.1.7 software. A total of 470 surveys were distributed to employees; however, only 400 respondents who completed all items were included in the final analysis. Incompletely filled surveys were excluded from the study. The data collection form required approximately 10 minutes to complete.

INFORMATION FORM

The information form included questions regarding the participants' individual characteristics, professional background, and working conditions.

The Technostress Creators Scale, originally developed by Tarafdar et al. and adapted into Turkish by Bulut, Şengül, and Akbal (2010), with its validity established in 2023, consists of 23 items across five factors: techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty [27]. The scale was designed using a 5-point Likert format. Higher scores on the scale indicate higher levels of technostress. The scale does not contain any reverse-scored items. The Turkish version of the scale demonstrated Cronbach's alpha coefficients ranging from 0.60 to 0.87 across the five factors. The Subjective Career Success Inventory (SCSI), originally developed by Shockley et al. and adapted into Turkish by Budak and Gürbüz (2017), consists of 24 items across eight factors (recognition, meaningful work, influence, quality work, authenticity, personal life, growth and development) [28]. The scale was designed using a 5-point Likert format. The scale does not contain any reverse-scored items. The Turkish reliability coefficient for the factors of the scale ranges from 0.79 to 0.91.

INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria were defined as: actively working as a physician, midwife, health technician, or medical secretary at the university hospital where the program is conducted, being 18 years of age or older, and completing the data collection form voluntarily. Exclusion criteria were listed as incomplete or erroneous data collection, classification according to the specified industries, refusal to participate in the study, or withdrawal from the study during the research process.

STATISTICAL ANALYSIS

Data were analyzed using IBM SPSS Statistics 26.0. The descriptive characteristics of the findings are presented as frequency (n), percentage (%), and mean ± standard deviation (minimum-maximum) values. Normality was assessed using Skewness and Kurtosis values, which ranged between -1.5 and +1.5, indicating that the data were consistent with a normal distribution [29]. For the Technostress Creators Scale, the Skewness and Kurtosis values were 0.112 and -0.283, respectively. For the Subjective Career Success Inventory, the values were -0.342 and 0.486. Descriptive data were evaluated using frequency (n), percentage (%), mean, standard deviation, median, minimum, and maximum values. The reliability of the scales was assessed using Cronbach's alpha internal consistency coefficient. Pearson's correlation test was used to examine correlations between variables. Simple linear regression analysis was used to determine whether the variables predicted each other. Since the data met the normality criteria, parametric tests (t-test, ANOVA) were applied for group comparisons. The χ^2 test was used to assess differences between categorical variables. Results were evaluated at a 95% confidence interval, with statistical significance set at $p<0.05$.

ETHICAL ASPECT OF THE RESEARCH

Before starting the research, permission was received from Selçuk University Faculty of Health Sciences Non-Invasive Clinical Research Ethics Committee (Date: 27/03/2024; Decree No: 2024/340).

RESULTS

The distribution of socio-demographic data for the healthcare professionals participating in the study is presented in Table 1.

TABLE 1: DISTRIBUTION OF PARTICIPANTS ACCORDING TO DESCRIPTIVE CHARACTERISTICS AND TEST RESULTS OF DIFFERENCES (N = 400)

Descriptive characteristics	n (%)	Technostress Total Mean±SD	Test/p	Subjective Career Success Inventory Total Mean±SD	Test/p
Education					
High school	39 (9.8)	2.75±0.68	F=1.345	3.45±0.72	F=0.256
Associate Degree	111 (27.8)	2.93±0.64	p=1.345	3.56±0.56	p=0.054
Bachelor's Degree	153 (38.3)	2.91±0.62		3.47±0.70	
Postgraduate	97 (24.3)	2.99±0.60		3.68±0.54	
Marital Status					
Single	166 (41.5)	2.81±0.63	t=1.025	3.50±0.64	t=0.021
Married	234 (58.5)	2.99±0.61	p=0.306	3.58±0.63	p=0.984
Gender					
Female	225 (56.3)	2.95±0.62	**t=-2.902**	3.55±0.61	t=-1.176
Male	175 (43.8)	2.88±0.63	**p=0.004**	3.54±0.66	p=0.240
Income Status					
Minimum wage	46 (11.5)	2.67±0.58	**F=5.225**	3.48±0.64	F=0.287
2 times the minimum wage	198 (49.5)	2.90±0.61	**p=0.006** Post-Hoc (Scheffe) 1<3	3.55±0.63	p=0.750
3 times the minimum wage and above	156 (39.0)	3.01±0.65		3.56±0.63	
Occupation					
Physician	78 (19.5)	3.06±0.62	**F=2.662**	3.72±0.52	**F=5.520**
Nurse-Midwife	118 (29.5)	2.91±0.59	**p=0.048** Post-Hoc (Scheffe) 4<1	3.46±0.66	**p=0.001** Post-Hoc (Scheffe) 2<1, 4<1
Health Technician	164 (41.0)	2.90±0.66		3.58±0.62	
Medical secretary	40 (10.0)	2.72±0.56		3.27±0.69	
Age					
18-24	63 (15.8)	2.73±0.56	**F=3.877**	3.51±0.50	F=0.177
25-31	138 (34.5)	2.88±0.66	**p=0.009** Post-Hoc (Scheffe) 1<4	3.54±0.65	p=0.912
32-38	103 (25.8)	2.95±0.64		3.54±0.72	
39 and older	96 (24.0)	3.06±0.57		3.58±0.59	
Professional experience					
1-4 years	137 (34.3)	2.82±0.60	F=1.682	3.49±0.57	F=1.105

5-8 years	72(18.0)	2.91±0.70	p=0.153	3.51±0.70	p=0.354
9-12 years	74 (18.5)	2.98±0.67		3.65±0.72	
13-16 years	43 (10.8)	2.91±0.56		3.50±0.64	
17 years and over	74 (18.5)	3.04±0.57		3.61±0.58	

A total of 400 employees participated in the survey, of whom 225 (56.3%) were female. The largest proportion of participants were health technicians (164, 41.0%), followed by nurses and midwives (118, 29.5%), physicians (78, 19.5%), and medical secretaries (40, 10%). The majority of participants were aged between 25 and 31 years (138 participants, 34.5%), and 234 participants (58.5%) were single. The sociodemographic data of the participants are presented in Table 1. All employees participating in the study fully completed the survey.

As a result of the t-test, a significant difference was found between the gender of the participants and their mean score on the Technostress Creators Scale ($p<0.05$). The mean score for female participants was higher compared to that for male participants. However, no statistically significant difference was found between marital status and the mean score on the Technostress Creators Scale ($p>0.05$). In addition, there were no statistically significant differences between marital status, gender, and the mean scores on the Subjective Career Success Inventory ($p<0.05$).

To assess whether the participants' educational status, income level, occupation, age, and years of professional experience were associated with the mean scores on the Technostress Creators Scale and the Subjective Career Success Inventory, a one-way analysis of variance (ANOVA) was conducted. The results revealed significant differences between income level, age group, and occupation, and their respective mean scores on the Technostress Creators Scale ($p<0.05$). It was found that participants earning three times or more than the minimum wage had higher mean scores on the Technostress Creators Scale than those earning the minimum wage. Similarly, participants over the age of 39 had higher mean scores compared to those in the 18-24 age group. In addition, physicians had higher mean scores on the scale compared to medical secretaries.

A significant difference was also found between participants' occupations and their mean scores on the Subjective Career Success Inventory ($p<0.05$). Physicians had higher mean scores on the Subjective Career Success Inventory compared to medical secretaries. However, no significant differences were found between participants' educational status, income level, age group, and years of professional experience and their mean scores on the Subjective Career Success Inventory ($p>0.05$).

TABLE 2. OVERALL SCALE AND FACTOR MEAN SCORES OF EMPLOYEES AND CORRELATION RESULTS (N = 400)

	mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. SCSI Total Score	3.54	0.63	**1**														
2. Recognition	3.74	0.84	**.642****	**1**													
3. Meaningful Work	3.38	0.83	**.728****	**.552****	**1**												
4. Influence	3.05	1.08	**.658****	**.345****	**.409****	**1**											
5. Quality Work	3.78	0.79	**.740****	**.472****	**.556****	**.430****	**1**										
6. Authenticity	3.43	0.91	**.776****	**.344****	**.466****	**.431****	**.502****	**1**									
7. Personal Life	3.43	0.87	**.643****	**.234****	**.299****	**.288****	**.243****	**.557****	**1**								
8. Growth and Development	3.68	0.78	**.779****	**.448****	**.540****	**.357****	**.597****	**.511****	**.491****	**1**							
9. Satisfaction	3.36	1.04	**.739****	**.338****	**.401****	**.362****	**.409****	**.585****	**.459****	**.576****	**1**						

10. Overall Technostress	2.92	0.63	**.237****	**.112***	**.103***	**.101***	**.119***	**.253****	**.260****	**.119***	**.259****	1					
11. Techno-overload	3.11	0.95	**.137****	.077	0.26	-.040	**.113***	**.154****	**.147****	**.130****	**.185****	**.741****	1				
12. Techno-invasion	2.96	0.89	**.211****	**.156****	**0.114***	**.151****	**.142****	**.204****	.075	**.158****	**.188****	**.670****	**.437****	1			
13.Techno-complexity	2.78	0.81	**.129****	.096	.076	.089	.008	**.121***	**.145****	**.018**	**.152****	**.773****	**.423****	**.448****	1		
14. Techno-insecurity	2.90	0.97	**.102***	.017	.028	-.050	.033	**.130****	**.234****	.022	**.162****	**.722****	**.395****	**.320****	**.433****	1	
15. Techno-uncertainty	2.83	1.00	**.239****	.044	**.119***	**.221****	**.111***	**.259****	**.285****	0.79	**.197****	**.537****	**.173****	**.145****	**.196****	**.335****	1

Bold values represent statistically significant results. * p<0.05, ** p<0.01, SD: Standard Deviation,

The correlation between Technostress and Subjective Career Success Inventory scores, as well as the individual factors of each, is presented in Table 2. A significant positive and very weak to weak correlation was found between the total scores and the factors of the scales (Table 2). Results were evaluated at a 95% confidence interval, with statistical significance set at p<0.05.

The mean score for the Technostress Creators Scale was 2.92±0.63, while the mean score for the Subjective Career Success Inventory was 3.54±0.63. These mean scores suggest that participants experienced a moderate level of technostress, while their subjective perceptions of career success were at a moderate-to-high level.

TABLE 3. REGRESSION ANALYSIS (N=400)

	B	Std Error	β	t	p
Constant	2.846	0.147		19.355	<0.001
Technostress	.240	0.049	0.237	4.863	<0.001

R=0.237; R2=0.056; F=23.648; The regression equation of the model is Y=2.846+0.240x

Simple linear regression analysis revealed that technostress significantly and positively predicted subjective career success ($R = 0.237$, $R^2 = 0.056$, $p < 0.001$). Although the explained variance was limited (5.6%), the relationship was statistically significant, indicating that technostress has a measurable effect on career perception. This finding suggests that technostress may play a significant role in how individuals perceive their career success and warrants further investigation in future research ($B = 0.240$, $t = 4.863$).

DISCUSSION

The correlation analysis conducted in this research reveals a weak and statistically significant positive correlation between technostress and subjective career success. Previous studies, such as those by Dragano and Lunau (2020), indicate that increasing technological demands in the workplace can create stress factors, yet, for some individuals, this stress can enhance professional competence and motivate personal development [30]. The positive contribution of technostress to subjective career success can be explained by both individual and institutional dynamics.

When examining the demographic variables related to technostress, it is evident that female participants reported significantly higher levels of technostress compared to their male counterparts. This may be attributed to factors such as insufficient institutional support for technology use, a higher likelihood of female employees experiencing work-family role conflicts, or additional pressures associated with gender roles [31].

In addition, a significant difference was found based on occupation. Physicians reported the highest mean technostress scores, while medical secretaries had the lowest. Physicians often encounter technological challenges related to patient management, advanced diagnostic and treatment tools, and electronic health record systems [32-33].

With respect to subjective career success, significant differences were observed based on occupation, while no significant differences were found in relation to gender, income, age, education level, or marital status. While married participants exhibited slightly higher subjective career success scores compared to their single counterparts, the lack of statistically significance suggests that work–life balance and family responsibilities did not significantly influence career success within this sample [34-35]. While exposure to high levels of technology is associated with increased risks of mental strain, fatigue, and cognitive overload, appropriate training and institutional support mechanisms can enhance employees' professional satisfaction and career success [36].

The findings show a statistically significant, though weak, association between technostress and subjective career success. This suggests that technostress has the potential to influence individuals' career development and should not be ignored, despite its low explanatory power. According to Conservation of Resources (COR) theory, challenging stressors can motivate individuals to increase their resources, learn, and develop; this could explain the positive impact of technostress on subjective career success. Furthermore, the task crafting process can function as a critical channel for individuals to transform stressors into innovative behavior. Regarding demographic and occupational differences, the higher technostress levels reported by female participants can be explained by work-family role conflicts and differences in access to technological support. The highest technostress scores among doctors can be linked to occupational technological challenges such as patient management, advanced diagnostic and treatment tools, and electronic health records. These results indicate that organizations can mitigate the negative effects of technostress and support individuals' career development by providing their employees with adequate training and technological support.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, this study aimed to explore the effects to technostress levels among professionals working in healthcare institutions on their subjective career success. The research findings indicate that technostress presents both challenges and opportunities. The study highlights that various factors of technostress exert different effects on employees. In particular, elements such as techno-overload, techno-invasion, and techno-uncertainty contribute to additional pressures. The findings suggest that, when adequate institutional support and guidance are provided during the technological adaptation process, the adverse effects of technostress can be mitigated. Furthermore, the research demonstrates that digital transformation processes within healthcare institutions can significantly influence employees' perceptions of professional success. This adaptation is closely linked to the institutional support mechanisms available. Based on these insights, several strategies are proposed to reduce technostress levels among employees in healthcare settings and enhance their subjective career success.

The findings of this study provide valuable insights for understanding and managing the effects of technostress on employees in healthcare institutions. To help healthcare professionals adapt to technological changes and sustain their professional success, systematic organizational support and training programs must be implemented.

COMPETING INTEREST:

There is no conflict of interest arising from the study on the part of the authors or from a third perspective.

ETHICAL STANDARDS:

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. In addition, the study (with Selçuk University SBF. Non-invasive Clinical Research Ethics Committee Approval Certificate dated 27.03.2024 and numbered 2024/340) was prepared in accordance with the rules of scientific research and publication ethics.

AUTHOR CONTRİBUTİONS:

ŞG: Conceptualization; writing—original draft; formal analysis; methodology; writing—review and editing

FE: Conceptualization; writing—original draft; formal analysis; methodology; writing—review and editing.
ŞS: writing—review and editing.
YET: writing—review and editing.

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RESEARCH ARTICLE

LINKING WORKPLACE OSTRACISM, PSYCHOLOGICAL CONTRACT VIOLATION, EMOTIONAL EXHAUSTION AND NURSES' DEVIANT BEHAVIOUR: A SERIAL MEDIATION FRAMEWORK

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ABSTRACT

PURPOSE

Nurses form the backbone of healthcare delivery, yet their effectiveness is often undermined by adverse workplace dynamics. This study investigates how workplace ostracism (WO) translates into deviant behaviour (DB) among nurses in Indian public hospitals, with psychological contract violation (PCV) and emotional exhaustion (EE) as serial mediators.

METHOD

Using survey data from 381 nurses selected from public hospitals across four metropolitan Indian cities. The theoretical model was tested through Partial Least Squares Structural Equation Modelling (PLS-SEM) and the serial mediational analysis was tested through the Variance Accounted For (VAF) technique

RESULTS

The PLS-SEM results confirmed that WO positively predicts DB both directly and indirectly through PCV and EE in sequence. Findings extend Social Exchange Theory (SET) by demonstrating that deviance arises not merely as an immediate retaliatory response but through a progressive erosion of trust and depletion of emotional resources. This dual-path mechanism offers a nuanced explanation of how negative social exchanges culminate in counterproductive outcomes in resource-constrained healthcare contexts.

CONCLUSION

The study advances existing literature by elucidating the 'partial serial mediation effect' of psychological contract violation and emotional exhaustion in the workplace ostracism–deviant behaviour relationship, thereby offering a more nuanced and theoretically enriched understanding of this dynamic. Theoretically, the study advances SET by integrating relational contract breaches with resource depletion processes. Practically, it highlights the urgent need for reforms in Indian public hospitals, including dedicated human resource leadership, mandated nurse-patient ratios, inclusive workplace policies, psychological support systems, and leadership development for nurse supervisors. Strengthening reciprocity and fairness in professional relationships is not only central to workforce well-being but also critical for patient safety and healthcare quality.

KEYWORD

Workplace ostracism; psychological contract violation; emotional exhaustion; deviant behaviour; nursing; serial mediation model; PLS-S

INTRODUCTION

Nurses form the backbone of healthcare delivery, constituting the largest group of health professionals worldwide and playing a decisive role in safeguarding patient safety and ensuring quality care [1]. Their responsibilities extend well beyond bedside care to include patient advocacy, education, and coordination within multidisciplinary teams, thereby directly shaping treatment outcomes and patient experiences. Recognizing this, the World Health Organization underscores that strengthening the nursing workforce is essential for advancing universal health coverage and building sustainable health systems [2]. In resource-constrained settings such as India, where public hospitals remain severely overburdened and nurse-to-patient ratios are critically low, the role of nurses becomes even more indispensable [3]. Positioned at the frontline of service delivery, nurses are uniquely tasked with identifying complications, preventing errors, and ensuring adherence to care protocols [4, 5]. Consequently, their professional conduct, psychological well-being, and sustained engagement are fundamental not only to institutional performance but also to broader public health outcomes [4, 6].

Yet, nurses, like employees in other organizational domains are vulnerable to counterproductive work behaviours (CWB), defined as actions that hinder organizational objectives, strain interpersonal relations, or compromise patient care [7, 8]. In healthcare, such behaviours may manifest as withdrawal, absenteeism, diminished empathy, resistance to collaboration, or subtle forms of incivility [6, 10]. These responses often arise from chronic stressors, including excessive workload, scarce resources, interpersonal conflict, or breaches of perceived fairness, and they carry grave implications for both organizational functioning and patient safety [11, 12]. Among these stressors, negative interpersonal experiences within the workplace can be particularly consequential, shaping nurses' attitudes and behaviours in ways that reverberate across teams and care outcomes [7, 10, 11, 12].

WO, a subtle but pervasive form of social exclusion, erodes nurses' sense of belonging and professional identity [6, 9]. When such exclusion is compounded by PCV, that is, perceptions of unmet organizational obligations, it amplifies feelings of betrayal and disillusionment. These processes frequently culminate in EE, a core dimension of burnout, which depletes psychological resources and undermines professional functioning [13, 14, 15]. Collectively, WO, PCV, and EE create a toxic cycle that fosters DB, thereby weakening teamwork, diminishing service quality, and jeopardizing patient safety [6, 7].

Despite the significance of these dynamics, extant research remains fragmented. Much of the existing scholarship has examined ostracism, contract breaches, or exhaustion in isolation, with limited inquiry into their interconnected pathways leading to deviant behaviour [6, 9, 13, 14]. Furthermore, prior studies have been concentrated primarily in corporate or educational contexts, with relatively little focus on healthcare settings, despite the higher stakes associated with nurses' performance and conduct [7, 15, 16, 17]. In India's public hospitals, these gaps are particularly pressing. Nurses work in environments marked by chronic understaffing, severe work overload, limited organizational support, inadequate training, and persistent security concerns [3, 13, 17, 18, 19]. Such systemic adversities intensify psychological strain and increase the risk of norm-violating behaviours, yet the relational dynamics underpinning these outcomes remain largely unexplored in the Indian context.

This study responds to these gaps by investigating the interrelationships between WO, PCV, EE, and DB in Indian public hospitals. Grounded in Social Exchange Theory (SET) [20, 42], the study examines how negative workplace experiences trigger DB through processes of perceived reciprocity violation and resource depletion. Specifically, it proposes and empirically tests a serial mediation framework, wherein WO leads to DB through PCV and EE in sequence. By doing so, the study extends SET's explanatory scope by integrating the cognitive dimension of contract breaches with the affective depletion associated with emotional exhaustion. Beyond advancing theory, this work contributes practical insights for designing targeted interventions to mitigate ostracism, restore trust, and preserve nurses' psychological resources, thereby improving well-being, professional conduct, and the quality of patient care in India's strained public hospital system.

THEORETICAL FRAMEWORK AND HYPOTHESES

WORKPLACE OSTRACISM AND DEVIANT BEHAVIOUR

WO, the perception of being ignored or excluded, is a subtle yet damaging form of mistreatment that undermines teamwork, trust, and belonging, especially in interdependent nursing contexts [13, 21, 22]. Unlike overt hostility, ostracism, whether intentional or not, induces social pain comparable to physical pain [6, 22]. DB, defined as voluntary acts that violate organizational norms and threaten institutional well-being [21, 23], has been consistently linked to WO, predicting outcomes such as counterproductive work behaviour and knowledge hiding [17, 22]. Guided by Social Exchange Theory (SET), ostracism signals a violation of reciprocity, prompting nurses to reciprocate exclusion with deviant responses, including reduced commitment and norm-violating behaviour [12, 16, 20]. Thus, the following is hypothesized:

H1 – Workplace ostracism is positively related with deviant behaviour.

WORKPLACE OSTRACISM AND PSYCHOLOGICAL CONTRACT VIOLATION

Nurses, whose roles are highly interdependent and emotionally demanding, experiences of ostracism can have particularly damaging consequences, as they undermine collaboration and disrupt the supportive climate essential for patient care [14, 21, 22]. Drawing on the theoretical foundations of SET, workplace ostracism violates the norms of reciprocity and fairness that underpin the psychological contract between employees and their organizations [6, 20]. When nurses perceive that their colleagues/ supervisors fail to acknowledge or respect them, they are likely to interpret this as a breach of the implicit obligations of respect, recognition, and support, thereby experiencing PCV [4, 7, 17, 22]. Based on these perspectives it is hypothesized that workplace ostracism contributes to heightened perceptions of PCV among nurses.

H2 – Workplace ostracism is positively related with psychological contract violation.

PSYCHOLOGICAL CONTRACT VIOLATION AND EMOTIONAL EXHAUSTION

The psychological contract reflects employees' beliefs about reciprocal obligations with their organization. When these expectations are unmet, PCV arises, often accompanied by feelings of betrayal and unfairness [6, 18, 23, 24, 25, 40, 41]. For nurses, whose roles demand high emotional investment and strong organizational support, such violations can be especially damaging [1, 7, 11] Rai & Verma, 2023]. From a SET perspective, unmet obligations disrupt reciprocity, leaving employees feeling undervalued and unsupported [20]. This imbalance depletes emotional resources, heightening strain and contributing to EE and burnout. Empirical evidence further shows that PCV intensifies stress and drains psychological energy, making nurses particularly vulnerable to exhaustion in resource-constrained healthcare contexts [8, 10, 11, 24]. Accordingly, this study hypothesizes that:

H3 – Psychological contract violation is positively related with emotional exhaustion.

EMOTIONAL EXHAUSTION AND DEVIANT BEHAVIOUR

EE, the core dimension of burnout, reflects a state of chronic energy depletion resulting from prolonged job stressors [1, 26]. For nurses working in emotionally demanding and resource-constrained settings, exhaustion undermines self-regulation, reduces empathy, and weakens adherence to organizational norms [4, 5 27]. Grounded in SET, employees who feel overextended and unsupported perceive inequities in the exchange relationship, often responding with negative reciprocity [5, 8, 26]. In this context, exhausted nurses may resort to DB, voluntary acts that violate organizational norms as a coping mechanism or a means of restoring balance [7, 8, 11, 17, 26]. Empirical evidence further indicates that exhaustion increases the likelihood of counterproductive outcomes such as withdrawal, reduced compliance, and retaliatory behaviours. Accordingly, this study hypothesizes that:

H4 – Emotional exhaustion is positively related with deviant behaviour

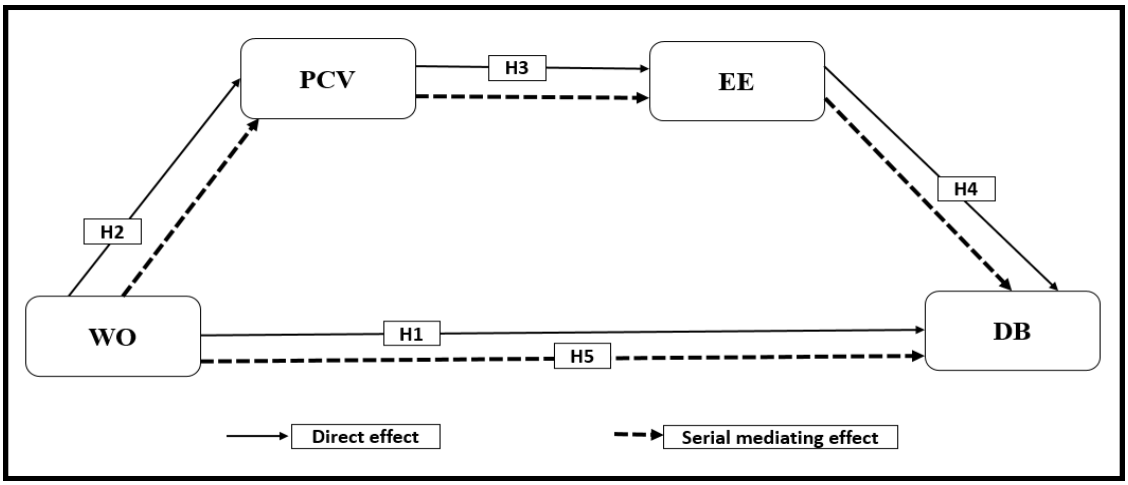
PSYCHOLOGICAL CONTRACT VIOLATION AND EMOTIONAL EXHAUSTION AS SERIAL MEDIATORS

In healthcare settings, particularly nursing, interpersonal relationships and organizational support are vital resources for sustaining performance and well-being. WO, by signalling exclusion and disregard, disrupts the reciprocity norms central to SET [20, 21, 28, 42]. Nurses perceiving ostracism are likely to interpret it as PCV, as expectations of respect, fairness, and collegial support are unmet [7, 16]. Such violations erode trust in the employment relationship, creating perceived

inequities and exchange imbalances [7, 10, 20]. The strain induced by PCV further manifests as EE, depleting nurses' psychological and social resources and reducing their capacity to cope with demanding work environments [5, 25, 26, 27]. Consistent with SET, persistent imbalance and lack of reciprocity may prompt nurses to engage in DB, violating organizational norms as a form of negative reciprocity or coping [23, 25, 28]. Accordingly, WO is expected to influence DB sequentially, first by generating PCV and subsequently heightening EE. The theoretical model is illustrated in Figure 1, and the following hypothesis is proposed:

H5. Psychological contract violation and emotional exhaustion sequentially mediate the relationship between workplace ostracism and deviant behaviour.

FIGURE 1: THEORETICAL MODEL



Note: WO-Workplace Ostracism; PCV-Psychological Contract Violation; EE- Emotional Exhaustion; DB-Deviant Behaviour.
Source: Author's own work

METHOD

PARTICIPANTS

The study sample comprised female nurses employed in public hospitals across four metropolitan cities in India, namely, Kolkata, Delhi, Hyderabad, and Chennai. A multi-stage sampling strategy was adopted. In the first stage, public hospitals in each city were identified in consultation with state health department listings. Subsequently, a random selection of hospitals was undertaken to ensure representation across major tertiary and secondary care institutions. In total, 43 hospitals participated in the study, with data collected from multiple functional units (e.g., general wards, intensive care units, and outpatient departments). In the second stage, the sampling frame comprised lists of staff nurses obtained through hospital administrative offices or nursing superintendents. Participants were recruited through coordinated administrative facilitation, and data were collected using a voluntary response approach. Questionnaires were distributed either in person or electronically, and respondents participated on a voluntary basis, with assurances of complete confidentiality and anonymity. The study employed a simple random sampling approach, which is commonly adopted in organizational research where access to respondents is mediated by institutional permissions. Inclusion criteria required participants to be full-time female staff nurses employed in public hospitals, with a minimum tenure of one year to ensure adequate exposure to workplace dynamics. Nurses on temporary contracts, interns, and those on extended leave during the data collection period were excluded from the study.

The focus on female nurses was theoretically and methodologically justified. Nursing in Indian public hospitals remains a predominantly female profession, with male nurses representing a relatively small minority [8, 10]. Their inclusion without adequate statistical representation could introduce sampling imbalance and potentially compromise parameter stability in the structural model. Furthermore, the focal constructs examined, workplace ostracism, psychological contract violation, deviant behaviour tendencies, and emotional exhaustion. These are closely embedded in gendered emotional labour expectations and relational workplace dynamics characteristic of female-dominated care work [1, 3]. As the study

did not aim to examine gender-based differences or moderation effects, maintaining gender homogeneity minimized potential confounding variance and enhanced the internal validity and interpretability of the findings.

Primary data were collected over a year, from July 2024 to June 2025. To mitigate the potential influence of common method bias (CMB), which is frequently associated with cross-sectional survey designs [7, 11], data collection was conducted in two temporally separated waves on a biannual basis. In the first wave, information pertaining to respondents' demographic characteristics and nurses' deviant behaviour tendencies was obtained. The second wave involved the collection of data on workplace ostracism, psychological contract violation, and emotional exhaustion experienced by the participants. Following the integration of responses from both phases (total responses = 397), a rigorous data-cleaning procedure was undertaken. This process involved the removal of six duplicate entries and ten incomplete questionnaires. Consequently, a final valid sample of 381 responses was retained for hypothesis testing and structural model estimation, yielding an effective response rate of 61.08%. The demographic characteristics of the respondents are presented in Table 1.

TABLE 1. DEMOGRAPHIC PROFILE

Demographic	Characteristics	Frequency	(%)
Age	18-25	193	50.66
	26-35	115	30.18
	36-45	58	15.22
	Above 45	15	3.94
Educational Qualification	Senior Secondary	211	55.38
	Diploma	118	30.97
	Graduation	52	13.65
Work Experience	0-10	201	52.76
	11-20	112	29.40
	21-30	52	13.65
	Above 31	16	4.20
Marital Status	Unmarried	152	39.90
	Married	201	52.76
	Widowed	3	0.79
	Separated	25	6.56

Source: Author's own work

ETHICAL CONSIDERATIONS

Ethical approval for the study was obtained prior to data collection in accordance with nationally recognized ethical standards governing research involving human participants in healthcare settings in India. Formal institutional authorization was secured from the administrative authorities of all participating hospitals and affiliated nursing colleges, including the respective Medical Superintendents and Principals, following the submission and review of a detailed research protocol and survey instrument. Participation in the study was entirely voluntary and based on informed consent. Each questionnaire was accompanied by a participant information sheet clearly outlining the objectives of the research, data privacy safeguards, confidentiality assurances, anonymity of responses, and the exclusive use of aggregated data for scholarly purposes. Participants were explicitly informed of their right to decline participation or withdraw from the study at any stage without penalty or adverse consequences. No personally identifiable information was collected at any stage of the research process. All responses were securely stored using restricted-access protocols and were accessed solely for academic analysis to ensure the confidentiality and protection of participant data.

MEASURES

Respondents used standard five-point Likert scale (1: "strongly disagree"; 5: "strongly agree") to respond to the survey questions as elucidated in Table 2.

TABLE 2. MEASUREMENT SCALES

Reflective Constructs	Reference	Items
Workplace Ostracism	[29]	WO1: Others ignored me at work WO2: My greetings have gone unanswered at work WO3: I involuntarily sat alone in a crowded lunchroom at work WO4: Others avoided me at work WO5: I noticed others would not look at me at work WO6: Others at work shut me out of the conversation WO7: Others refused to talk to me at work WO8: Others at work treated me as if I weren't there* WO9: Others at work did not invite me or ask me if I wanted anything when they went out for a coffee break WO10: I have not been included in conversations at work
Psychological Contract Violation	[28]	PCV1: Almost all the promises made by my organization during my recruitment have not been kept so far PCV2: I feel that my organization has not come through in fulfilling the promises made to me when I was hired PCV3: So far my organization has not done an excellent job of fulfilling its promises to me PCV4: I have not received everything promised to me in exchange for my contributions. PCV5: My employer has broken many of its promises to me even though I've upheld my side of the deal PCV6: I feel a great deal of anger toward my organization PCV7: I feel betrayed by my organization PCV8: I feel that my organization has violated the contract between us PCV9: I feel extremely frustrated by how I have been treated by my organization
Emotional Exhaustion	[30]	EE1: I have a good sense of why I have certain feelings most of the time EE2: I have good understanding of my own emotions* EE3: I am able to control my temper and handle difficulties rationally EE4: I am sensitive to the feelings and emotions of others EE5: I am a self-motivated person
Deviant Behavior	[31]	DB1: Spent too much time fantasizing or daydreaming instead of working DB2: Taken an additional or longer break than is acceptable at your workplace DB3: Come in late to work without permission DB4: Neglected to follow your supervisor's instructions DB5: Intentionally worked slower than you could have worked DB6: Discussed confidential company information with an unauthorized person* DB7: Put little effort into your work DB8: Dragged out work in order to get overtime DB9: Repeated a rumor or gossip about your boss or coworkers

* items removed due to low/ insignificant factor loadings ($p > 0.05$)

STATISTICAL PROCEDURES

The theoretical model was tested through partial least squares structural equation modelling (PLS-SEM) and the serial mediational analysis was tested through the Variance Accounted For (VAF) technique [10, 11, 32, 33, 34]. The hypothesized relationships were examined through SmartPLS version 4.1.1.7.

RESULTS

COMMON METHOD BIAS

In survey-based research, addressing the potential for Common Method Bias (CMB) is critical to ensure the validity and generalizability of PLS-SEM results [35]. A post-hoc Harman's single-factor test was conducted to assess CMB [35]. The analysis indicated that a single factor accounted for 39.18% of the total variance, below the recommended 50% threshold, suggesting that CMB is not a significant concern in this study. Additionally, as noted earlier, the study employed a multi-wave data collection design [35] to strengthen methodological rigor and mitigate potential sources of bias. In the first wave, information relating to nurses' demographic characteristics and the endogenous variable, deviant behaviour (DB), was collected. Subsequently, data concerning workplace ostracism, psychological contract violation, and emotional exhaustion experienced by the nurses were gathered during the second wave of data collection. The temporal separation of measurements served as a procedural remedy to minimize the likelihood of common method bias and enhance the robustness of the study's findings.

MEASUREMENT MODEL

The measurement model was initially assessed by specifying the reflective indicators associated with WO, PCV, EE, and DB. Internal consistency reliability was evaluated using Cronbach's alpha (α), Dillon–Goldstein's rho (ρA), and composite reliability (CR). As presented in Table 3, all reliability estimates exceeded the recommended threshold of 0.70, indicating satisfactory internal consistency and construct reliability [10, 11, 17, 32, 33]. Indicator reliability was subsequently examined through standardized outer loadings. The majority of indicators demonstrated loadings above the recommended threshold of 0.70, with the exception of EE2, WO8, and DB6. As all constructs were operationalized using a reflective measurement specification, indicators exhibiting loadings below 0.70 were removed following the guidelines proposed by Hair et al. [32], thereby improving the reliability and overall robustness of the measurement model.

Convergent validity was confirmed through Average Variance Extracted (AVE) values exceeding 0.50 [7, 11, 17, 32, 33]. Discriminant validity was evaluated using the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio of correlations [37, 38]. The square root of AVE values (Table 4) exceeded the inter-construct correlations, and all HTMT values as exhibited in Table 5, were below 0.85, satisfying recommended thresholds [38]. Collectively, these results establish robust reliability and validity for the proposed constructs, confirming the suitability of the measurement model for path analyses.

TABLE 3. MEASUREMENT MODEL ASSESSMENT

Reflective Constructs	Indicators	Loadings/ Coefficients	t-value	VIF	α	ρA	CR	AVE
	WO1	0.711	16.05		0. 885	0.886	0.884	0.604
	WO2	0.775	16.81					
	WO3	0.763	17.98					
Workplace Ostracism	WO4	0.811	19.2	2.24				
	WO5	0.822	19.32					
	WO6	0.829	19.48					
	WO7	0.789	18.54					
	WO9	0.882	20.73					
	WO10	0.703	16.52					

	PCV1	0.89	22.28		0.878	0.881	0.88	0.612
	PCV2	0.766	19.17					
Psychological	PCV3	0.795	19.90					
Contract Violation	PCV4	0.716	17.92	2.08				
	PCV5	0.777	19.45					
	PCV6	0.806	20.18					
	PCV7	0.79	19.78					
	PCV8	0.866	21.68					
	PCV9	0.781	19.55					
Emotional Exhaustion	EE1	0.732	12.27		0.78	0.798	0.789	0.655
	EE3	0.801	14.51	1.62				
	EE4	0.845	15.31					
	EE5	0.793	14.37					
	DB1	0.892	20.89		0.809	0.883	0.879	0.698
	DB2	0.813	18.16					
Deviant Behaviour	DB3	0.796	15.2	2.51				
	DB4	0.754	17.66					
	DB5	0.733	17.17					
	DB7	0.856	20.05					
	DB8	0.716	16.77					
	DB9	0.865	20.26					

All factor loadings are significant at 99% confidence levels.

Source: Author's own work

TABLE 4. DISCRIMINANT VALIDITY (FORNELL-LARCKER CRITERION)

Constructs	1	2	3	4
1. Deviant Behaviour	***0.841***			
2. Emotional Exhaustion	0.55	***0.738***		
3. Psychological Contract Violation	0.495	0.485	***0.771***	
4. Workplace Ostracism	0.445	0.459	0.749	***0.777***

Source: Author's own work

TABLE 5. DISCRIMINANT VALIDITY (HTMT)

Constructs	1	2	3	4
1. Deviant Behaviour				
2. Emotional Exhaustion	0.55			
3. Psychological Contract Violation	0.495	0.48		
4. Workplace Ostracism	0.444	0.453	0.748	

Source: Author's own work

STRUCTURAL MODEL DIRECT PATH ANALYSIS

Having established the reliability and validity of the measurement model, the hypothesized structural relationships were tested using PLS-SEM. Bootstrapping with 5,000 subsamples was employed to assess path significance and Bias-Corrected (BC) Confidence Intervals [7, 10, 11, 32, 33]. The results as exhibited in Table 6, indicate that WO is positively associated with nurses' DB ($\beta = 0.244$; $t = 3.477$; $p < 0.01$), supporting H1. WO also shows a strong positive relationship with PCV ($\beta = 0.749$; $t = 16.611$; $p < 0.01$), providing empirical support for H2. Furthermore, PCV significantly predicts EE ($\beta = 0.485$; $t = 7.321$; $p < 0.01$), confirming H3. Finally, EE has a significant positive effect on nurses' deviant behaviour ($\beta = 0.438$; $t = 6.147$; $p < 0.01$), thereby supporting H4. All structural path estimates were further substantiated using bias-corrected confidence intervals, wherein statistical significance was inferred from the absence of zero within the lower and

upper bounds of the interval [10, 11, 32, 33]. These findings collectively demonstrate strong association of ostracism at work with PCV, EE, and DB in the context of nurses in Indian public hospitals.

TABLE 6. DIRECT PATH ANALYSIS

Hypotheses	Paths	β	LLCI	ULCI	Support
H1	WO → DB	0.244	2.698	4.315	Yes
H2	WO → PCV	0.749	8.281	13.245	Yes
H3	PCV → EE	0.485	5.362	8.577	Yes
H4	EE → DB	0.438	4.842	7.746	Yes

Note: WO-Workplace Ostracism, PCV-Psychological Contract Violation, EE- Emotional Exhaustion, DB-Deviant Behaviour.
Source: Author's own work

SERIAL MEDIATIONAL PATH ANALYSIS

The indirect effect of WO on DB via the sequential mediators of PCV and EE was tested under H5. As presented in Table 7, the indirect path analysis revealed a significant positive effect (β = 0.159; t = 4.553; p<0.01), supporting H5. To further classify the type of serial mediation, the Variance Accounted For (VAF) technique was employed, which calculates the proportion of the total effect explained by the indirect paths [10, 11, 32, 33, 38, 39]. Table 8 presents the indirect, total, and VAF values for the serial mediational pathway. The analysis confirms that the effect of WO on DB operates through the consecutive mediators, PCV and EE. The VAF value of 0.395 indicates a partial serial mediation effect, consistent with the recommended threshold of 0.20–0.80 [7, 10, 11, 32, 33, 34]. Furthermore, the statistical significance of the serial mediation effect is confirmed by the bias corrected confidence intervals as the lower and upper bounds are both positive, indicating that zero is not contained within the interval [11, 32, 33].

These results demonstrate that the relationship between WO and DB is not merely direct but unfolds sequentially, ostracism first triggers perceptions of contract violation, which deplete emotional resources, ultimately leading to deviant behaviours. The partial mediation highlights that while other mechanisms may also contribute, PCV and EE constitute significant explanatory pathways in understanding nurses' counterproductive behaviour in Indian public hospitals. Furthermore, the explanatory power and the predictive validity of the hypothesized conceptual model was demonstrated through R^2 and Q^2 as exhibited in Table 9. The results exhibited that the serial mediation model explained 34.9% variance (R^2 = 0.349) in nurses' deviant behaviour, 32.5% of emotional exhaustion, and 56.2% of contract violation. The predictive power of the model is evidenced by a positive Q^2 value (Q^2 >0) of all the endogenous constructs [7, 10, 11, 32, 33]. Additionally, medium-relevance Q^2 values for all endogenous constructs, falling within the threshold (Q^2 = 0.15 - 0.35) [7, 34, 38] are demonstrated. This further reinforces the robustness and practical utility of the hypothesized conceptual model (PCV = 0.207; EE = 0.152; DB = 0.293) [11, 32, 33, 34, 39]. Finally, the overall model fit of the serial mediation model was assessed using the standardized root mean square residual (SRMR) [9, 34]. The obtained SRMR value of 0.072 was below the recommended threshold of 0.08, indicating an adequate level of model fit and suggesting that the conceptual model exhibited satisfactory correspondence with the observed data [11, 32, 34, 38].

TABLE 7. INDIRECT PATH ANALYSIS

Hypothesis	Paths	β	LLCI	ULCI	Support
H5	WO → PCV→EE→DB	0.159	1.758	2.812	Yes

Note: WO-Workplace Ostracism, PCV-Psychological Contract Violation, EE- Emotional Exhaustion, DB-Deviant Behaviour.
Source: Author's own work

TABLE 8. SERIAL MEDIATION MODEL

Hypothesis	Indirect Effect	Total Effect	VAF	Type	Support
H5	0.159	0.403	0.395	Partial Serial Mediation	Yes

Note: WO-Workplace Ostracism, PCV-Psychological Contract Violation, EE- Emotional Exhaustion, DB-Deviant Behaviour.
Source: Author's own work

TABLE 9. EXPLANATORY POWER AND PREDICTIVE RELEVANCE

Endogenous Reflective Construct	Q2	R2
Psychological Contract Violation	0.207	0.562
Emotional Exhaustion	0.152	0.325
Deviant Behaviour	0.293	0.349

Source: Author's own work

DISCUSSION

This study provides critical insights into the relational dynamics shaping nurses' experiences in Indian public hospitals by examining WO, PCV, EE, and DB. Consistent with prior research [3, 5, 7, 22, 25, 32, 40, 41], WO was positively associated with DB, indicating that nurses experiencing exclusion are more likely to engage in norm-violating actions. WO also significantly predicted PCV [3, 5, 19, 22, 33], highlighting that ostracism fosters perceptions of breached organizational obligations. PCV, in turn, intensified EE [12, 16, 17, 22], depleting emotional resources and leading to disengagement and DB [6, 12, 15, 17, 22].

The study's novel contribution lies in demonstrating the partial-serial mediation of PCV and EE between WO and DB. Grounded in SET [42], the findings extend the theory by illustrating that deviance emerges not as an immediate reaction to exclusion but through a sequential erosion of trust and emotional resources. PCV captures the cognitive and normative dimension of perceived broken exchange agreements, while EE reflects the affective and resource-depletion consequences. This dual-path process elucidates how ostracism disrupts relational reciprocity, drains psychological resources, and culminates in counterproductive behaviours, thereby advancing theoretical understanding of SET in high-stress healthcare environments.

Practically, these findings underscore urgent interventions for policymakers and hospital administrators. First, Indian public hospitals often lack a dedicated HR function with qualified personnel, compromising workforce morale and responsiveness to workplace issues; appointing a Chief Human Resources Officer (CHRO) is imperative [7]. Second, chronic understaffing amplifies stress and interpersonal tensions, highlighting the need for enforced minimum nurse-patient ratios. Third, WO should be recognized explicitly as a form of workplace mistreatment, with policies mandating anti-discrimination and inclusion codes of conduct. Fourth, hospitals must integrate psychological support mechanisms, including counselling, resilience training, and stress management workshops, to mitigate EE. Fifth, leadership development programs for nurse supervisors can foster inclusive, supportive, and fair work environments. Sixth, transparent communication regarding roles, expectations, and career progression, combined with periodic feedback, can reduce perceptions of PCV. Finally, embedding modules on civility, conflict management, and stress resilience into continuous professional education equips nurses to navigate challenging conditions effectively. Collectively, these interventions not only protect nurse well-being but also safeguard patient safety and service quality. A workforce free from ostracism, psychological contract breaches, and exhaustion is more engaged, empathetic, and reliable, enhancing organizational performance and public trust in healthcare institutions.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

The generalisability of the present findings should be interpreted with due caution. First, the study focuses exclusively on female nurses employed in public hospitals in India. Future research may extend this inquiry to male nurses and those working in private healthcare settings to examine whether the relationships among workplace ostracism, psychological contract violation, emotional exhaustion, and deviant behaviour tendencies vary across gender and institutional contexts. Second, the cross-sectional design of the study limits causal inferences. Although the proposed relationships are theoretically grounded, future studies should employ longitudinal or time-lagged designs to more rigorously capture causal dynamics and to validate the sequential mediation mechanisms identified in the present model. Third, while common method bias was addressed through a multi-wave data collection procedure and the application of Harman's single-factor test, additional methodological rigor may be achieved in future research by incorporating marker variables

and latent method factor techniques to further substantiate the independence of constructs. Finally, comparative cross-cultural investigations would provide valuable insights into the boundary conditions of the proposed model. Examining the perceptions and experiences of nurses in India relative to those in Western healthcare systems, which are often characterized by more advanced infrastructure and resource availability, may enrich the theoretical and practical understanding of workplace dynamics in nursing contexts.

CONCLUSION

To the author's knowledge, this study is the first to propose a serial mediation framework demonstrating how workplace ostracism translates into nurses' deviant behaviour through psychological contract violation and emotional exhaustion, grounded in Social Exchange Theory. The findings elucidate the sequential erosion of trust and emotional resources that underlies deviant behaviours, highlighting a dual-path mechanism whereby interpersonal mistreatment escalates into counterproductive outcomes in resource-constrained healthcare settings. Beyond theoretical contributions, the study underscores urgent practical imperatives: reducing ostracism, preventing contract breaches, and addressing emotional exhaustion are critical to safeguarding nurse well-being, organizational integrity, and patient safety. Policy interventions, including adequate staffing, inclusive workplace practices, leadership development, and psychological support are essential to cultivate resilient, supportive hospital environments. By promoting reciprocity, fairness, and care for the nursing workforce, Indian public hospitals can enhance both service quality and patient trust.

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RESEARCH ARTICLE

THE EFFECT OF SPORTS PARTICIPATION, ECONOMIC FACTORS, AND MEDICAL CAPACITY ON HEALTHCARE COSTS IN IRAN

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ABSTRACT

BACKGROUND:

Rising household healthcare expenditures have become a critical global concern, compelling health policymakers to identify effective strategies for cost management. Iran, grappling with significant economic and healthcare challenges, faces increasing financial burdens on households within its healthcare system. This study aims to investigate the relationship between sports participation, economic factors, medical capacity, and healthcare costs in Iran, drawing upon the theoretical framework of the Grossman Health Production Function.

METHODS:

This study utilizes panel data covering all Iranian provinces over a 15-year period (2008–2022), resulting in 420 observations. The Panel Estimated Generalized Least Squares (EGLS) approach is employed to estimate the long-run associations between the identified health-producing inputs and healthcare expenditures.

RESULTS:

The findings reveal that higher levels of sports participation are significantly associated with reduced healthcare costs. Economic growth, proxied by Gross Domestic Product (GDP), shows a negative association with healthcare spending. Conversely, an increase in the inactive population and physician manpower is linked to higher healthcare costs, while a higher density of authorized hospital beds is associated with a reduction in household healthcare expenditures, potentially reflecting enhanced service efficiency.

CONCLUSION:

The results suggest that integrating sports-based preventive programs with strategic management of medical capacity and economic planning could serve as a viable strategy for healthcare cost containment in Iran. Policymakers are encouraged to consider these multidimensional factors to mitigate the financial burden of healthcare on households and foster a more sustainable healthcare financing environment.

KEYWORDS

sports participation, health care, gdp, physician manpower, hospital beds, population.

INTRODUCTION

Household healthcare costs represent a substantial financial burden, particularly in developing and low-income countries, where high out-of-pocket expenditures can have severe economic consequences. These costs encompass all direct payments made by families for medical care, including doctor fees, hospitalization, and medications, often constituting a significant portion of household income [1]. The heavy financial burden can prevent lower-income families from accessing essential treatments [2]. Evidence indicates that healthcare costs for households can be enormous. For instance, Bangladeshi households spend up to 35% of their income on healthcare [1]. In developing countries, where individuals cover more than 75% of healthcare costs themselves, this issue can push them into severe poverty [3]. India has also experienced an increase in healthcare costs in the private sector, reaching 5,019 rupees, which is significantly higher compared to the 1,307 rupees in the public sector [4]. Rising healthcare costs are increasingly recognized as a major global concern, driven in part by the prevalence of chronic diseases such as chronic kidney disease, prostate cancer, and liver diseases [5]. Global healthcare costs reached $8.3 trillion in 2018, equivalent to 10% of global GDP. It is projected that this figure will rise to approximately $18.3 trillion, or 10.2% of global GDP, by 2040 [6].

Iran's healthcare financing system, though not fully dependent on out-of-pocket payments, faces major challenges, including heavy reliance on such payments and persistent inequalities in access [7]. Despite reforms such as the Health Transformation Plan (HTP), the system remains fragmented and inefficient, negatively impacting overall health outcomes, leading to increased household healthcare costs [2]. Healthcare expenditures have surged from $7 billion to $34 billion, while insurance coverage remains limited due to regressive financing and administrative gaps [8]. Understanding these factors is critical for policymakers to design effective, equitable health financing reforms [1]. enabling health managers to mitigate the growing financial burden.

It is believed that regular physical activity and exercise can offer long-term health benefits and are associated with a reduction in healthcare-related costs [9]. In fact, sports participation significantly reduces healthcare expenses due to health benefits. During childhood and adolescence, sports participation declines in adulthood, especially among older adults. Studies show positive impacts on cardiovascular and metabolic outcomes, mental health, and cost savings across different demographics [10, 11].

Effective management of healthcare costs through sports participation requires strategies tailored to a country's economic context [12]. Economic income can either increase or reduce healthcare costs, with rising incomes causing higher usage and costs, and economic development providing resources for public health programs and technological advancements [13]. Healthcare costs also vary across demographic groups; for instance, children typically incur lower expenses than adults or the elderly [14]. Homemakers may experience different health outcomes compared to employed women [15]. Prior studies have used GDP to assess the impact of economic factors on healthcare costs [16, 17]. and research highlights the role of population size and demographic trends in shaping healthcare expenditures [18, 19].

Medical capacity should undoubtedly be considered in healthcare cost policymaking. Healthcare infrastructure, including hospitals, clinics, and the number of physicians, significantly impacts costs [20]. A study on emergency departments (EDs) in Montreal revealed that variations in physicians' practice styles could lead to substantial differences in healthcare costs [21]. Additionally, a study focused on Medicare stakeholders identified regional characteristics, including the number of specialists available, as key determinants of healthcare costs at the end of life [9]. In situations where there is a shortage of beds, patients may be discharged quickly, potentially leading to readmissions and increased costs. Conversely, if beds are readily available, patients may stay longer than necessary, increasing costs [22].

Iran's healthcare system faces challenges that raise out-of-pocket costs. Although sports participation and effective management of healthcare capacity and economic factors can reduce expenses, their combined impact remains largely unexplored. This study examines these factors' influence on healthcare costs, providing actionable insights for policymakers and health managers.

METHOD

DATA AND VARIABLE

The theoretical foundation of this study is based on the Grossman Health Production Function (1972), which posits that individuals produce their own health through the investment of inputs such as time, lifestyle choices, and medical services. Within this framework, health is conceptualized as a durable capital stock that depreciates overtime, and investments in preventive measures are essential to maintain or enhance this stock. In the context of this study, sports participation is treated as a critical preventive investment that contributes to the 'health stock' of the provincial population. Consequently, the panel data model employed here seeks to estimate how variations in health-producing inputs—namely sports participation, economic growth (GDP), demographic factors (inactive population), and healthcare infrastructure (physician manpower and hospital beds)—relate to provincial healthcare expenditures. By adopting this theoretical lens, we frame healthcare costs not as independent outcomes, but as the result of cumulative investments and demographic shifts within the provincial health production process. Following this conceptual approach, the empirical model is specified as follows. Panel data will be used in this research. Therefore, data from all provinces of Iran were collected from the Statistical Center of Iran from 2008 to 2022. Observations were gathered for 15 years across 28 provinces of Iran (420 Observation).

Sports participation (SP) was measured as the number of registered athletes in official sports clubs who hold a valid membership and regularly attend sports venues. This indicator provides a consistent, government-verified measure of organized sports activity across province. The healthcare costs variable represents households' average annual healthcare expenditures, encompassing healthcare and insurance costs. The economic factors include the variables of Gross Domestic Product (GDP), the active population, and the inactive population. GDP which shows the total value of goods and services produced within Iran annually Also, GDP was measured in constant prices to remove the effect of inflation. The active population was calculated by determining the percentage of individuals from the population who are of working age (typically 15 to 64 years old) and are either employed or actively seeking employment (unemployed but looking for work). The inactive population was calculated as the percentage of individuals from the population who are of working age (typically 15 to 64 years old) but do not participate in economic activities, such as students, homemakers, and those with income but without employment. The medical capacity factors include physician manpower (the number of medical doctors) and hospital beds. These beds refer to those for which a hospital has obtained official government permission and the latest license, allowing them to be used and maintained. All monetary variables, specifically Healthcare Costs (HC) and Gross Domestic Product (GDP), were converted into constant prices (real terms) using the Consumer Price Index (CPI) obtained from the Statistical Center of Iran, with 2016 as the base year. The choice of 2016 (1395 SH) as the base year is based on the standards adopted by the Statistical Center of Iran for CPI calculation, aimed at maintaining consistency with official macroeconomic data. The information related to the variables and research data is presented in Table 1.

TABLE 1, DATA AND VARIABLE SUMMARY

Variable	Description	Symbol	Source	Unit
Sports Participation	Number of individuals actively engaged in sports, recorded systematically in sports club registries	SP	Statistical Center of Iran	Number
Healthcare Costs	Average annual healthcare expenditures of households, including healthcare and insurance costs	HC	Statistical Center of Iran	Constant 2016 Rials
Gross Domestic Product	The total value of goods and services produced within Iran annually	GDP	Statistical Center of Iran	Constant 2016 Rials

Active Population	Percentage of working-age individuals (15-64) who are employed or actively seeking employment.	AP	Statistical Center of Iran	Percentage
Inactive Population	Percentage of working-age individuals (15-64) who do not participate in economic activities.	IP	Statistical Center of Iran	Percentage
Physician Manpower	The number of medical doctors	PM	Statistical Center of Iran	Number
Approved Hospital Beds (B)	Number of hospital beds for which a hospital has obtained official government permission and the latest license	B	Statistical Center of Iran	Number

MODEL AND ANALYSIS

An equation is considered to estimate the study's results (EQ 1).

Eq1: $\ln(HC_{it})=\beta_0+\beta_1\ln(SP_{it})+\beta_2\ln(GDP_{it})+\beta_3\ln(AP_{it})+\beta_4\ln(IP_{it})+\beta_5\ln(PM_{it})+\beta_6\ln(B_{it})+\varepsilon_{it}$

In Equation (1), $\ln(HC_{it})$represents the natural logarithm of real healthcare costs, and $\ln(SP_{it})$, $\ln(GDP_{it})$, $\ln(AP_{it})$, $\ln(IP_{it})$, $\ln(PM_{it})$, and $\ln(B_{it})$represent the natural logarithms of sports participation, real Gross Domestic Product, active population, inactive population, physician manpower, and the number of approved hospital beds for province $i$at period t, respectively. The coefficients $\beta_1$through $\beta_6$represent the output elasticities of healthcare costs with respect to each independent variable. Finally, $\varepsilon_{it}$is the error term. Based on this specification, this study investigates the elastic relationship between sports participation, economic factors, medical capacity, and healthcare expenditures in Iran.

A potential threat to causal inference in this study is the risk of endogeneity arising from reverse causality between healthcare expenditures and economic development, as well as from omitted variable bias. To mitigate these concerns, and given that all monetary variables (HC and GDP) have been adjusted to constant 2016 prices to ensure cross-temporal comparability, this study employs panel data techniques that allow controlling for unobserved, time-invariant heterogeneity across provinces.

Specifically, the log-linear specification in Eq. 1 allows the estimated coefficients (β_1 to β_6) to be interpreted as elasticities, representing the percentage change in healthcare costs in response to a one-percent change in the independent variables. Fixed-effects estimation is utilized to account for province-specific structural characteristics that are not directly observable. Furthermore, time fixed effects are incorporated to capture macroeconomic shocks and nationwide policy changes affecting all provinces simultaneously.

To determine the most appropriate estimation method, both Fixed Effects (FE) and Random Effects (RE) models were estimated. The Hausman specification test indicated that the Fixed Effects model was preferred. However, diagnostic tests revealed heteroscedasticity and cross-sectional dependence. Therefore, the Panel Estimated Generalized Least Squares (EGLS) approach with period SUR weights was applied (incorporating both province and year fixed effects to control for provincial structural heterogeneity and temporal shocks) to obtain efficient and reliable estimates. This approach effectively addresses potential heteroscedasticity and autocorrelation that could otherwise violate the assumptions of OLS regression and bias the elasticity estimates.

To ensure the validity of our long-run estimates, we examined the integration properties of the variables using panel unit root tests (Levin-Lin-Chu and Im-Pesaran-Shin). Given that the variables were found to be $I(1)$, we proceeded to perform Pedroni's (2004) panel cointegration tests to detect the existence of a long-run equilibrium relationship. The reported results confirm that the variables are cointegrated, thereby justifying the use of the EGLS estimation method to capture the stable long-term relationship between sports participation and healthcare costs.

To address concerns regarding potential reverse causality, we incorporated lagged independent variables into our model. This dynamic specification accounts for the fact that the health benefits of sports participation—and consequently the reduction in healthcare expenditures—are not instantaneous and may materialize over time. Furthermore, as a robustness check, we considered a dynamic panel specification to assess the stability of our results against endogenous feedback loops.

Finally, to ensure the robustness of our findings, we performed several sensitivity analyses. This included excluding potential outlier provinces (e.g., Tehran) to verify that our results were not driven by idiosyncratic provincial characteristics. Additionally, we explored alternative model specifications to assess the stability of the estimated elasticities. The robustness of the model was further validated through the Pesaran Cross-Sectional Dependence (CD) test and the Jarque-Bera normality test, ensuring the reliability of our empirical framework.

RESULTS

This section presents the variables' descriptive statistics, followed by the diagnostic test results and, finally, the results of the EGLS regression.

TABLE2, DESCRIPTIVE STATISTICS

Variable	Mean	Std. Dev.	Minimum	Maximum
ln(HC)	16.32	1.91	14.41	22.86
ln(SP)	10.74	0.98	7.19	13.41
ln(GDP)	17.15	1.65	9.59	22.92
ln(AP)	3.58	0.44	3.26	4.53
ln(IP)	4.10	0.08	3.36	4.50
ln(PM)	6.58	0.91	5.57	9.10
ln(B)	7.63	1.05	6.34	11.29

Table 2 presents the descriptive statistics for the variables used in this study after applying the natural logarithmic transformation. The variable ln(HC) exhibits a mean of 16.32, with values ranging from 14.41 to 22.86, indicating significant variation in healthcare costs across provinces. The mean of ln (SP) is 10.74, with a standard deviation of 0.98, while ln (GDP) shows a mean of 17.15 and a range between 9.59 and 22.92. Regarding demographic indicators, ln (AP) and ln (IP) have mean values of 3.58 and 4.10, respectively. Finally, the infrastructure variables, ln (PM) and ln(B), report mean values of 6.58 and 7.63, respectively. This logarithmic transformation reduces the impact of scale differences and outliers, ensuring that the subsequent regression analysis provides robust estimates of the elasticities between sports participation and healthcare costs.

Before estimating the long-run elasticities of healthcare costs, we conducted a comprehensive series of diagnostic tests to ensure the validity of our econometric framework. Initially, the stationarity of all log-transformed variables—namely ln(HC), ln(SP), ln(GDP), ln(AP), ln(IP), ln(PM), and ln(B)—was examined using the Levin-Lin-Chu (LLC) panel unit root test. The results confirmed that all variables are integrated of order one, $I(1)$, at the 5% significance level, a necessary condition for exploring long-run equilibrium. Consequently, we performed the Pedroni (2004) panel cointegration test, which confirmed a stable long-run relationship among these variables, justifying the application of the Panel EGLS approach.
Furthermore, we evaluated the properties of the model's residuals to verify the reliability of our estimates. The Pesaran Cross-Sectional Dependence (CD) test yielded a statistic of 5.17 ($p < 0.01$), rejecting the null hypothesis of cross-sectional independence and indicating significant correlation across provincial error terms. Additionally, the Jarque-Bera test statistic (P<0.01) rejected the null hypothesis of normally distributed residuals.

Given these diagnostic findings—specifically the presence of cross-sectional dependence and non-normality in the error terms—the selection of the Panel EGLS method (with period SUR weights) is empirically justified. This estimator effectively

corrects for these violations, ensuring that the estimated elasticities (the coefficients $\beta_1$to β_6) are efficient and robust to the identified econometric challenges.

TABLE3, PANEL EGLS REGRESSION RESULTS

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.0385	1.0003	-3.0384	0.0025
ln(SP)	-0.1800	0.0082	-21.8628	0.0000
ln(GDP)	-0.2500	0.0462	-5.4089	0.0000
ln(AP)	-0.0500	0.1848	-0.2705	0.7869
ln(IP)	+0.2200	0.0598	3.6817	0.0003
ln(PM)	+0.3500	0.0129	27.1073	0.0000
ln(B)	-0.1200	0.0230	-5.2063	0.0000
R-squared	0.6982			
Adjusted R-squared	0.6945			
S.E. of regression	0.0842			
F-statistic	162.45			
Prob(F-statistic)	0.0000			
Durbin-Watson stat	1.98			

Table 3 presents the estimation results of the panel EGLS model (with period SUR weights) using log-transformed variables. As the variables are log-transformed, the estimated coefficients represent the long-run elasticities. The results show that ln(SP) is significantly associated with lower healthcare costs (β=-0.18,t=-21.86, p<0.01). This indicates that a 1% higher level of sports participation corresponds to a 0.18% lower level of healthcare expenditures, ceteris paribus.

Economic growth, proxied by ln(GDP), also demonstrates a statistically significant negative association with healthcare costs (β=-0.25, p<0.01). Among demographic variables, ln(IP) (inactive population) exhibits a positive correlation with healthcare costs (β=+0.22, p<0.01), suggesting that provinces with a higher proportion of inactive individuals tend to face greater healthcare financial pressure. Conversely, the association between ln(AP) (active population) and healthcare costs is found to be statistically insignificant.

Regarding infrastructure, ln(PM) (physician manpower) shows a positive elasticity of 0.35 (P<0.01). Finally, ln(B) (approved hospital beds) displays a negative elasticity of -0.12 (p<0.01), which may suggest that higher hospital capacity is linked to long-term efficiencies or reduced household out-of-pocket spending in the Iranian provincial context.

DISCUSSION

The first finding indicated that increased participation in sports is associated with a reduction in healthcare costs. The findings of studies by Codogno et al. (2020) and Karl et al. (2018) generally support this theory [10, 11]. In Iran, research has also shown that greater participation in sports is consistently associated with improved health outcomes and reduced healthcare costs, particularly in the case of chronic diseases [23]. However, other studies emphasize the increase in costs due to sports-related injuries [24]. It appears that the difference in findings may be attributed to the focus of these studies on specialized and professional sports, as well as short-term group surveys, such as those conducted with patients visiting a specific clinic. In contrast, the present study emphasizes all provinces of the country and considers the number of participants in organized sports.

Another finding indicated that a higher GDP is associated with a slight reduction in healthcare costs. This finding is consistent with studies that have shown a small but significant negative impact of economic growth on healthcare expenditures [17]. However, it somewhat contradicts other studies that suggest a positive relationship between GDP and healthcare costs [25]. The reason for this discrepancy lies in the different methods of calculating GDP in previous studies,

which considered GDP per capita, whereas the present study used the total GDP. Additionally, Iran has unique income conditions due to sanctions and economic challenges, which may differ from other countries.

Another economic finding of this study indicated that an increase in the inactive population leads to higher healthcare costs. Pakdaman et al. (2019) reported a positive and unidirectional relationship between population rate and healthcare expenditures, while Rezaei et al. (2016) showed that an increase in population leads to a reduction in healthcare costs [26, 27]. The reason for this discrepancy lies in the type of population considered in the calculations. The present study includes the percentage of household members, students, and others between the ages of 15 and 65, whereas the study by Rezaei et al. (2016) focuses on individuals aged 65 and older.

The results of the study further indicated that an increase in physician manpower leads to higher healthcare costs. This finding is consistent with the research of Gowrisankaran (2018) and Panahi et al. (2015)[21, 28].

Finally, the results of the study showed that an increase in approved hospital beds leads to a reduction in healthcare costs. Hajizadeh & Nghiem (2013) found that a higher number of hospital beds per capita is associated with better quality of care [29]. In contrast, Panahi et al. (2015) suggested that an increase in the number of physicians and hospital beds could lead to higher healthcare costs [28]. The reason for this discrepancy lies in the different time periods of the studies. Panahi et al. analyzed data from 2001 to 2010, during which Iran faced significant economic and sanction-related challenges, leading to numerous changes in both healthcare and economic sectors.

IMPLICATIONS OF THE RESEARCH FOR HEALTHCARE MANAGERS AND POLICYMAKERS

Healthcare managers and policymakers may consider implementing strategic planning to manage Iran's healthcare expenditures effectively, taking into account the factors identified in this study. Integrating healthcare and sports management could potentially expand sports participation and contribute to lower healthcare costs through preventive measures. Such an objective might be facilitated through the establishment of joint agreements or the implementation of sports-based preventive health programs within the community.

Given that Iran has faced economic challenges and a decline in household purchasing power in recent years, fluctuations in the country's GDP may be influenced by broader economic factors. Therefore, policymakers might find it beneficial to incorporate the current economic landscape into their planning for healthcare cost management. Potential strategies could include emphasizing the domestic production of medical equipment and pharmaceuticals, implementing evidence-based health policy reforms, and enhancing the overall efficiency of healthcare service delivery. As Iran's healthcare financing system faces various challenges—often resulting in increased out-of-pocket expenses—the growing demand for services among the inactive population appears to be linked to rising healthcare costs. To address this, health authorities could explore strategies such as reforming financing mechanisms for diverse population groups, expanding disease prevention initiatives, and enhancing elderly care services. Providing more robust insurance coverage for these groups may help mitigate the upward pressure on healthcare costs associated with a larger inactive population. The capacity of the medical sector is a significant factor that, if managed strategically, could influence the financial burden of healthcare on households. An increase in the number of physicians is associated with a higher volume of patient visits, which may correlate with higher overall healthcare expenses. In this regard, more comprehensive insurance coverage policies could potentially assist in reducing the financial impact on households and might transform the growing physician workforce into an opportunity by providing individuals with expanded access to care.

Finally, while an increase in the number of authorized hospital beds might initially appear to contribute to higher expenditures, it may also enhance accessibility and provide individuals with more options, potentially leading to lower long-term household healthcare burdens. Consequently, implementing optimal hospital bed management policies could potentially improve patient access to medical services while contributing to cost-containment efforts.

RESEARCH LIMITATIONS AND SUGGESTIONS FOR FUTURE STUDIES

Other economic and medical variables, such as the number of hospitals, healthcare service centers, and income inequality, can also be estimated and examined alongside sports participation in future research. It should be noted that Sports participation measure may not capture informal or unorganized sports participation. Future studies are encouraged to incorporate broader measures of physical activity if such data becomes available. Moreover, this combination of variables can be analyzed in other countries, allowing for comparisons between their results and the findings of this study The data for this research were collected from the Statistical Center of Iran, which was the only available source providing data with such a combination of variables. Consequently, decisions regarding the time frame, variable units, and the number of observations were influenced by the data published by this center. Therefore, although variables such as inflation, insurance coverage, and healthcare policies may influence healthcare expenditures, consistent provincial data for the study period were not available.

CONCLUSION

This study provides insights into the dynamics of healthcare cost management for policymakers and healthcare administrators in the Iranian context. The findings suggest that higher levels of sports participation, increased GDP, and expanded access to hospital beds are associated with a reduction in healthcare expenditures. Conversely, an increase in physician manpower and a larger inactive population are linked to higher household healthcare costs.

Based on these results, it is suggested that healthcare managers and policymakers consider comprehensive planning strategies to manage expenditures effectively. Potential solutions might include the establishment of inter-sectoral agreements to support sports-based preventive health programs, the implementation of evidence-based policy reforms, and enhancements in the efficiency of healthcare delivery. Furthermore, prioritizing domestic production of medical supplies and optimizing the management of medical capacity could serve as valuable strategies for cost containment.

In summary, to mitigate the financial burden of healthcare on households, it appears beneficial for policymakers to explore the integration of sports-based preventive initiatives with broader medical capacity and economic planning. Adopting such a multi-faceted approach may contribute to more favorable outcomes in healthcare cost management and long-term financial sustainability.

CONCFLICTS OF INTEREST:

There is no conflict of interest.

FINANCIAL SUPPORT:

This study has received no financial support.

ETHICAL DECLARATION:

This study exclusively utilized secondary, aggregated data obtained from the Statistical Center of Iran, with no access to individual-level or personally identifiable information. Consequently, formal ethical approval was not required for this research, in accordance with standard practices for studies using publicly available, de-identified datasets.

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RESEARCH ARTICLE

VIEWS ON AI AS AN INSTRUMENT OF MENTAL HEALTH CARE: QUALITATIVE PERSPECTIVES OF PSYCHOLOGISTS FROM INDIA AND NEPAL

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ABSTRACT

BACKGROUND:

AI innovation in research, therapy, education and health care has made informed and strategic implementation an inevitable step forward for practitioners, clients, policy makers and AI developers. To create and empower a holistic system that helps in filling the gap in mental health care, Psychologists must have a realistic understanding of the power and limitations of using AI-based tools and chatbots in mental health care.

OBJECTIVE:

To explore the attitudes and perceptions of psychologists from India and Nepal toward the integration of AI-based tools in mental healthcare and how they view the potential benefits, challenges, and risks associated with using these in mental health practice.

DESIGN:

In this qualitative study thematic analysis was used as an analytical method. The study explored the perceptions and experiential accounts of psychologists regarding the integration of AI-based tools in mental health contexts.

RESULTS:

Seventeen practising psychologists were recruited, fourteen from India and three from Nepal. Three overarching themes were identified: (i) Current Utilisation of AI– AI's current use as a vector for procedural streamlining and optimization of preliminary processes; (ii) Complaints, Cautions and Risks– current concerns as well as the dissatisfaction and general atmosphere of uncertainty surrounding it; and (iii) Hope and hesitation– functional scope in behavioural analytics and preliminary diagnosis along with concerns surrounding ethics, dependency risks, and exclusion of certain socially marginalized or technically inept demographics.

CONCLUSION:

The emergent discourse reflects a persistent ambivalence- AI is valued for its capacity to enhance logistical fluency and broaden access yet remains restricted by its inability to engage with the embodied, cultural, and relational substrates of psychological care. Robust planning and monitoring are required for the ethical implementation of AI-based tools in mental health care to avoid misuse and prevent harm.

KEYWORDS

Artificial Intelligence, AI-based tools, Chatbots, Human-AI Interface, India, Mental Health care, Nepal, Psychologists

INTRODUCTION

Artificial Intelligence (AI) is defined as "a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation" [1]. In mental healthcare, AI offers detection methods, therapeutic tools and virtual platforms. AI has a great potential to enhance existing mental healthcare by increasing and improving its delivery, supporting clinical decision-making, providing round-the-clock support as well as personalized treatment [2]. Despite the potential, the adoption of AI has been slower in mental health than in physical health [3], particularly since mental health professionals use guidebooks, assessment tools and rely on experience and therapeutic skills to diagnose, classify and implement intervention techniques [8].

The research on AI in mental health has evolved significantly over the past decade, with the applications ranging from natural language processing for symptom detection to the use of chatbots that reduce depression and anxiety depending on the severity, digital literacy and degree of comfort with non-human agents. Studies conducted on young college students and adult psychiatric groups with measurable depression and anxiety symptoms, show a reduction of 29 - 34% in symptoms following therapy with AI chatbots [4] [5] [6]. Despite AI's efficiency in triage and workflow management [7] [2], concerns persist about weakened therapeutic alliance and patient preference for human judgment in ambiguous and nuanced cases [8] [9]. Researchers are concerned about privacy, algorithmic bias, and reliance on Western-centric models that might misinterpret non-Western expressions of distress [10] [11] [12]. Another issue that exacerbates the concern is the digital divide, which reinforces inequities in terms of access, literacy and infrastructural robustness [13] [14]. Along with creating discrepancies in clinical trials, data protection and user retention, the unregulated mental health apps risk misinformation, self-diagnosis and commodification [15] [16]. Though the practitioners welcome AI as an adjunct, they express unease about its encroachment in core therapeutic functions, deskilling of professional judgement, the erosion of empathic engagement, and the medico-legal liabilities entailed in AI-driven decisions [3] [17] [18].

In India, mental disorders were the leading cause of non-fatal disease burden in 2017, with one in seven suffering from a mental disorder (197 million people), with depressive and anxiety disorders contributing the most [19]. Similar concerns exist in the neighboring country, Nepal, with a 12.9% prevalence (13.2% among adults and 11.2% among children) of mental disorders [20]. Scarcity of mental health professionals per 100,000 population in India (0.07 psychologists and 0.3 psychiatrists) is also reflected in Nepal (0.68 psychiatrists and 0.17 and psychiatric nurses) and both are lower than the global average which according to the World Mental Atlas is 9 per 100,000 population [21]. Both governments allocate approximately 1% of total health expenditure on mental health services (India 1.30% and Nepal 1%) [21] [22]. India and Nepal, both lower-middle-income countries, face substantial gaps in access to mental health care [23]. So, AI can be positioned as a supplement to reduce diagnostic delays, outreach issues and systemic deficits [24]. Global attitudes towards AI mental health chatbots seem to vary significantly by region and culture.

In a comprehensive literature and narrative review, Balcombe (2023) points to higher trust and awareness about AI-based tools among adolescent, young adults, university students, managers and other specific underserved groups like veterans [25]. In a multinational study across 21 Arab countries, majority (72.5%) of the population were aware of chatbots, yet usage was low (26.4%). AI was viewed as a supplementary tool to human healthcare professionals [26]. Western adolescents prefer direct, solution-focused communication, whereas Eastern and Indian adolescents prioritize privacy and responses that emphasize social harmony and family relationships [27]. Nepal focuses mainly on AI for general healthcare but shows early promise for mental health uses. AI use in mental healthcare in Nepal is held back by weak infrastructure and local adaptation issues [28]. A study on Australian mental health professionals revealed that despite carrying a positive attitude towards AI, these professionals used it more for research and report writing [29].

AI use is expanding in most sectors particularly in Information Technology, Finance, Banking and Healthcare. In mental health care, a crucial factor is the attitude and perceptions of mental health practitioners in using and promoting AI-based mental health apps in their work with clients. This study was designed to explore their unique perspectives as a decisive influencing factor in the escalating use of AI in mental health care.

Despite the increasing evidence of AI-based tools in mental health care, there are significant research gaps to be addressed. Current studies related to AI chatbots in mental health care are mostly focused on chatbot efficacy and adolescent preferences. The researchers have not found studies which explore mental health practitioners' attitudes towards use of AI chatbots or tools, particularly in the Indian subcontinent. Though India and Nepal share similar mental health burdens and shortage of skilled manpower few comparison studies have been identified. There are no guidelines for mental health professionals on the integration or adoption of AI [10], except for qualitative research which proposes such a framework [3]. In addition, the application of Western-centric AI-based tools and the possibility of misinterpretation of psychological distress when applied to South Asian clinical contexts are yet to be explored.

Keeping these gaps in mind this study aims to explore the attitudes and perceptions of psychologists from India and Nepal towards the use of AI-based apps in mental health care. Analysing the views of psychologists will help the mental health fraternity, as well as app developers, gain a better understanding of optimum utilization and risks of AI-based apps in mental health care. It can also outline future direction in relation to wider use. The following research questions guided the research:

1. What are the attitudes and perceptions of psychologists from India and Nepal toward the integration of AI-based applications in mental healthcare and how they view the potential benefits, challenges, and risks associated with using AI-powered apps in mental health practice?

METHODS

STUDY DESIGN

This qualitative study employed thematic analysis to explore the perceptions and experiential accounts of psychologists regarding the integration of AI-based tools in mental health contexts. Ethical clearance was obtained from the Departmental Ethics Committee (DEC/Psy/2023/A003, 14/09/2023) prior to the commencement of data collection, and all procedures were conducted in accordance with established academic research standards. COREQ [30] reporting guidelines were followed.

PARTICIPANTS AND RECRUITMENT

Participants were practising psychologists based in India and Nepal. Psychiatrists and social workers were excluded to maintain professional homogeneity. Purposive sampling was utilized to capture variation across geographical location, gender, qualifications, years of experience, and employment context. Out of thirty-two psychologists approached, twenty-five consented to participate. Following attrition due to scheduling conflicts and technical limitations, seventeen participants ultimately contributed to the study. Each psychologist was assigned a participant code (P1 to P17) to preserve confidentiality.

DATA COLLECTION

Initially the participants were identified through professional contacts of the researchers in India and Nepal. These participants also referred their colleagues through professional networks. The researchers made an attempt to identify participants from various geographical locations in India through their contacts. The participants who gave consent were given the option of responding to the study questions either through a semi-structured interview or in written form. This approach accommodated different participant preferences while maintaining consistency in the questions asked. Five interviews were through telephone/ Google meet and twelve were written responses.

Semi-structured interviews conducted through telephone or via Google Meet were carried out by both Author 1 and Author 2 between October 2023 and April 2024. On an average, the interviews lasted for 30 minutes each. With participant consent, verbal interviews were recorded and then transcribed verbatim.

For written interviews, participants received an email with an interview schedule, details about the purpose of the interview and the contact details of the authors if case of any queries or clarifications. Participants took their time to respond to the email. Reminder emails were sent to the participants after a week if no response was received.

DATA ANALYSIS

The interview transcripts and written responses were treated as equivalent qualitative textual data and was analysed using thematic analysis. Authors 1 and 2, both (PhDs), females, with a combined experience of 25 plus years in academics and consultancy were at the time of the study, engaged in full time teaching and administrative posts in higher education. They independently analyzed the data thematically through iterative reading and manual coding. Codes were consolidated into subthemes and overarching themes through collaborative deliberation. Codes and themes were further reviewed to align with the research questions.

RESULTS

The demographic information of all the 17 participants is mentioned in table 1.

TABLE 1. DEMOGRAPHIC DETAILS OF THE PARTICIPANTS

Participant	Age (in years)	Gender	Experience (in years	Qualification	Practice	Country	Region
P-1	26	Female	3	M.Phil	Public	India	East
P-2	41	Male	10	M.Phil, PhD	Public	India	North
P-3	32	Male	5	M.Phil	Public	India	East
P-4	29	Female	4	M.Phil	Public	India	East
P-5	38	Male	8	M.Phil, PhD	Public	India	Central
P-6	39	Female	15	M.Phil, PhD	Public	India	West
P-7	75	Male	40	M.Phil, PhD	Private	India	South
P-8	28	Female	2	M.Sc Counselling Psychology	Private	India	South
P-9	33	Female	8	M.A, EdM Counselling Psychology	Private	India	Central
P-10	42	Female	3	M.A Clinical Psychology, Diploma in DBT	Private	India	Central
P-11	47	Female	8	M.A, PhD	Private	India	Central
P-12	35	Female	7	M.Sc, PhD	Private	India	West
P-13	40	Female	8	M.A Clinical Psychology	Private	India	West
P-14	55	Male	21	PhD Clinical Psychology	Public	Nepal	Nepal
P-15	45	Male	15	PhD Clinical Psychology	Private	Nepal	Nepal
P-16	46	Male	16	PhD Clinical Psychology	Public	Nepal	Nepal
P-17	45	Female	15	M.Sc, PhD	Private	India	West

Out of the 17 participants, nine were female and eight were male. Fourteen Psychologists were from India and three from Nepal. The average age of the Psychologists was 41 years with an average professional experience of 11. 5 years. The qualitative analysis revealed three themes. The first theme- current utilization of AI, incorporates the experiences and perceptions of participants on the use of AI based tools to optimize the process of registration, case history taking, assessment, monitoring and feedback. It also includes how they view AI as a good assistant. The theme also talks about the familiarity of participants with AI based tools. Since some of the participants have not used these tools, it also explores their awareness regarding them.

The second theme- complaints, cautions and risks, reveals how participants perceive AI-based tools in terms of cultural nuances and the therapeutic characteristics of AI. It also focuses on the perceived lack of reliability and accuracy, risk of over-dependence and cautions for their use.

The third theme of hope and hesitation mentions how the participants see a ray of hope through AI-based tools to reduce the existing gap by being available all the time and for quick access. Despite this, the participants seemed hesitant of its use due to biases it might generate, the automatic responses it gives and the confidentiality concerns.
The themes, codes and the selected excerpts are presented in table no. 2.

TABLE 2. THEMES, SUB-THEMES AND EXCERPTS

Themes	Sub-themes	Excerpts
Current Utilisation of AI	**Optimization of processes**	*Effective in providing pre-existing check-list based diagnosis [P-3]*
		We use these tools for scoring only [P-5]
		I have used AI to book appointments and do registrations…the data collected by these applications are very useful for follow-ups [P-7]
		Use AI tools to ease out the workload and for follow-ups. They act as quick reference guides…save a lot of time [P-10]
		They are used while preparing the report of assessment and diagnosis [P-14]
	Diagnosis and finding links	*These tools accurately diagnosed neuropsychological impairments and cognitive functioning among patients with organicity [P-4]*
		They offer continuous monitoring and feedback…identify patterns and triggers…provide valuable insights…can help in the screening and early detection [P-5]
		Case history modules are good...based on ICD -11 they give quick diagnosis [P-7]
	AI as an assistant	*AI tools should be used as complementary aids that can help in the screening and early detection…are not a substitute for qualified professionals [P-5]*
		It's a foot in the door. It is currently on par with self-help books [P-8]
		Most of the AI apps I have suggested to numerous clients are meditation apps like…as they are solely geared towards meditation [P-9]
		Analysis must be done by psychologists and not AI…because there are no generalizations made for attributes…diagnosis has to be done by the human professional [P-10]
		It can be fairly accurate provided there are inputs from a team of practising professionals [P-17]
	Limited awareness and adoption	*I'm not using or familiar with diagnosis tools [P-9]*
		I am still exploring…I have heard of some tools…but I am still a little traditional because I was not born in that era of education [P-11]
		I am not aware of AI based tools but there are some softwares being used. They are used for assessment only [P-12]

		Not widely used, currently a chatbot in child and adolescent mental health is in discussion [P-15]
		To my knowledge...we use AI-based tools to write report. However, I do not think these tools are used to explore mental health issues [P-16]
Complaint, cautions and risks	**Lack of knowledge of cultural nuances and empathy**	*Lack the human empathy and emotional support that individuals may need…AI cannot provide the level of personalized and specialized care [P-4]*
		May lack the human element that is crucial for effective therapy [P-5]
		Cultural factors and nuances may not be adequately captured or understood by AI algorithms, limiting their effectiveness for users from diverse backgrounds [P-6]
		The therapists' attitude towards the client…space that they provide, just mere presence in general…gets eliminated in the form of an AI… [P-9]
		The background, the causes, and the triggers are so diverse, coming from genetics to social issues, to current situations [P-11]
	Lack of reliability and accuracy	*AI-powered apps may provide inaccurate or misleading information, leading to incorrect self-diagnosis or inappropriate treatment recommendations [P-5]*
		AI algorithms can inherit biases present in the data they are trained on, which may lead to disparities or inaccuracies [P-6]
		Making of a diagnosis requires a lot of clinical knowledge…if AI is not able to pick up on certain things that the client is presenting…giving wrong feedback can have negative consequences..not confident about the accuracy of AI [P-9]
		They are not up to the mark…they are still amateur…so, I fully can't rely on AI [P-11]
		AI tools are not up to the mark...I wouldn't recommend fully relying on them yet [P12]
		The accuracy of these tools cannot be commented yet because it needs more use and study in the relevancy of this technology [P-14]
		I think AI-based tools are accurate to some extent, especially with proper instructions, but need practicing professionals' input [P17]
	Absence of therapeutic environment and human touch	*The absence of human interaction and understanding may hinder the therapeutic process…lack of individuation can limit the effectiveness of the support provided [P-4]*
		The therapist's body language, tone, eye contact, and just their presence in general account for a large part of whether or not therapy will be successful[P-9]
		Personally, I would not prefer AI it because certain things are observational only [P-10]
		Lack of specific and customized approaches can lead to inadequate success of the therapy [P-17]

	Risk of over-reliance and dependency	*Overreliance on AI apps may create dependency…can lead to individuals' neglecting other important aspects of their well-being [P-4]*
		We can end up having further psychological issues in humans if we are using AI a lot…one of my known person is now continuously talking with the AI on the Apple Siri.. So I see that again as a problem. [P-11]
		AI apps are designed beautifully which can attract the clients aesthetically so one can feel connected to the app…but they may not be very client friendly. It just becomes another business model [P-13]
		It is likely that use of AI tools may produce internet addiction [P-14]
	Addressing cautions and possible guidelines	*The accuracy of these tools depends on how you develop them…if you have a disclaimer then there is no danger or risk [P-7]*
		But should not be given to the patient themselves…[P-10]
		It cannot be a fixation [solution], like a fixation for not having more mental health professionals…that cannot be, can never be an alternative [P-11]
		Only if it is done ethically and keeping client in mind [P-13]
		Needs regular research and development to enhance the accuracy [P-15]
		Proper training to users can to large extent help can reduce the gap…provided AI is used properly and is monitored properly [P-16]
Hope and Hesitation	**Bridge the gap**	*AI definitely will reduce the gap and give immediate access…just to make the person feel a few positive words here and there..but that can be a temporary relief for the person [P-11]*
		Referred to who don't feel comfortable for face-to-face counselling [P-13]
		They are evolving and likely to be incredibly helpful, further down the line [P-17]
	Increased accessibility and availability	*When you have that insecurity of revealing yourself or taking a leap of faith and going for the mental health help to a human professional...it will reduce the gap…if via apps I can speak with someone… availability will reduce that gap of seeking a psychologist [P-10]*
		It can be used as a, like a catalyst where the person is reaching out for immediate help and then figures out a way to reach out to a real[human] professional [P-11]
		People can get service on time [P-14]
		Recommended to those who cannot afford fees [P-17]
	Professional concerns: Biases, Marginalization and Automation	*Rural populace will still be marginalized…can increase hopelessness in people who do not benefit [P-2]*
		If individuals solely rely on AI applications for mental health support, they may delay seeking face-to-face therapy or professional help when it is needed [P-4]
		Another thing is, people should not get the impression that this is the only one [P-7]

	of therapeutic processes	*It will only reach people willing to engage with it and is not applicable for people all demographics and backgrounds[P-8]*
		This generation is very, very different…if you give them a machine or the robot and if that is helping them even for a bit, they'll be happy to go with them… probably the human mental health professionals may have to be prepared for [P-11]
		With little knowledge and training, AI based tools can be error prone [P-16]
	Client level concerns: Privacy, Data-Security and Confidence	*Potential algorithmic bias, privacy concerns might hinder personalized care [P-3]*
		AI algorithms can inherit biases present in the data they are trained on, which may lead to disparities or inaccuracies in the assessment and recommendations [P-6]
		Issues related to data breaches, privacy, and confidentiality are always there. Since most of the data is on the cloud, safety is an issue here [P-7]
		Breach of ethical standards and safety of client's data can be a risk… access of AI apps to client who actually needs immediate medical attention could be a problem...consistency of the sessions may get reduced [P-13]
		Accuracy of understanding of instructions and activity is in doubt that may produce negative result of treatment than positive [P-14]

DISCUSSION

This study offers an insightful look into how psychologists in India and Nepal perceive and engage with Artificial Intelligence (AI) in mental health practice. With AI-based tools becoming more embedded in clinical and institutional workflows, the findings reveal a careful balancing act: psychologists acknowledge the operational advantages of AI, especially in reducing administrative burdens, but remain cautious when it comes to more interpretive or relational uses. These views echo prior research, such as Zhang et al. [3], where AI was welcomed as an assistive tool but viewed with hesitation when proposed as a clinical decisionmaker. Participants in this study largely saw AI as helpful in saving time, improving efficiency, and supporting routine processes like appointment management and client follow-ups, confirming similar conclusions in Rollwage et al. [7] and David et al. [31]. Still, the value of AI was perceived in how it supports human effort, not in its potential to replace it.

The first major theme, Current Utilization, shows AI being used primarily for basic, structured, and often clerical purposes. Participants described how AI assists with administrative tasks and serves as a reference point during scoring or preliminary assessment, particularly when used in conjunction with formal diagnostic systems. This mirrors prior findings from Jiang et al. [32] and Sadeh-Sharvit et al. [6], who noted AI's growing role in early detection and behavioral monitoring. However, psychologists were also quick to point out the limits of such systems, especially in handling complex, comorbid, or culturally nuanced cases. Most of them emphasized that AI-generated insights, though sometimes accurate, cannot substitute professional judgment. This aligns with Maslej et al. [9], who found a strong preference for human-led decisions in ambiguous diagnostic scenarios. In short, AI was perceived as useful, but only when closely guided by clinical expertise.

In contrast, the second theme, Complaints, Cautions, and Risks, highlighted strong concerns about AI's ability to engage in therapeutic relationships or respond meaningfully to emotional nuances. Many participants described the absence of non-verbal sensitivity in AI systems, such as failure to recognize tone, posture, or eye contact, as a key reason why AI cannot be trusted in deeper clinical roles. Gabbard and Crisp-Han [8] have similarly argued that empathy, attunement, and embodied presence are foundational to effective therapy. Beyond emotional limits, psychologists were also worried about potential over-reliance. They noted how clients might develop dependency on AI tools, even interacting

compulsively with chatbots, creating a false sense of therapeutic progress. This risk of relational displacement is consistent with Sadeh-Sharvit et al. [6], who warn of AI systems acting as inadequate relational substitutes. Ethical concerns, including data privacy and algorithmic opacity, were also central. Many participants expressed discomfort about how client information is stored or shared, particularly given the lack of regulation in some regions. These fears echo those in Malik et al. [16] and Fiske et al. [10], where the ethical infrastructure around AI remains patchy or insufficiently transparent. The theme highlights how much importance the Psychologists give to the core therapeutic qualities of a professional required for successful therapy and how they feel that AI-based tools lack these. The participants were also concerned about the misleading information that AI tools might provide and the harm they may cause.

In the third theme, hope and hesitation, participants perceived AI as having the ability to bridge gaps in access, especially for individuals who are reluctant to seek traditional therapy. The anonymity, constant availability, and digital accessibility of AI-based tools were seen as valuable starting points, particularly for people in distress who might not yet be ready to engage in human therapy. This is consistent with findings from Bucci et al. [14] and Wasil et al. [15], who noted that AI can act as a catalyst for initial help-seeking. However, these benefits were viewed as temporary or supplementary. Participants in the present study also raised concerns about the digital divide, literacy barriers, and unequal infrastructure, particularly in less urbanised areas. These limitations, noted by Robotham et al. [13], suggest that AI might inadvertently exclude the very populations it aims to support. Several also warned that AI might oversimplify complex clinical processes or deskill human practitioners if implemented without nuance, echoing concerns from Terra et al. [33] and Joseph and Babu [18].

Within this limited sample, participants from Nepal frequently raised infrastructure and connectivity issues. Indian participants frequently discussed cultural sensitivity, ethical safeguards and issues of overreliance and dependency. An interesting finding related to the demographic information of the participants was the adoption of AI-based tools by them. It was observed in this limited dataset that psychologists working in public sector, i.e., the hospital settings were more open to the use of AI-based tools in mental health care as compared to those working in private set ups. Another important finding was the limited knowledge of the participants regarding the AI-based tools in mental health care. This finding indicates a potential gap in awareness and suggests a need for professional training and workshops in this area. Structured training and workshops might help psychologists develop knowledge and skills to appropriately integrate AI-based tools into their own professional practice and into client care as and when needed.

The study reveals a profession that is cautiously optimistic yet ethically alert. Psychologists appear ready to engage with AI where it enhances procedural efficiency and access, but remain guarded about its application in emotionally complex or culturally sensitive scenarios. AI, at this stage, is seen as a support system, not a substitute, for human clinical work. Psychologists in this study have acknowledged that AI-based tools have potential but also emphasize the need for rigorous standards, enhanced training, and human oversight to ensure that the tools are ethically sound and clinically useful. Future directions must include participatory design with both practitioners and clients, greater regulatory clarity, and long-term studies examining not just outcomes but relational quality, cultural fit, and practitioner identity.

LIMITATIONS

Despite taking care to eliminate room for subjectivity, this study being a qualitative one, is subjected to constraints and limitations of methodology and analysis. Only Psychologists were recruited in the present study. Including Psychiatrists and other mental health professionals could have helped in gaining broader perspective as well as in comparing the perspectives of different professionals on the same area. Though caution was taken to cover all the regions of India and include psychologists with a variety of experience, level of education and interests the purposive sampling used in the present study could have limited the participant pool. The sample size of Psychologists from Nepal was very small which in turn affects the generalizability of results. Another limitation is the unequal representation of Psychologists from India and Nepal. Regarding method limitations, the interview modes were heterogenous and the participants differed in their actual exposure to AI-based tools. Despite the limitations, this study may be considered as a stepping stone in identifying the views and perceptions of Psychologists from India and Nepal towards the probable use and current utilization of AI-based tools in mental health care.

CONCLUSION

This study elucidates the layered and often ambivalent orientations of psychologists toward the use of AI in mental health care. While AI-based tools are acknowledged by psychologists for their operational and diagnostic utility, the views on limitations in empathy, contextual interpretation, and cultural nuance restrain their therapeutic applicability. Psychologists in the study think that the AI-based tools should be integrated in mental health care system under supervision rather than as an autonomic replacement of a professional. Their views echo the stress on privacy, cultural adaptation, professional accountability and human oversight. These views also warn against unmonitored implementation that might create public health concern. Training and capacity building programmes might help psychologists in increasing awareness about AI-based tools, use them appropriately and integrate them in professional practice and client care when required.

ETHICAL CONSIDERATION

The current study was approved by the Department Ethics Committee, Department of Psychology, Hislop College, Nagpur (Ref: Hislop/DEC/Psy/2023/A003, 14/09/2023). Informed consent was obtained from all the participants.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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RESEARCH ARTICLE

BRIDGING DIVIDES, BUILDING SOLUTIONS: STAKEHOLDER CONSULTATIONS ON SRH DISPARITIES IN JAIPUR DISTRICT, INDIA

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ABSTRACT

Women's Sexual and Reproductive Health (SRH) remains a critical area of concern, particularly in contexts were gendered power relations limit women's autonomy and decision-making capacity. This study investigates the multifaceted aspects of SRH including family planning, maternal healthcare, awareness of sexually transmitted infections (STIs), and women's autonomy through a comparative analysis of rural and urban women in Jaipur district, Rajasthan. Using an exploratory research design, the study draws insights from a diverse group of stakeholders including policymakers, healthcare professionals, academicians, NGO (Non- government Organization) representatives, community leaders, and frontline workers. Purposive sampling was employed to recruit panel members with relevant expertise and engagement in the field of SRH. Data was collected through stakeholder consultation meetings, utilizing the Delphi method to facilitate structured discussions and consensus-building around complex SRH challenges. Findings highlight significant disparities in SRH awareness, access to healthcare services, and decision-making power between rural and urban women. The study underscores the urgent need for context-specific policy interventions, community engagement, and multi-sectorial collaboration to enhance SRH outcomes and uphold women's reproductive rights in Rajasthan.

KEYWORDS

sexual and reproductive health, urban and rural disparities, family planning, challenges and opportunities, Delphi method, stakeholder's consultation, rajasthan.

INTRODUCTION

The World Health Organization defines Sexual and Reproductive Heath as a comprehensive state of physical, emotional, mental and social well-being concerning sexuality and the functioning of the reproductive system [1]. With in the Indian context- particularly in the Northern zone regions- deeply entrenched patriarchal structure and ideologies continue to pose significant challenges to women's overall wellbeing. These socio-cultural frameworks not only shape gender roles rather systematically constrain women's autonomy and agency. Consequently, women's SRH and their decision-making capacities must be examined with in the broader context of patriarchy and traditional organization, where in power relations are inherently gendered and often skewed in favour of men.

Rural areas in India are frequently characterized by structural limitations, including inadequate healthcare infrastructure, limited awareness, restrictive cultural norms, and persistent socioeconomic constraints, all of which adversely influence SRH outcomes among women [2].

In contrast, urban settings tend to offer relatively better access to healthcare services, higher levels of education, and increased employment opportunities, there by contributing to comparatively SRH indicators. A critical examination of the disparities between rural and urban contexts is therefore essential for the development of nuanced, evidence-based policies and interventions aimed at addressing the diverse and context specific SRH needs of women [3].

Scholarly discourse on women's decision-making power, particularly in the domain of SRH, has increasingly emphasized the role of gendered power relations. Women often remain marginalized in decision-making processes, with their reproductive rights insufficiently acknowledged or prioritized. Health outcomes and rights are profoundly shaped by an array of social and cultural determinants. From an early age, individuals are socialized into distinct gender roles through culturally embedded practices, symbols, norms, and value systems that construct and reinforce notions of masculinity and femininity [4].

Therefore, the present study is theoretically anchored in the theory of Gender and Power proposed by R.W. Connell. which offers a robust analytical framework for examining gender-based disparities in SRH. The theory delineates three different but interrelated structures; namely, the sexual division of labour, the sexual division of power, and the structure of cathexis, each of which critically influences women's access to resources, autonomy in decision making and health related behaviours. With in SRH domain, these structural dimensions shape women's ability to access maternal healthcare services, utilize family planning methods, and acquire knowledge regarding sexually transmitted infections (STI).

In regions such as the Jaipur district of Rajasthan, where socio-cultural norms and economic conditions exhibit considerable variations across rural and urban settings, these gendered power dynamics assume a decisive role in shaping health outcomes. By employing the theoretical lens, the study moves beyond an individualistic understanding of health behaviour and instead foregrounds the structural and systemic determinants of SRH. Accordingly, the study seeks to critically examine how entrenched social norms and structural inequalities influence women's autonomy and access to SRH services, while incorporating insights from a diverse range of stakeholders, including policymakers, healthcare professionals, academicians, and community leaders.

RESEARCH METHODOLOGY

STUDY AREA:

The comparison of SRH between Rajasthan's rural and urban women illuminates the complex issues that are present in this particular geographic setting. Over the years, Rajasthan, a state with a largely rural terrain, has seen a dramatic urbanization process that has changed the population's health characteristics. Examining SRH discrepancies is made more interesting by the state's distinctive features, which include differences in healthcare infrastructure, cultural variety, and economic development levels, offer an engaging context for analysing SRH discrepancies. This study seeks to explore the multifaceted aspects of SRH, encompassing family planning, maternal healthcare, awareness of sexually transmitted infections (STIs), and women's autonomy in decision-making. By conducting a comparative analysis, we aim to uncover disparities in SRH outcomes and access to healthcare services among rural and urban women in Rajasthan.

The study is conducted in Jaipur also referred as 'Pink City'. Rajasthan, encompassing both rural and urban settings to capture variations in sexual and reproductive health (SRH) indicators. Since this paper is derived from an on-going major research project sponsored by ICSSR, New-Delhi where we proposed study area as Jaipur District, the most populous district of Rajasthan State. It comprises of 13 Tehsils, each encompassing both urban towns and rural villages. From these Tehsils, 'Jaipur Tehsil' is meticulously chosen due to its substantial population size and its inclusion of both urban and rural areas. In the rural segment, five of the most populous villages were purposively selected from a total of 72 villages to ensure adequate population representation: *Niwaroo* (11,745), *Boytawala* (8,667), *Kalwar* (8,393), *Vijaypura (*8,000), *and*

Hathod (6,199). In the urban segment, the study area comprised *Jaipur* Town, administered by the Municipal Corporation of Jaipur, which has a total population of 763,574 across 77 wards. Five wards were randomly selected to represent the urban population, ensuring geographic and demographic diversity. The inclusion of both rural villages and urban wards enabled a comparative assessment of SRH indicators, including family planning practices, maternal healthcare utilisation, awareness of sexually transmitted infections, and reproductive healthcare access, across different socio-cultural and infrastructural contexts in Jaipur district.

ETHICAL CLEARANCE STATEMENT:

The research work titled "*Bridging Divides, Building Solutions: Stakeholder Consultations on SRH Disparities in Jaipur District*" is conducted under the **ICSSR sponsored project** at the **University of Rajasthan, Jaipur**. The study received ethical clearance from the Institutional Ethics Committee, University of Rajasthan. All procedures performed in this study involving human participants were in accordance with the ethical standards of the Departmental research committee and the guidelines of the Indian Council of Social Science Research (ICSSR). Informed consent was obtained from all participants, and confidentiality, anonymity, and voluntary participation were strictly maintained throughout the research process.

STUDY DESIGN AND RESPONDENTS:

An exploratory qualitative research design was employed for the study to get insights on opportunities and challenges for enhancing knowledge and practice on women's SRH in the urban and rural areas of Jaipur district from experts, policymakers, academicians, healthcare professionals, community representatives, NGO's and frontline workers to facilitate structured dialogue and consensus among key stakeholders.

STAKEHOLDER IDENTIFICATION AND ENGAGEMENT IN THIS QUALITATIVE LEG OF DATA COLLECTION:

The study adopted purposive sampling to recruit participants. Panel members were purposefully selected based on their experience, expertise and engagement in the field of SRH of women. To ensure comprehensive understanding of SRH landscape in the region, experts from multidisciplinary background including policymakers, academicians, implementers and healthcare providers were included in the sample. Altogether, 55 experts agreed to participate in the meeting, representing a broad spectrum of disciplines. The diversity was intended to enhance the validity and generalizability of the consensus outcomes and conclusions.

The stakeholder mapping and analysis framework was employed to identify the roles and level of involvement of various stakeholders. A total of 55 members, comprising of both state- level informants and community-level informants, participated in the process. The expert panel (N=55) was purposively balanced to include both macro-level perspectives (State Directors and Development Partners) and micro-level insights. To ensure rural-urban parity, the consultation included equal representation from grassroots functionaries (ASHA, ANM) across the five purposively selected rural villages and five randomly selected urban wards.

Participants for the stakeholder's meet were policymakers, state Development partners included representatives from UNICEF and *Jhpiego*, while state-level participants comprised Director RCH, Additional State Programme Officer, Representative from State Institute of Health and Family Welfare Rajasthan, *Saksham Mahila Samiti*, and Foundation for Reproductive Health Services (FRHS). The meeting also included representatives from UPHC, *Gandhi Nagar* and UPHC *Shanti Nagar*, senior medical officers, and community workers such as *Sarpanch*, ASHA, and ANM, reflecting a broad spectrum of disciplines and perspectives.

DATA COLLECTION:

Duration and Format of the Stakeholders' Consultation

The study incorporated a one-day stakeholders' consultation as part of its qualitative research design. The consultation was conducted over a duration of approximately six hours (09:30 AM–03:45 PM) and was organised as a face-to-face structured consultative workshop. The format combined expert presentations, guided discussions, and experience-sharing sessions to elicit policy, programmatic, and community-level perspectives on sexual and reproductive health (SRH) in Rajasthan.

The consultation was systematically structured into three components: an inaugural and contextualisation phase, thematic expert presentations, and facilitated discussion rounds. This format enabled both evidence-based framing of SRH issues and participatory engagement of diverse stakeholders, including policymakers, academicians, healthcare providers, grassroots workers, development organisations, and community representatives.

DISCUSSION ROUNDS

Two thematically guided discussion rounds were conducted to ensure depth and triangulation of perspectives.

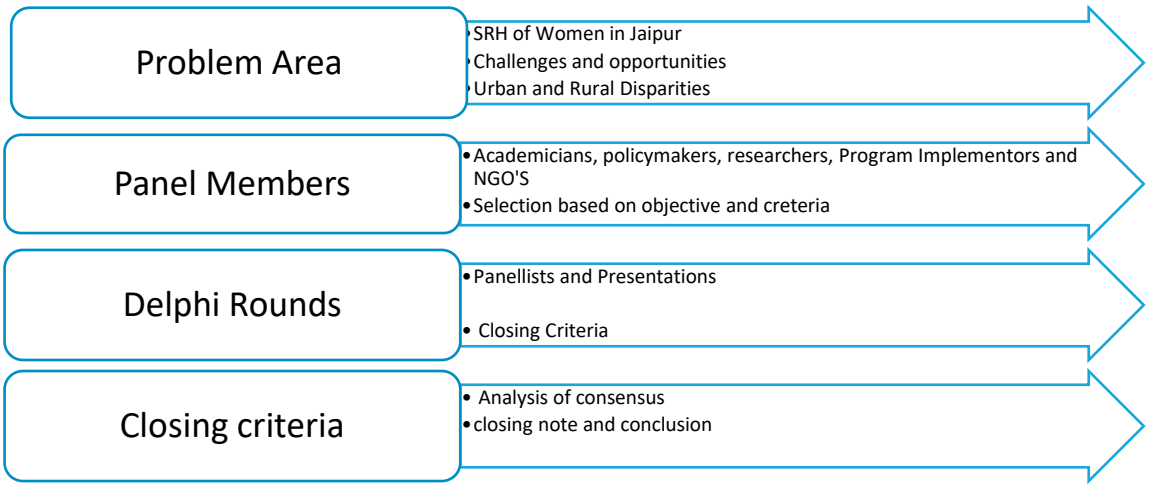
Discussion Round I Challenges and Opportunities in SRH (11:30 AM–01:00 PM) focused on structural, policy, and health system–related dimensions of SRH. Participants deliberated on barriers faced by marginalised women in accessing SRH services, the role of the public healthcare system, the influence of gender norms and power relations on women's reproductive decision-making, and gaps in existing policies and programmes requiring reform.

Discussion Round II Government Schemes and Innovation on SRH Rajasthan (01:45 PM–03:45 PM) was designed as an experience-sharing and participatory dialogue session. Grassroots health functionaries (ASHA, ANM, AWW), elected local representatives, development organisations, non-governmental organisations, and community members shared field-level experiences related to service delivery, utilisation challenges, sociocultural constraints, and implementation gaps. This round strengthened the qualitative component of the study by incorporating lived experiences and contextual realities.

The data was collected through panel discussion and presentations given during the Stakeholders consultations meet. Prior to data collection, all participants were briefed about the objectives of the study and informed consent was obtained for recording their responses. The panel discussion was facilitated by a moderator, assisted by a note-taker and a local translator. With prior consent from the panel members, the discussions were audio-recorded in addition; the presentations delivered during the session were also audio recorded with the permission of the key informants and participants. Panel discussion and presentation on SRH was held in English and the local language.

The Delphi technique was originally designed as a tool for business forecasting, utilizing structured discussions among panel of experts, based on the premise that collective judgement tends to be more reliable than individual assessments [5]. This approach is particularly useful in areas where statistical evidence is lacking, knowledge remains uncertain or incomplete and where the consensus of experts is considered more dependable than isolated opinions [6].

FIGURE 1: STEPWISE ASSESSMENT OF DELPHI METHODOLOGY



DATA ANALYSIS:

The audio files were transcribed verbatim, and translations into English were carried out where required. To ensure confidentiality, all transcripts were anonymized through systematic coding, with no identifying information retained. Prior informed consent was obtained from participants for the use of verbatim quotations during the stakeholder consultation meeting. The coded data were stored securely on a password protected laptop, accessible only to the researcher. The transcripts were processed and edited using Microsoft Word. The field notes were anonymized using special codes and added to the edited transcripts. The major themes and subthemes pertaining to SRH were identified using a thematic framework technique. We used *Murray-Webster & Simon's (2006)* stakeholder mapping analysis approach, which first characterizes stakeholders in terms of their potentials - power, attitude, and interest [7].

POTENTIALS OF STAKEHOLDERS

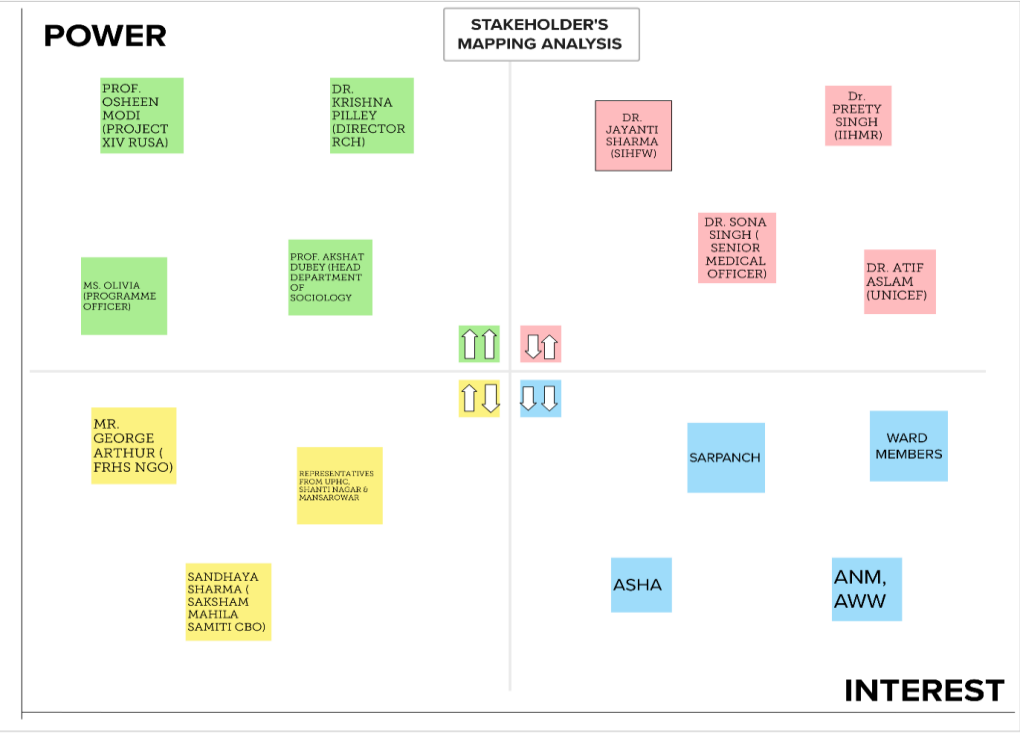
The framework divides stakeholder potentials into three categories, starting with

Power: This relates to how stakeholders view their ability to influence the State's execution of the SRH program. Their influencing ability was classified as "strong" or "weak" in this study.

Attitude: This relates to how stakeholders view their support for the State's implementation of the SRH program. Their support was classified in this study as "non-supportive" for negative views and "supportive" for positive attitudes.

Interest: This is how stakeholders view the implementation of the SRH program. Interest was divided into two categories: "passive" for those who are unwilling or reluctant to participate in the adolescent SRH program and "active for those who are highly interested and willing to do so.

FIGURE 2: STAKEHOLDER'S MAPPING FRAMEWORK ANALYSIS



(NOTE: All names used in this matrix are pseudonyms and have been anonymized to protect the identity and confidentiality of stakeholders involved in the consultation.)

FIGURE 3: RESULT MATRIX OF STAKEHOLDER'S CONSULTATION MEET TABLE

Stakeholder	Power	Interest	Quadrant
Prof. Osheen (Project XIV, RUSA)	High	High	Manage Closely
Prof. Akshat Dubey (Head, Sociology)	High	High	Manage Closely

Dr. Krishna Pilley (Director RCH)	High	High	Manage Closely
Ms. Olivia (Programme Officer)	High	Low	Keep Satisfied
Dr. Preety Singh (IIHMR)	High	High	Manage Closely
Dr. Atif Aslam (UNICEF)	High	High	Manage Closely
Dr. Sona Singh (Senior Medical Officer)	High	High	Manage Closely
Dr. Jayanti Sharma (SIHFW)	High	High	Manage Closely
Mr. George Arthur (FRHS NGO)	Low	High	Keep Informed
Sandhaya Sharma (Saksham Mahila Samiti, CBO)	Low	High	Keep Informed
Representatives from UPHC, Shanti Nagar, Mansarovar	Low	High	Keep Informed
Sarpanch	Low	Low	Monitor
Ward Members	Low	Low	Monitor
ASHA ANM AWW	Low	Low	Monitor

RESULT: CHALLENGES AND OPPORTUNITIES IN THE AREA OF SRH OF WOMEN

The shareholders consultation meeting was attended by key stakeholders including healthcare professionals, policymakers, and researchers. Participants emphasized the critical role of SRH in public sector and in promoting gender equality. They also highlighted the importance of interdisciplinary collaboration in addressing systemic barriers. Special attention was given to the disparities in SRH services between urban and rural populations. The findings from the consultation are as follows:

SRH PROGRAM AND POLICIES IN RAJASTHAN

Government Schemes and Their Accessibility

India's Family Welfare Programme, instituted in 1952, represents a pioneering effort in public health policy, positioning the country as the first globally to implement a comprehensive, state-sponsored family planning initiative. The programme's principal objective is to achieve population stabilization through the provision of accessible and equitable family planning services to eligible couples [8]. Concurrently, it seeks to mitigate maternal and infant mortality by advocating for pregnancies at biologically appropriate ages and promoting optimal birth spacing through informed contraceptive practices.

Even the study done by Sharma, S.P, *et al*. underscores that, despite the rapid urbanization of Jaipur, reproductive health perceptions and practices remain deeply embedded within entrenched socio-cultural frameworks. Traditional gender norms, patriarchal structures, and intra-household power hierarchies particularly the influence exerted by husbands and mothers-in-law—continue to shape decisions concerning family size and a persistent preference for male offspring. While Jaipur's near-universal institutional birth rate of 99.8% constitutes a significant public health achievement, contrary to this finding also revealed enduring constraints on women's autonomy, especially in rural settings. In these areas, the prevalence of early marriage—nearly twice that observed in urban counterparts results in a substantial proportion of women entering motherhood before the age of eighteen, often with limited educational attainment. This perpetuates a cyclical pattern of disadvantage, wherein the mere availability of healthcare infrastructure and medical professionals does not necessarily translate into autonomous healthcare-seeking behavior. Instead, such decisions remain largely

mediated by prevailing familial and cultural dynamics, thereby undermining women's agency in matters of reproductive health [9].

The different government schemes that have been started in Rajasthan are;

Janani Suraksha Yojana *(JSY)* Maternal Mortality Rate (MMR) in Rajasthan has significantly reduced from 141 to 87 in recent years. One of the key interventions contributing to this decline is the *Janani Suraksha Yojana* (JSY), implemented under the National Heath Mission, is a safe motherhood initiative designed to decrease maternal and neonatal mortality [10]. The program encourages institutional deliveries, particularly among economically disadvantaged pregnant women. This scheme provides conditional cash transfers to encourage institutional deliveries and improve access to medical care. It is a centrally sponsored scheme that integrates financial assistance with delivery and post-natal care services. A critical component of JSY is the involvement of Accredited Social Health Activist (ASHA) who serves as a vital link between the health system and pregnant women, ensuring timely access to services and promoting health awareness.

Pradhan Mantri Matru Vandana Yojana *(PMMVY)* is a maternity benefit scheme administered by the ministry of Women and Child Development, Government of India [11]. Initially introduced in 2010 as the *Indira Gandhi Matritva Sahyog Yojana*, it was restructured and renamed as PMMVY in 2017 [12][13]. The program is a conditional cash transfer initiative targeted at women aged 19 years and above, applicable for their first living child during pregnancy and lactation [14]. It seeks to provide partial wage compensation for women to compensate for wage-loss during childbirth and childcare. Along with income support, the scheme also seeks to encourage safe delivery practices, proper nutrition and healthy feeding habits for both mother and child.

Mission Parivar Vikas is a focused initiative launched by Government of India to address high fertility in selected districts. The campaign promotes responsible reproductive choices- by improving access to family planning services, particularly in high-fertility districts. The key objective of MPV include increasing the availability and use of modern contraceptives, raising awareness about family planning, and strengthening the supply chain to ensure uninterrupted availability of contraceptive commodities.

Innovations in creating awareness on SRH in Rajasthan

Nayi Pahal Kits – These kits distributed to newly married women, include bridal ornaments and contraceptives, to promote awareness about reproductive health and family planning. The kit contains condoms, birth control pills, a mirror, two towels, handkerchiefs for the husband and wife, a bindi, comb, nail cutter, and an informative booklet that highlights the importance of planned parenthood. This initiative reflects the government's thoughtful and sensitive approach to engaging newlywed couples in discussion around reproductive health and family planning.

FEMALE ASHA "ASHA *worker actively participates in this scheme by distributing the kits. Open conversations around this delicate subject are possible when frontline worker build rapport and establish trust, which lays the foundation for the healthy communication and strong relationship in the future. To raise awareness about safe sex and family planning among newlywed couples, this initiative has been started.*"

Purush Sahbhagita Sammelan – In the context of rising population growth, male involvement in family planning has become crucial. While family planning is important for both men and women, the uptake of male contraceptive method remains low. Even in a study done by Diamond-Smith et al. (2024) in *Udaipur* and *Rajsamand* districts found that family planning remains heavily 'feminized'. Men often view contraception as 'women's business', and significant cultural barriers prevent husbands from engaging in SRH dialogues, fearing a loss of 'masculinity' [15]. Therefore, to encourage greater male participation, a vasectomy acceptor is invited to serves as a role model. He is honoured and encouraged to share his personal experience to promote awareness and acceptance of male sterilization and vasectomy.

Prof. Osheen "*Include Men in this crusade, this is human right not women's issue and men and women are equally part of it and living in 2025 this mind-set must be challenged and changed.*"

Key initiatives in Rajasthan

Saas Bahu Sammelan - A "*Saas Bahu Sammelan*," or Mother-in-Law and Daughter-in-Law Meeting," is a community event, typically organized by government or community organizations, to foster better relationships and promote healthy practices within households. These events focus on key issues such as maternal and child health, family planning, and addressing misconceptions related to childbirth and nutrition. More than 30,000 *'Saas Bahu Sammelans'* are organized annually in Rajasthan's rural areas.

Dr. Usha prof. IIHMR "In many households Mother-in-law often plays a key role in decision-maker particularly regarding reproductive choices, such as when the newlyweds will have children and expectation around the gender of the child."

Meena Rural Woman "My baby was seven months in my womb when I lost the pregnancy, Doctor said it was because of iron deficiency, but my family refused to believe it. After the miscarriage, my periods stopped, and instead of taking me to a doctor, they whispered that an evil spirit had caught me… that something had 'bound' my body. My mother-in-law kept me inside the house, made me sit alone in dark corners, and warned me not to step out at dusk. Even today, the fear of that time still sits inside me."

Tele counselling and Family welfare counselling centre-The government of Rajasthan has launched an initiative, offering 24X7 counselling services to married couples through a toll-free number. In rural areas where healthcare providers are often limited or unavailable, tele-counselling can play a crucial role in supporting informed decision-making and improving access to reproductive health information.

Tele-counselling allows individuals and couples to receive guidance on family planning, spacing practices, maternal care, and adolescent health through remote platforms, which is particularly useful for those living in geographically or socially constrained settings [16]. Family Welfare Counselling Centres operate at selected public health facilities and provide personalised, in-person counselling on contraceptive options, postpartum family planning, fertility-related concerns, and appropriate referrals [17]. Both services emphasise informed choice, confidentiality, and voluntary participation, and are aligned with broader family welfare initiatives such as Mission Parivar Vikas. Collectively, these mechanisms contribute to strengthening awareness, counselling quality, and continuity of family welfare services across rural and urban areas of Rajasthan.

EXISTING CHALLENGES AND OPPORTUNITIES

Gender norms and Decision-making

Despite over five decades of commemorating International Women's Day and sustained global and national commitments toward gender equality, the imperative to accelerate progress remains pressing. Although numerous initiatives have been implemented, their impact is often constrained by fragmented and siloed approaches. Achieving meaningful societal transformation and advancing national development necessitate the systematic translation of empirical evidence and community perspectives into coherent, actionable policy frameworks.

Access to sexual and reproductive health (SRH) services continues to represent a critical public health challenge, particularly for women. This access is shaped by a constellation of interrelated factors, with gender inequality serving as the foundational determinant that exacerbates other structural and socio-cultural barriers. While notable progress has been made, significant gaps persist, and considerable efforts are still required to ensure that all women and girls can fully exercise their reproductive rights.

Empirical evidence from the longitudinal UDAYA (Understanding the Lives of Adolescents and Young Adults) study conducted in Uttar Pradesh and Bihar highlights substantial deficiencies in SRH knowledge among adolescent girls in India. This knowledge gap exposes them to a range of preventable health risks, including early and unintended pregnancies, as well as gynecological morbidities such as irregular menstrual cycles and abnormal urethral discharge, among others. Deeply entrenched social stigma, coupled with limited autonomy, further restricts adolescents—particularly those from marginalized communities—from accessing accurate, comprehensive, and timely SRH information through familial or local healthcare channels.

These barriers significantly undermine health-seeking behaviors and contribute to avoidable adverse reproductive health outcomes. In urban contexts such as Jaipur, where SRH remains a socially sensitive and often stigmatized subject, innovative approaches are essential. In this regard, social media and digital platforms offer considerable potential as transformative tools for disseminating information, fostering awareness, and addressing misconceptions surrounding SRH in a culturally sensitive manner [18].

Men are expected to be assertive and powerful while women are often perceived as weak or passive. In rural areas women juggle multiple responsibilities day and night, leaving no time for self-care moreover no say in deciding when to have child, number & spacing of children since the decision-making power is in the hand of mother-in-law or husband.

Prof. Olivia "A woman or girl's fundamental rights to equality, privacy, and bodily integrity are based on her ability to make independent decisions regarding her own body and reproductive functions. Women's empowerment is the first step toward their freedom to express themselves and make decisions."

Inclusion of Men & Breaking Taboos

There are a multiple contraceptive options available for women but very few for men. Women can choose from wide range of methods such as, *MALA-N, E pills, Chhaya,* Contraception injection *Antara, IUCD*, Sub dermal contraceptive implant and female sterilization. In contrast, the options for men are limited primarily to vasectomy, condoms and withdrawal methods. To address this imbalance and promote male participation in family planning, district and regional level consultation and training should be mandatory. These platforms are essential for dispelling myths and misconceptions surrounding male vasectomy and encouraging informed, positive attitudes towards male contraceptive responsibility.

Anita (ASHA WORKER): "more incentives are provided to ASHA/ front line workers to mobilize male members for sterilization but they refuse saying their masculinity will be lost in the whole process but when the research was carried out the results were shocking as it's the female members of the family who act as the major barrier in decision making."

Sunita (Rual Woman) "I have been pregnant nine times, and five of those babies were girls… so I was forced to abort them. The guilt and pain kept building inside me. I couldn't bear it anymore, so I secretly got the sterilization done without telling my family. Since then, I feel extremely weak, emotionally and physically."

*Dr Suman (PHC DOCTOR**): "**When a 16-year-old boy approached the PHC to ask about the benefits of condoms and pregnancy prevention, it highlighted the discomfort adolescents often face in seeking such information. To mitigate this, sanitary pads and condoms were placed at an external counter accessible round the clock, ensuring privacy and ease of access."*

The above narrations depicts that reproductive health is not just a women's issue it is a human rights issue. Male participation is the key in decision-making which is still challenging in many rural areas in Rajasthan.

Community & Mind-set Shift

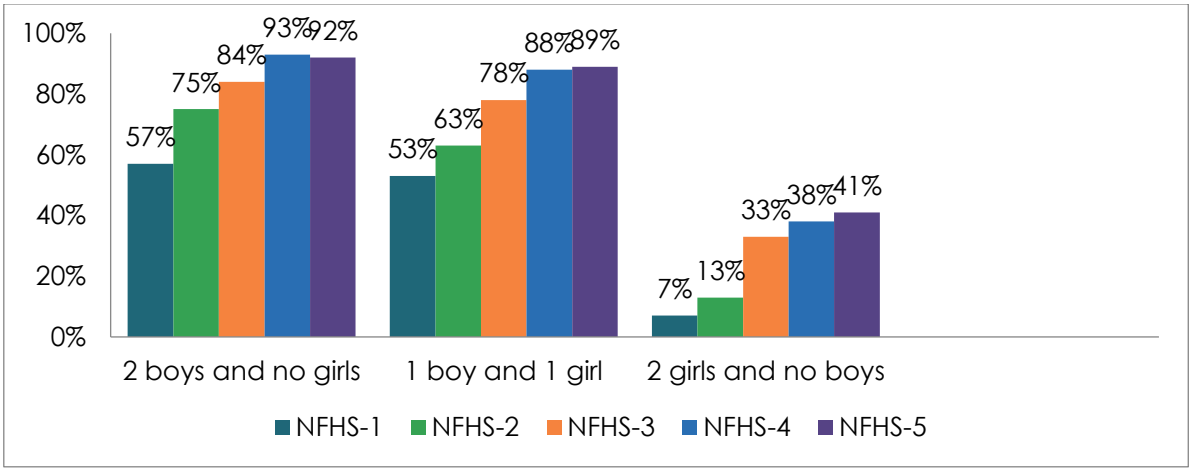
At the grassroots level, many ASHA/ANM themselves are not fully convinced about promoting contraceptive methods, particularly male vasectomy. Therefore, addressing misconception around male sterilization and family planning at this level is crucial. Changing perception among frontline worker can create a ripple effect, ultimately transform community attitudes and expand acceptance in the long run. For instance, *Antara* injections require women to take two doses within a specific time frame. However, many women either discontinue the injection or delay the second dose, leading the contraceptive failure. This is often due to misinformation, such as being told that the injection is unhealthy or that reduces fertility. This highlights the urgent need for training at grass root level to shift mind-set and challenge prevailing societal norms. While a woman has access to a basket of contraceptive options, it is the grassroots health workers who guide them in making informed choices through personal counselling and support. Since there grassroots workers are also a part of the same community, it is necessary to address their attitude and behaviour first before addressing the community's drift.

Deepika Rural woman "The ASHA worker comes to our house just long enough to take my signature and then leaves. She never explains anything, never brings medicines or sanitary pads, and never checks on our health. At the grassroots, many of them treat their work like a routine tick-mark activity, so women like us remain unaware and unsupported. It feels as though the system reaches our village on paper, but not in practice."

Social and Cultural Stigma

Despite its rich cultural legacy, Rajasthan continues to grapple with several social and cultural taboos, particularly those related to marriage, menstruation, and gender roles. The dominance of a patriarchal system often restricts women's ability to fully exercise their autonomy over their sexuality and reproductive choices. Prevailing social norms tend to reinforce female submissiveness, restrict sexual agency and maintains male control over decisions in the sexual and reproductive sphere [19]. While certain customs gradually fading due to urbanization and industrialization. Son preference continues to persist in some communities, influencing family size and in some cases, contributing to harmful practices such as female feticide. In Rajasthan, most married individuals prefer smaller families, with around 70% of women and 67% of men wanting no more children or being sterilized. Among those who do want more children, many prefer to wait at least two years before the next birth. Despite widespread acceptance of a two-child norm, a strong preference for sons remains. About 16% of both women and men want more sons than daughters, while only 2% prefer more daughters. This gender bias influences reproductive choices especially among women with two daughters, many of whom continue childbearing in hopes of having a son [20].

FIGURE 4: CURRENT SEX COMPOSITION OF FAMILIES WITH TWO LIVING CHILDREN



Source: International Institute for Population Sciences (IIPS) and ICF. 2021. National Family Health Survey (NFHS-5), India, 2019-21: Rajasthan. Mumbai: IIPS

Certain communities observe restrictions on food preparation and consumption during specific times or for certain individuals, such as during menstruation, pregnancy or religious rituals.

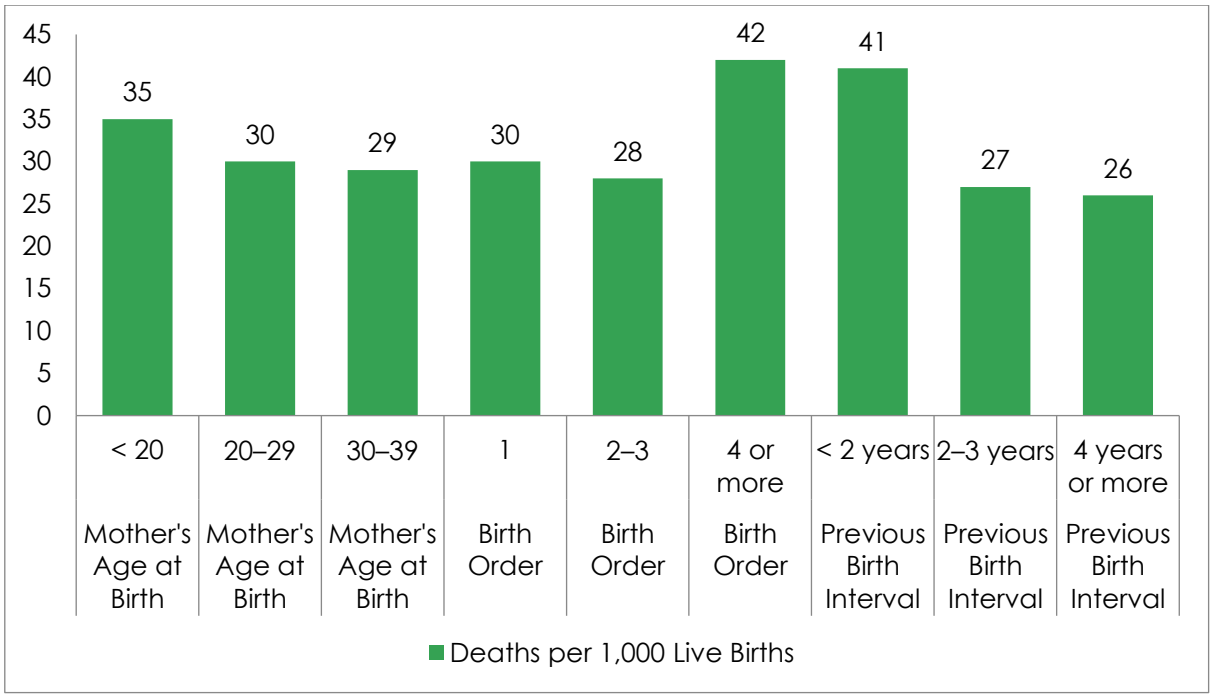
Dr. Krishna Pilley (Director RCH) : During a filed visit to an Anganwadi centre in Udaipur, one of the panel members, accompanied by teammates and state-level officers was shocked to find that a 4-month-old child weighed only 1.5 kg. Upon further inquiry, it was revealed that the mother avoided consuming all white foods, including milk due to prevailing cultural belief or personal misconception. This case highlights the urgent need for nutrition education and behaviour change communication and the grassroots level.

They organized "*Saas-Bahu Sameelan*" to dispel the myth that white food items should be avoided. The key message shared was if you don't eat healthily, how can your child be healthy? As a result of these efforts, the child's weight has improved from 1.5 Kg to 2.6 kg, and the team continues to monitor the situation to ensure the child's survival and development.

Another significant barrier is early marriage in many rural areas; girls are married off before the age of 18 long before they gain understanding of family planning, safe sex, or reproductive autonomy. Adolescents' mothers face increased risk of

complications such as preterm birth and low birth weight babies. Additionally, son preference continues to prevail in some communities, influencing family size decision and contributing to sex-selective practices. Infants born to mothers younger than 20 years old face a greater risk of dying in their first year compared to those born to women aged 20 to 29 [21], who are in the typical childbearing range. Among teenage mothers, the infant mortality rate is 35 per 1,000 live births. In comparison, it's 30 per 1,000 for mothers aged 20 to 29, and slightly lower at 9 per 1,000 for those aged 30 to 39. Infant deaths are more common in rural areas than in cities, while the mortality rate for older children (under age 5) tends to be higher in urban settings. Additionally, a mother's level of education plays a significant role in infant survival. Children of mothers with no formal education face higher mortality rates than those whose mothers completed some schooling. The lowest rates are found among children whose mothers have more than 10 years of education.

FIGURE 5: HIGH-RISK BIRTHS HAVE HIGHER MORTALITY RATES (DEATHS IN THE FIRST YEAR OF LIFE PER 1,000 LIVE BIRTHS)



Source: (Source: International Institute for Population Sciences (IIPS) and ICF. 2021. National Family Health Survey (NFHS-5), India, 2019-21: Rajasthan. Mumbai: IIPS

Despite decades of independence, the presence of an education system, and numerous awareness campaigns, gender-based violence and discrimination remain deeply rooted across both rural and urban communities. Among these, menstrual health continues to be a taboo subject, especially in conservative rural communities. Menstruation marks the beginning of a women's reproductive life and plays a vital role in overall health. This is why the desert state of Rajasthan is making an extra effort to raise awareness of the tabooed subjects of menstruation health, sanitation, and hygiene on women's health. However, breaking the taboo will still take many years**.** The menstruation situation is linked to secrecy in these conservative societies. Menstruation myths are harmful social beliefs that create unnecessary shame and fear around a natural, healthy process. Common myths include the idea that menstruation blood is dirty and harmful. Social taboo around menstruation leads to shame, isolation and school absenteeism among adolescent girls and school dropout among young girls.

Prof. Amelia (IIHMR) "I went to Chandalai School where girls from school's dropout when their periods start as mostly answered that they are told to isolate in such a situation and are offered different food and kept in a room."
Himani (Rural Woman) "After attending several health camps and seeing awareness campaigns on social media, I have come to understand the importance of changing sanitary pads and maintaining hygiene. I make sure my daughter has access to sanitary pads and explain to her how important it is to stay clean during her periods."

Education & Empowerment

In order to enlighten us as human beings about our fundamental rights, education can be a helpful tool that is included into the system. Information and choice go hand in hand; without the former, you are left without an option. Empowering women to participate in decision-making should be the first step, and this can only be accomplished via education.
One panel member shared an observation from a field visit, where she met a girl who was officially 14 years old but was being presented as 18 years old. The girl had no knowledge of safe sex practices, consent, or contraception. Early marriage, coupled with lack of awareness significantly contributes to high rated of anaemia, maternal mortality, adolescent pregnancies, and inadequate prenatal care in rural areas. These factors put both the mother and her unborn child at serious risk. Another case involved a 21years old woman who was married at the age of 18 and has undergone five abortions to date. This raises concerns about the risk of infections, uterine damage, and future pregnancy complications. The lack of open discussion around safe sex, consent, and reproductive rights, largely due to social taboos, combined with high rates of early marriages, contributes to the prevalence of teenage pregnancies and unsafe reproductive practices. Even Goyal and Ambedkar investigated gender mainstreaming in Rajasthan and found that even women in leadership roles (for example councillors) also face 'intersectional oppression' and a lack of institutional support for gender specific health issues which reinforce the 'silence'. This underscores the urgent need for the comprehensive sex education, particularly for rural women to raise awareness, empower them with knowledge and promote informed decision making about reproductive health [22].

Access to Contraceptive & Healthcare

Over 62% of couples use some form of contraception, yet the responsibility disproportionately falls on women [20]. In many low- and middle-income countries, poor access and low prevalence of contraception are common. Contraceptive uptake varies by region, leading to high unmet needs because of various socio-economic and cultural factors. Women's fear of side effects or other health concerns related to contraceptive methods, as well as opposition from husband- often rooted in concern about trust or perceived infidelity [23]

Dr. Krishna Pilley (Director RCH) "one of the male patients underwent a vasectomy and after few days his wife became pregnant and the husband started questioning about the child's paternity, leading to marital dispute."

In this case the doctor and the ASHA/ANM workers should have properly counselled the patient about the need to use condom or abstain from sexual contact for at least three months after vasectomy, as the procedure does not provide immediate sterility. In a patriarchal society the emotional burden women bear often get unacknowledged. Many women, despite being malnourished or physically vulnerable, end up prioritizing their partners comfort and pain over their own wellbeing.

To maintain SRH, people need accessibility to safe, effective, affordable and acceptable contraception methods. They must be informed and empowered to protect themselves from sexually transmitted diseases. And when they plan to have children, women must have awareness and access to proper health services that can help to have a safe pregnancy, safe delivery and healthy child. Every individual has a fundamental right to make their choices about their SRH matters. According to Green (2018) relevant information, awareness and accessibility of family planning products and services are limited to women in India, and their decision-making power is also considerably very low [24].

CONCLUSION

Investing in women's health is essential for overall development, and reproductive health is a fundamental human right. While significant progress has been made, more efforts are needed to ensure that all women in Rajasthan have equitable access to reproductive health services. While Rajasthan has seen rapid clinical improvements, the deep-seated cultural norms surrounding menstrual taboos and reproductive autonomy change at a much slower pace. Based on current trends in the World Economic Forum's Global Gender Gap Report, achieving full gender parity in health and economic

participation could take over five generations (approximately 131 years) globally if interventions do not accelerate beyond their current trajectory [25]

To effectively address SRH issues, the use of technology should be promoted at the local level. Debunking myths and misinformation are essential to creating lasting change and shifting societal attitudes towards women. In rural areas, the abortion rate remains high often due to lack of accurate information and limited access to contraception
In general, social change is difficult, and it becomes even more complex when it touches on deeply rooted gender roles within the home and society. There is a growing recognition that the norms governing the roles, status and resource access of men and women can significantly influence the prospects for equitable and sustainable development. In the era of rapid urbanization and globalization, improving the lives of both men and women requires local solutions one that reflects regional realities and cultural customs and are grounded in a shared understanding of justice, including gender equality. Not just women, but all members of society are affected by reproductive health and access to reproductive health care. The ultimate goal of reproductive rights is to ensure the well-being of the individual and the family. In addition to protecting citizens' right to choose their reproductive outcomes while also taking into consideration local and cultural norms and preferences, governments have a duty to offer their citizens high-quality reproductive health services. Additionally, there is a rising need to educate the legal system on the importance of informed consent in the context of abortion, ensuring that reproductive rights are upheld within right based and ethical framework.

Recently, HPV vaccinations have been made available in field settings given the high prevalence of anaemia, adolescent pregnancies, and limited access to the HPV vaccine, [26] it is imperative to incorporate comprehensive reproductive health education into the school curricula. Introducing sex education at an early stage can significantly improve women's health outcomes and shift societal perspectives towards reproductive health.

By concentrating on four key areas of concern, we can move forward and accomplish our goals of enhancing women's SRH*:*

Universal access- It is crucial to guarantee that everyone has access to complete reproductive healthcare services. Introduction of *Chiranjeevi yojana, bhramasatra yojana* has led to greater accomplishment in health service providing field and making Rajasthan the biggest state with great number of insurance coverage. *Nishulk dawai yojana, Jannani Suraksha yojana* are the schemes that have promoted universal access to each and every segment of the society especially targeting rural women.

Research and Innovation- Putting money into research and innovation will advance reproductive health solutions and technologies. When it comes to women's health and decision-making power the rural and urban setting varied significantly. Hence providing the right information and the right time is crucial. The action needs to be taken to translate the research work into policies to enable the change now.

Infrastructure- For better service delivery, hospital infrastructure and human resources must be strengthened. But the major drawback comes when there is no staff available/ employed or we can address the term as hidden employment leading to staff deficit impacting the common people and overall.

Social hurdles- In order to achieve reproductive health equity, it is still imperative to address social and cultural barriers. As from NFHS1 to NFHS 5 i.e. 1952 to 2025 no such major changes have taken place when we talk about rural development and women's SRH [27]. The discussions reinforced that reproductive health is not just about contraception, it's about ensuring women have the right information, resources, and autonomy to make decisions for themselves. Small steps today can lead to big changes in the future.

RECOMMENDATIONS

To significantly improve health and wellness outcomes across Rajasthan's urban and rural populations, the Ministry of Health and Family Welfare must urgently expand and deepen its digital health mission. While the state has made remarkable progress by registering over 6.22 million *Ayushman Bharat Health Accounts* (ABHA) [28], rural awareness of this initiative remains limited, necessitating targeted outreach through local languages and community networks. Simultaneously, the inclusion of women over 45 years who hold influential roles as primary decision-makers within families and communities in SRH programs is critical to advancing gender equality and empowering communities. These women serve as vital community influencers whose engagement can accelerate positive behavior change and family planning acceptance.

In the clinical domain, it is imperative to safeguard women's health by ensuring that IUCD insertions, particularly first-time or medically complex cases, are conducted by qualified doctors rather than Auxiliary Nurse Midwives (ANMs) alone. Establishing clear referral protocols will reduce the risk of complications, reinforce clinical quality, and strengthen trust in public health services. Furthermore, reproductive health education should be normalized within co-educational settings to dismantle long-standing stigmas promoting open dialogue and shared learning between boys and girls. This approach fosters psychological comfort and encourages young people to become informed, supportive adults who can serve as future community role models.

The study reveals that high institutional birth rates (99.8% in Jaipur) do not equate to reproductive autonomy. The above data on the paternity dispute and male sterilization fears suggests that policy must move beyond female-centric clinics. Therefore, we recommend mandating *Men-only Sammelans* that utilize vasectomy acceptors as role models to decouple sterilization from loss of masculinity. Even in another study done by Prusty & Begum (2023), suggested that the greater participation of men in family planning has been shown to enhance women's reproductive health and promote more equitable gender outcomes. However, in the Indian context, contraceptive practices continue to be predominantly centered on women. [29]

Men's engagement is equally vital in shifting family planning paradigms from women-centered responsibility to shared duty. Organizing men only *Sammelans* and group discussions in both rural and urban areas will create safe spaces for open conversations, addressing fears and misconceptions about male contraceptive methods such as vasectomy. Introducing modest financial incentives and public recognition can motivate greater male participation, while respectful, myth-busting counseling ensures informed decision-making. Drawing on stakeholders' emphasis on the need to "include men in this crusade" and the identified gap in male-focused counselling to mitigate marital tensions, the study advocates for the institutionalization of "*men-only sammelans*" as a culturally sensitive forum to challenge and dispel prevailing myths surrounding contraception.

Frontline health workers including ASHAs, ANMs, and MPWs should be empowered as active referral agents for family planning services trained to promote the 24x7 toll-free helpline and equipped with culturally appropriate, dialect-specific IEC materials. This localized communication strategy is essential for building trust and overcoming barriers related to language and tradition.

Addressing persistent menstrual health taboos requires a comprehensive community-based strategy that integrates menstrual hygiene education in schools, capacity building for teachers and health workers, and active involvement of men and boys in awareness efforts. Improved access to affordable and eco-friendly menstrual hygiene products, alongside enhanced sanitation infrastructure, will directly impact women's health and dignity. Engaging religious and community leaders in respectful dialogue can help reinterpret cultural norms, fostering an environment that supports women's empowerment and generational change.

Together, these interlinked measures can create a robust ecosystem that improves reproductive health outcomes, advances gender equality, and promotes holistic wellbeing for Rajasthan's diverse populations.

CONFLICT OF INTEREST:

The authors declare no conflict of interest.

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RESEARCH ARTICLE

FACTORS ASSOCIATED WITH QUALITY OF LIFE AMONG HEALTHCARE WORKERS IN A TERTIARY HOSPITAL

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ABSTRACT

BACKGROUND

Assessment of the QoL and well-being among healthcare workers is vital for better healthcare and is an essential indicator for competent health service delivery.

OBJECTIVES

This cross-sectional study aims to determine the characteristics and associated factors towards QoL and well-being among healthcare workers in a tertiary hospital by using a Significant Quality of Life Measure (SigQOLM), a recent scale developed and published in 2023 which consists of four dimensions,18 domains and 69 items.

DESIGN

It performed a secondary analysis of primary data obtained from a total of 406 healthcare workers who are currently working in a tertiary hospital.

SETTING

All the 406 healthcare workers holding various job positions in a tertiary hospital were recruited for participating in this cross-sectional study.

MAIN OUTCOME MEASURES RESULTS

Apart from "Sleep quality", "Eating regime" and "Body image", all the other domains reported a score of more than 70.0% which indicates good to excellent QoL and well-being in these healthcare workers. Overall, the QoL and well-being among healthcare workers are good. Nevertheless, three of the modifiable factors provided a major contribution towards their QoL: marital status ($p<0.05$), job occupation ($p<0.05$) and health condition ($p<0.05$).

CONCLUSIONS

It is recommended to measure people's QoL and well-being using a broader spectrum of measurable parameters to elicit a more holistic understanding of their QoL and well-being so that all necessary actions can then be taken to improve their overall QoL.

KEYWORDS

healthcare workers, quality of life, SigQOLM, tertiary hospital, well-being

1. INTRODUCTION

Every human being has an innate desire to attain the highest possible quality of life (QOL) and overall well-being. The pursuit of these goals is fundamental, as they are regarded as essential elements that enable individuals to flourish and succeed in various aspects of their lives. Indeed, optimal QOL and well-being are not just abstract concepts; they encompass physical health, emotional stability, social connections, and personal fulfilment [1,2]. These factors collectively contribute to an individual's ability to navigate the complexities of the world, overcome challenges, and achieve personal and professional aspirations. Therefore, the importance of quality of life and well-being cannot be overstated, as they are vital for the holistic development and sustained happiness of individuals across diverse contexts and cultures.

1.1 LITERATURE REVIEW

Much of the humanitarian efforts made by governments and non-governmental organizations are aimed at enhancing people's QOL and well-being in various aspects [1,2]. Given the high value being placed on QOL and well-being, how can individuals determine and measure whether their lives are considered 'excellent' or otherwise? Traditionally, two measures are commonly used to assess the QOL and well-being of individuals. The first relies on statistical indicators developed by economists, epidemiologists, and methodologists to gauge a country 's or state's performance. The second relies on self-reported outcomes from individuals [3,4,5]. Throughout history, measures such as life expectancy, literacy rates, per capita income, and mortality and morbidity statistics have been widely utilized to construct various indices of well-being. Many countries around the world commonly employ statistical indicators such as the Consumer Price Index (CPI), foreign direct investment (FDI), inflation rate, and Statistical Capacity Indicators and Index (SCI) to represent a country's performance, which indirectly reflects the QOL and well-being of its people. However, there is a consensus that objective measures such as per capita income are insufficient in capturing the full spectrum of well-being [5,6,7].

1.1.1 Theoretical Framework of Occupational Stress and Well-Being

This study is informed by established occupational stress frameworks to guide the identification of factors associated with quality of life and well-being among healthcare workers in a tertiary hospital. The Job Demands–Resources (JD-R) model provides the primary structure, suggesting that job demands such as workload and time pressure may negatively influence well-being, whereas job resources including social support and autonomy may enhance it [8,9]. This framework supports the examination of workplace characteristics as key explanatory variables.

In addition, the burnout framework developed by Christina Maslach conceptualizes burnout as emotional exhaustion, depersonalization, and reduced personal accomplishment, representing a potential pathway through which occupational stressors influence overall well-being [10,11]. By integrating these frameworks, the present study conceptualizes work characteristics and psychosocial factors as determinants, and quality of life and well-being as outcomes. This theoretical positioning directly supports the study objective of determining the associated factors influencing healthcare workers' quality of life and well-being.

1.1.2 Rationale and study objectives

Quality of life (QOL) should ideally be determined by a broader spectrum of measurable parameters. A recent development in measuring QOL and well-being is the Significant Quality of Life Measure (SigQOLM) [7]. The SigQOLM encompasses 4 elements and 18 domains comprising 69 items, offering a more comprehensive approach to measuring QOL and well-being compared to previous scales. The SigQOLM assesses health, relationships, functional activities, and survival. Therefore, an individual with excellent QOL and well-being is one who possesses optimal health, maintains positive relationships, engages in various functional activities, and demonstrates excellent survival in life. Assessment of the quality of life (QoL) among healthcare workers (HCWs) is vital for better healthcare and is an essential indicator for competent health service delivery.

This study aims to administer the SigQOLM to measure the QOL and well-being of healthcare workers specifically in a tertiary hospital. It also seeks to determine their QOL and well-being and to identify factors associated with the QOL and well-being. From these findings, we can deduce that a list of pertinent issues might have an impact on the quality-of-life of a healthcare worker, which can often be helpful for analyzing the personal and professional requirements of a healthcare worker and also to determine the association between a list of pertinent factors and quality-of-life (as well as an overall sense of well-being) of all healthcare workers.

2. MATERIALS AND METHODS

2.1 STUDY DESIGN

This cross-sectional study aims to determine the characteristics and associated factors towards quality of life (QoL) and well-being among healthcare workers in a tertiary hospital. It is based on the analysis of secondary data collected from a previous primary study aimed at developing a scale to measure quality of life and well-being, known as the Significant Quality of Life Measure (SigQOLM), successfully developed in 2023 which was previously published elsewhere [7].

2.2 STUDY SETTING

The dataset comprises 406 healthcare workers in various job positions and health conditions who are currently working in a single tertiary hospital, namely: Sarawak General Hospital. This is the largest tertiary hospital and also the main referral hospital in the state of Sarawak, Malaysia.

2.3 STUDY SAMPLE

The data had already been collected based on a cross-sectional study design from a previous primary study for developing a new scale for measuring QoL and well-being of the people called 'Significant Quality of Life Measure' (SigQOLM) in year 2023 which was previously published elsewhere. Therefore, this study used secondary data for analysis.

2.4 INCLUSION AND EXCLUSION CRITERIA

The inclusion criteria for recruiting the study respondents for this self-administered survey are: (i) all workers currently working in a healthcare setting including permanent, contract, and temporary staff, (ii) age of at least 18 years old and above, and (iii) agree to provide consent for participating in the study. The exclusion criteria are: (i) any respondents who are unconscious, (ii) are too sick, or (iii) have an unstable mental condition during the period of recruitment. The justification for these exclusion criteria is that all the respondents participating in this study are required to fill in their responses by answering an online questionnaire.

2.5 DATA COLLECTION

This study did not apply a primary data collection because all the data for this study were already collected during the initial development of the SigQOLM in 2022, when the respondents were collected within two months from February 2022 until the end of April 2022. Therefore, this study involved a secondary analysis of primary data that were previously collected by performing statistical tests on those variables from demographic profile of respondents, their health condition and SigQOLM items.

2.6 STUDY TOOL

Significant Quality of Life Measure (SigQOLM) is a generic and dynamic scale to measure QoL and well-being of people. The scale was successfully developed in 2023 which was previously published elsewhere [7]. The SigQOLM consists of four elements (namely: "Health", "Relationships", "Functional activities" and "Survival"), 18 domains, and 69 items, with scores presented as percentages indicating higher scores reflecting better quality of life and well-being. Besides SigQOLM items, this study also observed demographic profile (gender, age, ethnicity, marital status, job position, etc) and clinical parameter of respondents (health status).

2.7 DATA ANALYSIS

Descriptive analysis was performed to derive the overall profile of the basic demographic characteristics, health conditions, and their QOL and well-being of participants were measured by using the SigQOLM. Scores were categorized into four categories: ≥80% (Excellent), 70 < 80% (Good), 50 < 70% (Moderate), and < 50% (Poor), in addition to reporting mean, standard deviation, and 95% confidence interval. The rationale for these recommended cut-off scores is based on interpreting a Likert scale for SigQOLM. SigQOLM uses the Likert scale with the following definitions: 'Never' (score=4), 'Seldom' (score=3), 'Sometimes' (score=2), 'Normally' (score=1), and 'Always' (score=0). The cumulative scores are converted into percentages. Thus, a higher percentage indicates a higher QOL and well-being.

In order to identify those factors that might be associated towards QOL and well-being, a General Linear Model based on Analysis of Covariance was performed as a multivariate analysis to eliminate any potential sources of bias. Besides, it is necessary to check for multicollinearity in order to avoid bias that could possibly result from correlation between independent variables in a regression model. Highest education level and salary would not be included as independent variables due to their significant association with types of occupation. Therefore, multicollinearity must be identified and then eliminated in order to avoid introducing bias in the subsequent analysis.

All missing data shall be treated as missing values. A unique code will therefore be used to represent the missing value. All analyses were conducted using IBM SPSS software (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.).

2.8 ETHICAL CLEARANCE

This study used secondary data obtained from a previous cross-sectional study for developing a new scale for measuring QoL and overall well-being. Therefore, prior written informed consent was not necessary. This study was approved by Medical Research and Ethics Committee (MREC) and the publication of the study results was also approved by the Director-General of the Ministry of Health, Malaysia. The MREC have granted ethics approval for this study that is registered under NMRR ID-21-01979-XDL (IIR).

3. RESULTS

3.1 SAMPLE DEMOGRAPHICS

This study was utilizing the secondary data of 406 healthcare workers who are currently working in a single tertiary hospital, with the majority being female (81.8%), aged between 18 to 35 years (53.0%), and of Malay ethnicity (34.0%). Additionally, 68.0% were reported to be married. In terms of occupation, nurses comprised the majority. Furthermore, 70.6% reported to have excellent health, indicating they were healthy without any disease (Table 1).

TABLE 1: BASIC SOCIO-DEMOGRAPHIC PROFILES AND HEALTH CONDITIONS OF RESPONDENTS

Profile	Profile category	n	%
Gender			
	Male	74	18.2
	Female	332	81.8
Age group			
	18 to 35 years	215	53.0
	36 to 40 years	88	21.7
	41 to 50 years	89	21.9
	51 to 60 years	14	3.5
Ethnicity			
	Malay	138	34.0
	Chinese	73	18.0
	Iban	79	19.5
	Bidayuh	83	20.4
	Other Sarawak Indigenous	19	4.7
	Others	14	3.4
Highest education level			
	Secondary school	19	4.7
	Graduated with certificate or diploma	265	65.3
	Graduated with undergraduate degree	91	22.4
	Graduated with postgraduate degree, specialty and/or fellowship training	31	7.6
Marital status			
	Married	276	68.0
	Single and never married	114	28.1
	Divorcee/Spouse passed-away	16	3.9
Occupation			
	Specialist/Medical doctor	73	18.0
	Pharmacist	16	3.9
	Nurses	257	63.3
	Assistant Medical Doctor	13	3.2
	Other allied health officer	35	8.6
	Other occupations	12	3.0
	Health condition		
	Excellent health	284	70.6
	Moderate health	96	23.9
	Poorest health	22	5.5

3.2 ASSESSMENT OF QUALITY OF LIFE

According to Table 2, all domains reported mean scores of more than 70.0%, indicating good to excellent levels, except for "Sleep quality," "Eating regime," and "Body image." Specifically, 27.1% reported poor sleep quality, 22.4% had poor body image, and 16.7% reported poor eating regime. The top three domains with the highest mean scores were "Self-care," followed by "Independent," and "Mobility." In terms of elements, "Survival" had the highest mean score, followed by "Relationship," "Functional activities," and "Health." In general, all domains show moderate to excellent scores, as shown in Table 2.

TABLE 2: SIGQOLM SCORES BY ELEMENTS, DOMAINS AND THE SUM TOTAL

Elements/Domains	Mean	SD	95%CI		Excellent > 80	Good 70 ≤ 80	Moderate 50 ≤ 69	Poor < 50
HEALTH	75.8	14.0	74.4	77.1	41.1%	26.6%	28.6%	3.7%
Pain	72.8	19.3	70.9	74.7	41.1%	21.4%	29.8%	7.6%
Physical Energy	72.1	22.1	69.9	74.2	40.6%	14.8%	32.5%	12.1%
Emotional symptoms	78.5	20.5	76.5	80.5	52.7%	14.3%	27.3%	5.7%
Independent	95.0	12.3	93.8	96.2	90.6%	3.9%	4.4%	1.0%
Mobility	95.2	10.4	94.1	96.2	92.4%	4.7%	2.2%	0.7%
Sleep Quality	67.6	23.2	65.4	69.9	35.2%	11.3%	36.7%	16.7%
Eating regime	59.7	27.3	57.1	62.4	23.4%	15.8%	33.7%	27.1%
Body Image	65.9	28.3	63.2	68.7	39.7%	9.4%	28.6%	22.4%
Perception of Health	73.2	24.0	70.9	75.6	46.1%	12.3%	32.5%	9.1%
RELATIONSHIP	88.5	13.1	87.2	89.8	77.3%	13.8%	7.4%	1.5%
Family Relationship	91.0	15.0	89.5	92.4	82.5%	7.6%	7.1%	2.7%
Friendship	88.2	16.1	86.6	89.8	71.7%	15.0%	11.3%	2.0%
Religiosity	86.4	20.3	84.4	88.4	72.7%	9.4%	12.3%	5.7%
FUNCTIONAL ACTIVITIES	84.2	13.5	82.9	85.5	64.0%	20.7%	13.5%	1.7%
Self-Care	96.1	10.2	95.1	97.1	91.6%	5.2%	2.7%	0.5%
Social Life	74.4	22.8	72.2	76.6	45.8%	13.8%	29.3%	11.1%
Time Usage	78.1	20.9	76.1	80.2	55.7%	16.5%	19.5%	8.4%
SURVIVAL	88.9	12.8	87.6	90.1	78.1%	15.3%	4.7%	2.0%
Basic Needs	90.3	14.3	88.9	91.6	81.0%	9.1%	8.9%	1.5%
Safety	89.9	14.9	88.4	91.3	79.3%	10.3%	8.9%	1.5%
Future Condition	86.8	18.6	85.0	88.7	76.1%	8.9%	10.8%	4.2%
SigQOLM	76.6	11.2	75.6	77.7	42.1%	31.8%	22.4%	2.2%

3.3 ASSOCIATION OF FACTORS WITH QUALITY-OF-LIFE MEASURES

Table 3 studies on the association of factors towards QOL and well-being. The analysis revealed that gender and ethnicity only affected the domain of "Religiosity" ($p < 0.05$), while age, marital status, occupation, and health condition significantly impacted most domains ($p < 0.05$). The most common factors contributing to poorer QOL and well-being were observed among individuals who were divorced or were made a widow (or widower), as well as those with the poorest health conditions.

TABLE 3: ASSOCIATION BETWEEN SOCIO-DEMOGRAPHIC FACTORS AND QUALITY OF LIFE

	Associated Factors (p<0.05)						
Elements/Domains	Sex	Age	*Eth*	*Mar*	*Occ*	*Hea*	Summary*
HEALTH				x	x	x	D/P, Other occupation, Poorest health
Pain				x	x	x	D/P, Nurses, Poorest health
Physical Energy				x		x	D/P, Poorest health
Emotional Symptoms				x	x		D/P, Other occupation
Independent Mobility						x	Poorest health
Sleep Quality				x	x	x	D/P, Medical doctor, Poorest health
Eating		x		x	x	x	Oldest, D/P, Pharmacist, Moderate health
Body Image					x		Medical doctor
Perception Health				x	x	x	D/P, Other occupations, Poorest health

RELATIONSHIP				x			D/P
Family Relationship		x		x		x	Youngest, D/P, Poorest health
Friendship				x			D/P
Religiosity	x		x	x	x		Male, Chinese, D/P, Medical doctor
FUNC. ACTIVITIES		x		x	x		Youngest, D/P, Medical doctor
Self-Care		x					Youngest
Social Life				x			D/P
Time Usage		x		x	x		Youngest, D/P, Medical doctor
SURVIVAL		x		x			Youngest, D/P
Basic Needs							
Safety				x			D/P
Future Condition		x		x	x	x	Youngest, D/P, Medical doctor, Poorest health
SigQOLM				x		x	D/P, Poorest health

Note

Multivariate analysis was conducted using General Linear Model Analysis of Covariance (ANCOVA)

*Report the lowest score for each variable found to be statistically significant ($p<0.05$)

Eth refers to ethnicity

Mar refers to marital status and considered as a modifiable factor

Occ refers to occupation and considered as a modifiable factor

Hea refers to health's condition and considered as a modifiable factor

D/P refers to divorcee or spouse passed away

4. DISCUSSION

Main findings of this study

This study represents the inaugural utilization of the SigQOLM scale to assess the quality of life (QOL) and well-being among healthcare workers within a specific tertiary healthcare institution.

What is already known on this topic

Previous research has consistently recognized QOL as a pertinent measure across diverse populations, including employed individuals, as work inherently influences overall well-being [12,13].

What this study adds

Therefore, this study's pioneering application of the SigQOLM scale to gauge QOL and well-being among healthcare workers is justified.

4.1 THE QUALITY OF LIFE (QOL) AMONG HEALTHCARE WORKERS

Apart from the three domains of "Sleep quality", "Eating regime" and "Body image", this cross-sectional study had reported mean scores of more than 70.0% in all the other domains of HRQOL, which was indicating good to excellent levels of the healthcare workers' overall QOL and well-being,

4.2 DETERMINANTS OF QOL AMONG HEALTHCARE WORKERS

This cross-sectional study had identified three domains that contributed to the low score of QOL and well-being namely: dissatisfaction with eating regime, body image, and sleep quality. Research indicates that various physical, psychological, social, and environmental factors can influence overall QOL among healthcare workers [14,15]. This study reveals that age, marital status, occupation, and health condition significantly correlate with QOL and well-being, while gender and ethnicity demonstrate minimal impact. This suggests a positive trend, indicating a lack of serious gender and racial discrimination within this population.

Health

Previous studies have highlighted that compromised HRQOL among healthcare workers, stemming from factors like poor work conditions or excessive stress, can detrimentally affect work performance and patient outcomes [16,17]. In the current healthcare environment, indicators of work stress pose significant public health concerns, underscoring the importance of addressing work and personal-related aspects that may impact healthcare workers' QOL and well-being [18,19,20].

In summary, this study has successfully identified dissatisfaction with eating regime, body image, and sleep quality as key contributors to deficient HRQOL, as indicated by QOL scores below 70.0%. Approximately 30.0% of healthcare workers in this setting were reporting to have experienced comorbidities, suggesting that many may adhere to restrictive eating regimes. Sleep quality is also affected, likely due to the necessity of working on call and night shifts. Moreover, marital status, occupation, and health condition emerge as significant independent factors associated with the health element, suggesting their substantial impact on overall QOL and well-being [21,22]. While these factors may be challenging to modify, healthcare workers must prioritize maintaining good health and adjusting their lifestyles, particularly since poor health is prevalent among divorcees and individuals who have lost their spouses.

Relationship

This study indicates that healthcare workers, particularly within this population, generally do not experience significant relationship issues, as evidenced by scores above 85.0% for family relationships, friendships, and religiosity. This positive finding is encouraging, as strong relationships enrich individuals' experiences, shape their perspectives, and profoundly influence their QOL and well-being [23,24]. Notably, many respondents' friendships are primarily with their colleagues, fostering healthy connections that contribute to emotional well-being and personal growth [25].

Functional activities

Functional activities, encompassing routine tasks performed daily, are integral to overall QOL and well-being. While healthcare workers demonstrate excellent scores in self-care, indicating proficiency in activities such as bathing and dressing, scores for domains such as social life and time usage are moderate, falling below 80.0%. Social participation and engagement are closely linked to functional activities, with limitations potentially leading to social isolation and reduced community participation, negatively impacting QOL [26]. Furthermore, engaging in physical and mental activities promotes social well-being, with research suggesting that a sense of purpose contributes to better physical health and life satisfaction [27,28,29]. Therefore, healthcare workers must prioritize engaging in healthy activities amidst their busy schedules.

Survival

Given that respondents are employed in a secure environment, scores for survival and their respective domains (i.e., basic needs, safety, and perception of future conditions) are excellent, contributing to their overall QOL and well-being. This aligns with previous findings indicating that housing conditions, health, and social support significantly influence QOL [30]. QOL and well-being encompass various factors beyond health, including relationships, social belonging, and the built environment [31]. Therefore, the SigQOLM scale's versatility, incorporating multiple elements and domains, offers a comprehensive approach to assessing an individual's QOL and well-being.

The importance

The present findings have important practical implications for healthcare management and workforce planning. The identification of modifiable occupational factors associated with quality of life and well-being suggests that organizational interventions, rather than solely individual coping strategies, are critical for improving staff outcomes [32,33]. Translating these results into practice, healthcare managers should prioritize workplace policies that address workload distribution, staffing adequacy, and supportive work environments, as these factors are consistently linked to better well-being among healthcare workers [9,34].

In particular, the observed association between sleep quality and well-being underscores the need for structured fatigue-risk management strategies. Hospital administrators could consider optimizing rostering systems to limit excessive

consecutive night shifts, ensuring adequate recovery time through minimum rest intervals between shifts, and implementing forward-rotating schedules where feasible [32,35]. In addition, providing protected rest breaks during prolonged duties and promoting a workplace culture that recognizes fatigue as a patient-safety issue may help mitigate the adverse effects of sleep deprivation on both staff well-being and clinical performance [33,36]. Overall, translating the study findings into actionable policies reinforces the applied relevance of this research.

Strengthening these practice-focused implications can further enhance the manuscript's relevance to healthcare managers, policymakers, and system planners. Translating study findings into actionable strategies such as optimizing staffing patterns, implementing fatigue-risk management protocols, promoting supportive leadership, and enhancing recognition and professional development programs allows healthcare organizations to directly address factors that influence staff quality of life and well-being. These operational recommendations support workforce sustainability and patient safety while also contributing to the broader health services management literature by providing evidence-informed strategies that link occupational stressors with tangible organizational interventions.

5. CONCLUSION

In summary, ample evidence suggests that QOL and well-being result from various factors and reflect individuals' perceptions and reactions to these elements of life. The ability of SigQOLM scale to incorporate a broader range of considerations underscores its value in assessing QOL and well-being across diverse populations, including healthy and non-healthy individuals. Moving forward, future studies are encouraged to utilize the SigQOLM scale to measure QOL and well-being comprehensively, reflecting the complexity of human life.

5.1 IMPLICATIONS OF THE STUDY

This study has implemented a pioneering application of the SigQOLM scale to gauge QOL and well-being among the healthcare workers and such an application proves to be well-justified. Therefore, the results of this study have found that the SigQOLM scale shall enable us to assess the QoL and well-being among healthcare workers within a specific tertiary healthcare institution.

5.2 RELEVANCE FOR CLINICAL PRACTICE

The study suggests that a distinctive feature of this new SigQOLM scale is its ability to incorporate a broader range of considerations for an assessment of QOL and well-being across diverse populations, including healthy and non-healthy individuals. Since the assessment of the QOL among healthcare workers (HCWs) is vital for better healthcare and is an essential indicator for competent health service delivery, hence the results of this study have identified the clinical application of this new SigQOLM scale for gauging QOL and well-being among the healthcare workers within a specific tertiary healthcare institution.

5.2 STRENGTHS, LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The strength of this study lies in the fact that it is the first to report quality of life (QOL) and well-being using the newly developed scale, SigQOLM, among healthcare workers. Hence, the findings may serve as a benchmark for future studies. Irrespective of the above, the results of this study do have limitations whereby all the inferences and conclusions drawn from this study have specifically been derived from healthcare workers who are currently working in a single tertiary centre (which is the Sarawak General Hospital in Malaysia). Secondly, SigQOLM is a relatively long scale that may introduce respondent fatigue. However, future studies may consider using a shorter version of SigQOLM [37]. In addition, future studies may need to be carried out which can be offer a better representation of this determination of QoL and well-being for all healthcare workers in the whole country of Malaysia and also in various other parts of the world. Similar studies also can be carried out in the near future to study QOL and well-being for a variety of other industries and organizations which may be present in specific localities, districts, states or even countries. Besides that, future studies encourage researchers to explore SigQOLM to provide evidence of its applicability for an objective evaluation of the effect of specific interventions on QoL in studies of various research designs.

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None.

CONFLICT OF INTEREST

The authors have no relevant financial or non-financial interests to disclose.

AVAILABILITY OF DATA AND MATERIALS

Data requests need to be made from the Director General Ministry of Health Malaysia. The request can be made via the corresponding author. Once granted the approval, the anonymous data will be made available.

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RESEARCH ARTICLE

AN EXPLORATORY CLUSTERING ANALYSIS OF DIGITAL READINESS AND MATURITY FOR ELECTRONIC MEDICAL RECORD IMPLEMENTATION IN INDONESIA

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ABSTRACT

The Satu Sehat platform for Electronic Medical Records (EMR), launched in Indonesia in 2022, represents an important step toward national health data integration. However, variation in hospital digital readiness may affect the implementation of EMR systems across regions. This study aimed to explore digital maturity and EMR readiness profiles among hospitals in Indonesia.

METHODS:

A cross-sectional secondary dataset from 711 hospitals was analyzed using an exploratory, unsupervised machine-learning approach. K-means clustering and Principal Component Analysis (PCA) were used to identify hospital digital maturity profiles and visualize clustering patterns.

RESULTS:

The analysis identified six hospital clusters with heterogeneous digital maturity characteristics across provinces. Information Systems and Infrastructure, Standards and Interoperability, and Human Capital had the highest overall average scores, whereas Data Analytics had the lowest. Hospitals from East Java, Central Java, and Lampung were distributed across multiple clusters, while hospitals from Papua and Maluku were more concentrated in lower digital maturity profiles.

CONCLUSIONS:

Overall, the findings suggest that hospital readiness for EMR implementation in Indonesia is multidimensional and unevenly distributed. Exploratory clustering may help identify distinct readiness profiles and support more targeted planning for digital health implementation.

KEYWORDS

Electronic medical records; digital maturity; digital readiness; K-means clustering; principal component analysis; Satu Sehat

INTRODUCTION

The integration of Electronic Health Records (EHRs), including Electronic Medical Records (EMRs), into healthcare systems has been widely recognized as an important step in modernizing healthcare delivery and improving patient care.[1] EMR systems have the potential to enhance efficiency, improve the quality of care, and strengthen patient safety by reducing errors associated with incomplete, misplaced, or inaccessible medical records.[2–6] In addition, digital health records can facilitate better coordination among healthcare professionals, support more comprehensive patient management, and reduce errors related to data loss.[7,8]

In Indonesia, the government has strengthened efforts to accelerate digital health transformation through regulations introduced in 2022 and the implementation of the Satu Sehat platform, which aims to unify health data across healthcare facilities and improve interoperability in medical data management.[9] Through this platform, patient health information can be accessed more efficiently across locations, supporting continuity of care even when individuals seek services outside their home healthcare facility.

Despite these efforts, the adoption of EHRs, particularly EMRs, remains uneven across Indonesia. Many hospitals and healthcare facilities continue to face substantial barriers to implementation, including limited infrastructure, disparities in information and communication technology capacity, and insufficient human resource readiness. [10–13] Variations in digital capacity across provinces and institutions may affect the transition from paper-based medical records to digital systems, making readiness for EMR implementation an important issue in the Indonesian healthcare context. [10–13]

Assessing digital readiness is essential because successful EMR implementation depends on multiple interrelated factors, including technological infrastructure, institutional support, workforce competency, interoperability, and data governance. [12,14–18] In this context, the Digital Maturity Index provides a useful framework for evaluating the readiness and progress of healthcare institutions in adopting digital systems. Maturity models help identify stages of adoption, measure institutional preparedness, and support the alignment of digital transformation with clinical and operational goals.[19] Previous studies have also shown that the transition from traditional record-keeping to EMR systems requires an adaptation process involving staff training, infrastructure development, and organizational support. [19–21]

Although several studies in Indonesia have described EMR readiness, limited evidence has examined how digital maturity and readiness patterns are distributed across hospitals and regions using a data-driven analytical approach. In particular, few studies have explored whether hospitals can be grouped into distinct readiness and maturity profiles based on key digital health indicators. This represents an important gap in the literature, as identifying such profiles may support more targeted implementation planning and policy development. Therefore, this study aimed to explore digital readiness and maturity profiles for EMR implementation among hospitals in Indonesia using clustering analysis. Specifically, this study addressed the following research questions: **(1)** What digital readiness and maturity profiles can be identified among hospitals in Indonesia? **(2)** Which key digital maturity indicators most strongly characterize these hospital profiles? and **(3)** How may these profiles inform more targeted strategies for EMR implementation and digital health strengthening in Indonesia?

METHODS

STUDY DESIGN AND DATA SOURCES

This study used a cross-sectional secondary data analysis with an exploratory unsupervised machine learning approach to identify digital maturity and EMR readiness profiles among hospitals in Indonesia. An unsupervised approach was selected because it allows the identification of hidden patterns and similarities in multidimensional data without requiring predefined outcome labels. [21,22]

The study used a secondary dataset from the Ministry of Health of Indonesia, based on the Digital Maturity Index assessment for 2024, collected by the Digital Transformation Officer. The final analytic dataset included 711 hospitals from provinces across western, central, and eastern Indonesia. Although this provided broad geographic coverage, the dataset was not treated as a fully nationally representative sample because some provinces, particularly in eastern Indonesia, had more incomplete records. Because this study relied on an existing administrative dataset, the authors did not conduct any additional primary sampling. Hospitals were included if data were available for the selected digital maturity variables used in the analysis; records with incomplete information on these variables were excluded from the final analytic dataset.

The dataset contained hospital-level indicators related to digital readiness and EMR implementation, including Information Systems and Infrastructure, Standards and Interoperability, Human Capital, Data Analytics, Competence and Usage, Security and Privacy, and Electronic Health Records, as well as an overall Maturity Level variable. These indicators were used to characterize hospital digital maturity and readiness for EMR implementation.

VARIABLES AND MEASUREMENT

The analysis used hospital-level digital maturity indicators available in the Ministry of Health dataset, including Information Systems and Infrastructure, Standards and Interoperability, Human Capital, Data Analytics, Competence and Usage, Security and Privacy, and Electronic Health Records. These domains were treated as proxy indicators of hospital digital readiness for EMR implementation.

For descriptive analysis, the available domain-related data were operationalized into aggregated ordinal scores on a 1–5 scale, with higher scores indicating greater digital maturity within each domain. These aggregated scores were used to summarize the distribution of digital maturity indicators across hospitals and to support the descriptive comparisons presented in Table 1.

For the unsupervised analysis, the clustering procedure was conducted using the selected domain-level indicators after preprocessing and standardization. In this step, the variables were used as analytic features to identify data-driven similarity patterns across hospitals rather than as predefined ordinal readiness categories. Accordingly, the cluster labels generated by the K-means analysis were treated as algorithm-generated identifiers rather than as equivalent to the descriptive maturity scores. The overall Maturity Level variable in the source dataset was used only for descriptive comparisons and was conceptually distinct from the clustering-derived hospital profiles.

CLUSTERING AND STATISTICAL ANALYSIS

Before clustering, the selected domain-level digital maturity indicators were organized into a structured analytic dataset and standardized to improve comparability across variables. Feature scaling was applied to reduce the influence of differences in variable magnitude on the clustering results.

K-means clustering was performed in Python using the scikit-learn library to identify groups of hospitals with similar digital maturity and EMR readiness characteristics. Because K-means is a centroid-based clustering method, similarity was assessed in standardized feature space using Euclidean distance. The number of clusters was assessed using the elbow method by examining the reduction in within-cluster sum of squares across different values of K. Based on this exploratory assessment, a six-cluster solution was selected as a reasonable balance between reduction in cluster inertia and interpretability of hospital profiles. The resulting cluster labels (0–5) were treated as algorithm-generated identifiers rather than predefined ordinal readiness scores.

Principal Component Analysis (PCA) was also implemented using scikit-learn to reduce the dimensionality of the dataset and support visualization of the clustering structure. [21,22] PCA projected the multidimensional hospital data into a lower-dimensional space, facilitating interpretation of the relative separation and overlap among the identified clusters. In addition, descriptive statistical analysis was conducted to summarize hospital digital maturity indicators across the original maturity-level categories in the source dataset. Continuous or score-based variables were presented as means and

standard deviations, and group differences were assessed using one-way analysis of variance (ANOVA), with p-values < 0.05 considered statistically significant.

ETHICAL CONSIDERATIONS

The study got a letter of ethical clearance (No. KET 180/UN2.F12.D.1.2.1/PPM. 00.02/2024). The study adhered to ethical guidelines concerning data privacy and confidentiality. Since the dataset was anonymized and provided by the Ministry of Health, no personally identifiable information was included in the analysis. The authors are committed to upholding ethical standards in publishing this study's findings by ensuring organizational privacy and data confidentiality throughout the digital health implementation process.

RESULT

Table 1 presents the distribution of 711 hospitals across six clusters by province, showing regional variation in digital maturity profiles. Hospitals from Lampung, East Java, and Central Java were distributed across multiple clusters, indicating heterogeneity in cluster membership within these provinces. East Java was represented in all six clusters, reflecting variation in hospital-level digital maturity characteristics. In contrast, provinces such as Papua and Maluku had fewer hospitals and were more concentrated in clusters with lower digital maturity.

TABLE 1. DIGITAL MATURITY AND READINESS FOR ELECTRONIC MEDICAL RECORDS AMONG HOSPITALS IN INDONESIA

Province	∑ Sample	% Cluster of Digital Maturity						% mean	P Value
		0	1	2	3	4	5		
Aceh	27	1.9	5.0	4.5	3.6	1.7	6.6	3.8	0.001
South Sumatera	21	2.9	5.0	2.3	0	1.7	3.8	3.0	
West Sumatera	26	1.0	4.3	6.0	14.3	1.1	3.8	3.0	
Bengkulu	20	1.9	3.1	2.3	7.1	3.4	1.9	2.8	
Lampung	69	10.5	9.9	3.8	7.1	12.9	11.3	9.7	
Jakarta	54	13.3	5.6	8.3	7.1	7.9	3.8	7.6	
West Java	56	10.5	5.0	6.0		10.1	10.4	7.9	
Central Java	75	9.5	13.0	10.5	3.6	9.0	12.3	10.5	
Jogjakarta	52	4.8	5.6	10.5		10.1	5.7	7.3	
East Java	93	20	9.3	12.8	7.1	15.7	15.7	13.1	
Banten	24	3.8	3.1	1.5	3.6	3.9	4.7	3.4	
Bali	32	2.	4.3	7.5		2.8	6.6	4.5	
West Kalimantan	18	2.9	2.5	4.5		1.7	1.9	2.5	

South Kalimantan	14	2.9	0.6	3.0		0.6	4.7	2.0
Central Sulawesi	11	1.9	3.1	0.8	7.1	0.6		1.5
South Sulawesi	34	6.7	5.6	2.3	3.6	6.2	2.8	4.8
Southeast Sulawesi	25	1.0	5.6	2.3	14.3	3.4	1.9	3.5
Maluku	1	0.1						0.1
North Maluku	15	1.0	3.1	0.8	10.7	2.2	0.9	2.1
Jambi	2		0.6			0.6		0.3
South Sumatera	4		0.6	0.8		0.6	0.9	0.6
Babel	3		0.6			0.6	0.9	0.4
NTB	13		1.9	3.0	3.	1.7	1.9	1.8
NTT	5		0.6	0.8			2.8	0.7
North Kalimantan	1		0.6					0.1
North Sulawesi	1		0.6					0.1
Gorontalo	5		0.6	2.3			0.9	0.7
Riau	3			2.3				0.4
Riau Island	3			1.5	3.6			0.4
Central Papua	1				3.			0.1
North Kalimantan	1					0.6		0.1
Papua Barat Daya	1					0.6		0.1

Note: Cluster 0 or 1 means ready to EMR/digitalization; 2 or 3 moderately ready, 4 or 5 not ready

Table 2 presents the average scores of the digital maturity indicators on a 1–5 scale across the hospital clusters. Information Systems and Infrastructure, Standards and Interoperability, and Human Capital had the highest overall mean scores, each at 3.5. In contrast, Data Analytics had the lowest overall mean score at 2.4. Differences in mean scores across clusters were also observed, indicating variation in digital maturity characteristics among the identified hospital groups.

TABLE 2. MEAN (SD) OF DIGITAL MATURITY INDICATORS BY ORIGINAL MATURITY LEVEL AMONG HOSPITALS IN INDONESIA

Key indicator	Cluster 0 Mean (SD)	Cluster 1 Mean (SD)	Cluster 2 Mean (SD)	Cluster 3 Mean (SD)	Cluster 4 Mean (SD)	Cluster 5 Mean (SD)	Overall Mean (SD)	P-value
Information Systems & Infrastructure	4.4 (0.4)	2.9 (0.5)	3.4 (0.5)	1.9 (0.4)	3.9 (0.4)	3.4 (0.5)	3.5 (0.7)	<0.001
Standards & Interoperability	4.5 (0.5)	2.5 (0.6)	3.9 (0.5)	1.9 (0.7)	4.0 (0.6)	3.0 (0.7)	3.5 (1.0)	<0.001
Human Capital	4.6 (0.7)	1.9 (0.6)	2.4 (0.7)	1.1 (0.5)	3.8 (0.6)	3.0 (0.6)	3.0 (1.2)	<0.001
Data Analytics	4.0 (0.7)	1.3 (0.3)	1.9 (0.6)	0.3 (0.3)	2.9 (0.5)	2.5 (0.5)	2.4 (1.1)	<0.001
Competence and Usage	4.6 (0.3)	2.4 (0.5)	3.1 (0.1)	1.2 (0.5)	4.0 (0.4)	3.5 (0.5)	3.4 (1.0)	<0.001
Security & Privacy	4.3 (0.5)	1.8 (0.6)	2.1 (0.7)	1.0 (0.4)	3.3 (0.7)	3.1 (0.1)	2.7 (1.1)	<0.001
Electronic Medical Records	4.4 (0.4)	2.8 (0.6)	3.6 (0.5)	1.3 (0.8)	3.8 (0.4)	3.4 (0.5)	3.4 (0.5)	<0.001
Overall Maturity Level	4.4 (0.5)	2.8 (0.4)	3.2 (0.4)	1.9 (0.4)	4.0 (0.1)	3.4 (0.5)	3.5 (0.8)	<0.001

Note: Values are presented as mean (SD), where SD = standard deviation. P-values were calculated using one-way analysis of variance (ANOVA).

Figure 1 presents a pair plot of the key digital maturity indicators, providing an overview of their distributions and pairwise relationships. The diagonal density plots show the distribution of each variable, while the off-diagonal scatterplots illustrate the relationships between indicators. Information Systems and Infrastructure showed a slightly left-skewed distribution, indicating that most hospitals had relatively high scores, with fewer hospitals showing lower values. In contrast, Security and Privacy displayed a broader distribution, suggesting greater variability across hospitals.

The scatterplots show generally positive relationships among several indicators. Stronger positive associations were observed between Information Systems and Infrastructure and Human Capital, and between Competence and Usage and Electronic Health Records. By comparison, Security and Privacy showed weaker visual associations with several other indicators. Overall, the figure indicates that digital maturity domains were related to each other, although the strength of these relationships varied across indicators.

FIGURE 1. PAIRWISE RELATIONSHIPS AMONG DIGITAL MATURITY INDICATORS IN HOSPITALS IN INDONESIA

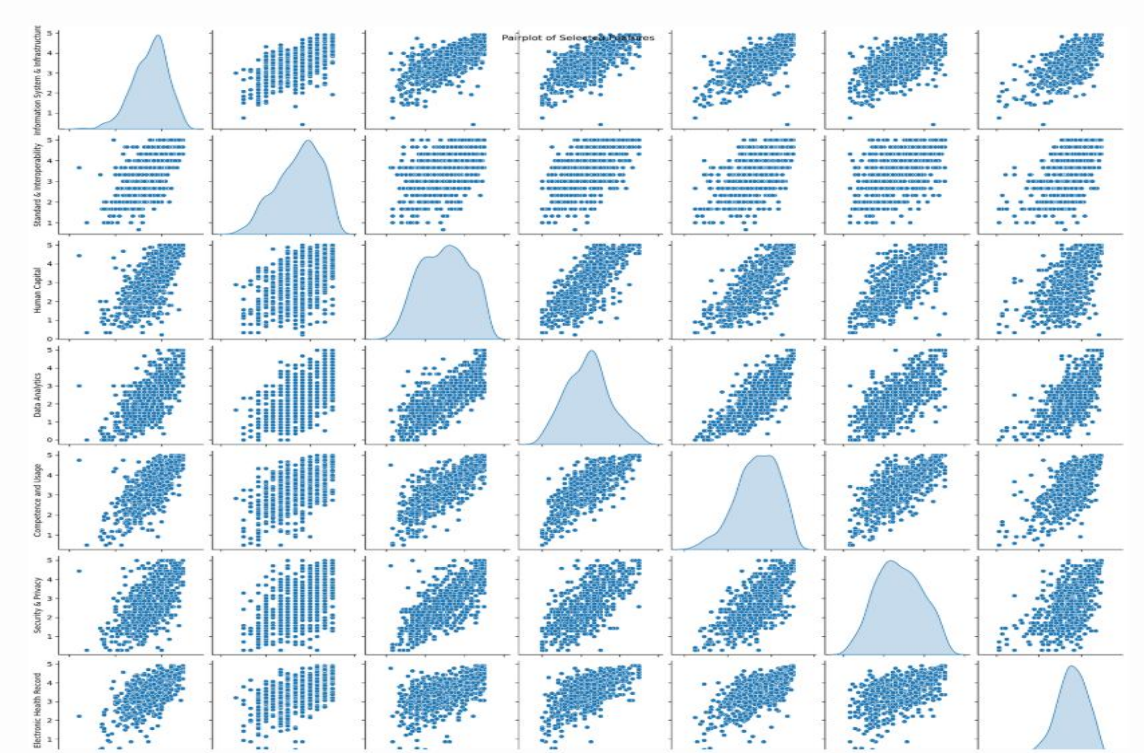


Figure 2 presents the elbow plot used to assess the number of clusters in the K-means analysis. The within-cluster sum of squares decreased substantially from K = 1 to K = 3, after which the rate of reduction became more gradual. This pattern indicates diminishing gains in compactness as additional clusters were added. For this exploratory analysis, a six-cluster solution was retained to provide more detailed differentiation of hospital digital maturity profiles. The resulting labels 0–5 were used as cluster identifiers only and were not interpreted as direct readiness scores.

FIGURE 2. ELBOW PLOT FOR CLUSTER SELECTION IN THE K-MEANS ANALYSIS

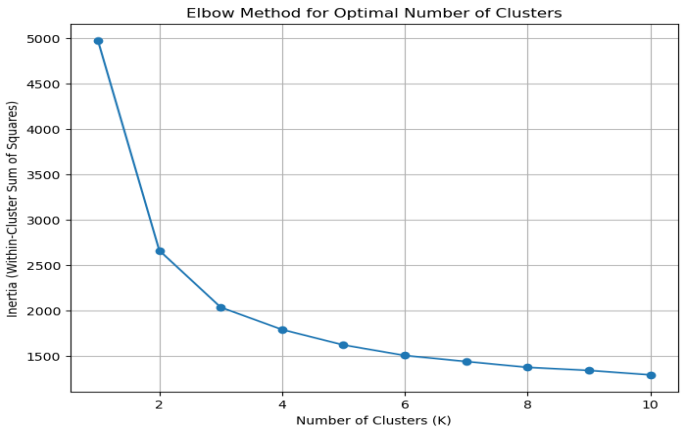
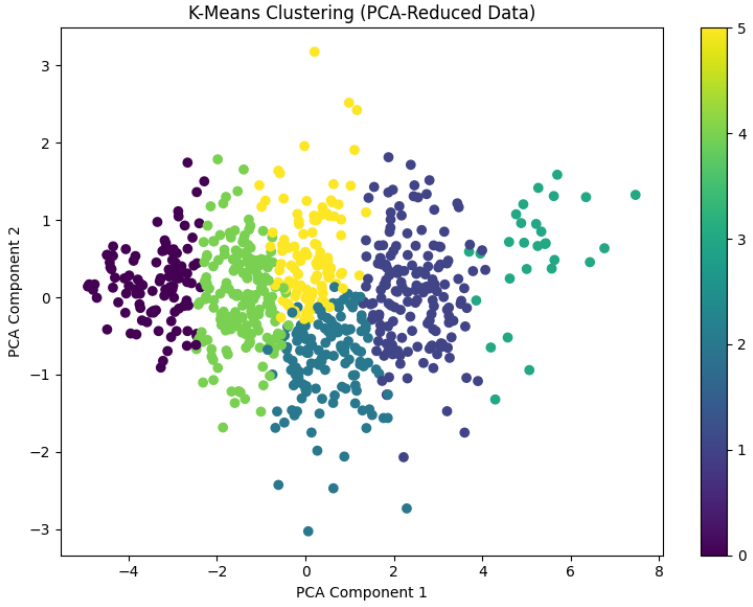


Figure 3 presents the PCA-based visualization of the six-cluster solution derived from the K-means analysis. The plot shows that the clusters were distinguishable in the reduced-dimensional space, although partial overlap was observed among several groups. Cluster 2 and Cluster 3 were located near the central region of the plot, whereas clusters with relatively different digital maturity patterns appeared more separated along the first principal component.

The PCA plot also shows that Cluster 2 was positioned close to Cluster 3, while the other clusters were more distinctly distributed across the reduced-dimensional space. Hospitals in Cluster 2 and Cluster 3 showed lower scores across several domain indicators, including Human Capital, Data Analytics, and Security and Privacy, compared with clusters characterized by relatively higher domain scores. These two clusters included hospitals from both urban and non-urban provinces, including West Sumatra, Maluku, Central Papua, and Jakarta.

FIGURE 3. PCA-BASED VISUALIZATION OF THE SIX-CLUSTER SOLUTION



DISCUSSIONS

Digital transformation in healthcare has been widely recognized as an important strategy for improving service quality, coordination, and system efficiency.[23–25] However, successful implementation of EMR systems depends not only on the availability of digital tools but also on institutional readiness across multiple domains, including infrastructure, human resources, interoperability, and governance.[24,25] In this study, the clustering analysis showed that hospital digital maturity in Indonesia was heterogeneous, with variation observed not only across provinces but also within the same province. This finding suggests that EMR readiness should not be understood as a uniform regional characteristic, but rather as a multidimensional institutional condition that differs across hospitals.

The study also showed that some domains of digital maturity were relatively stronger than others. Information Systems and Infrastructure, Standards and Interoperability, and Human Capital had higher average scores, whereas Data Analytics showed the lowest overall score. This pattern is consistent with broader international literature showing that many health systems reach the stage of basic digital documentation before developing more advanced capacities for data use, analytics, and decision support. In this sense, digital maturity is not simply defined by the existence of EMR systems, but by the extent to which digital information can be integrated, interpreted, and translated into better clinical and managerial decision-making. The low score in Data Analytics suggests that digital maturity in many hospitals may still be limited to system adoption rather than effective data utilization. This is important because the value of EMR systems depends not only on whether records are digitized, but also on whether digital data can be translated into meaningful clinical, managerial, and policy insights.

The relationships observed across domains further support the view that digital maturity is a multidimensional construct. The pair-plot analysis showed stronger positive associations between infrastructure and human capital, and between competence and EMR use, indicating that technical capacity and workforce readiness often develop together. At the same time, Security and Privacy showed weaker alignment with several other domains, suggesting that progress in digital adoption does not automatically ensure progress in data protection and confidentiality. This is important because international EMR readiness frameworks generally emphasize that digital maturity requires balanced development across technological, organizational, and governance domains, rather than progress in a single area alone. From this perspective, the findings of this study reinforce the need to evaluate digital readiness as a staged and multidimensional process.

Another important finding is that lower-readiness hospital profiles were identified in both urban and non-urban settings. Although hospitals in provinces such as Jakarta and East Java are often assumed to benefit from stronger infrastructure and greater workforce availability, some hospitals in these areas were still classified as lower-maturity profiles. Conversely, hospitals in provinces such as Central Papua and Maluku also appeared in lower-readiness clusters, reflecting continuing structural limitations. This pattern suggests that geography alone does not fully explain digital readiness. Institutional governance, local implementation capacity, staff competence, and organizational support may also play major roles in shaping EMR adoption. This interpretation is aligned with previous studies emphasizing that human competency, training, infrastructure readiness, and organizational support are central determinants of EMR implementation success. [7,11,12,28–30]

From a health information systems perspective, this study contributes by showing the value of exploratory clustering for identifying hospital digital maturity profiles beyond simple descriptive categorization. Rather than treating hospitals as belonging to a single linear level of readiness, the clustering approach enabled identification of groups with distinct patterns of strengths and weaknesses across domains. This has implications not only for Indonesia but also for broader digital health systems research, particularly in settings where digital transformation is progressing unevenly across institutions. Profiling hospitals in this way may support more targeted implementation strategies, allowing policymakers to tailor interventions according to dominant readiness barriers, such as workforce development, security and privacy, or data analytics capacity.

LIMITATIONS

This study was exploratory and relied on secondary administrative data, so the identified clusters should be interpreted as empirical profiles rather than definitive or validated readiness categories. Although the dataset covered hospitals from provinces across Indonesia, the analytic sample was not treated as fully nationally representative because some provinces, particularly in eastern Indonesia, had more incomplete records. In addition, the digital maturity domains were operationalized as proxy indicators from the available dataset and may not fully capture institutional readiness for EMR implementation. Finally, cluster evaluation in the original analysis relied on the elbow method and PCA-based visualization, and additional clustering validity indices were not available. Even so, the study provides useful early evidence on variation in hospital digital maturity and highlights the need for more context-sensitive approaches to digital health implementation in Indonesia.

CONCLUSION

This study identified heterogeneous profiles of digital maturity and EMR readiness among hospitals in Indonesia using an exploratory clustering approach. Digital maturity was not distributed uniformly across provinces or hospitals, with substantial variation observed both across and within regions. Hospitals from East Java, Central Java, and Lampung were distributed across multiple clusters, whereas hospitals from Papua and Maluku were more concentrated in lower digital maturity profiles.

Across the domains of Information Systems and Infrastructure, Standards and Interoperability, and Human Capital, average scores were relatively higher, while Data Analytics had the lowest overall score. Differences in Human Capital, Data Analytics, Security and Privacy, and other domain-level indicators helped characterize the hospital profiles identified in the clustering analysis.

Overall, these findings suggest that hospital readiness for EMR implementation in Indonesia is multidimensional and cannot be captured by a single uniform level. The identified profiles may support more targeted digital health strategies by highlighting areas of need, including infrastructure development, workforce strengthening, data analytics capacity, and improvements in security and privacy. Further studies using stronger validation methods and broader longitudinal assessment are needed to refine these readiness profiles.

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COMPETING INTERESTS:

No competing interests were disclosed.

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RESEARCH ARTICLE

EQUITY IN THE UTILIZATION OF PRIMARY HEALTH CARE SERVICES AMONG THE THAI POPULATION

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ABSTRACT

BACKGROUND:

Equity in primary health care (PHC) utilization is a central principle of Thailand's Universal Health Coverage (UHC) policy. Despite near-universal insurance coverage, disparities in health care utilization may still arise from demographic, socioeconomic, and health system factors.

OBJECTIVES:

This study aimed to 1) describe the characteristics of the Thai population; 2) examine differences in health needs across demographic and regional factors; 3) identify determinants of illness as a proxy for primary health care utilization; and 4) assess equity in PHC access.

METHODS:

Secondary data from the Health and Welfare Survey 2023 were analyzed using descriptive statistics, Chi-square tests, and complex samples logistic regression. Illness during the past month was used as a proxy indicator for health care needs and potential utilization. Both crude odds ratios (COR) and adjusted odds ratios (AOR) with 95% confidence intervals (CI) were estimated.

RESULTS:

A total of 69,078 individuals were included in the analysis, of whom 13.3% reported illness during the past month. Bivariate analysis showed significant associations between illness and sex, age, education, health insurance, and region ($p < 0.001$). In multivariable analysis, age (AOR=1.29, 95% CI: 1.23–1.36), sex (AOR=1.02, 95% CI: 1.02–1.02), education (AOR=0.92, 95% CI: 0.91–0.93), and health insurance (AOR=1.12, 95% CI: 1.06–1.19) remained significant predictors (all $p < 0.001$), while region was not statistically significant after adjustment (AOR=1.00, 95% CI: 0.98–1.02, p=0.819).

CONCLUSIONS:

Thailand's Universal Health Coverage policy has contributed to improving equity in primary health care utilization. Although regional differences were not statistically significant after adjustment, demographic and socioeconomic characteristics continued to influence health care needs. These findings suggest that achieving sustainable health equity requires strengthening primary care capacity, workforce competency, service quality, and continuous monitoring of contextual disparities beyond insurance coverage alone.

KEYWORDS

equity; primary health care; universal health coverage; health and welfare survey; Thailand; health inequality

INTRODUCTION

Primary health care (PHC) is a fundamental component of health systems, playing a crucial role in disease prevention, health promotion, and ensuring equitable access to healthcare services [1]. In Thailand, the implementation of the Universal Coverage Scheme (UCS) has significantly improved access to health services and reduced financial barriers, contributing to better health outcomes across the population [2,3]. However, despite these achievements, inequalities in healthcare utilization remain evident across different socioeconomic groups and geographic regions [4,5].

Structural characteristics of the health system, including the distribution of healthcare workforce and service availability, play a significant role in shaping access to care [6]. Thailand's UCS has achieved coverage of more than 99% of the population, making it one of the most successful universal health coverage models among middle-income countries [3]. The system emphasizes primary care delivery through community-based services, helping to reduce financial burden and improve access [7]. Nevertheless, structural barriers such as transportation, awareness of entitlements, and service quality continue to contribute to disparities in actual utilization [8].

Equity in healthcare systems is commonly defined in terms of horizontal and vertical equity [9, 10]. In many countries, disparities in access to primary healthcare persist across income, education, and geographic lines, leading to unequal health outcomes [11]. Individual characteristics such as age, gender, and education have been consistently associated with healthcare-seeking behavior [12-14]. These factors influence not only perceived health needs but also access to and utilization of healthcare services.

In addition, methodological and statistical approaches are essential in examining equity in healthcare utilization. Proper study design, adequate statistical power, and appropriate analytical techniques are required to ensure valid and reliable findings [15, 16, 17]. Furthermore, recent evidence in Thailand has shown that socioeconomic inequalities in health outcomes still persist despite universal coverage, particularly among vulnerable populations such as older adults [18].

Beyond individual determinants, recent evidence highlights the importance of system-level factors, including organizational capacity and workforce development, in improving healthcare service performance [19]. Strengthening both infrastructure and human resources is essential to ensure effective service delivery and long-term sustainability of health systems.

Beyond individual determinants, recent evidence highlights the importance of system-level factors, including organizational capacity and workforce development, in improving healthcare service performance [19]. Empirical evidence from private hospitals in Northeastern Thailand demonstrated that registered nurses' cross-cultural competence, self-directed career and learning skills, critical thinking and problem-solving, and collaboration, teamwork, and leadership were significant predictors of perceived organizational effectiveness [20]. These findings suggest that strengthening health systems requires parallel investment in workforce competencies and organizational learning capacity, not only in physical infrastructure.

In Thailand, ongoing decentralization of primary healthcare services has introduced additional challenges related to workforce capacity, governance, and resource allocation [21]. Without adequate support mechanisms, such reforms may increase system vulnerability and widen disparities in access to care.

At the same time, evidence from a recent provincial panel study of all 77 provinces in Thailand showed that, although the Universal Coverage Scheme substantially reduces direct financial barriers, satisfaction among older adults was influenced by contextual factors such as bed occupancy, physician availability, population density, and provincial

economic conditions [22]. These findings indicate that insurance entitlement alone does not guarantee equitable service capacity, responsiveness, and patient experience across provinces.

Moreover, digital inequality and health literacy have emerged as important determinants of healthcare utilization. Access to digital health information and the ability to interpret such information influence health behaviors and decision-making processes [23]. Limited access to digital resources may disproportionately affect vulnerable populations, particularly older adults. In addition, healthcare personnel's competency in using digital health technologies has become a critical factor influencing service quality and equity, especially in underserved areas [24].

Given these considerations, understanding the determinants of healthcare utilization is essential for informing policy and improving equity in health systems. Therefore, this study aims to examine factors associated with the utilization of primary healthcare services among the Thai population using nationally representative data.

METHODS

STUDY DESIGN

This study employed a quantitative cross-sectional design using secondary data from the Health and Welfare Survey 2023 conducted by the National Statistical Office of Thailand (NSO) [25]. The dataset is a nationally representative household survey that collects information on health status, health service utilization, health insurance coverage, and socioeconomic characteristics. The use of secondary data is appropriate for examining population-level health outcomes and service utilization patterns efficiently and systematically [15].

STUDY POPULATION AND SAMPLE

The target population comprised Thai residents living in households included in the Health and Welfare Survey 2023. The study sample consisted of individuals who completed the individual-level questionnaire.
Inclusion criteria were:
1) being listed as a household member in the NSO sampling frame; and
2) having complete data for key variables, including sex, age, illness during the past month, health insurance scheme, and region of residence.

Individuals with missing data in key variables were excluded using listwise deletion. After applying these criteria, a total of 69,078 individuals remained in the final analytical sample. Population weights provided by the National Statistical Office were applied to ensure national representativeness [25].

DATA SOURCE AND SAMPLING DESIGN

The Health and Welfare Survey 2023 employed a two-stage stratified sampling design. In the first stage, stratification was conducted by geographic region or province. In the second stage, primary sampling units (PSUs) were selected within each stratum. Within selected households, individuals were randomly selected to complete the individual questionnaire. The dataset includes sampling weights to ensure national representativeness. All analyses accounted for the complex survey design to produce valid population-level estimates and standard errors [15]

DEFINITION OF VARIABLES

The dependent variable was illness during the past month, derived from the survey question asking whether the respondent had been ill or felt unwell. Responses were re-coded into a binary variable: 1 = ill and 0 = not ill. This variable was used as a proxy indicator of health need and potential healthcare utilization [9]. Although this measure does not represent actual service utilization, previous studies have used similar indicators to examine inequities in healthcare access [8].

Independent variables included demographic and socioeconomic characteristics such as age, sex, education level, health insurance scheme, and region of residence. These variables have been widely recognized as determinants of healthcare utilization.

Control variables included occupation, industry category, and population weights, which were incorporated to improve model accuracy and representativeness.

MISSING DATA HANDLING

Missing data were assessed and found to account for less than 5% of the total sample, which is generally considered acceptable for statistical analysis [16]. Cases with missing values were excluded using listwise deletion.

WEIGHTING

To ensure population representativeness, population weights were applied in all analyses. Weighting is essential in survey data analysis to obtain unbiased estimates of population parameters.

STATISTICAL ANALYSIS

Descriptive statistics were used to summarize participant characteristics. Bivariate analysis using chi-square tests was conducted to examine associations between illness and independent variables.

Binary logistic regression analysis was performed to identify factors associated with illness. Both crude odds ratios (COR) and adjusted odds ratios (AOR) with 95% confidence intervals (CI) were reported. CORs were obtained from univariate models, while AORs were derived from multivariable logistic regression models including all independent variables.

The logistic regression model was expressed as follows:

$$\log(\frac{P}{1-P}) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p$$

where P represents the probability of illness, β_0 is the intercept, β_i–β_k are regression coefficients, and X_i–X_k represent independent variables included in the model.

To account for the complex survey design, complex samples logistic regression was applied. The model incorporated sampling weights, strata, and primary sampling units. This approach is consistent with standard practices for analyzing nationally representative survey data [9].

Sensitivity analysis was conducted to compare results between weighted and unweighted models. The consistency of findings confirmed the robustness of the analytical approach.

SOFTWARE AND ANALYTICAL TOOLS

All analyses were conducted using IBM SPSS Statistics version 29.0. The Complex Samples module was used to ensure appropriate estimation under the survey design, producing valid population estimates and standard errors. This approach is widely recommended for analyzing nationally representative survey data.

RESEARCH ETHICS

This study utilized secondary data provided by the National Statistical Office of Thailand. The dataset was de-identified and approved for academic use. Ethical approval was obtained from the Human Research Ethics Committee of Sirindhorn College of Public Health, Phitsanulok (Approval No. SCPHPL 2/2568.1.2).

The study adhered to the principles of the Declaration of Helsinki and ensured confidentiality, integrity, and data security throughout the research process.

RESULTS

This study examined equity in primary health care utilization among the Thai population using data from the Health and Welfare Survey 2023 conducted by the National Statistical Office of Thailand [25]. The survey included a nationally representative sample of households across all regions of the country.

After data cleaning and exclusion of incomplete records, a total of 69,078 individuals were included in the final analysis, representing 95.1% of the original sample. All analyses were weighted using population weights to ensure nationally representative estimates.

OBJECTIVE 1: CHARACTERISTICS OF THE STUDY POPULATION

A total of 69,078 respondents were included in the analysis. Females accounted for 52.0% of the sample, while males comprised 48.0%. The mean age was 42.21 ± 22.35 years, with the majority belonging to the working-age group (25–59 years).

Regarding educational attainment, most respondents had completed primary education or lower (40.9%), followed by secondary education (33.9%). In terms of health insurance coverage, the majority were covered under the Universal Coverage Scheme (UCS) (77.8%), followed by the Social Security Scheme (SSS) (9.2%) and the Civil Servant Medical Benefit Scheme (CSMBS) (6.1%).

Regionally, the largest proportion of respondents resided in the Northeastern region (28.6%), followed by the Central (26.2%), Northern (18.6%), Southern (13.4%), and Bangkok Metropolitan Region (13.1%). Table 1 presents the general characteristics of the study population.

TABLE 1. GENERAL CHARACTERISTICS OF THE STUDY POPULATION (N = 69,078)

Variable	Category	n	%
Sex	Male	33,115	48.0
	Female	35,963	52.0
Age (years)	Mean ± SD	42.21 ± 22.35	–
Education	Primary or lower	27,711	40.9
	Secondary	23,424	33.9
	Vocational/Associate	8,226	11.9
	Bachelor or higher	9,717	14.1
Health insurance	UCS	53,714	77.8
	SSS	6,326	9.2
	CSMBS	4,215	6.1
	Others	4,823	7.0
Region	Northern	12,870	18.6
	Northeastern	19,740	28.6
	Central	18,113	26.2
	Southern	9,285	13.4
	Bangkok	9,070	13.1

OBJECTIVE 2: ILLNESS STATUS AS A PROXY FOR HEALTH CARE UTILIZATION

Illness during the past month was used as a proxy indicator of health care need and potential service utilization. The results showed that 13.3% of respondents reported illness, while 86.7% reported no illness (Table 2).

Self-reported measures may underestimate minor or transient conditions because some respondents may not report mild symptoms.

TABLE 2. ILLNESS DURING THE PAST MONTH (N = 69,078)

Illness status	n	%
Ill	9,176	13.3
Not ill	59,902	86.7
Total	69,078	100.0

OBJECTIVE 3: BIVARIATE ANALYSIS OF FACTORS ASSOCIATED WITH ILLNESS

Chi-square analysis indicated that sex, age, education, health insurance scheme, and region were significantly associated with illness during the past month ($p < 0.001$). Table 3 presents the results of the bivariate analysis.

TABLE 3. BIVARIATE ANALYSIS OF FACTORS ASSOCIATED WITH ILLNESS

Variable	χ^2	p-value
Sex	45.23	<0.001
Age	67.12	<0.001
Education	33.75	<0.001
Health insurance	21.09	<0.001
Region	56.41	<0.001

*Chi-square test

OBJECTIVE 4: MULTIVARIABLE ANALYSIS OF FACTORS ASSOCIATED WITH ILLNESS

Binary logistic regression analysis was conducted to identify factors associated with illness during the past month, which was used as a proxy indicator of health care need and potential primary health care utilization. Both crude odds ratios (COR) and adjusted odds ratios (AOR) with 95% confidence intervals (95% CI) were estimated.

In the univariate analysis, age, sex, education, health insurance scheme, and region were all significantly associated with illness during the past month ($p < 0.001$). Older individuals demonstrated higher odds of reporting illness (COR = 1.31, 95% CI: 1.25–1.37), while females were slightly more likely to report illness than males (COR = 1.01, 95% CI: 1.009–1.011). Health insurance coverage and educational attainment were also significantly associated with illness status.

After adjustment in the multivariable logistic regression model, age, sex, education, and health insurance remained statistically significant predictors of illness. Older age remained associated with higher odds of illness (AOR = 1.29, 95% CI: 1.23–1.36, $p < 0.001$). Female respondents continued to demonstrate slightly higher odds of reporting illness compared with males (AOR = 1.02, 95% CI: 1.015–1.017, $p < 0.001$). Educational attainment was inversely associated with illness (AOR = 0.92, 95% CI: 0.907–0.933, $p < 0.001$), suggesting that individuals with higher education levels were less likely to report illness. Likewise, respondents covered under more comprehensive health insurance schemes demonstrated lower adjusted odds of illness (AOR = 1.12, 95% CI: 1.056–1.189, $p < 0.001$).

In contrast, regional differences were no longer statistically significant after adjustment (AOR = 1.00, 95% CI: 0.982–1.023, $p = 0.819$), suggesting that the apparent regional disparities observed in the bivariate analysis were likely explained by demographic and socioeconomic characteristics included in the model.

The final multivariable logistic regression model demonstrated acceptable model performance. The classification accuracy of the model was 87.3%, indicating good predictive performance for distinguishing between respondents who reported illness and those who did not. In addition, the Nagelkerke R^2 value was 0.035, suggesting that although the

identified predictors contributed significantly to the model, a substantial proportion of variation in illness status may also be explained by other unmeasured factors.

The logistic regression model was expressed as follows:

$$\text{logit}(p) = \beta_0 + \beta_1(\text{Age}) + \beta_2(\text{Sex}) + \beta_3(\text{Education}) + \beta_4(\text{Health Insurance}) + \beta_5(\text{Region})$$

where p represents the probability of reporting illness during the past month.

Overall, the findings suggest that demographic and socioeconomic characteristics played a more important role than geographic region in explaining differences in illness status. Although some disparities in health needs remain across population groups, the absence of statistically significant regional inequities after adjustment may reflect the relatively equitable distribution of primary health care services under Thailand's Universal Coverage Scheme.

TABLE 4. FACTORS ASSOCIATED WITH ILLNESS DURING THE PAST MONTH (LOGISTIC REGRESSION)

Variable	COR (95% CI)	AOR (95% CI)	p-value
Age	1.31 (1.25–1.37)	1.29 (1.23–1.36)	<0.001
Sex	1.01 (1.009–1.011)	1.02 (1.015–1.017)	<0.001
Education	0.89 (0.879–0.902)	0.92 (0.907–0.933)	<0.001
Health insurance	1.32 (1.256–1.393)	1.12 (1.056–1.189)	<0.001
Region	1.02 (1.002–1.040)	1.00 (0.982–1.023)	0.819

Note:
COR = Crude Odds Ratio
AOR = Adjusted Odds Ratio
CI = Confidence Interval
Nagelkerke R^2 = 0.035
Overall classification accuracy = 87.3%

DISCUSSION

This study provides a comprehensive assessment of equity in primary health care utilization among the Thai population using nationally representative survey data. The findings suggest that Thailand's Universal Coverage Scheme (UCS) has contributed to improving access to primary health care services; however, variations in health needs and utilization patterns persist across demographic and socioeconomic groups.

The findings indicate that demographic characteristics, educational attainment, and health insurance status continue to influence illness reporting and potential health service utilization. Although regional disparities were observed in the bivariate analysis, these differences were no longer statistically significant after adjustment, suggesting that socioeconomic and demographic factors may play a more important role than geographic location in explaining inequities in primary health care utilization.

From a systems perspective, the results highlight that equitable health service utilization is shaped not only by individual characteristics but also by broader structural and organizational factors. Recent evidence from Thailand further suggests that workforce competencies, organizational learning, and leadership capacity are important determinants of organizational effectiveness, which ultimately influence service quality and health system responsiveness [20].

Previous studies in Thailand have emphasized that strengthening workforce capacity, organizational performance, and service quality is essential for improving health system effectiveness and equitable access to care [19, 20]. Consistent with the present findings, these observations support integrated policy approaches that address both individual-level and system-level determinants of health equity through investments in workforce availability, competency-based professional development, and organizational learning systems.

POPULATION CHARACTERISTICS AND IMPLICATIONS FOR SERVICE UTILIZATION

The demographic profile observed in this study is generally consistent with Thailand's population structure, characterized by a predominance of working-age individuals and a substantial proportion of individuals with lower educational attainment. Previous studies have reported that demographic and socioeconomic characteristics are associated with differences in access to and utilization of primary health care services [18].

The high coverage of the Universal Coverage Scheme (UCS) may reflect the effectiveness of Thailand's health financing system in expanding access to essential health services. However, the concentration of individuals with lower educational attainment suggests the need for targeted health communication, outreach strategies, and equitable service design to improve access among vulnerable population groups.

INEQUALITIES IN HEALTH NEEDS AND UTILIZATION

The bivariate analysis revealed significant differences in illness across sex, age, education, health insurance, and region. These findings suggest that demographic and socioeconomic disparities remain associated with variations in health needs and primary health care utilization.

Consistent with previous epidemiological and health services research, regional variations may reflect differences in infrastructure, healthcare workforce distribution, service capacity, and access to health services. Recent provincial evidence from Thailand further indicates that, despite universal health coverage, contextual factors such as physician availability, bed occupancy, and local economic conditions continue to influence healthcare experiences and perceived service adequacy [22].

Although Thailand's Universal Coverage Scheme has substantially expanded access to care, the findings indicate that inequalities related to demographic and contextual characteristics continue to exist. These results support the need for ongoing efforts to strengthen equitable distribution of primary health care resources and improve access among vulnerable populations [18]. These findings reinforce that insurance entitlement alone does not necessarily ensure equitable service capacity or patient experience across provinces [22].

MULTIVARIABLE DETERMINANTS OF UTILIZATION

After adjusting for covariates, age, sex, education, and health insurance remained significant predictors of illness, whereas region was no longer statistically significant. These findings suggest that regional differences observed in the bivariate analysis may be partially explained by demographic and socioeconomic characteristics. However, the absence of a statistically significant regional association after adjustment should be interpreted cautiously. The regional variable represents a broad geographic classification and may not capture important differences in healthcare resources, service congestion, workforce availability, and local socioeconomic conditions across provinces. Recent evidence from a nationwide provincial panel study demonstrated that physician availability, bed occupancy, and provincial economic conditions remained associated with healthcare experiences under Thailand's Universal Coverage Scheme [22].

The findings indicate that structural inequalities related to population characteristics may contribute more substantially to variations in health needs and primary health care utilization than geographic location alone. Previous studies have similarly reported that socioeconomic conditions, access to information, health system characteristics, and local service capacity are associated with differences in health service utilization [8, 22].

The relatively low explanatory power of the model suggests that additional unmeasured factors, including environmental conditions, service quality, behavioral determinants, and contextual influences, may also contribute to utilization patterns. These findings highlight the complexity of achieving equity in primary health care utilization within diverse population settings [23].

IMPLICATIONS FOR EQUITY IN PRIMARY HEALTH CARE

When considering all analytical results together, the findings suggest that Thailand has achieved a relatively equitable distribution of primary health care access under the Universal Coverage Scheme (UCS). The absence of statistically significant regional differences after adjustment may indicate improvements in reducing geographic disparities in access to care [18].

However, equity in health care should not be interpreted solely based on statistical significance or broad geographic classifications. Although regional differences were not statistically significant after adjustment, inequities may still arise from differences in healthcare resource availability, service congestion, workforce capacity, and local socioeconomic conditions across provinces, as demonstrated in recent Thai evidence [22].

Methodological limitations should also be acknowledged. The use of illness during the past month as a proxy indicator does not directly measure actual service utilization and therefore cannot conclusively determine whether utilization itself is fully equitable. In addition, unmeasured contextual factors, including perceived quality of care, accessibility, and service responsiveness, may also influence health care utilization patterns.

These findings highlight the importance of continuous equity monitoring using more sensitive indicators, including healthcare workforce distribution, physician availability, service congestion, and local health system capacity, together with adaptive policy responses to strengthen equitable primary healthcare services across Thailand [22].
In addition, strengthening workforce competencies, organizational learning, and leadership development should complement workforce expansion to enhance service responsiveness and long-term health system performance [20].

POLICY IMPLICATIONS

The findings of this study have several important policy implications. First, strengthening primary health care systems in underserved areas remains important. Investments should continue to focus on improving workforce distribution, infrastructure, service accessibility, and organizational capacity in regions with limited resources. In addition to increasing workforce availability, competency-based professional development and organizational learning should be promoted to improve service responsiveness and long-term health system performance [20].

Second, improving service quality across health insurance schemes may help reduce disparities in health care utilization. Although the Universal Coverage Scheme has substantially expanded coverage, differences in perceived and actual quality of care may still influence utilization patterns.

Third, the development of integrated health equity monitoring systems may provide more comprehensive insights into unmet health needs and service gaps. Linking household survey data with administrative health data could support more evidence-informed policy evaluation. Equity monitoring should incorporate indicators beyond insurance coverage, including physician availability, healthcare workforce density, service congestion, and contextual provincial characteristics to better identify persistent geographic inequalities [22].

In addition, promoting health literacy and digital inclusion may contribute to improved access to health information and health services, particularly among vulnerable populations.

Finally, intersectoral collaboration remains important for strengthening policy coherence across different health financing schemes and population groups in Thailand. These strategies should support not only equitable access but also equitable service capacity and responsiveness across different population groups and geographic settings.

RECOMMENDATIONS FOR FUTURE RESEARCH

Future studies should incorporate broader determinants of health care utilization, including socioeconomic status, service quality, accessibility, and contextual factors, to provide a more comprehensive understanding of equity in primary health

care utilization. Integrating household survey data with administrative health databases may also improve the accuracy of analyses and support more evidence-informed policy evaluation.

In addition, longitudinal and mixed-methods approaches may help capture changes in health care access over time and provide deeper insights into the experiences and barriers faced by different population groups. Further research using advanced analytical methods and more comprehensive indicators of health equity would strengthen understanding of the complex factors influencing equitable access to primary health care services in Thailand.

LIMITATIONS AND ADVANTAGES OF THIS STUDY

This study has several strengths, including the use of a large nationally representative dataset from the Health and Welfare Survey 2023 and the application of analytical methods that accounted for the complex survey design. These features enhance the generalizability and robustness of the findings.

However, several limitations should be acknowledged. First, illness during the past month was based on self-reported data and used as a proxy for primary health care utilization, which may introduce reporting bias and may not fully reflect actual service utilization. Second, the cross-sectional design limits the ability to infer causal relationships between health needs and service utilization. Third, some important contextual variables, such as household income, service quality, travel accessibility, and geographic accessibility, were not available in the dataset and therefore could not be included in the analysis.

CONCLUSION

This study demonstrates that Thailand's Universal Coverage Scheme has contributed substantially to improving equity in primary health care access. Although geographic disparities appear to have been reduced, socioeconomic and individual-level factors continue to influence health care utilization patterns.

The findings suggest that Thailand has achieved a relatively equitable distribution of primary health care services at the national level. However, persistent differences related to demographic and socioeconomic characteristics indicate that deeper forms of inequity may still exist.

Future policy efforts should focus on strengthening primary care capacity, improving service quality, enhancing health literacy, and addressing emerging challenges such as digital inequality. Continuous equity monitoring and context-sensitive policy development will be essential for achieving sustainable and inclusive health care equity in Thailand.

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AUTHOR CONTRIBUTIONS

The authors responsible for the conceptualization of the study, research design and methodology, data analysis, manuscript writing, and revision of the final version prior to submission.

CONFLICT OF INTEREST STATEMENT

The author declares that there are no conflicts of interest related to the conduct of this research, the data analysis, or the preparation of this manuscript.

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RESEARCH ARTICLE

DECODING THE DYNAMICS OF HEALTHCARE QUALITY: DEVELOPING THE MICE MATRIX AS A CONCEPTUAL FRAMEWORK

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ABSTRACT

Sustaining quality in healthcare remains a complex and persistent challenge across health systems worldwide. This paper applies the MICE Matrix—Money, Ideology, Compromise, and Professional Ego—as an analytical framework to decode the underlying behavioral and systemic factors influencing the sustainability of healthcare quality. The framework moves beyond conventional structural or process-based assessments and examines how economic incentives, ideological orientations, institutional compromises, and professional egos collectively shape the culture of care and performance outcomes. The "Money" dimension captures the financial drivers and constraints that influence resource allocation and incentive structures. "Ideology" reflects the value systems and philosophical orientations—such as healthcare as a right versus a commodity—that affect organizational priorities. "Compromise" denotes the negotiated trade-offs among stakeholders balancing cost, access, and excellence, while "Professional Ego" represents hierarchical dynamics, resistance to change, and professional identity conflicts that hinder collaboration. Drawing on theoretical insights and illustrative examples from both public and private healthcare contexts, the paper contends that quality improvement must be viewed as a social and behavioral process embedded in institutional realities rather than a purely technical pursuit. The study concludes that addressing the four MICE dimensions holistically—through aligned incentives, shared ideology, transparent governance, and inter-professional respect—is essential to achieve sustainable, patient-centred quality in healthcare delivery. This conceptual framework model offers a novel tool for researchers and policymakers to design integrated strategies that bridge human behavior, institutional culture, and systemic reform.

KEYWORDS

Healthcare quality; MICE Matrix; conceptual framework; health systems; behavioral determinants; quality sustainability

INTRODUCTION

Healthcare quality has long been recognized as the foundation of an effective health system, yet ensuring its sustainability continues to challenge policymakers, administrators, and practitioners worldwide. The issue is not merely about introducing new programs or achieving accreditation benchmarks; it lies in maintaining consistent standards of care amid evolving economic pressures, workforce challenges, and organizational change. The World Health Organization (WHO) has repeatedly emphasized that universal health coverage cannot be achieved without sustained quality care. In India and other developing health systems, despite significant progress through initiatives such as the National Quality Assurance Standards (NQAS) and the National Accreditation Board for Hospitals (NABH), maintaining these standards

over time remains unsatisfactory. This situation highlights a deeper systemic issue—as quality improvement efforts often fade over after the facilities get certified due to inadequate supervision or funding issues.

Over the past few decades, various frameworks and tools are being used for quality assessment and enhancement. Few important ones are such as Donabedian's Structure–Process–Outcome model, Total Quality Management (TQM), and Continuous Quality Improvement (CQI) .These models have played an vital role in operational improvements but now their limitations are increasing apparently Most of these approaches are technocratic in nature, focusing heavily on measurable structures and processes, but not able to manage effectively the behavioral and institutional forces that shape how quality is sustained in daily practice. Quality improvement, as many health administrators observe, is as much about values, motivation, and collaboration as it is about protocols and performance indicators.

Many LMICs countries particularly in South East region having mixed kind of healthcare system where public and private healthcare providers coexists with their different financial perspectives and professional cultures as Consumer Protection Act is not applied on public health facilities. These differences are main reasons in sustainability issue in delivering quality healthcare services to the community. It has also been observed here, that quality is influenced not only by technical standards but also by the ideologies, compromises, and interpersonal dynamics that govern institutions. For instance, financial constraints can lead to short-term compromises, while conflicting ideologies between welfare-oriented and profit-driven institutions sometimes create policy fragmentation. Hierarchical cultures and professional ego can limit collaboration, impeding the continuity of quality improvement initiatives.

Against this backdrop, this paper introduces the MICE Matrix—Money, Ideology, Compromise, and Professional Ego—as a conceptual framework for interpreting the complex dynamics of healthcare quality sustainability. The framework suggests that sustaining quality is not simply a technical or managerial pursuit but a process shaped by interrelated economic, ideological, institutional, and behavioral factors. By decoding these four dimensions, suggested MICE Matrix provides a structured way to understand comprehensively why quality efforts often not sustained despite well-designed systems and capable professionals.

The objective of this paper is twofold: first, to conceptually explore how these four dimensions interact to influence healthcare quality; and second, to propose a conceptual framework that can guide future empirical validation of the model. This framework is proposed to enrich the theoretical discourse on healthcare quality by situating it within a broader behavioral and systemic context.

In summary, the paper aims to map the interlinkages among financial, ideological, institutional, and behavioral determinants of quality through the MICE Matrix framework.

REVIEW OF LITERATURE

DEFINING HEALTHCARE QUALITY

Healthcare quality has been widely recognized as a cornerstone of effective health systems and a prerequisite for achieving Universal Health Coverage (UHC). It should be effective, efficient, equitable, timely, patient-centred, and safe [1]. This definition is quiet comprehensive, but translating it into sustained practice remains a global concern. The most influential and accepted theoretical contribution to this field is Donabedian's (1980) structure–process–outcome model, which conceptualizes quality as a function of organizational structures (infrastructure, workforce, financing), processes (clinical and administrative practices), and outcomes (patient health and satisfaction) [2]. Later on, various other models such as Continuous Quality Improvement (CQI) and Total Quality Management (TQM) have emphasized data-driven decision-making, continuous monitoring, and performance measurement to enhance efficiency and accountability.

These frameworks give more emphasis on measurable indicators over the social, behavioral, and institutional realities that shape day-to-day healthcare delivery. While many health systems have achieved short-term improvements in quality

indicators, but due to its some limitations, sustaining those gains has become more difficult. Although existing quality models emphasize structures and processes, recent literature highlights the critical role of organizational, contextual, and human factors in sustaining quality improvements over time [3–5].

CHALLENGES IN SUSTAINING HEALTHCARE QUALITY

Several studies have underscored that healthcare quality is not merely a product of sound infrastructure or standardized protocols but also depends on alignment among stakeholders, institutional governance, and professional behavior. Leadership commitment and system-level integration is very much desired in maintaining consistent standards [5], and in the absence of leadership involvement, fragmented governance structures often disrupt continuity in quality assurance [6].

Few studies carried out in Indian context argued that technological and managerial innovations alone cannot sustain quality without corresponding shifts in organizational culture and stakeholder motivation. Persistent issues such as inadequate funding, uneven policy implementation, and resistance to feedback or change further complicate quality governance. These findings suggest that financial incentives, institutional ideology, and Human behaviour affect healthcare quality in many indirect ways that existing quality models do not fully consider [7,8].

Some studies have found that when health financing, government policies, and health system reforms work together, health reforms are more likely to be accepted and sustained [9.10]. However, this is often difficult because different stakeholders have different priorities and responsibilities are not clearly defined.

THEORETICAL GAPS AND RATIONALE FOR A NEW FRAMEWORK

Existing models of healthcare quality—though analytically powerful—often fall short of explaining the "why" behind persistent quality gaps. Most frameworks address "what" constitutes quality and "how" to measure or improve it, but few explore why quality initiatives fail to sustain even in well-resourced environments. The literature reveals three recurring limitations:

1. Overemphasis on structure and process: Quantitative metrics and compliance audits dominate, not much focussing to understand the internal motivations and institutional politics.
2. Neglect of behavioral and ideological factors: Professional hierarchies, organizational ego, and conflicting values influence quality policies'perception and its implementation.
3. Limited integration across domains: Financial, managerial, and behavioral factors are studied in isolation rather than as interconnected dimensions of the same system.

To bridge these gaps, this study proposes the MICE Matrix (Money, Ideology, Compromise, Professional Ego) as a comprehensive conceptual framework that unites these dimensions under a single interpretive model.

CONCEPTUAL FRAMEWORK: THE MICE MATRIX

Sustaining healthcare quality requires a multidimensional understanding that extends beyond technical standards and performance indicators.

The proposed MICE framework is not intended to replace established healthcare quality models such as Donabedian, CQI, or TQM. Rather, it complements these models by addressing an underexplored dimension—the organizational and behavioural determinants that influence the long-term sustainability of healthcare quality initiative.

MONEY: THE ECONOMIC DETERMINANT OF QUALITY

Money is the financial and material resources that enable or hinder quality improvement efforts. Adequate financing affects infrastructure quality, staffing, training, technology, and monitoring systems. Many healthcare facilities invariable experience the financial pressures also in running the system which may also distort the priorities in the context of quality. Public health system faces the budget constraints often lead to underinvestment in quality monitoring and workforce

development. Private healthcare organizations may focus more on earning profits and reducing costs than on maintaining high-quality healthcare over the long term, resulting in the commodification of care which may ignore the social, moral or social responsibilities.

Thus, the financial dimension affects not only what is possible but also what is prioritized. Hence aligning the financial incentives with quality outcomes become imperative to make quality sustainable rather than episodic.

IDEOLOGY: THE VALUE SYSTEM THAT SHAPES POLICY AND PRACTICE

The belief systems and institutional philosophies define how healthcare is perceived and delivered. Whether healthcare is viewed as a social right or a market commodity, and whether organizations are driven by public service values or competitive market figures.

Ideology affects everything—from policy formulation and budgeting decisions to the ethics of patient care. For instance, a public health ideology prioritizes equity and access, but may underplay innovation or responsiveness. Conversely, a market-oriented ideology encourages efficiency and innovation, but may neglect equity and long-term accountability. Many times policymakers, providers, and administrators face ideology conflicts which can fragment the vision for quality. Sustainable quality, therefore, demands a shared ideological orientation that keeps patient welfare at the core of both public and private decision-making.

COMPROMISE: THE INSTITUTIONAL BALANCING ACT

Compromise represents the organizational and systemic trade-offs made among competing priorities—such as cost containment versus quality enhancement, access versus excellence, and innovation versus regulation. In complex healthcare systems, such compromises are inevitable, but when they become routine or politically motivated, they dilute accountability and weaken standards.

For instance, hospital administrators may compromise between accreditation compliance and operational cost-saving, while policymakers may sacrifice quality oversight to expand coverage rapidly. These compromises may appear ideal or practical that time but often erode system integrity gradually. To maintain high-quality healthcare over the long term, decisions should be open, evidence based, focused on patients' best interests instead of short-term financial or organizational benefits.

PROFESSIONAL EGO: THE BEHAVIORAL BARRIER TO COLLABORATION

This is one of the biggest culprits amongst the four components of MICE framework Ego reflects the psychological and hierarchical dynamics that influence behavior and teamwork within healthcare organizations. It manifests in professional rivalries, resistance to feedback, or reluctance to share authority. Physicians may resist team-based approaches or external audits, perceiving them as threats to autonomy; administrators may be unwilling to acknowledge systemic failures due to reputational concerns.

Such ego-driven behaviors fragment interprofessional collaboration, impede communication, and discourage learning cultures—all of which are critical for sustained quality. Building a culture of mutual respect, reflective practice, and shared accountability is thus important to counter the negative influence of professional ego to promote collective ownership of quality goals.

INTERLINKAGES AND SYSTEMIC INTERACTION

Figure no.1 highlights that the four MICE dimensions do not act in isolation; they interact dynamically within healthcare systems.

- Money shapes ideological priorities—what is funded reflects what is valued.
- Ideology determines the nature of compromises organizations make.
- Compromises are often influenced by leadership priorities, professional interests, and organizational power dynamics.
- These interactions collectively determine whether quality initiatives are sustained, adapted, or abandoned.

FIGURE 1: CONCEPTUAL MODEL OF THE MICE MATRIX INFLUENCING SUSTAINED HEALTHCARE QUALITY



Figure 1 illustrates the proposed MICE framework, highlighting how Money, Ideology, Compromise, and Professional Ego interact and collectively influence the sustainability of healthcare quality. The bidirectional arrows represent the interdependent relationships among the four dimensions, while the inward arrows indicate their direct contribution to sustainable healthcare quality.

CONCEPTUAL RESEARCH DESIGN

This paper adopts a conceptual research design approach to explore and theorize the underlying dynamics that influence the sustainability of healthcare quality through the proposed MICE Matrix framework. The present study, therefore, does not involve primary data collection but constructs a conceptual foundation to integrate existing knowledge into a coherent interpretive model for future empirical inquiry.

CONCEPTUAL CONSTRUCTS

The model identifies **four independent constructs**—Money, Ideology, Compromise, and Professional Ego—each representing a dimension that influences the dependent construct, **Sustainable Healthcare Quality** as also shown in Figure 1, creating a dynamic system where changes in one dimension influence others. The central proposition of this conceptual design is that alignment among the four MICE dimensions fosters an environment conducive to sustained healthcare quality, while misalignment leads to fragmentation and decline in standards.

FUTURE EMPIRICAL PATHWAY

While this paper remains conceptual, it proposes a two-phase empirical pathway for future validation:

1. **Qualitative Phase:** Exploratory interviews or focus group discussions with policymakers, administrators, and healthcare professionals to refine and contextualize the MICE dimensions.
2. **Quantitative Phase:** Development of a measurement instrument (MICE Scale) followed by structural equation modeling (SEM) to test the relationships between constructs and assess their predictive influence on quality sustainability.

RESEARCH UTILITY

This conceptual research design provides a foundation for interdisciplinary inquiry, linking behavioral science, economics, and public health policy. It offers a replicable framework for future studies seeking to understand how motivation, ideology, institutional compromises, and leadership behavior collectively influence healthcare quality.

DISCUSSION

The findings of this conceptual analysis emphasize that sustaining healthcare quality is not merely a matter of designing efficient structures or enforcing standardized processes; it is equally dependent on the alignment of financial, ideological, institutional, and behavioral dynamics within the health system. The MICE Matrix offers a novel interpretive lens through which these interdependencies can be examined, moving the discourse beyond traditional mechanistic and compliance-based models toward a more holistic, behavioral-systems understanding of quality.

THEORETICAL INTEGRATION WITH EXISTING FRAMEWORKS

The proposed MICE Matrix complements and extends the classical Donabedian model (structure–process–outcome) by incorporating the behavioral and motivational layers that underpin these components. While Donabedian's framework remains foundational for assessing quality, it primarily explains what constitutes quality and how it can be measured. In contrast, the MICE framework addresses the why—why quality initiatives fail to sustain even when structural and process elements are adequately established. The MICE model enriches Donabedian's conceptual logic with deeper psychosocial and institutional dimensions.

Similarly, Total Quality Management (TQM) and Continuous Quality Improvement (CQI) approaches emphasize process optimization and feedback loops but often underplay the contextual forces that determine whether quality improvement becomes embedded or remains superficial. The MICE Matrix helps explain why certain organizations internalize quality as a cultural norm while others perceive it as an external imposition. It suggests that without addressing ego-driven resistance, ideological misalignment, or resource distortions, even the most advanced TQM systems may fail to achieve sustainable impact.

The framework also resonates with contemporary health systems governance models, which emphasize accountability, stakeholder participation, and adaptive learning. MICE integrates these governance principles by highlighting how decision-making (Compromise) and leadership dynamics (Professional Ego) shape institutional trust and collaborative functioning. This integration situates MICE as a multi-level conceptual bridge—connecting individual motivation, organizational culture, and systemic governance under a unified explanatory structure.

THEORETICAL AND RESEARCH SIGNIFICANCE

Theoretically, the MICE Matrix advances the discourse on healthcare quality by integrating behavioral economics, organizational sociology, and health policy analysis into a single interpretive model. It provides a conceptual vocabulary for analyzing how human motivations and institutional values shape policy outcomes. Empirically, it establishes a foundation for developing multi-dimensional assessment tools that can capture the "soft" determinants of healthcare quality—often neglected in quantitative performance metrics.

This conceptual contribution is especially relevant for developing health systems such as India's, where reforms must balance expansion of access with quality assurance amid diverse institutional cultures. By framing quality as both a technical and social construct, the MICE framework motivates researchers to explore how systems can evolve from compliance-based accountability to shared ownership and continuous learning.

POLICY AND PRACTICAL IMPLICATIONS

The sustainability of healthcare quality depends on the integration of policy intent, institutional governance, and behavioral commitment. The MICE Matrix (Money, Ideology, Compromise, Ego) provides a structured lens for identifying

leverage points where interventions can enhance quality sustainability. Each dimension offers distinct but interrelated implications for policy formulation, organizational management, and professional practice.

FINANCIAL REALIGNMENT: MANAGING THE 'MONEY' DIMENSION

Quality cannot be sustained without adequate and strategically allocated financial resources. Policymakers must ensure that funding models and incentive structures reward long-term quality outcomes rather than short-term service volume or cost containment.

- Introduce value-based financing models linking reimbursement to patient outcomes, safety indicators, and satisfaction.
- Establish protected quality budgets for staff training, accreditation, and quality monitoring.
- Encourage public–private partnerships that prioritize quality innovation and equitable service delivery.
- Develop performance-linked incentive systems to motivate quality-oriented behavior at all levels of the health system.

A coherent financial strategy transforms quality from an optional cost center into a strategic investment in sustainable health outcomes.

IDEOLOGICAL ALIGNMENT: REINFORCING THE 'IDEOLOGY' DIMENSION

The ideological orientation of a healthcare system—whether driven by social welfare or market competition—deeply influences its quality priorities. Sustaining quality requires a shared ideological foundation anchored in patient-centred care, ethical practice, and equity.

- Promote national and institutional quality charters that define shared values and ethical commitments.
- Embed quality and patient safety values into the training curricula of health professionals.
- Cultivate an organizational ideology that views quality not as an administrative requirement but as a moral and social obligation also.
- Align private and public providers under a common regulatory ethos emphasizing accountability and transparency.

Ideological coherence emphasizes that all stakeholders—policy, management, and clinical, work toward the same important purpose of patient well-being and system integrity.

INSTITUTIONAL TRANSPARENCY: ADDRESSING THE 'COMPROMISE' DIMENSION

Compromises are inevitable in healthcare, but they must be transparent, evidence-based, and ethically defensible. Few actions are needed to ensure the unbiased compromise if needs in the system as:

- Institutionalize evidence-based decision frameworks for resource allocation and policy trade-offs.
- Implement quality governance boards at national and institutional levels to oversee difficult decisions.
- Establish accountability mechanisms to monitor how compromises affect patient outcomes.
- Strengthen health information systems to ensure that decisions are guided by data, not expediency.

By institutionalizing transparency, health systems can balance competing priorities without sacrificing long-term quality.

LEADERSHIP AND CULTURE: MANAGING THE 'PROFESSIONAL EGO' DIMENSION

The behavioral dimension—ego—remains one of the most subtle yet powerful barriers to quality. Professional hierarchies, status concerns, and resistance to feedback can derail even well-funded quality programs. Sustainable quality improvement therefore requires transformational leadership and collaborative culture, which can be achieved by:

- Promote inter-professional teamwork and shared decision-making across medical, nursing, and administrative cadres.
- Develop leadership training programs emphasizing emotional intelligence, humility, and communication skills.
- Introduce non-punitive feedback systems to encourage reporting of errors and learning from failures.
- Recognize and reward collaborative achievements rather than individual status or hierarchy.

Managing ego constructively to transforms the healthcare workplace into a learning organization where quality improvement is collective, continuous, and compassionate.

SYSTEMIC INTEGRATION OF THE MICE FRAMEWORK

The four MICE dimensions are interdependent and must be addressed holistically rather than sequentially. Effective quality governance should therefore:

- Integrate MICE principles into national quality assurance programs and hospital accreditation systems.
- Use the MICE Matrix as a diagnostic and planning tool for quality audits and institutional assessments.
- Facilitate cross-sectoral dialogue between policymakers, providers, and civil society to align financial, ideological, and behavioral goals.
- Monitor the balance among MICE dimensions as an indicator of system maturity in sustaining healthcare quality.

TABLE NO. 1 IMPLICATIONS SUMMARY OF CONCEPTUAL MICE FRAMEWORK

Dimension	Policy Action	Expected Outcome
Money	Value-based financing, incentive-linked quality programs	Sustained investment in long-term quality outcomes
Ideology	Shared quality charters, patient-centred culture	Alignment of values and vision across stakeholders
Compromise	Transparent governance and data-based decisions	Ethical and accountable trade-offs
Professional Ego	Leadership development and teamwork culture	Collaborative environment supporting continuous quality

The MICE framework in table no.1 reveals that sustaining healthcare quality requires more than protocols and performance metrics—it demands a deliberate alignment of economic priorities, ideological coherence, institutional transparency, and behavioral maturity. Policies that integrate these dimensions will not only strengthen quality assurance but also transform healthcare systems into learning, adaptive, and people-centred entities capable of sustaining excellence over time.

This study has several limitations. The proposed MICE framework is conceptual in nature and has not yet been empirically validated. The relationships among its four dimensions have not been statistically tested, and their influence may vary across different healthcare systems and organizational contexts, thereby limiting generalizability. Furthermore, constructs such as ideology, compromise, and professional ego are subjective and require standardized operational definitions and validated measurement instruments. In addition, the framework does not explicitly incorporate broader external influences, such as political, technological, and regulatory factors, which may also shape sustainable healthcare quality. Despite these limitations, the present study provides a novel conceptual framework that integrates organizational and behavioural dimensions to complement existing quality improvement approaches and establishes a foundation for future empirical validation, scale development, and practical application.

CONCLUSION

Sustaining healthcare quality continues to be an important challenge for health systems worldwide. Although considerable progress has been achieved through well-established frameworks such as Donabedian's Structure–Process–Outcome model, Total Quality Management (TQM), and Continuous Quality Improvement (CQI), ensuring the long-term sustainability of quality improvement initiatives remains an ongoing area of interest. While these frameworks have made significant contributions to advancing the technical and procedural aspects of healthcare quality, there is growing recognition that organizational, institutional, and human behavioral factors also play an important role in influencing whether quality improvement efforts become embedded within organizational culture and are sustained over time.

This paper introduced the MICE Matrix—Money, Ideology, Compromise, and Ego—as a novel conceptual framework to decode these underlying dynamics. The model emphasizes that healthcare quality is not sustained merely through

structural arrangements or regulatory compliance but through the alignment of financial priorities, ideological commitments, institutional transparency, and behavioral maturity.

The conceptual research design proposed in this study provides a foundation for future empirical validation. Qualitative exploration can help refine the MICE dimensions and capture context-specific variations, while quantitative modelling can assess their interrelationships and predictive influence on quality outcomes. Such research will advance the evidence base for behavioral and systemic determinants of healthcare quality.

Study invites policymakers, administrators, and practitioners to move beyond fragmented interventions toward integrated, value-driven strategies that embed quality in every layer of the health system. By decoding the deeper dynamics of Money, Ideology, Compromise, and Ego, healthcare systems can move closer to achieving sustained, equitable, and patient-centred care excellence.

FUTURE DIRECTIONS FOR THE STUDY

Future research should focus on empirically validating the MICE framework through the development of a standardized MICE Scale, followed by psychometric testing and evaluation using Structural Equation Modelling (SEM) or Partial Least Squares Structural Equation Modelling (PLS-SEM). Such studies will establish the framework's validity, applicability, and practical relevance. The MICE framework is intended to complement existing quality improvement programmes by providing additional insights into the organizational and behavioural factors that support sustainable healthcare quality.

DECLARATIONS

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Conflict of Interest

The authors declare that they have no conflict of interest.

Ethics Approval

This study is a conceptual paper based on published literature and does not involve human participants, animals, or identifiable personal data. Therefore, ethical approval was not required.

Consent to Participate

Not applicable.

Author Contributions (CRediT)

Dr. Yogesh Chandra (Corresponding Author): Conceptualization, literature review, framework development, methodology, writing—original draft, visualization, and manuscript writing—review and editing.

Dr. A. K. Jain: Supervision, critical review, intellectual input, refinement of the conceptual framework.

Dr. Amit Prakash Sharma: Literature review and references management

Data Availability

No datasets were generated or analyzed during the current study

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RESEARCH ARTICLE

PREDICTING FERTILITY DETERMINANTS IN BANGLADESH USING MACHINE LEARNING MODELS

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ABSTRACT

BACKGROUND:

Fertility is a key demographic indicator that influences population dynamics, economic growth, social welfare, and public policy. Understanding fertility determinants is crucial for addressing population challenges in developing countries like Bangladesh. This study aims to fill a gap in existing research by applying advanced machine learning (ML) methods to predict fertility outcomes and identify key fertility determinants in Bangladesh using data from the Bangladesh Demographic Health Survey (BDHS) 2017–18.

METHODS:

The dataset comprised 20,127 women, reflecting the fertility landscape in Bangladesh. We employed both conventional statistical methods and various machine learning models including Random Forest (RF), Decision Tree (DT), K-Nearest Neighbors (KNN), Logistic Regression (LR), Support Vector Machine (SVM), XGBoost, LightGBM and Neural Networks (NN). The performance of the models was evaluated based on metrics such as accuracy, precision, recall, F1 score, Area Under the Receiver Operating Characteristic Curve (AUROC) and alongside K-fold cross-validation.

RESULTS:

The SVM model emerged as the most effective, with macro average recall (89%), precision (89%) and F1 score (89%) as well as weighted average recall (96%), precision (95%), F1 score (95%) and accuracy was 95.5%. The results revealed that access to mass media, father's education level, mother's highest educational attainment, number of household members, maternal Body Mass Index (BMI), number of living children and child mortality (i.e., incidents of sons or daughters dying) were the most influential factors of fertility in Bangladesh.

CONCLUSIONS:

Our findings demonstrate that machine learning models, particularly SVM, provide superior predictive power compared to traditional statistical methods in identifying key fertility determinants. These insights contribute to a deeper understanding of fertility dynamics in Bangladesh and suggest that targeted interventions—focusing on media access, parental education, and healthcare improvements could significantly influence fertility rates. Future research should explore the use of ensemble models and longitudinal data to enhance predictive accuracy and capture temporal changes in fertility determinants.

KEYWORDS

fertility, boruta algorithm, machine learning, SVM, best model

INTRODUCTION

Fertility is a critical demographic indicator shaping the socio-economic and public health landscape of nations. As a core measure of population growth, it is intricately linked to various facets of human development, including health, education, and economic prosperity. Globally, significant reductions in fertility rates have been observed over recent decades largely driven by improvements in healthcare expanded access to education and the increased availability of family planning services [1, 2].

In Bangladesh, fertility has undergone substantial changes in recent decades. In 1975 the Total Fertility Rate (TFR) was 6.3 births per woman [3] reflecting the socio-economic barriers and limited access to family planning services at the time. By the 2017-18 period the TFR had decreased dramatically to 2.3 births per woman [4] underscoring significant progress in reproductive health, women's empowerment and public health initiatives. Yet, despite these advances Bangladesh's TFR remains relatively high compared to other developing countries, signaling persistent socio-economic and cultural challenges that continue to shape reproductive behaviors [5].

Research has consistently identified key factors that influence fertility rates. Age at first marriage and first birth are prominent determinants: early marriages often lead to early childbearing and higher fertility while delayed marriage tends to reduce family size. Education, especially for women plays a pivotal role in fertility reduction [1], [6], [7] . Additionally, women's employment [8]–[11] and economic empowerment have contributed to fertility declines as working women often prioritize career development and tend to have fewer children. Access to contraception [1], [12]–[15] enables couples to plan family size more effectively reducing overall fertility rates. Urbanization, with improved healthcare and education, leads to smaller families, while access to healthcare and family planning in rural areas is crucial for reducing fertility rates by empowering informed reproductive choices [8], [10], [16]–[20].

While these factors have been well-established in the literature much of the existing research relies on traditional statistical methods such as regression analysis to explore the relationships between fertility determinants [7], [13], [21–24]. These methods, while useful for identifying linear relationships, often fall short in capturing complex interactions and non-linear dynamics among fertility-related factors. Fertility behavior is shaped by a range of socio-economic, demographic and cultural influences that interact in intricate ways patterns that traditional models may not detect [25–27].

Machine Learning (ML) offers a powerful alternative for analyzing fertility data. ML techniques excel at processing large datasets and identifying non-linear trends and complex interactions that traditional methods might miss. They can model relationships between variables with greater accuracy and handle high-dimensional data, allowing researchers to evaluate multiple factors simultaneously without overfitting [28]–[31]. This is particularly useful for studying fertility, where factors like education, employment, and healthcare interact in complex ways.

The rationale for this study stems from the growing recognition that ML techniques due to their flexibility and capacity to manage large and complex datasets frequently outperform conventional statistical methods. While traditional approaches have been successful in identifying simple relationships, they often struggle to account for the non-linear and multidimensional nature of fertility determinants. This research fills a critical gap by applying ML methodologies to fertility analysis offering more robust and precise insights compared to previous studies that relied predominantly on conventional techniques.

This study aims to leverage ML techniques to: (i) identify the key factors influencing fertility in Bangladesh and (ii) predict fertility using data from the Bangladesh Demographic and Health Survey (BDHS) 2017-18 [4]. By integrating advanced computational methods with demographic data this research aims to offer a more comprehensive understanding of fertility determinants in Bangladesh with important implications for public health planning and policy development

METHODS AND MATERIALS

ETHICAL STATEMENT

Bangladesh Demographic and Health Survey (BDHS) secondary data were used in this study; this is a nationally representative survey conducted in Bangladesh at regular intervals. The BDHS collects crucial information on health, family planning, and socio-demographic factors. It is carried out by the National Institute of Population Research and Training (NIPORT) under the Ministry of Health and Family Welfare, with technical support from ICF International. Permission for the survey protocol was secured from the ORC Macro (Macro International Inc.) Institutional Review Board and the National Research Ethics Committee in Bangladesh. The study relied on existing public domain survey datasets freely available online. Before analysis, all identifying information of the respondents was removed. The dataset for this research was acquired after obtaining permission by the authors from the Demographic and Health Surveys (DHS) program.

DATA

This study utilizes Bangladesh Demographic and Health Survey (BDHS) conducted in 2017-18 data which is part of an ongoing series initiated in 1993. The nationally representative surveys employed a two-stage stratified sampling design covering all administrative divisions in Bangladesh. The BDHS ensured consistency in comparing different demographic data by employing nearly identical questionnaires over time. Comprehensive details of sampling and survey methodology regarding the BDHS have been previously documented [4] and all survey data considered secondary data are publicly accessible. For this research we specifically extracted information from the BDHS (2017-2018) datasets with a focus on female respondents excluding temporary (de jure) residents and cases with missing values. The dataset comprising 20,127 weighted observations serves as a robust foundation for our analysis. This data cleaning process ensured consistency across all variables used in the machine learning models and prevented bias that could arise from incomplete records.

TARGET VARIABLE

The primary target variable in this study was Children Ever Born (CEB), representing the total number of children a woman had given birth to at the time of the survey. For descriptive analysis (Table 2), CEB was grouped into three categories: no children (0), 1–3 children, and four or more children (≥4) to facilitate interpretation of fertility patterns. However, for the machine learning models, CEB was retained as seven categories (0, 1, 2, 3, 4, 5, and 6 or more children) to capture finer variation in fertility outcomes.

INDEPENDENT VARIABLES

The list of independent variables appears in Table 1

TABLE-1: INDEPENDENT VARIABLES

Variables	Variables Coding
Division	0= Barishal, 1= Chattogram, 2= Dhaka, 3= Khulna, 4= Rajshahi, 5= Mymensingh, 6= Rangpur, 7= Sylhet
Type of place of residence	1= Rural, 0= Urban
Religion	1=Muslim, 2=Non-Muslim
Wealth index	0=Poorest, 1=Poorer, 2=Middle, 3=Richer, 4=Richest
Mother's educational level	0=No education, 1=Primary, 2=Secondary, 3=Higher
Father's education level	0=No education, 1=Primary, 2=Secondary, 3=Higher
Father's occupation	1=Agriculture, 2=Worker or Labor, 3=Professional Worker, 4=Business & Others
Mother's occupation	0= Housewife, 1=Worker or Labor, 2=Professional Worker, 3=Business & Others
Type of Toilet Facilities	1=Toilet With Flush, 2= VIP latrine, 3=Pit Latrine, 4=Hanging toilet and Other
Sources of Drinking Water	1=Other than Tubewell or Borehole, 2=Tubewell or Borehole
Number of household members	1=1-3 Member, 2=4-6 Member, 3=Over 6 Member

Type of Cooking Fuel	1= Kerosene or Natural Gas, 2=Wood, 3=Agricultural Crop, 4=Animal Dung and Others
Number of living children	0=No Child, 1=One Child, 2=Two Child, 3=Three Child, 4=Four Child, 5=Five or more Children
Body Mass Index (BMI)	1=Thin(<18.5), 2=Normal (18.5-24.99), 3=Overweight (25-29.99), 4=Obese(>=30)
Age at first Marriage	1=Below 18years old, 2=18 years and above
Contraceptive use and intention	1=Using modern method, 2=Using traditional method, 3=Non-user - intends to use later, 4=Does not intend to use
Son or daughter died	0=No, 1=Yes
Access to Media	0=No, 1=Yes
Sex of household head	1=Male, 2=Female
Ideal number of children	1=0-2 Children, 2=3-4 Children, 3=Over 4 Children
Currently breastfeeding	0=No, 1=Yes
Desire for more children	1=Wants within 2 years, 2=Wants after 2+ years, 3=Wants, unsure timing/Undecided, 4=Wants no more, 5=Sterilized (respondent or partner)/Declared infecund
Father's desire for children	1=Both want same, 2=Husband wants more, 3=Husband wants fewer, 4=Don't know

STATISTICAL ANALYSIS

This study integrates both traditional statistical methods and modern machine learning techniques to explore fertility determinants combining SPSS for statistical analysis, R for feature selection and Python for model building and evaluation. This study aims to explore risk factors associated with fertility by employing various machine learning classification models namely Random Forests (RF), Decision Tree (DT), K-Nearest Neighbors (KNN), Logistic Regression (LR), Support Vector Machine (SVM), XGBoost, LightGBM and Neural Network (NN). The dataset was divided into an 80% training set and a 20% test set. The training set was used to train the machine learning models, while the test set evaluated their performance. The models were trained using the training dataset and evaluated using the independent test dataset. The evaluation of predictive models was conducted and compared with metrics such as the macro average and weighted average of the Confusion Matrix, Accuracy, F1 Score, Precision, Recall, Area Under the Receiver Operating Characteristics Curve (AUROC) and K-fold cross-validation.

In this study, several software tools were employed to achieve a comprehensive analysis of fertility determinants. SPSS Version 25 was utilized for bivariate analysis specifically chi-square tests to identify significant variables related to fertility. These tests provided a foundation for comparing traditional statistical approaches with machine learning techniques.

For feature selection the Boruta algorithm was employed in R. The Boruta algorithm is a powerful all-relevant feature selection method based on the Random Forest classifier. Its unique approach involves creating shadow features (randomly permuted versions of the original variables) and comparing their importance with the actual features. By retaining only those variables that outperform their shadow counterparts Boruta ensures that all relevant features are included in the model, providing a robust selection of fertility-related factors.

Machine learning models were built using Python (version 3.0) specifically employing various libraries including pandas, scikit-learn, XGBoost, LightGBM and matplotlib.

The dataset was processed using the scikit-learn Pipeline framework to ensure a consistent and reproducible preprocessing workflow for all machine learning models.

The preprocessing procedure included the following steps:

1. Removal of observations containing missing values to ensure a complete dataset for model training and evaluation.
2. Encoding categorical variables using OneHotEncoder to convert categorical features into numerical format suitable for machine learning algorithms.
3. Standardization of numerical variables using StandardScaler so that all numerical features had a mean of 0 and a standard deviation of 1.
4. Feature selection using the Boruta algorithm to retain only the most relevant predictors for fertility.
5. Splitting the dataset into training (80%) and testing (20%) subsets to evaluate model performance on unseen data.

Standardization was particularly important for distance-based and kernel-based models such as K-Nearest Neighbors (KNN) and Support Vector Machines (SVM), as these models are sensitive to differences in feature scale.
This combination of SPSS, R and Python allowed for a multi-faceted analysis facilitating a rigorous comparison between traditional statistical methods and modern machine learning approaches in predicting fertility determinants.

Decision Tree (DT)

The Decision Tree (DT) algorithm uses a tree-like structure to classify data based on recursive splitting [32]. Its intuitive design makes it easy to interpret and useful for both categorical and continuous variables. The Decision Tree (DT) algorithm using the CART method classifies data by recursively splitting it based on feature values. Each internal node represents a decision and leaf nodes represent outcomes making the model intuitive and easy to interpret. DTs are effective for both categorical and continuous data but can overfit if the tree becomes too complex. In this study it helps identify key decision points related to fertility predictions.

Random Forest (RF)

Random Forest (RF) is an ensemble method that builds multiple decision trees and averages their outputs to improve prediction accuracy. It reduces overfitting and handles high-dimensional data efficiently [33]. RF's robustness makes it ideal for analyzing complex fertility determinants.

Support Vector Machine (SVM)

Support Vector Machine (SVM) is a powerful classification method that constructs hyperplanes to separate data into distinct classes [34]. It excels in high-dimensional spaces and performs well with small, complex datasets. In fertility prediction, SVM's flexibility ensures high accuracy.

Logistic Regression (LR)

Logistic Regression (LR) is a probabilistic model for binary classification, often used to predict outcomes like fertility determinants. It estimates the probability of an event based on input features. LR's simplicity and interpretability make it an excellent choice for categorical data [35].

K-Nearest Neighbors (KNN)

K-Nearest Neighbors (KNN) is a non-parametric, instance-based algorithm that classifies data points based on the majority class among the k-nearest neighbors in feature space [36]. Its simplicity makes it easy to implement, but it can struggle with high-dimensional data and is sensitive to feature scaling and outliers.

Extreme Gradient Boosting (XGBoost)

XGBoost (Extreme Gradient Boosting) is a powerful and efficient gradient boosting framework that enhances decision tree performance through regularization techniques to prevent overfitting [37]. It excels in handling large datasets and offers high predictive accuracy, making it a popular choice for data science competitions and complex structured data problems.

Light Gradient Boosting Machine (LightGBM)

LightGBM (Light Gradient Boosting Machine) is a gradient boosting framework designed for speed and efficiency, using a novel tree-building algorithm. It supports large datasets with faster training times and lower memory usage compared to traditional methods. LightGBM can also directly handle categorical features, improving model performance [38].

Neural Network (NN)

Neural Networks are advanced computational models inspired by the human brain, consisting of interconnected layers that learn to extract patterns from data. The Neural Network (NN) [39] used here is a Multi-Layer Perceptron (MLP) consisting of input hidden and output layers. It uses the ReLU activation function in the hidden layers and is trained with backpropagation. NN models are powerful for capturing complex non-linear relationships though they require more data and computational resources. In this study the MLP is applied to predict fertility outcomes based on socio-economic and demographic factors.

Hyperparameter Tuning

To optimize model performance, hyperparameter tuning was performed using GridSearchCV with 10-fold cross-validation on the training dataset. Key parameters were tuned for each algorithm, including n_estimators and max_depth for Random Forest, C and gamma for Support Vector Machine, and the number of neighbors (k) for K-Nearest Neighbors. For gradient boosting models (XGBoost and LightGBM), parameters such as learning rate, max_depth, and number of estimators were optimized. For the Neural Network, the hidden layer size and regularization parameter (alpha) were tuned. The final model parameters were selected based on the highest cross-validated accuracy, ensuring improved predictive performance and reduced risk of overfitting.

SENSITIVITY ANALYSIS

A sensitivity analysis was conducted to evaluate the robustness of the machine learning models. The models were re-estimated under alternative preprocessing settings and cross-validation configurations. The results showed that model performance remained consistent across these variations, indicating that the findings were stable and not sensitive to minor changes in model specification.

Confusion Matrix Performance Parameters

A confusion matrix is used to evaluate classification performance by comparing predicted versus actual outcomes. It provides metrics like accuracy, precision, sensitivity, and specificity. These metrics offer insight into model effectiveness, especially in fertility predictions.

Receiver Operating Characteristic (ROC) Curve

The ROC curve visually represents a model's ability to differentiate between classes by plotting true positive rates against false positives. The Area Under the Curve (AUC) measures overall performance [40]. Higher AUC values indicate a better-performing fertility prediction model.

Boruta Algorithm

Boruta, a Random Forest-based feature selection method, was chosen for its ability to retain all relevant features by comparing them with shadow features. Unlike other methods like Lasso or Recursive Feature Elimination (RFE), Boruta [41] ensures that no potentially important fertility-related variable is overlooked making it ideal for high-dimensional data in this study.

RESULTS

DESCRIPTIVE STATISTICS

The results presented in Table 2, Division, Type of residence, Religion, Wealth index, Maternal and Father's education, Occupation, Toilet facilities, Water sources, Household size, Cooking fuel, and several others are significant fertility determinants at the 5% level ($p<0.001$). Factors like Mother's Age, Body Mass Index, Age at first Marriage, Contraceptive

use, Son or daughter death, Access to media, Marital status, Ideal children number, and Desire for more children also show significant relationships (p<0.001), with Father's desire for children (p<0.001) and Sex of household head (p=0.020).

TABLE-2 DESCRIPTIVE ANALYSIS OF BACKGROUND CHARACTERISTICS

Characteristics	Total	Children Ever Born			χ2	p-value
	n(%)	No children n(%)	1 to 3 children n(%)	4 or More Children n(%)		
Division						
Barishal	1125(5.59)	102(9.07)	757(67.29)	266(23.64)		
Chattogram	3622(18)	355(9.8)	2325(64.19)	942(26.01)		
Dhaka	5123(25.45)	601(11.73)	3577(69.82)	945(18.45)		
Khulna	2336(11.61)	237(10.15)	1802(77.14)	297(12.71)	323.96	<0.001
Mymensingh	1546(7.68)	160(10.35)	1006(65.07)	380(24.58)		
Rajshahi	2801(13.92)	261(9.32)	2064(73.69)	476(16.99)		
Rangpur	2380(11.83)	196(8.24)	1681(70.63)	503(21.13)		
Sylhet	1193(5.93)	114(9.56)	705(59.09)	374(31.35)		
Type of place of residence						
Urban	5729(28.46)	628(10.96)	4196(73.24)	905(15.8)		
Rural	14398(71.54)	1397(9.7)	9722(67.52)	3279(22.77)	121.81	<0.001
Religion						
Muslim	18251(90.67)	1889(10.35)	12435(68.13)	3927(21.52)	94.98	<0.001
Non-Muslim	1877(9.33)	137(7.3)	1483(79.01)	257(13.69)		
Wealth index						
Poorest	3743(18.6)	277(7.4)	2407(64.31)	1059(28.29)		
Poorer	3956(19.66)	349(8.82)	2575(65.09)	1032(26.09)		
Middle	4059(20.17)	387(9.53)	2828(69.67)	844(20.79)	464.30	<0.001
Richer	4183(20.79)	497(11.88)	2917(69.73)	769(18.38)		
Richest	4183(20.79)	515(12.31)	3190(76.26)	478(11.43)		
Maternal educational level						
No education	3333(16.56)	112(3.36)	1663(49.89)	1558(46.74)		
Primary	6290(31.25)	342(5.44)	4148(65.95)	1800(28.62)	3218.38	<0.001
Secondary	7973(39.61)	979(12.28)	6225(78.08)	769(9.65)		
Higher	2531(12.58)	592(23.39)	1882(74.36)	57(2.25)		
Father's education level						
No education	4077(21.54)	151(3.7)	2381(58.4)	1545(37.9)		
Primary	6081(32.12)	508(8.35)	4127(67.87)	1446(23.78)	1599.57	<0.001
Secondary	5675(29.98)	694(12.23)	4249(74.87)	732(12.9)		
Higher	3098(16.36)	520(16.79)	2402(77.53)	176(5.68)		
Father's occupation						
Agriculture	4902(25.87)	295(6.02)	3103(63.3)	1504(30.68)		
Worker/Labor	9075(47.9)	1078(11.88)	6441(70.98)	1556(17.15)	621.71	<0.001
Professional Worker	1046(5.52)	187(17.88)	787(75.24)	72(6.88)		

Business & Others	3924(20.71)	319(8.13)	2838(72.32)	767(19.55)		
Mothers's occupation						
Housewife	10026(49.83)	1361(13.57)	7008(69.9)	1657(16.53)		
Worker/Labor	6909(34.34)	283(4.1)	4640(67.16)	1986(28.75)	730.96	<0.001
Professional Worker	2480(12.33)	265(10.69)	1764(71.13)	451(18.19)		
Business & Others	705(3.5)	115(16.31)	501(71.06)	89(12.62)		
Type of Toilet Facilities						
Toilet With Flush	5724(30.95)	650(11.36)	4194(73.27)	880(15.37)		
VIP latrine	2748(14.86)	252(9.17)	1954(71.11)	542(19.72)	302.31	<0.001
Pit Latrine	9673(52.3)	745(7.7)	6377(65.93)	2551(26.37)		
Hanging toilet and Other	351(1.9)	16(4.56)	236(67.24)	99(28.21)		
Sources of Drinking Water						
Other than Tubewell or Borehole	195(10.36)	1368(72.69)	319(16.95)	1882(100)	32.94	<0.001
Tubewell or Borehole	1468(8.84)	11393(68.57)	3753(22.59)	16614(100)		
Number of household members						
1-3 Member	4258(21.16)	601(14.11)	3169(74.42)	488(11.46)		
4-6 Member	11287(56.08)	831(7.36)	7976(70.67)	2480(21.97)	517.49	<0.001
Over 6 Member	4581(22.76)	593(12.94)	2773(60.53)	1215(26.52)		
Type of Cooking fuel						
Kerosene or Natural Gas	3769(20.4)	415(11.01)	2838(75.3)	516(13.69)		
Wood	8436(45.65)	790(9.36)	5690(67.45)	1956(23.19)	223.78	<0.001
Agricultural Crop	4918(26.61)	360(7.32)	3306(67.22)	1252(25.46)		
Animal Dung and Others	1356(7.34)	96(7.08)	916(67.55)	344(25.37)		
Number of living children						
No Child	2138(10.62)	2025(94.71)	109(5.1)	4(0.19)		
One Child	4574(22.73)	0(0)	4556(99.61)	18(0.39)		
Two Child	6205(30.83)	0(0)	6038(97.31)	167(2.69)		**<0.001***
Three Child	4053(20.14)	0(0)	3215(79.32)	838(20.68)		
Four Child	1863(9.26)	0(0)	0(0)	1863(100)		
Five or more Children	1294(6.43)	0(0)	0(0)	1294(100)		
Body Mass Index						
Thin	2285(11.55)	315(13.79)	1453(63.59)	517(22.63)		
Normal	11173(56.47)	1237(11.07)	7578(67.82)	2358(21.1)	158.29	<0.001
Overweight	5036(25.45)	342(6.79)	3683(73.13)	1011(20.08)		
Obese	1290(6.52)	76(5.89)	969(75.12)	245(18.99)		
Age at first Marriage						
<18	15166(75.35)	1192(7.86)	10315(68.01)	3659(24.13)	638.86	<0.001
18+	4962(24.65)	834(16.81)	3603(72.61)	525(10.58)		

Contraceptive use and intention						
Using modern method	9854(48.96)	401(4.07)	7518(76.29)	1935(19.64)		
Using traditional method	1889(9.38)	77(4.08)	1229(65.06)	583(30.86)	2685.50	<0.001
Non-user - intends to use later	5081(25.24)	1275(25.09)	3382(66.56)	424(8.34)		
Does not intend to use	3304(16.41)	273(8.26)	1789(54.15)	1242(37.59)		
Son or daughter died						
No	17036(84.64)	2025(11.89)	12779(75.01)	2232(13.1)	4071.07	<0.001
Yes	3091(15.36)	0(0)	1139(36.85)	1952(63.15)		
Access to Media						
No	6847(34.02)	529(7.73)	4202(61.37)	2116(30.9)	658.04	<0.001
Yes	13280(65.98)	1497(11.27)	9715(73.16)	2068(15.57)		
Sex of household head						
Male	17166(85.29)	1767(10.29)	11822(68.87)	3577(20.84)	7.78	0.020
Female	2960(14.71)	258(8.72)	2096(70.81)	606(20.47)		
Ideal number of children						
0-2 Children	15520(77.61)	1803(11.62)	11518(74.21)	2199(14.17)		
3-4 Children	4361(21.81)	205(4.7)	2322(53.24)	1834(42.05)	1823.94	<0.001
Over 4 Children	117(0.59)	5(4.27)	33(28.21)	79(67.52)		
Currently breastfeeding						
No	15989(79.44)	2025(12.66)	10287(64.34)	3677(23)		
Yes	4138(20.56)	0(0)	3631(87.75)	507(12.25)		**<0.001***
Desire more children						
Wants within 2 years	2253(11.87)	934(41.46)	1285(57.04)	34(1.51)		
Wants after 2+ years	3928(20.69)	791(20.14)	3095(78.79)	42(1.07)		
Wants, unsure timing/Undecided	577(3.04)	102(17.68)	457(79.2)	18(3.12)	6110.81	<0.001
Wants no more	10256(54.02)	21(0.2)	7313(71.3)	2922(28.49)		
Sterilized (respondent or partner)/Declared infecund	1970(10.38)	34(1.73)	1045(53.05)	891(45.23)		
Father's desire for children						
Both want same	14118(79.05)	1588(11.25)	10150(71.89)	2380(16.86)		
Husband wants more	1939(10.86)	65(3.35)	1232(63.54)	642(33.11)	565.93	<0.001
Husband wants fewer	1089(6.1)	65(5.97)	805(73.92)	219(20.11)		
Don't know	714(4)	162(22.69)	343(48.04)	209(29.27)		

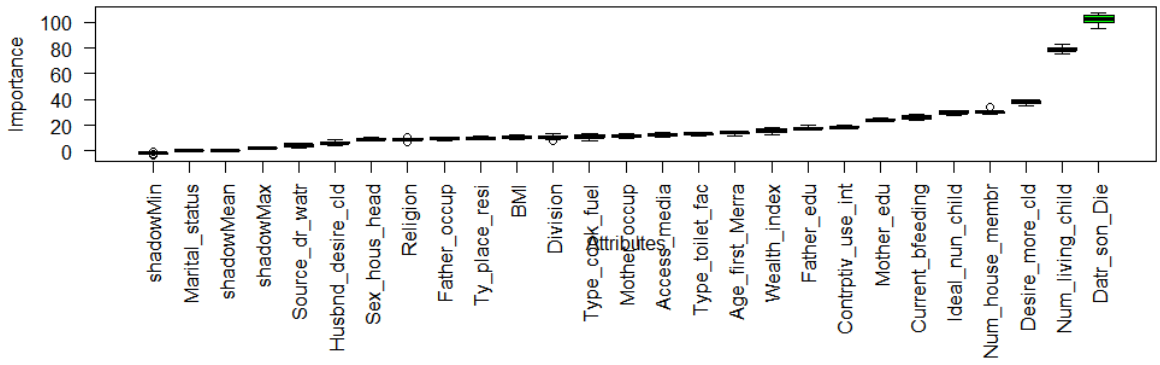
* Fisher's Exact test was utilized in place of chi-square.

SELECTION OF THE BEST FEATURES

Figure-1 the Boruta algorithm illustrates that we opted to keep 23 variables as a determinant of fertility i.e., Division, Type of place of residence, Wealth index, Maternal educational level, Father's education level, Father's occupation, Mothers' occupation, Number of household members, Type of Toilet Facilities, Sources of Drinking Water , Type of Cooking, Number of living children, Maternal age at first birth, Contraceptive use and intention, Body Mass Index, Son or daughter died, Access to Media, Sex of household head, Ideal number of children, Currently breastfeeding, Desire for more children,

Husband's desire for children out of 23 variables are determined most influential factors to predict the fertility in Bangladesh.

FIGURE 1: FEATURE SELECTION USING BORUTA ALGORITHM



PREDICTING FERTILITY USING MACHINE LEARNING APPROACHES

The machine learning models namely Random Forests (RF), Decision Tree (DT), K-Nearest Neighbors (KNN), Support Vector Machine (SVM), Logistic Regression (LR), XGBoost, LightGBM and Neural Network (NN) were utilized to build a model for prediction of fertility in Bangladesh. After training each predictive model with 80% of the data then testing was conducted with the remaining 20% of the dataset.

The Support Vector Machine (SVM) achieved the highest fertility prediction accuracy (95.55%), followed by LightGBM (94.91%) and Random Forest (94.85%), with strong weighted average metrics in recall, precision, and F1 score (all above 95%). Logistic Regression and Decision Tree also performed well, with accuracies of 89.04% and 88.16% respectively, while K-Nearest Neighbors (76.06%) showed the lowest accuracy. Across models, SVM, LightGBM, and Random Forest had the least misclassifications in predicting the number of children ever born (table-3).

TABLE-3: PREDICTIVE MODELS OF PERFORMANCE OF FERTILITY

Predictive Models Performances								
	RF		**DT**		**KNN**		**LR**	
Accuracy	94.85%		88.16%		76.06%		89.04%	
	Macro Average	Weighted Average	Macro Average	Weighted Average	Macro Average	Weighted Average	Macro Average	Weighted Average
Recall	88%	95%	79%	89%	66%	78%	81%	90%
Precision	88%	95%	82%	88%	69%	76%	82%	89%
F1 score	88%	95%	80%	89%	67%	76%	80%	89%

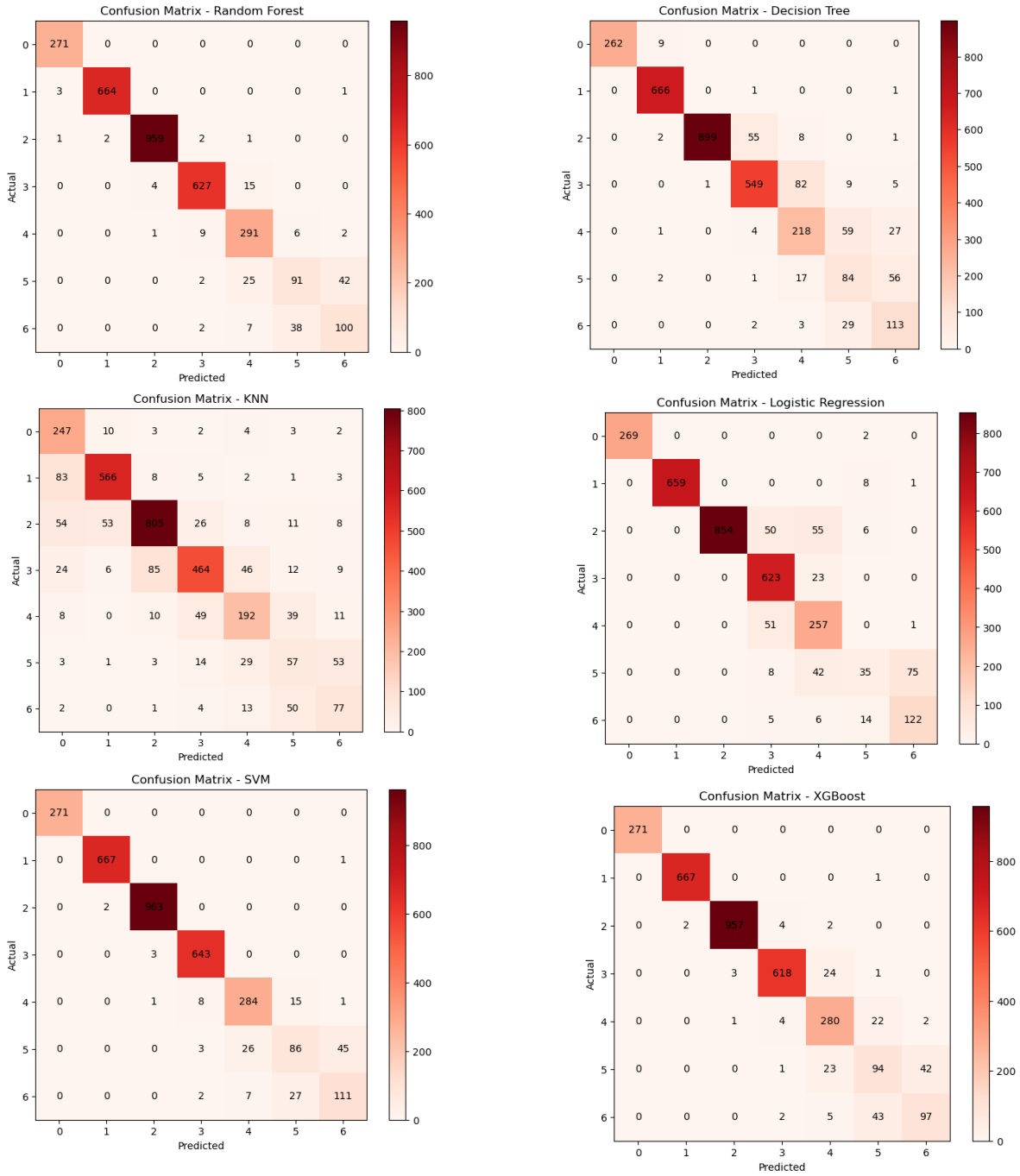
	SVM		**XGBoost**		**LightGBM**		**NN**	
Accuracy	95.55%		94.25%		94.91%		92.74%	
	Macro Average	Weighted Average	Macro Average	Weighted Average	Macro Average	Weighted Average	Macro Average	Weighted Average
Recall	89%	95%	87%	94%	88%	95%	85%	93%
Precision	89%	96%	87%	94%	88%	95%	86%	93%
F1 score	89%	95%	87%	94%	88%	95%	86%	93%

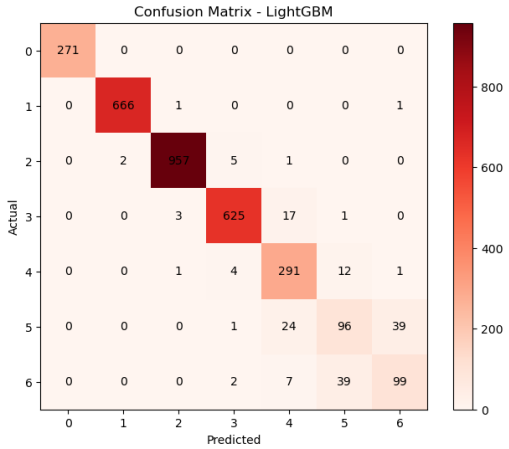
Models with higher recall might be preferred if correctly identifying positive cases (fertility cases in this context) is of utmost importance. Models with higher precision are crucial when reducing false positive cases is a priority. The weighted averages provide insights considering class imbalances, while macro averages treat all classes equally. This analysis

suggests that while all models perform reasonably well the choice among them might be based on the specific needs computational complexity and the importance of correctly identifying fertility cases versus minimizing false positives. Figure-2 presents the confusion matrix and Figure-3 presents AUROC of all models comparative performances. According to the findings presented in Table-3 the predictive model performance results indicate that the Support Vector Machine (SVM) outperformed other models utilized in this study as the most effective predictor of fertility.

Figure 2 presents confusion matrices for eight machine learning models, showing their performance in predicting fertility determinants. The Random Forest, Neural Network, and SVM models perform best, with more correct predictions (darker diagonal lines), while models like KNN and LightGBM show higher misclassification rates.

FIGURE-2: CONFUSION MATRIX OF CLASSIFICATION RESULTS.





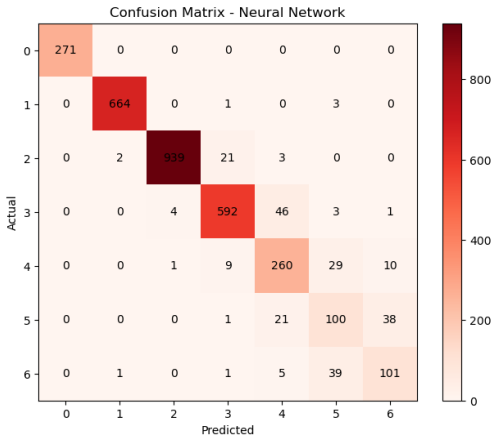
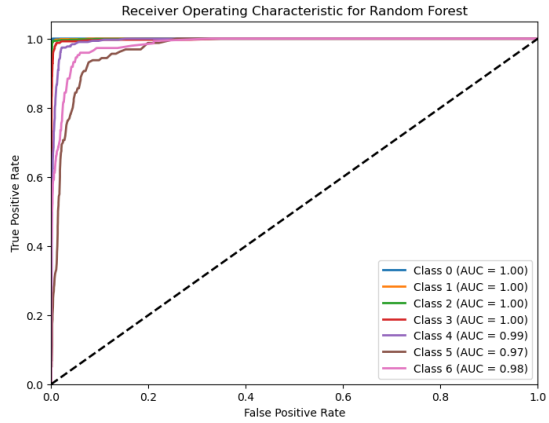
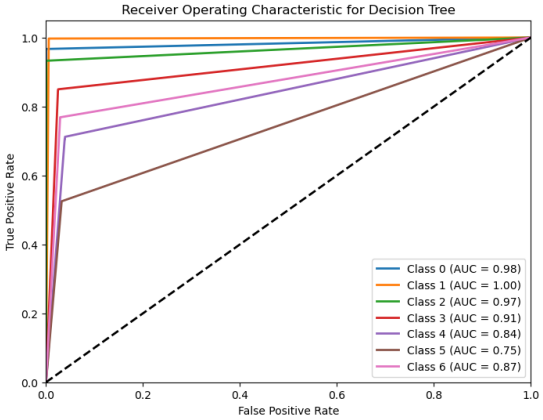
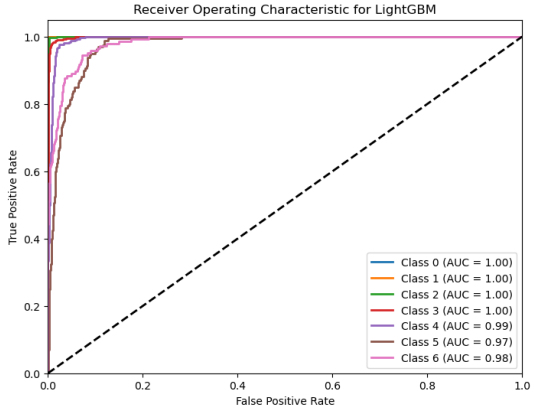
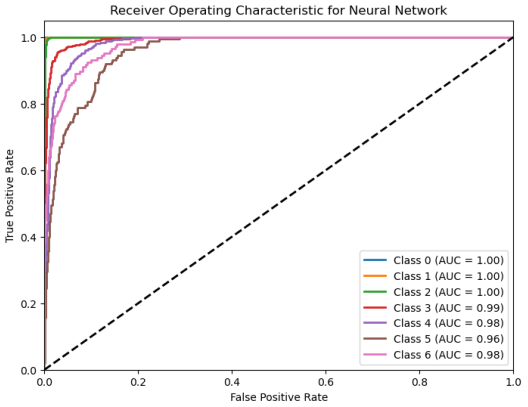


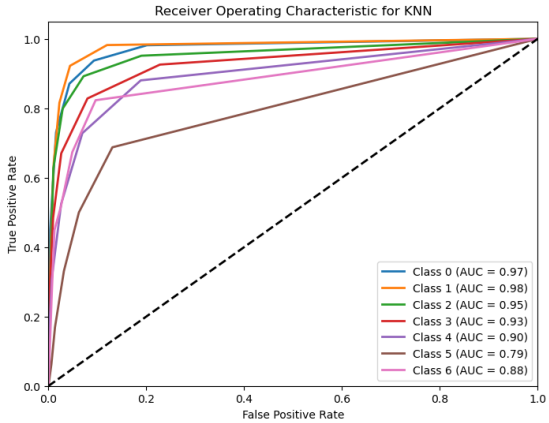
FIGURE-3: THE ROC CURVES TO PREDICT FERTILITY IN BANGLADESH USING RF, DT, KNN, LR, SVM, XGBOOST, LIGHTGBM AND NN MODELS

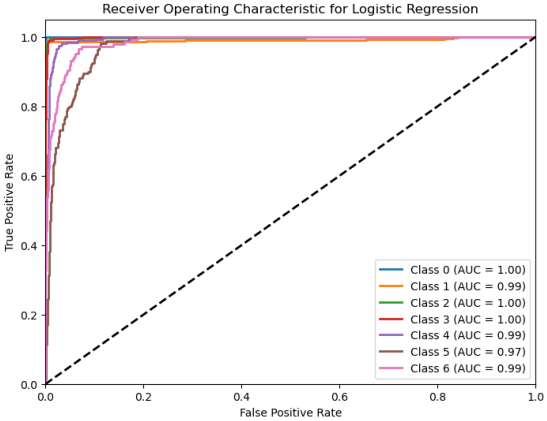


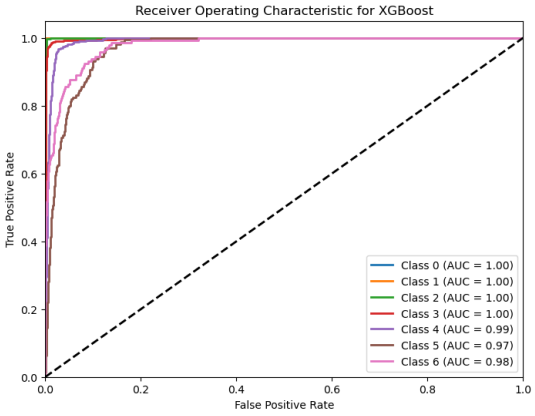


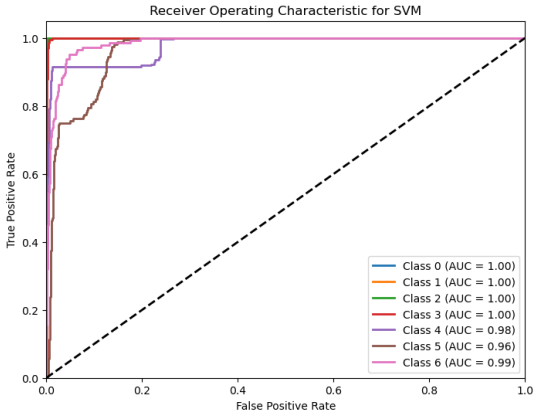












SENSITIVITY ANALYSIS

To assess the robustness of the predictive models, a sensitivity analysis was conducted by comparing model performance using the original dataset and a dataset balanced using the Synthetic Minority Oversampling Technique (SMOTE). The results presented in Table 4 indicate that model performance remained largely consistent across both scenarios. In the original dataset, the Support Vector Machine (SVM) achieved the highest accuracy (96.08%), followed by Random Forest (96.02%) and LightGBM (95.67%). After applying SMOTE, SVM continued to demonstrate the strongest performance with an accuracy of 95.55%, followed by LightGBM (94.91%) and Random Forest (94.85%). Although SMOTE slightly improved recall for some minority fertility categories, overall accuracy and weighted performance metrics showed only minor changes across models, suggesting that the predictive results are robust to class imbalance.

TABLE-4 SENSITIVITY ANALYSIS RESULTS OF MACHINE LEARNING MODELS

Models	Without SMOTE	With SMOTE
RF	96.02%	94.85%
DT	94.15%	88.16%
KNN	80.20%	76.06%
LR	89.80%	89.04%
SVM	**96.08%**	**95.55%**
XGBoost	95.48%	94.25%
LightGBM	95.67%	94.91%
NN	95.17%	92.45%

K-FOLD CROSS-VALIDATION RESULTS

We performed k-fold cross-validation with 5-fold, 10-fold, 15-fold, 20-fold, and 30-fold splits to evaluate the robustness of the machine learning models. Table 5 presents the mean accuracy scores for each model across these fold values. After testing various fold values, k=10 emerged as the most consistent and reliable across most models, and was therefore chosen for the final evaluation in this study.

Among the models, the Support Vector Machine (SVM) consistently delivered the highest accuracy of 95.90% across all fold values, demonstrating strong robustness in predicting fertility determinants. Logistic Regression (LR), a widely recognized model in fertility prediction, also performed well, achieving 95.72% accuracy under 10-fold cross-validation. Given its established reputation, Logistic Regression was used as the benchmark ("gold standard") for comparing the performance of more advanced machine learning models.

Random Forest (RF), LightGBM, and XGBoost all achieved strong results, with mean accuracies exceeding 95%. Models like Decision Tree (DT) and Neural Networks (NN) performed slightly lower, with accuracies around 94%. However, K-

Nearest Neighbors (KNN) lagged significantly, with an accuracy of around 57%, indicating it may not be suitable for this dataset.

TABLE-5: K-FOLD CROSS VALIDATION OF MACHINE LEARNING MODELS

Models	Mean Accuracy of K-Fold				
	5-Fold	10-Fold	15-Fold	20-Fold	30-Fold
RF	0.9496	0.9512	0.9503	0.9496	0.9511
DT	0.9348	0.9375	0.9363	0.9354	0.9349
KNN	0.5647	0.5709	0.5707	0.5727	0.5737
LR	0.9577	0.9572	0.9579	0.9574	0.9574
SVM	0.9590	0.9590	0.9590	0.9590	0.9590
XG Boost	0.9519	0.9534	0.9526	0.9533	0.9537
Light GBM	0.9529	0.9535	0.9534	0.9536	0.9545
NN	0.9351	0.9380	0.9375	0.9352	0.9373

In summary, SVM provided the best predictive performance for fertility determinants in this dataset, with Logistic Regression serving as a solid baseline. The selection of k=10 for cross-validation was supported by the stability and consistent performance of the models.

FIGURE-4 IMPORTANT FEATURES VISUALIZATION USING ML SVM CLASSIFIER

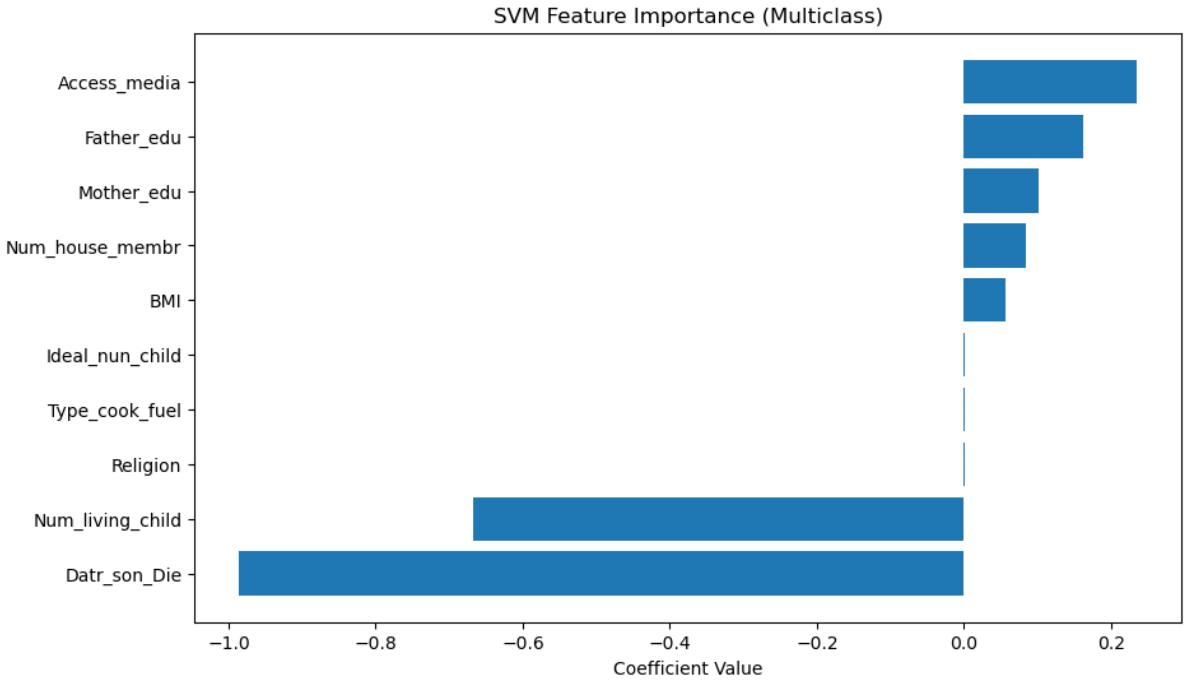


Figure-4 presents a visualization of the most influential features identified through the SVM (Support Vector Machine) classifier in the context of predicting fertility-related outcomes in Bangladesh. These features are crucial in determining the predictions made by the machine learning model. There are several factors such as access to mass media, parents' education levels, household size, Body Mass Index (BMI), number of living children, and experiences of child mortality have been found to influence the model's predictions, this does not imply a direct causal relationship between these factors and fertility. These features are significant within the confines of the SVM algorithm, but further investigation is required to understand their role in the broader socio-economic and cultural determinants of fertility.

DISCUSSION

This study makes a significant contribution to fertility research in Bangladesh by combining traditional statistical methods with advanced machine learning techniques to identify key determinants of fertility. While traditional chi-square tests revealed several important factors such as Division, Type of Residence, Religion, Wealth Index, and Parental Education, machine learning allowed for a deeper analysis of their relative importance and provided a more focused perspective on the most critical predictors.

At the 5% level of confidence, traditional chi-square tests confirmed that determinants like

Division, Type of residence, Religion, Wealth index, Maternal and Father's education, Occupation, Toilet facilities, Water sources, Household size, Cooking fuel, Mother's Age, Body Mass Index, Age at first Marriage, Contraceptive use, Son or daughter death, Access to media, Marital status, Ideal children number, and Desire for more children, Father's desire for children and Sex of household head play a statistically significant role in fertility. These factors align with existing literature [5], [9], [12]–[14], [42], but the application of machine learning allowed us to assess their relative importance compared to other variables. The identification of media access as a significant predictor emphasizes the role of mass communication in shaping reproductive behaviors [9]. This insight opens new opportunities for policy interventions that leverage media-based education especially in promoting family planning.

Moreover, the importance of parental education, household size and maternal BMI underscores the multifaceted nature of fertility decisions. Larger households as our analysis suggests, tend to have higher fertility rates and educational attainment remains a crucial factor [15], [30], [43]–[45]. The positive correlation between maternal BMI and fertility also aligns with broader health-related findings, indicating that nutritional and health status plays a key role in reproductive outcomes [46], [47] .

While conventional approaches such as the chi-square test revealed a wide range of significant factors including Division, Type of Place of Residence, Religion, Wealth Index and Parental Education and many more, on the other hand the Support Vector Machine (SVM) offered a refined and focused most influential predictors. Figure 2 illustrates the confusion matrices for the various machine learning models used in this study, providing a comparative view of their classification performance. Notably, the SVM model outperformed others, showing higher accuracy with fewer misclassifications, as seen by the concentration of predictions along the diagonal.

The Support Vector Machine (SVM) model has identified seven essential determinants: access to mass media, father's education, mother's education, number of household members, maternal Body Mass Index (BMI), number of living children and child mortality events (i.e., incidents of sons or daughters dying). These findings not only confirm prior research but also offer new insights into the specific factors influencing fertility dynamics in Bangladesh.

Moving forward, there are several avenues for future research incorporating real-time data from mobile health apps and wearable devices could enhance fertility predictions. Social media sentiment analysis may reveal shifts in attitudes toward family planning. Incorporating economic indicators like employment and income levels could broaden the understanding of fertility trends. Data from healthcare systems and electronic records can improve model accuracy and personalization. Advancements in AI will further refine models, offering actionable insights for policy interventions.

In conclusion, our study demonstrates the powerful potential of machine learning in fertility research. This study highlights key factors like media access, parental education, and maternal BMI, number of living children, and child mortality events offering valuable insights that can help policymakers and health professionals make informed decisions. These findings suggest that targeted interventions focusing on media-based education and improving healthcare access could significantly impact fertility rates in Bangladesh. Future research should continue exploring advanced machine learning

models and longitudinal datasets to further refine our understanding of fertility determinants and inform data-driven policymaking.

STRENGTHS AND LIMITATIONS

The country representative BDHS-2017-18 dataset were used in this study. Causal inference is not feasible as this analysis is cross-sectional. The results we examined rely on self-reporting and are thus vulnerable to variation in memory and social desirability. We have used 08 (eight) different types of Machine Learning models: Random Forests (RF), Decision Tree (DT), K-Nearest Neighbors (KNN), Logistic Regression (LR), Support Vector Machine (SVM), XGBoost, LightGBM and Neural Network (NN) for examining and seeking the best output.

Another limitation of this study is the absence of external validation using an independent dataset. Although internal validation was performed through k-fold cross-validation to assess the robustness of the machine learning models, the models were not tested on an external dataset from a different survey wave or population. Future studies should consider validating the proposed models using independent datasets, such as more recent Bangladesh Demographic and Health Survey (BDHS) rounds, to further assess the generalizability and stability of the predictive models across different populations and time periods.

CONCLUSION

This study demonstrates that Machine Learning (ML) models, particularly Support Vector Machines (SVM), provide more reliable and precise predictions of fertility determinants in Bangladesh compared to traditional statistical models. By leveraging training data for model construction and test data for validation, ML techniques enabled the identification of key fertility predictors with greater accuracy. Our findings reveal that access to mass media, father's education level, mother's education, household size, maternal Body Mass Index (BMI), number of living children, and child mortality events (i.e., incidents of sons or daughters dying) are the most influential factors in predicting fertility.

The integration of ML into fertility research represents a significant methodological advancement, allowing for the handling of complex, non-linear relationships between variables. This approach enhances the understanding of fertility dynamics and provides insights that may be overlooked by conventional statistical methods. These findings offer valuable evidence for policymakers to design targeted interventions to address fertility issues in Bangladesh.

Future research should explore more advanced ensemble ML models or utilize longitudinal data to capture temporal changes in fertility determinants. Expanding the scope of study to other regions or countries could also offer comparative insights into global fertility patterns.

DECLARATIONS

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Ethics approval and consent to participate

No ethical approval for this study because this analysis is secondary and research is based on BDHS (2017-18) data. The data were completely anonymous and there is no identifiable information was there and available DHS website.

Funding

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Consent for publication

Consent for publication is not required for this study, as no personal information, images, or videos of individual participants were used. Furthermore, all the data utilized in the study are publicly available.

Availability of data and materials

Sourced from the publicly available dataset at https://dhsprogram.com/data/available-datasets.cfm the manuscript incorporates secondary data.

Competing interests

The authors declared no competing interests exist.

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ACHSM Asia-Pacific Journal of Health Management

RESEARCH ARTICLE

DO DISPOSITIONAL PECULIARITIES MATTER? AN INTERPLAY OF TRAITS AND ORGANIZATIONAL COMMITMENT AMONG HEALTHCARE PROFESSIONALS

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ABSTRACT

BACKGROUND:

Organizational commitment has endured heightened interest from behavioral scientists and practicing managers owing to its linkages with positive workplace behaviors and outcomes. Therefore, identifying factors that can facilitate organizations to have committed workforce is essential. Extant literature has identified several such factors; however dispositional antecedents of this attitude have remained under-represented.

OBJECTIVE:

Given the fact that many scholars have lately called for examining its dispositional antecedents, the current study has analyzed the impact of agreeableness, conscientiousness and extraversion on organizational commitment and its two dimensions- affective and normative, among hospital employees in a non-western context.

METHODS:

Using systematic sampling technique, 379 health professionals working across northern India were selected. PLS-SEM was used to assess the study's model and hypotheses.

RESULTS:

The results indicate that extraversion did not significantly influence overall organizational commitment among hospital employees. A similar outcome was found for normative commitment, while extraversion significantly impacted affective commitment. Additionally, agreeableness showed a significant positive effect on overall organizational commitment and both its dimensions. Likewise, conscientiousness was found to significantly influence overall commitment and its components.

CONCLUSIONS:

The findings highlight the varying roles of personality traits in shaping employees' commitment within hospital settings. Hence, the present study suggests the hospital authorities to give due consideration to traits particularly agreeableness and conscientiousness, while hiring, training and retaining employees. Aligning human resource practices with these psychological elements are more likely to create a base of highly committed healthcare employees.

KEYWORDS

Affective commitment, healthcare, normative commitment, personality.

INTRODUCTION

Organizational commitment stated as the employee's strong desire to maintain membership in the organization and a firm belief in its values and goals [1], has remained crucial to the field of organizational behavior [2, 3]. This job attitude has endured a lot of interest from behavioral scientists and practicing managers [4] owing to its associations with crucial employee behaviors including absenteeism [5], turnover [6-8], employee performance [9,10], and organizational citizenship behavior [9,11,12]. Consequentially, contemporary organizations including hospitals have progressively become more dependent on committed workforce for coping with serious challenges posed by shortage of resources including manpower and infrastructure, and high service demands [57]. Therefore, selecting and retaining highly committed employees has become a fundamental component of the human resource management strategy of these organizations [14-16].

Extant literature has identified two broad categories of factors predicting commitment- work characteristics and personal characteristics [9, 17, 18]. Surprisingly, research has only recently witnessed growing debates on personality traits as antecedents of this job attitude [14, 19-22]. Previously, organizational commitment scholars concluded that dispositional factors might not play a key role in shaping organizational commitment [9]. Of late, however, several calls have been made by scholars who believe that this conclusion may be premature and dispositional characteristics, including Big Five personality traits, could also prove significant determinants of organizational commitment [14,19,20]. Individuals tend to look at similar work environments distinctively as they prefer information that confirms their predispositions through selective exposure, selective perception, and selective retention [23]. Hence, individual differences in terms of personality traits other than the environmental factors [14] can affect their levels of organizational commitment. Furthermore, trait theory of personality states that traits are relatively stable characteristics that influence how an individual thinks, feels and behaves [32; 58]. Consequently, traits can also have a meaningful impact on employees' psychological attachment to the organization.

Furthermore, extraversion, agreeableness and conscientiousness traits are highly significant in hospital setting owing to the unique demands of healthcare services [24, 25]. A high level of interpersonal engagement that is required among patients, families and medical teams is supported by extraversion trait. Correspondingly, the caregiving mission of hospitals aligns well with empathy, desire to assist others, and cooperation characteristics of agreeable people. Furthermore, upholding professional standards and patient safety in stressful environment of hospitals depends upon peculiar tendencies of conscientiousness, including discipline, reliability and a strong sense of responsibility. Conversely, the other two traits of Big Five have not been regarded as positive drivers in hospital settings. Neuroticism has been associated with heightened emotional instability in a stressful work environment [24], while openness to experiences has been linked with an enhanced tendency toward abandoning a workplace [26].

However, there exists a dearth of both empirical and theoretical research on personality-commitment linkages [21, 27]. Although some researchers have emphasized that the level and forms of commitment can be molded by individual characteristics, culture and unique context [26, 27, 28, 29], this significant research domain remained under-explored. For instance, scant studies have examined these linkages in developing economies [18, 30], where collectivist values exist. Similarly, only fewer research works have highlighted how traits affect commitment in healthcare sector [31]. Against this backdrop, the present study seeks to investigate the extent to which the select traits predict organizational commitment among healthcare employees in a non-Western context. Given the theoretical focus of this research on positive psychological attachment, affective and normative commitment were considered the most relevant dimensions for inclusion. These are positive forms of commitment, often found to be strongly correlated and to frequently share the same antecedents and outcomes, thereby implying that the mindsets of desire and obligations may co-occur [9]. While continuance commitment has been largely linked with negative antecedents and outcomes [13]. Hence, the present study is an endeavor to address scholarly calls for examining the dispositional basis of this positive attitude by exclusively focusing on affective and normative commitment. Moreover, by analyzing the aforementioned relationships in a non-

Western healthcare context, the present work can add to literature by determining how people's characteristics affect their commitment to work and organization because of diversity in culture.

THEORY AND HYPOTHESES DEVELOPMENT

TRAIT THEORY OF PERSONALITY

Trait theory is a key framework in the domain of personality. The theory holds that personality encompasses a variety of traits that are fundamental for understanding attitudes and behaviors of an individual. Traits represent broad dimensions of human characteristics that manifest consistency, stability and relative permanence [32]. Traits influence an individual's general approach to adjusting to and engaging in the social sphere [70]. Consequently, organizational psychologists and behavioral scientists have shown enormous interest in trait theory. Likewise, "Big Five" taxonomy has been identified as central to understanding individual differences in personality [72]. Proponents of big five taxonomy believe that employees develop specific patterns of thoughts, feelings and behaviors depending on their relative standing on the basic five traits [32; 58]. This argument holds specific relevance in healthcare settings, where employees operate in an environment characterized by high work demands and burnout. Personality traits influence how healthcare professionals cope with these challenges and utilize their personal resources at the workplace. For instance, extraverted employees may derive greater support from social interactions, agreeable employees tend to establish supportive workplace relationships, and conscientious employees are more likely to exhibit reliability and responsibility. As a result, these traits can facilitate stronger emotional attachment and normative obligations toward the organization, thereby enhancing organizational commitment.

EXTRAVERSION AND ORGANIZATIONAL COMMITMENT

Extraversion implies how assertive, dominant, active, lively and passionate an individual is [32]. Extraverts have a strong desire for sensory stimulation and are frequently social and outgoing. Due to their propensity for social interaction and building relationships with co-workers, highly extraverted employees frequently demonstrate higher levels of organizational commitment [33, 34, 35]. Extraverted employees are more likely to remember good things that happened at work and are happier in their positions. This inclination makes them feel more affectively attached to their workplace and the people over there [14,19, 27]. The extant research has also shown a positive association between extraversion and affective components of organizational commitment [33, 34]. Additionally, extraverted employees consider social interactions inside the workplace more rewarding than introverted employees due to their positive emotionality [35]. Hence, extraverted workers may feel obliged to give back to the organization for creating such a welcoming social atmosphere. This can eventually increase their normative commitment levels [19, 36]. Similarly, various hospital roles require frequent interaction with patients, families and co-workers. These interactions are often sensitive and consequential [24]. Hence, extravert employees' optimism and effective communication can play a significant role in these high-stress and emotionally charged environments [25]. This ability to build strong workplace relationships fosters a sense of belonging, which eventually can reinforce their commitment to the organization. Hence, it is hypothesized that:

H1: Extraversion positively influences organizational commitment among healthcare professionals

H1a: Extraversion positively influences affective commitment among healthcare professionals

H1b: Extraversion positively influences normative commitment among healthcare professionals

AGREEABLENESS AND ORGANIZATIONAL COMMITMENT

Agreeableness represents individual traits such as cooperativeness, tolerance, generosity and trust [37]. Agreeable individuals have the propensity to assist others [32]. This willingness might translate into a propensity to assist the whole organization, which could lead to strong work commitment [38]. Highly agreeable employees are motivated to satisfy basic needs connected to affiliation by being compliant, loyal and trusting [39]. Due to their motive of getting along with others, agreeable employees try to establish and maintain harmonious relationships with other organizational members [40, 41]. These interpersonal bonds contribute to a pleasant work environment and reinforce emotional attachments to the organization [14]. However, this association has received limited attention from researchers, though it seems theoretically sound. Additionally, agreeable individuals are kind, accommodating, and selfless. People who have these characteristics are more likely to develop obligations to their organizations. Moreover, agreeableness should be

connected to emotional warmth that positively influences an employee's social identity with the work environment [17]. This can result in enhancing his or her need to reciprocate the organization for providing a supportive social environment. Similarly, in hospital settings, team-based work of doctors, nurses and paramedics depends heavily on trust, cooperation and low interpersonal conflict. Particularly in case of critical service delivery and direct patient care, there remains a great demand for interdependence and collaboration among different healthcare professionals [24, 25]. Hence, agreeable employees are more probable to relate to a hospital's caregiving mission and to experience a sense of belonging towards it. In line with this, it is hypothesized that:

H2: Agreeableness positively influences organizational commitment among healthcare professionals

H2a: Agreeableness positively influences affective commitment among healthcare professionals

H2b: Agreeableness positively influences normative commitment among healthcare professionals

CONSCIENTIOUSNESS AND ORGANIZATIONAL COMMITMENT

Conscientiousness represents the propensity to be responsible, trustworthy, diligent, persistent, punctual and work-oriented [42]. Several scholars have proposed conscientiousness as the dispositional basis of organizational commitment [43,44]. Conscientious employees possess a "generalized work involvement tendency" [41; p. 341], owing to which these employees are more likely to form an emotional connection with the organization. Employees who exhibit high levels of conscientiousness have a strong desire to be appreciated and recognized by their employers [21]. Both tangible and intangible rewards are extremely enjoyable for these employees since they act as testimonials of their hard work. Therefore, receiving rewards may lead to more affective commitment among such employees [45]. Apart from that, highly conscientious people are also expected to have higher levels of normative commitment [14, 21]. Since they sense moral obligations to conduct honorably for their organization, these people are more likely to experience higher degrees of normative commitment [14]. Highly conscientious workers continue to carry out their obligations and responsibilities, even when they feel that their growth efforts are not being supported in any significant way [46]. Owing to their dispositions of dependability and loyalty, conscientious workers prefer establishing and upholding a long-term relationship with their organization [47]. Hence, normative commitment may be thought to be only naturally due [48].

In healthcare sector, job duties and procedures are usually standardized, governed by rules, and required to adhere to professional guidelines. Healthcare workers' negligence, disregard for regulations, and lack of attention to detail can have an adverse impact on patient safety [24]. Consequentially, conscientious employees are best suited to working in such an environment. Moreover, conscientiousness has been identified by numerous researchers as the most pertinent trait in healthcare, predominantly for addressing public health emergency situations such as pandemics [25, 49]. This clearly indicates that conscientiousness aligns well with the level of professionalism required in medical settings, thereby making these employees committed to their roles and organizations. Against this argument, the study hypothesized that:

H3: Conscientiousness positively influences organizational commitment among healthcare professionals

H3a: Conscientiousness positively influences affective commitment among healthcare professionals

H3b: Conscientiousness positively influences normative commitment among healthcare professionals

RESEARCH METHODOLOGY

PARTICIPANTS AND PROCEDURE

The data were collected from employees working across tertiary care public hospitals in Jammu and Kashmir, India. Prior to data collection, necessary approvals were obtained from the relevant hospital authorities. Additionally, information regarding the total number of employees was gathered to facilitate sampling. The total population (N) was 7151. To determine the optimal sample size, the formula given by Yamane [50] was applied that yielded a required sample of 379 participants. These respondents were selected using a systematic random sampling technique. The study participants were selected at an interval of five from the list of employees provided by each tertiary care hospital.

DEMOGRAPHIC PROFILE

Out of 379 healthcare professionals, 37% were doctors, 45% were nurses, and 18% were paramedics. Out of these respondents, 42 % were males and 58% were females. It was further revealed that the majority of the respondents had

MD/MS/DNB/M.Sc. (49.10%) as their highest qualification. Most of them fall in the age group of 25-39 years (66.20%) and had less than ten years of job experience (71.50%).

MEASURES

A questionnaire containing 26 items for measuring the select personality traits and 12 items for measuring affective and normative commitment was self-administered. To measure personality traits, items were adopted from Big Five personality scale [51]. Likewise, organizational commitment scale [52] was adopted for measuring affective and normative forms of commitment. The study participants were asked to respond to these questionnaire items on a five-point Likert scale - with 1 indicating 'strongly disagree' to 5 indicating 'strongly agree'. Further, the respondents were assured about the anonymity and confidentiality of data well in advance.

COMMON METHOD BIAS (CMB)

The study used Harman's single-factor test and full collinearity test to assess CMB. The result of Harman's single-factor test revealed that the total variance explained by a single factor was 28.99%, which is below the threshold limit of 50% [53]. Moreover, the full collinearity test also indicated that there were no significant issues regarding CMB in the data because the inner VIFs of all the latent constructs (Table 1) were also below the threshold of 3.3 [53].

TABLE 1: FULL COLLINEARITY TEST

Variables	AC	AGREE	CONS	Dummy	EXTRA	NC
AC				1.192		
AGREE				1.902		
CONS				2.191		
Dummy						
EXTRA				1.781		
NC				1.309		

RESEARCH ETHICS

The data used in this study were collected on an individual basis, with all respondents' identities kept strictly confidential. The research adhered to the fundamental principles of informed consent and confidentiality. Participants voluntarily agreed to take part in the study after being adequately informed about its purpose and scope. Moreover, formal research permission was granted by the healthcare authorities (Reference Numbers: DHSK/Sch/1236-39, dated 10/02/2021, and SIMS/ACAD/Data/21-2691-95, dated 22/03/2021). The approval granted by the healthcare authorities served as the institutional clearance.

DATA ANALYSIS AND RESULTS

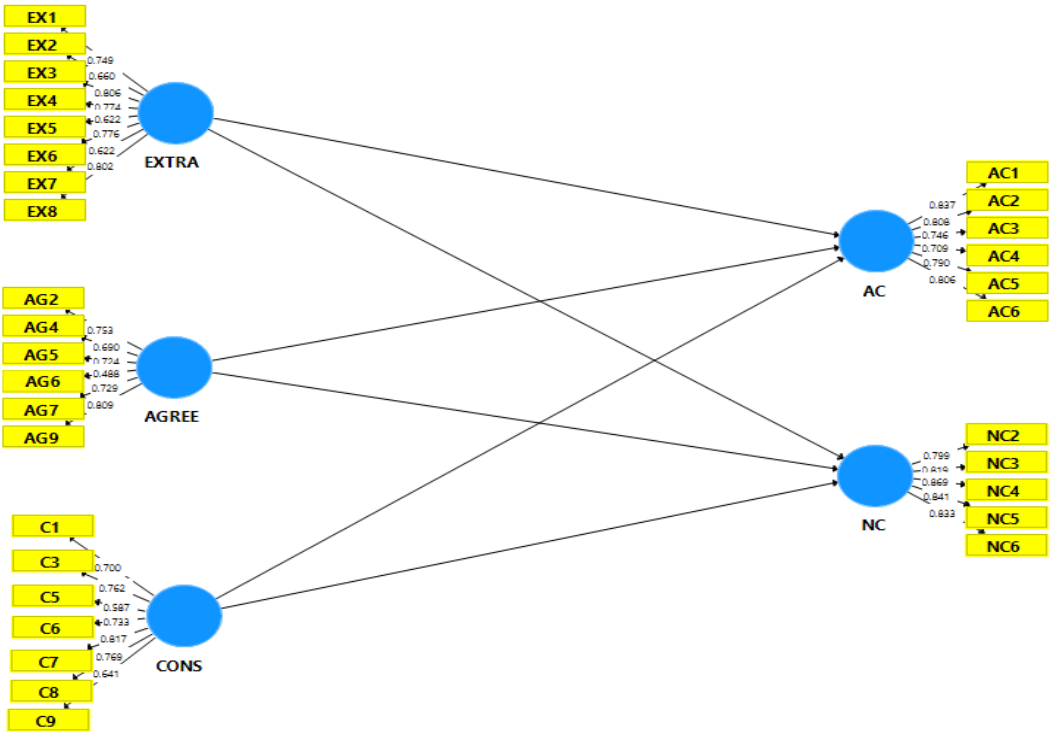
In line with the previous research, the study has employed the PLS-SEM technique through SmartPLS to analyze the data [54-56]. This technique was selected because the current study aimed to explain variance in organizational commitment which is a higher-order construct. The presence of a higher order construct adds complexity to the model. Subsequently, the two-step procedure (measurement and structural model assessment) was used to analyze the data [56] as recommended by Hair et al. [59].

MEASUREMENT MODEL ASSESSMENT

In this assessment, the factor loadings of the scale items, reliability, and validity scores of the constructs are determined [59, 60]. As indicated by experts, e.g., Roy et al. [61] organizational commitment is a higher-order reflective construct, hence we have to conduct hierarchical component modeling (HCM) in two stages [62]. In the first stage, the lower-order constructs viz., three personality traits and two components of organizational commitment will be tested for their reliability and validity (figure 1), followed by the second stage in which higher-order construct- organizational commitment will be assessed (figure 2).

Stage 1: The factor loadings for all the items of lower-order constructs were found above the acceptable limit of 0.5 [63], except for six items of personality traits and one item of normative commitment. All these items were excluded from further analysis except one item (AG6) whose loading was 0.488. According to Hair et al. [63], an item with loading above 0.4 can be retained if it does not have any adverse impact on the composite reliability (CR) and average variance extracted (AVE) scores of that construct. As revealed by Table 2, the CR and AVE values for agreeableness meet respective threshold limits of 0.7 and 0.5, therefore AG6 was retained for further analysis.

FIGURE 1. LOWER-ORDER MEASUREMENT MODEL



The reliability of all study constructs was determined via Cronbach Alpha and composite reliability measures (see Table 2). All the scores for Cronbach Alpha were above 0.7 recommended level [63], hence the reliability of the lower-order constructs was confirmed. In addition, the composite reliability scores were above the threshold of 0.7. Further, the AVE values for all the selected personality traits, affective and normative commitment meet 0.5 threshold level [64]. Hence, the convergent validity for all the lower-order constructs was also established.

TABLE 2: RELIABILITY AND CONVERGENT VALIDITY SCORES

Construct	Cronbach- Alpha	Composite Reliability	AVE
Extraversion	0.881	0.900	0.533
Agreeableness	0.792	0.854	0.500
Conscientiousness	0.842	0.881	0.518
Affective Commitment	0.877	0.905	0.614
Normative Commitment	0.889	0.919	0.693
Organizational commitment	0.782	0.902	0.821

To determine the discriminant validity, HTMT ratio criterion was employed. As shown in Table 3, all the scores obtained were below the recommended value of 0.85 [65]. Therefore, the discriminant validity of all lower-order constructs stood confirmed.

TABLE 3: DISCRIMINANT VALIDITY OF LOWER ORDER CONSTRUCTS (HTMT RATIO)

Variables	AC	AGREE	CONS	EXTRA	NC
AC					
AGREE	0.415				
CONS	0.489	0.798			
EXTRA	0.367	0.586	0.650		
NC	0.697	0.453	0.464	0.283	

Moreover, cross loading criterion was employed to check whether factor loadings of all the items were stronger on the underlying construct to which they belong instead of other constructs. The results as displayed in Table 4 evidenced for discriminant validity of the lower order constructs.

TABLE 4: DISCRIMINANT VALIDITY OF LOWER ORDER CONSTRUCTS (CROSS LOADINGS CRITERION)

	AC	AGREE	CONS	EXTRA	NC
AC1	0.836	0.291	0.363	0.294	0.599
AC2	0.806	0.414	0.430	0.338	0.562
AC3	0.748	0.200	0.288	0.255	0.367
AC4	0.711	0.182	0.234	0.163	0.353
AC5	0.791	0.231	0.305	0.250	0.467
AC6	0.804	0.323	0.384	0.332	0.582
AG2	0.281	0.753	0.505	0.393	0.257
AG4	0.184	0.690	0.372	0.318	0.314
AG5	0.263	0.724	0.472	0.417	0.283
AG6	0.241	0.488	0.363	0.391	0.205
AG7	0.229	0.729	0.508	0.318	0.222
AG9	0.333	0.809	0.534	0.437	0.324
C1	0.237	0.504	0.700	0.447	0.231
C3	0.293	0.597	0.762	0.470	0.316
C5	0.333	0.310	0.588	0.332	0.282
C6	0.282	0.509	0.733	0.429	0.309
C7	0.356	0.629	0.816	0.548	0.368
C8	0.383	0.440	0.769	0.490	0.317
C9	0.299	0.278	0.642	0.305	0.217
EX1	0.189	0.333	0.319	0.748	0.137
EX2	0.227	0.239	0.314	0.660	0.124
EX3	0.328	0.517	0.543	0.806	0.280
EX4	0.248	0.531	0.519	0.774	0.225
EX5	0.141	0.180	0.273	0.622	0.056
EX6	0.348	0.474	0.594	0.776	0.339
EX7	0.193	0.169	0.331	0.622	0.052
EX8	0.286	0.437	0.432	0.802	0.254
NC2	0.428	0.305	0.336	0.220	0.801
NC3	0.518	0.295	0.296	0.182	0.821
NC4	0.614	0.346	0.417	0.282	0.870
NC5	0.495	0.296	0.292	0.271	0.837
NC6	0.594	0.349	0.354	0.255	0.833

Stage 2: In this stage, two lower-order constructs viz. affective commitment and normative commitment were entered as two indicators of the organizational commitment (OC) (higher-order construct) (Figure 2). The factor loadings of

organizational commitment were found above the threshold of 0.5. Additionally, the Cronbach alpha, composite reliability and AVE scores for organizational commitment were also satisfactory as displayed in Table 2. Using the methods of HTMT (Table 5) and Cross loading (Table 6), the discriminant validity of organizational commitment was also confirmed.

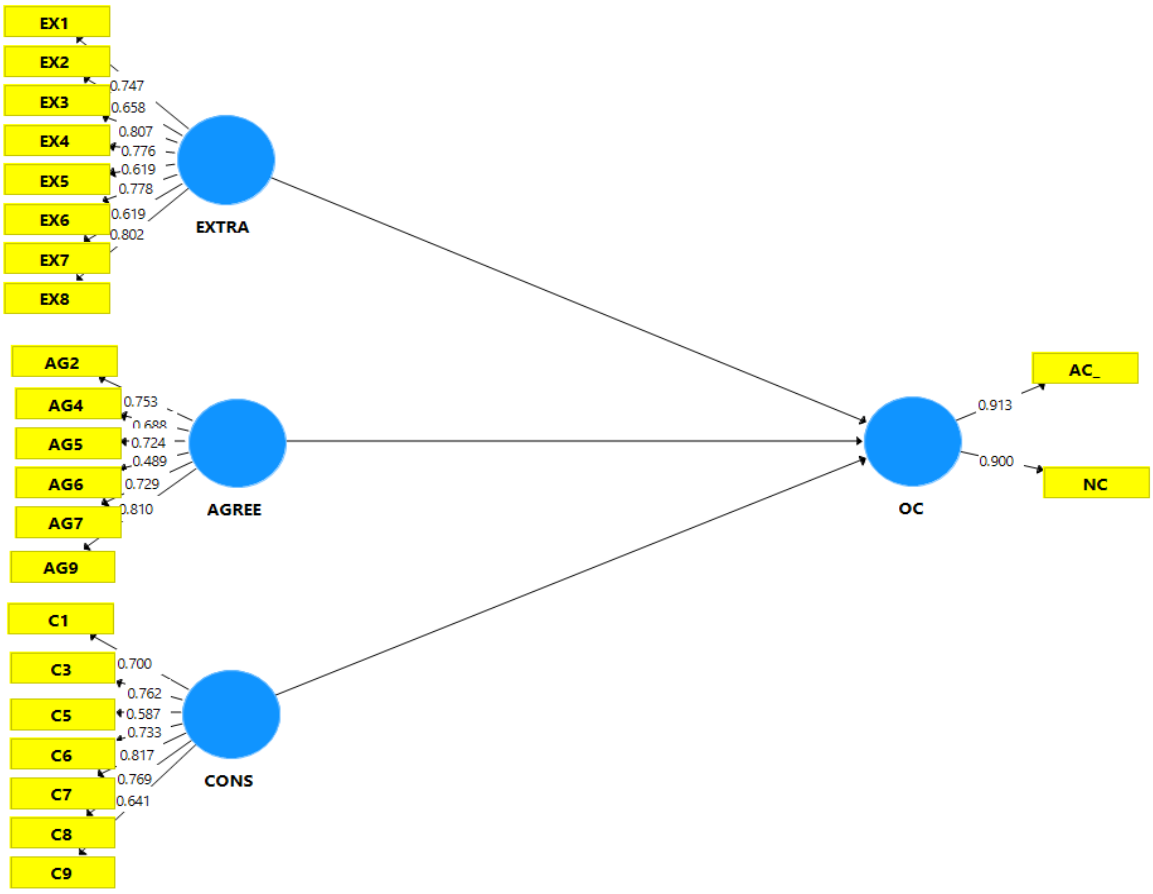
TABLE 5: DISCRIMINANT VALIDITY OF HIGHER ORDER CONSTRUCT (HTMT RATIO)

Variables	AGREE	CONS	EXTRA	OC
AGREE				
CONS	0.798			
EXTRA	0.586	0.650		
OC	0.524	0.573	0.386	

TABLE 6: DISCRIMINANT VALIDITY OF HIGHER ORDER CONSTRUCTS (CROSS LOADINGS CRITERION)

1.	2. AGREE	3. CONS	4. EXTRA	5. OC
6. AG2	7. 0.753	8. 0.506	9. 0.394	10. 0.298
11. AG4	12. 0.688	13. 0.372	14. 0.319	15. 0.273
16. AG5	17. 0.724	18. 0.472	19. 0.418	20. 0.301
21. AG6	22. 0.489	23. 0.363	24. 0.390	25. 0.247
26. AG7	27. 0.729	28. 0.508	29. 0.320	30. 0.249
31. AG9	32. 0.810	33. 0.534	34. 0.437	35. 0.363
36. C1	37. 0.504	38. 0.700	39. 0.448	40. 0.259
41. C3	42. 0.597	43. 0.762	44. 0.471	45. 0.336
46. C5	47. 0.310	48. 0.587	49. 0.330	50. 0.340
51. C6	52. 0.509	53. 0.733	54. 0.430	55. 0.326
56. C7	57. 0.629	58. 0.817	59. 0.549	60. 0.400
61. C8	62. 0.441	63. 0.769	64. 0.491	65. 0.387
66. C9	67. 0.278	68. 0.641	69. 0.304	70. 0.286
71. EX1	72. 0.333	73. 0.319	74. 0.747	75. 0.182
76. EX2	77. 0.239	78. 0.314	79. 0.658	80. 0.196
81. EX3	82. 0.517	83. 0.543	84. 0.807	85. 0.337
86. EX4	87. 0.531	88. 0.519	89. 0.776	90. 0.262
91. EX5	92. 0.181	93. 0.273	94. 0.619	95. 0.111
96. EX6	97. 0.475	98. 0.594	99. 0.778	100.0.380
101.EX7	102.0.169	103.0.331	104.0.619	105.0.138
106.EX8	107.0.437	108.0.432	109.0.802	110.0.299
111.AC	112.0.368	113.0.441	114.0.361	**115.0.913**
116.NC	117.0.384	118.0.412	119.0.295	**120.0.900**

FIGURE 2. HIGHER ORDER MEASUREMENT MODEL



STRUCTURAL MODEL ASSESSMENT

This assessment involves testing hypotheses and determining the explanatory power of the model. The study utilized bootstrapping procedure with 5000 subsamples to test the statistical robustness of results. Moreover, significance levels for one-tailed testing along with bias-corrected and accelerated (BCa) bootstrap confidence intervals approach were employed to run the procedure. Table 7 reveals the results of all the research hypotheses.

As indicated by results, extraversion did not have any significant influence on overall organizational commitment among hospital employees which is evident with its p-value beyond 0.05 level, hence this hypothesis (***H1***) was not supported. However, extraversion has a significant positive impact on affective commitment (β = 0.122, p < 0.01**).** Although the effect size is modest, it is significant in OB research where personality traits often produce small but stable effects [66]. Hence, ***H1a*** stands supported. Furthermore, it was also revealed that extraversion has no significant impact on normative organizational commitment (β = 0.026, p > 0.01**).** Hence**, *H1b*** was not supported.

The table also reveals that agreeableness has a significant positive impact on organizational commitment **(**β = 0.165, p <0.01**)**, thereby supporting ***H2.*** This finding indicates that healthcare employees who are agreeable, kind and cooperative tend to exhibit high level of commitment towards their organization. Moreover, agreeableness has significant positive impact on affective commitment (β =0.108, p <0.01) and normative commitment (β =0.194, p <0.01). Hence, sub-hypotheses ***H2a***, and ***H2b*** were also supported.

Likewise, as hypothesized ***(H3)***, conscientiousness trait was found to exert a significant and substantial influence on the level of overall organizational commitment (β =0.312, p <0.01). Highly conscientious healthcare employees are more likely to form enduring psychological bonds with their workplace. Furthermore, the findings also indicated significant positive impact of conscientiousness on both affective (β =0.297, p <0.01). and normative (β =0.269, p <0.01). forms of commitment. Hence, ***H3*** and its sub hypotheses ***H3a*** and ***H3b*** were all supported in the current study.

Additionally, ***Coefficient of Determination (R^2)*** calculated to assess the explanatory power of the model revealed an adjusted R^2 value of 0.240. Since the study model comprises multiple independent variables, therefore adjusted R^2 was used. Adjusted R^2 accounts for the number of predictors and penalizes for adding irrelevant variables. Therefore, it provides a more accurate estimate of the model's explanatory power [67]. In this study, the adjusted R^2 value indicated that 24% of the variance in organizational commitment was explained by the select personality traits. Though this value might seem to be moderate, it is not unusual in social science research because several factors interact and affect human behaviors and attitudes. Moreover, this value is in line with recommended score of 0.10 or above [68]. Hence, it can be concluded that the explanatory power of the model (figure 3) was satisfactory. It suggests that personality traits have a significant, though not exclusive, influence on organizational commitment. Moreover, the R^2 values for affective commitment and normative commitment were 0.230 and 0.201 respectively, when modeled separately as lower order constructs. These values also indicated moderate explanatory power of the respective models. Furthermore, Stone-Geisser's Q^2 value for organizational commitment was 0.194 (greater than 0), which confirmed the predictive relevance of the model.

FIGURE 3. STRUCTURAL MODEL (AFTER BOOTSTRAPPING)

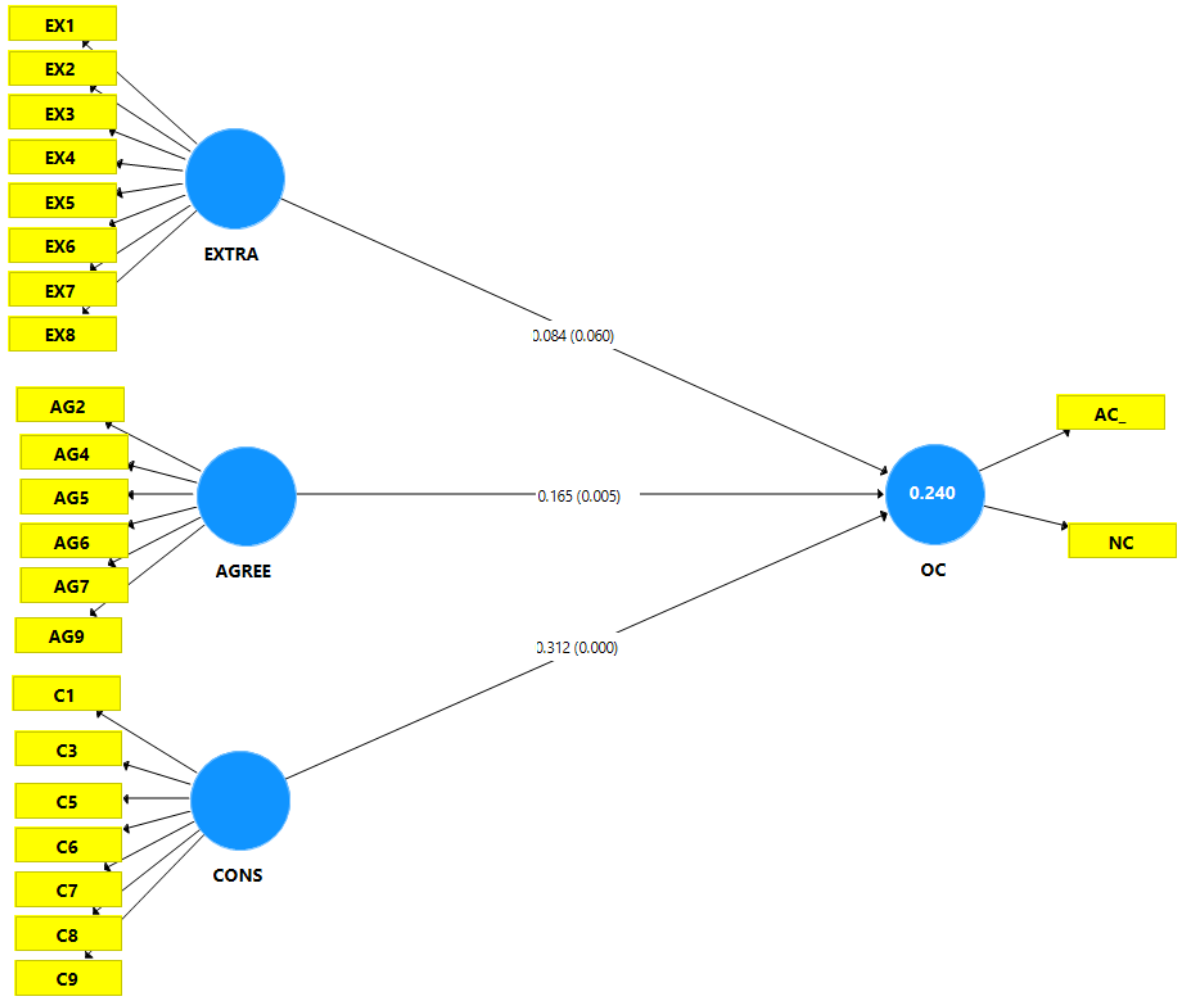


TABLE 7: HYPOTHESES TESTING (PATH COEFFICIENTS, T VALUES, AND P VALUES)

Hypotheses	Coefficient	S. D	t- value	p-value	LLCI	ULCI	Decision
(H1) Extraversion-> OC	0.084	0.063	1.559	0.060	-0.008	0.166	Not supported
(*H1a*) Extraversion-> AC	0.122	0.059	2.067	0.002	0.030	0.228	Supported
(*H1b*) Extraversion-> NC	0.026	0.054	0.475	0.317	-0.058	0.122	Not Supported
(H2) Agreeableness-> OC	0.165	0.063	2.595	0.005	0.059	0.265	Supported
(*H2a*) Agreeableness-> AC	0.108	0.065	1.649	0.050	0.006	0.222	Supported
(*H2b*) Agreeableness-> NC	0.194	0.066	2.934	0.002	0.088	0.305	Supported
(H3) Conscientiousness-> OC	0.312	0.068	4.567	0.000	0.200	0.421	Supported
(*H3a*) Conscientiousness-> AC	0.297	0.074	4.008	0.000	0.173	0.414	Supported
(*H3b*) Conscientiousness-> NC	0.269	0.071	3.786	0.000	0.150	0.383	Supported

LLCI- lower limit confidence interval

ULCI- upper limit confidence interval

DISCUSSION AND IMPLICATIONS

The study did not find extraversion exerting any significant influence on the level of organizational commitment among hospital professionals. Since extraverted individuals have inclinations towards sociability and positive affectivity, these employees tend to get more attached to their organizations. Besides, in case of public hospitals, immense traffic of patients is witnessed on a daily basis. The shortage of healthcare workers in hospitals makes the situation even more challenging [13]. According to [69, 71], owing to heavy workload, extended working hours, and insufficient rest time, healthcare professionals experience high stress, which leads to burnout, thereby minimizing their social interactions to the least. The lack of socialization might not bode well with these extraverted workers, leading to lower levels of organizational commitment. Moreover, given such circumstances, hospitals might not provide a welcoming social atmosphere to extraverted employees. Due to this deficiency, healthcare employees may not be expected to feel obliged to reciprocate to the organizations and show higher levels of normative commitment. Furthermore, a study by Spagnoli and Caetano [73] in the Portuguese context reported that extraversion had no significant impact on normative commitment, hence substantiating the study findings. On the other hand, the study has revealed a positive effect of extraversion on affective commitment. The plausible explanation might be that the extraverted employees' optimism plays a significant role in emotionally charged hospital environments [25]. Their ability to remember good things at the workplace may also foster their level of affective commitment. This finding is in line with previous studies [34] that have also found extraverted employees emotionally attached to their workplace.

The study has also revealed agreeableness as a significant antecedent of organizational commitment and its two components, which is in line with several studies that have assessed the relationship in other contexts [19,21, 26, 42]. This finding suggests that agreeable employees may develop commitment primarily through a sense of moral obligation towards their organization rather than solely through emotional attachment. Thus, the result holds particular relevance in

healthcare environments, given the profession's emphasis on teamwork, trust, prosocial behavior, patient care, and adherence to ethical responsibilities [24, 25]. Agreeable people are characterized by cooperation, compassion, altruism, loyalty, and concern for maintaining interpersonal relationships [39, 40]. These characteristics may make them more likely to remain committed, as they may perceive a moral obligation to support colleagues, patients, and the broader goals of the organization.

Moreover, the findings revealed that conscientiousness trait exhibits a significant positive effect on both forms of commitment. In line with several previous studies [22, 43, 47], this study has also found conscientiousness as a relevant trait to determine overall commitment. Owing to their features of dependability, dutifulness, and achievement-seeking, conscientiousness has been identified by numerous researchers as an important trait in healthcare [25, 49]. This indicates that conscientiousness aligns well with the level of professionalism required in hospital settings. This might result in making these employees exhibit high levels of affective and normative forms of organizational commitment. The study provides important theoretical and practical implications to the existing body of literature.

THEORETICAL IMPLICATIONS

This study contributes to the literature on organizational commitment by addressing the underexplored role of personality traits as its antecedents [21, 27]. While previous research primarily focused on situational and job-related factors, this study reinforces the argument that dispositional characteristics significantly shape organizational commitment [14, 19]. By demonstrating the impact of agreeableness and conscientiousness on both affective and normative commitment, the study supports the trait-based perspective of organizational behavior. Furthermore, the findings revealed agreeableness as relatively stronger predictor of normative commitment than affective commitment among healthcare professionals. This finding highlights the criticality of agreeableness in hospital settings for making employees feel more obligated to maintain their end of the social exchange by expressing normative commitment. Additionally, the findings challenge prior assumptions that extraversion universally fosters commitment. It is believed that extraverted employees frequently demonstrate higher levels of organizational commitment due to their propensity for sociability and building relationships with co-workers. The sense of belonging that is fostered by these social ties has a positive impact on commitment [35]. Additionally, the growing body of research has corroborated this assertion [14, 33, 34]. However, the present work has not found extraversion having any significant impact on organizational commitment among the healthcare employees. The probable reason could be heavy workload and staff shortages in public hospitals that might hinder socialization. This highlights the need for context-specific examinations of personality-commitment relationships. Moreover, this study enriches the cross-cultural understanding of organizational commitment by exploring these dynamics in a non-Western setting. Cultural diversity affects work attitudes, and the study's findings contribute to refining commitment models in varying sociocultural environments. The results also provide empirical backing to research that emphasizes the interplay of dispositional and contextual factors in shaping workplace attitudes.

PRACTICAL IMPLICATIONS

The study's findings hold significant practical relevance for hospital administrators in particular and HR professionals in general. Given that agreeableness and conscientiousness strongly influence organizational commitment, hospitals should incorporate personality assessments into their hiring and selection processes. Identifying candidates with these traits may lead to a more committed workforce, ultimately improving patient care and the operational efficiency of healthcare organizations. Such committed healthcare workers could display better resilience in times of extreme work pressure, thereby reducing their likelihood of experiencing occupational burnout [74]. Furthermore, organizations can design specialized training programs to foster these traits among employees. For example, workshops that foster empathy and teamwork can boost agreeableness, while training in goalsetting and time management skills can improve conscientiousness. Mentorship initiatives that involve pairing employees with their role models can also promote development of more responsible behaviors. These organizations can also utilize team composition strategies to maximize performance and team dynamics. The study also suggests hospital management to create opportunities for social engagement that can enhance organizational attachment among extraverted employees.

Additionally, to mitigate stress and enhance commitment, hospital administrators should focus on improving working conditions. Implementing policies that promote work-life balance, mental health support and peer recognition can enhance employees' psychological well-being. This can reduce occupational stress and strengthen their organizational commitment. By integrating these insights into HR strategies, hospitals can improve employee retention, job satisfaction and overall organizational performance. This will ultimately result in benefiting both healthcare professionals and patients.

CONCLUSIONS

The study has tested linkages between the select personality traits and organizational commitment among hospital workers. The results revealed a significant impact of agreeableness and conscientiousness on their commitment levels. However, in case of extraversion, a significant impact was reported on affective commitment only. Hence, this study has contributed to the literature on organizational commitment by way of examining personality traits as antecedents to this job attitude. In that, this study has attempted to address recent scholarly calls by scholars who believe that dispositional characteristics play a significant role in shaping commitment [14,19,20]. This study has also added to the limited pool of such empirical works in a non-western context, thereby augmenting the literature by determining how individual predispositions influence his work commitment because of diversity in culture [26, 27]. In the light of these findings, the present study suggests that the hospital authorities should give due consideration to traits particularly agreeableness and conscientiousness while selecting, training and retaining employees. Through the alignment of human resource practices with these psychological elements, healthcare organizations can improve resilience and employee engagement. Ultimately, such strategic initiatives could prove instrumental for enhancing organizational performance. Simultaneously, these could assist in safeguarding long-term sustainability of the healthcare workforce amid global staffing shortages and growing environmental uncertainties.

LIMITATIONS AND FUTURE RESEARCH AVENUES

The present study, however, suffers from a few limitations. Although the study has focused on healthcare sector, the core insights derived have a broader applicability. Organizations in similar demanding, people-centered sectors, including education, social work or customer service might find it useful to consider these traits while designing various HR strategies. However, generalizing the results to other sectors should be ideally supported by further empirical studies. Future research is, therefore, suggested replicating the study in other sectors and cultures, in order to test the applicability of the current framework. In line with several studies [20, 61], the present study has measured organizational commitment as a reflective construct and examined affective and normative dimensions only. However, such exclusion may also limit the generalizability of the findings. Moreover, the moderate level of explanatory power (R^2 =0.24) of the model indicates that a large proportion of the variance remains unexplained. Hence, incorporating continuance commitment in the model could enhance the results. Similarly, several individual, organizational and contextual variables including work engagement, perceived organizational support, person-organization fit, ostracism or occupational burnout, could also influence the relationship between personality and commitment. Hence, future research is suggested to add some individual, organizational or contextual variable to the model as mediator/moderator to enhance its explanatory power. Moreover, the responses for dependent and independent variables were collected from the same source. Though statistical tests revealed no significant issues regarding CMB, there still remains a chance of biasness. Future research can obtain responses from various sources at different time intervals to avoid any possibility of CMB. Additionally, longitudinal research designs should be used by future research instead of cross-sectional designs to gain more valid insights about the relationship.

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CONFLICT OF INTEREST:

The authors declare they have no competing interests

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RESEARCH ARTICLE

A BLENDED LEADERSHIP MODEL FOR TURKISH HEALTH POLICY GOVERNANCE: INSIGHTS FROM PRIVATE HOSPITAL EXECUTIVES

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ABSTRACT

OBJECTIVE:

To determine the leadership characteristics of health policymakers in Türkiye from the perspectives of private hospital managers and to propose the most appropriate blended leadership model in line with the unique characteristics of the health sector.

DESIGN:

The study employed a qualitative research design with content analysis based on face-to-face semi-structured interviews.

SETTING:

Using purposive sampling, this exploratory case-based study included five managers from private hospitals (four secondary-level and one tertiary-level) operating in the Gaziosmanpaşa district of Istanbul, providing context-specific insights into the perspectives of private hospital executives.

MAIN OUTCOME MEASURES:

It was determined that all private hospital managers interviewed positioned Turkish healthcare policymakers as autocratic leaders, and it was observed that this leadership style caused resistance and loss of institutional autonomy in the sector.

RESULTS:

On the other hand, when private hospital managers were asked to recommend an appropriate leadership style to healthcare policymakers for the effective and efficient delivery of healthcare services, all managers recommended the adoption of Visionary, Democratic and Ethical leadership styles together, while 3 managers expressed the view that Servant leadership should also be included.

CONCLUSIONS:

The findings suggest that, due to the unique characteristics of the Turkish healthcare system, a single leadership style is not sufficient. Consequently, it has been established that healthcare policymakers should adopt a leadership model that combines Visionary, Democratic, Ethical, and Servant leadership styles. The adoption of this model by health policymakers to increase both transparency and stakeholder participation is not merely an academic recommendation but also an important managerial necessity for establishing efficiency and trust in the healthcare sector.

KEYWORDS

health policy, blended leadership, healthcare governance, autocratic leadership, qualitative research, private hospitals, policy makers.

INTRODUCTION

The healthcare sector in Türkiye operates within a highly centralized governance structure in which major policy decisions are primarily shaped by national health authorities and directly affect both public and private healthcare providers. As private hospitals play a substantial role in healthcare delivery and are highly sensitive to regulatory decisions, reimbursement policies, and competitive pressures, the leadership style adopted by health policymakers is of critical importance for the functioning and sustainability of the sector. The healthcare sector has a politically complex structure due to persistent ethical challenges, regulatory pressures, and rapid technological developments. Pandemics, economic crises, and other unforeseen global systemic shocks require health policymakers to adopt leadership approaches that are not only effective under current conditions but also adaptable to future developments. In such a volatile environment, maintaining quality and efficiency in healthcare provision depends heavily on the relational dynamics between policymakers and field actors. Studies have shown that top-down management approaches that do not adequately consider the views of healthcare managers may undermine institutional autonomy, reduce adaptability, and erode trust over time [1–6].

Private hospital managers represent a particularly important stakeholder group because they are directly affected by policy decisions related to reimbursement, pricing regulations, accreditation requirements, and market competition. As far as is known, their perspectives can provide valuable insights into how policy decisions are translated into operational realities and how leadership approaches may influence organizational performance and service delivery. In addition, emerging leadership literature suggests that complex healthcare systems may benefit from blended or fusion leadership approaches rather than reliance on a single leadership style [7-9]. Although a substantial body of research has examined different leadership theories, an extensive literature review indicates a paucity of research specifically exploring the leadership style of health policymakers and the most appropriate leadership model from the perspective of private hospital managers in Türkiye. Accordingly, this study explores how private hospital managers perceive the current leadership type(s) of Turkish health policymakers and proposes a blended leadership model consisting of visionary, democratic, ethical, and servant leadership styles.

METHODS

The study was conducted using a qualitative research design with content analysis and is best interpreted as an exploratory case-based inquiry [10]. The target population of the study comprises private hospital managers in Istanbul, while the sample is specifically drawn from the Gaziosmanpaşa district. Private hospital managers in the Gaziosmanpaşa district were identified as key stakeholders.

At the time of the study, it was determined that there were 8 private hospitals in the Gaziosmanpaşa district. However, interviews were conducted with 5 private hospital managers; 4 of these hospitals are second-level private hospitals and 1 is a third-level private hospital. Although 3 managers declined to be interviewed, the 5 interviews yielded repeated data, and no new themes or codes emerged after the fifth interview, suggesting that data saturation had been reached.

Participants were provided with brief definitions of 18 leadership types, adapted from Northouse (2021), to ensure terminological consistency across interviews [11]. These included charismatic, democratic, autocratic, laissez-faire, delegative, team, servant, visionary, participative, interactive, coercive, relational, educational, transformational, paternalistic, supportive, creative, and ethical leadership. Following this introduction, participants were asked the following questions:

Interview questions:

1. In the provision of healthcare services in Türkiye, which leadership style would you place healthcare policymakers in, and why?

2. Considering the unique characteristics of healthcare, what leadership style(s) would you recommend for healthcare service delivery?
3. What do you think might be the advantages and disadvantages of implementing this leadership model?

Data were collected through face-to-face interviews (June 2022) using a semi-structured form, with interviews lasting an average of 30 minutes. Data analysis was performed through content analysis of transcribed audio recordings. Subsequently, the written data were coded; categories were determined, themes of common topics were formed, and findings were defined and interpreted. Based on the participants' responses, the themes, categories, and codes created are presented in Table 1 in the findings section. Furthermore, the participants' statements corresponding to the codes indicated in the table are presented verbatim in quotation marks and italics. The numbers at the end of the statements indicate the participant numbers.

To enhance analytical credibility, the coding and theme development process was independently reviewed by a qualitative research expert.

ETHICAL CONSIDERATIONS

The study procedures were conducted in accordance with relevant institutional/national ethical standards. The study was conducted in accordance with the decision of the Istanbul Medipol University Ethics Committee dated 23 June 2022, No. 579. Informed verbal consent was obtained from participants on a voluntary basis during interviews. To ensure the confidentiality of participants' and hospitals' names, hospitals and participants are referred to using codes (e.g., H1, H2).

RESULTS

TABLE 1: PRIVATE HOSPITAL MANAGERS' PERCEPTIONS OF HEALTH POLICY LEADERS: CONTENT ANALYSIS RESULTS

Theme	Category	Codes	H1	H2	H3	H4	H5
1. Determining the Type of Leadership Used by Health Policy Makers and Factors Influencing This Choice	1.1. Type of Leadership Used	Autocratic Leadership	X	X	X	X	X
	1.2. Factors Influencing the Type of Leadership Used	Lack of Consultation	X	X	X		X
		Restriction	X	X	X		X
		Sanctions		X	X		
		Inability to Reach Authorities		X	X	X	X
2. Leadership Types Proposed by Hospital Managers in the Provision of Healthcare Services	2.1. Recommended Leadership Types	Ethical Leadership	X	X	X	X	X
		Servant Leadership	X	X	X		
		Visionary Leadership	X	X	X	X	X
		Democratic Leadership	X	X	X	X	X
3. Opinions on the Use of Leadership Styles Recommended by Hospital Administrators in the	3.1. Advantages of Using the Recommended Model	Rapid Decision Making	X	X	X	X	X
		Ability to Compete on Equal Terms	X	X	X		

Provision of Healthcare Services		System Development	X	X		X	X
		Feeling Valued	X	X	X		X
		Growth of the Sector	X	X			X
		Easy Access	X	X	X	X	X
		Reduced Workload	X	X	X		X
		Service Quality	X	X	X	X	X
		Efficiency	X	X	X	X	X
		Satisfaction	X	X	X	X	X
		Up-to-date Data	X	X	X	X	X
		Time Saving		X			X
	3.2. Disadvantages of Using the Proposed Model	Undermining Authority		X			
		Misuse		X			
		Inability to Make the Right Decision				X	
		No Disadvantage	X		X		X

THEME 1: DETERMINING THE TYPE OF LEADERSHIP USED BY HEALTH POLICYMAKERS AND THE FACTORS INFLUENCING THIS CHOICE

Category 1.1 in the table: There was unanimous agreement among all five participants that Turkish health policymakers predominantly adopt an autocratic leadership style.
H5: 'Autocratic leadership because the state alone determines all the rules of the healthcare services we provide, and we are obliged to sign the contract...'

Category 1.2 in the table: The codes under this category indicate that participants perceived the current policy environment as highly centralized and restrictive. Participants consistently reported limited consultation, extensive sanctions, and difficulties in communicating directly with policymakers. Together, these experiences suggest that the prevailing leadership approach reduces institutional autonomy and constrains the ability of private hospitals to respond effectively to operational challenges.

H1: *'Regardless of the hierarchical position as a hospital manager, or where you are in the healthcare system, in this country, many healthcare issues are managed through official letters sent to you a certain time in advance. For example, the conditions and capabilities of my hospital are never the same as those of hospital X in terms of being able to comply with the decision(s) taken, but these rules apply equally to all of us. So, the boundaries are very sharply drawn here ...'*
Participants attribute the abundance of sanctions and the inability to reach the authorities to the sector being managed with autocratic leadership.

H2: *'The SGK tells me that it allows me to charge the patient a 200% difference, but I cannot charge more than that. For example, the SGK pays me 32 TL for an internal medicine consultation, 3x2, 64 TL, and says you can charge the patient this amount. But it is impossible for me to run the hospital with these amounts. Unfortunately, when we try to convey the problems we experience in this field, we cannot reach the authorities...'*

THEME 2: TYPES OF LEADERSHIP PROPOSED BY HOSPITAL MANAGERS IN THE PROVISION OF HEALTHCARE SERVICES

Category 2.1 in the table: Participants consistently emphasized that no single leadership style would be sufficient to address the complexity of healthcare governance. There was unanimous agreement that ethical, visionary, and democratic leadership styles should be adopted together, while three participants additionally recommended the inclusion of servant leadership to strengthen operational support for healthcare institutions.

H5: *'By consulting those directly involved in the field, we can achieve the best outcome for the healthcare system. Furthermore, technology is advancing rapidly, and there are numerous innovations to keep up with. The world has become quite small; diseases and epidemics can spread through human travel. From this perspective, healthcare policymakers need to clearly define their vision for the future, and all leaders must act fairly and ethically...'*

Regarding politicians adopting a servant leadership style:
H3*: 'As the healthcare sector is an incredibly fast-growing structure, unfortunately, unilateral decision-making proves ineffective in the current dynamic landscape, they must support hospitals by backing policy decisions with necessary financial allocations to improve the country's healthcare system...'*

THEME 3: VIEWS ON THE USE OF LEADERSHIP STYLES RECOMMENDED BY HOSPITAL MANAGERS IN THE PROVISION OF HEALTHCARE SERVICES

Category 3.1 in the table: The codes under this category indicate that participants expected the proposed blended leadership model to facilitate more rapid and informed decision-making, improve communication and access to policymakers, reduce operational burdens, strengthen perceptions of being valued, promote fair competition, enhance efficiency and service quality, increase patient satisfaction, provide more up-to-date information, save time, and support the overall development and growth of the healthcare sector.

- On the possibility of competing on equal terms, the growth of the healthcare sector, and the development of the healthcare system:

H1 *'First and foremost, I believe that the conditions of competition would be fairer. It would force you to work by reducing the scale of the risks you take without forcing you into anything, thereby encouraging you to provide better services. The most important thing we would achieve or aim for here would be an advanced healthcare system and the further growth of the sector...'*

- Regarding the ability to make quick decisions, making them feel more valued, reducing their workload, and improving service quality:

H2 *'...When the authorities support us in our responsibilities and work, we can already provide more dedicated service by minimizing the difficulties of our work... If these views are considered, managers' work environment will be eased, and they will be able to make faster decisions...'*

- Regarding increased patient satisfaction:

H3: *'It brings significant satisfaction to patients and the system develops... '*

- Regarding easy access to policymakers, time savings, and enabling officials to access up-to-date data on field issues:

H5 *"...when we try to reach the health minister, we first try to meet with the general manager, we try to meet with the department heads, and they also say they cannot meet with the minister themselves...As a result, time losses of perhaps 6 months, 8 months, 1 year, 2 years, or 5 years occur... Therefore, it is not possible to move forward and make decisions. However, if the model we propose is implemented, we can access the authorities more easily, and problems can be quickly resolved by hearing directly from the first hand, i.e., the managers in the field...'*

- Regarding increased efficiency:

H4 *'...When different ideas are heard, a more accurate decision will emerge... strategic thinking, research and developments will always steer the healthcare system in the right direction and increase efficiency...'*

Category 3.2 in the table: *When asked about the disadvantages that could arise from using the model they proposed in combination, three participants stated that there would be no disadvantages.*
Although most participants reported that the proposed model would have no significant disadvantages, two participants raised concerns regarding the possible erosion of authority, misuse of participatory processes, and the risk that decisions could be influenced by less informed stakeholders.

- *In this regard:*

H3*: 'There will be no disadvantages. After you have trained someone, selected the right person and placed them in the right department, given them the right authority, and made decisions democratically by discussing your decisions and visions together, combining these management models will never harm anyone...'*

- *Regarding the possibility of undermining authority and potential misuse:*

H2*: '... If implemented, the disadvantage is that authority may be undermined due to more moderate leadership, and of course, it may be abused depending on the individuals ...'*

- *Regarding the failure to make the right decisions:*

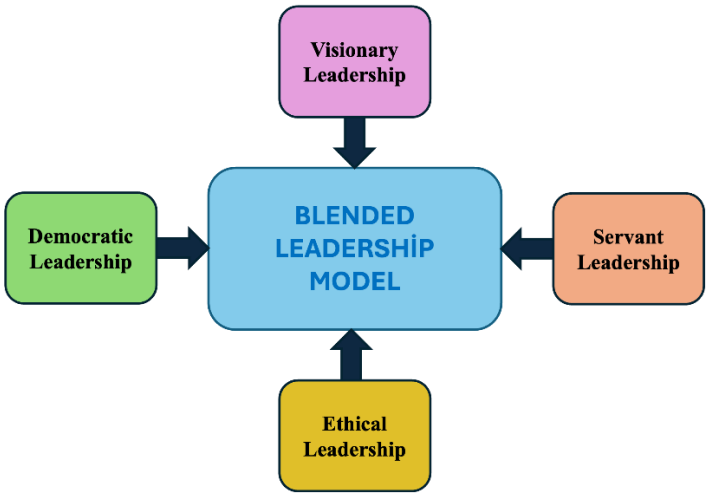
H4*: 'When everyone participates in the decision-making process, and since the participants do not have the same level of education and experience, and everyone has the same amount of say, those with less experience and knowledge can also be heard within the system. If everyone's opinion is equal, what the majority says becomes more important than how valuable the ideas are. Evaluating ideas can sometimes become difficult in such situations ...'*

Overall, the findings indicate that private hospital managers unanimously perceived Turkish health policymakers as adopting an autocratic leadership style characterized by limited consultation, regulatory restrictions, sanctions, and difficulties in accessing decision-makers. At the same time, participants consistently emphasized that no single leadership style would be sufficient to address the complexity of healthcare governance. Instead, they recommended a blended leadership model integrating visionary, democratic, ethical, and, where appropriate, servant leadership. According to participants, this model would improve communication, accelerate and enhance decision-making, strengthen efficiency and service quality, and support the long-term development of the healthcare sector. Although most participants anticipated no major disadvantages, some expressed concerns regarding the potential erosion of authority and the risk of less informed decision-making in highly participatory processes.

DISCUSSION

The study examined private hospital managers' perceptions of the current autocratic leadership style and recommended the adoption of a blended leadership model. Subsequently, as shown in Figure 1, a discussion will be held on the theoretical justification of each component of the blended leadership model, which combines different leadership styles, in line with the challenges of modern healthcare governance.

FIGURE 1: PROPOSED BLENDED LEADERSHIP MODEL



Although each leadership style in the blended leadership model proposed in Figure 1 is distinct, they are complementary in nature. The visionary leadership style provides long-term strategic direction. It also enhances preparedness for both technological and epidemiological changes. Democratic leadership not only encourages stakeholder participation but also ensures that policy decisions are informed by operational processes. Ethical leadership provides a normative safeguard by strengthening justice, accountability and transparency. Servant leadership, meanwhile, complements these elements by emphasising organisational support and sensitivity to the needs of healthcare providers. When all these leadership styles are used together, they form an integrated management model aimed at balancing strategic consistency, participation, ethical integrity and operational support.

Studies revealing the policy style in Türkiye have emphasized that the policy style has not changed despite changes in administrations and that characteristics reflecting the autocratic type have been reinforced under the leadership of healthcare policymakers [12,13]. This finding is consistent with the results of the study. As stated by private hospital managers, issues such as 'not being consulted' and 'restrictions' clearly reveal a centralized management style, particularly during the pandemic, where the rapid decision-making process was concentrated among a few health policymakers. On the other hand, there are studies in the literature that argue that an inclusive approach has been adopted in policy design and implementation in Türkiye [14].

This contradiction can be explained by differences in perspective and analytical focus. Previous studies appear to have characterized the policy-making process in Türkiye as inclusive at the macro level. In contrast, the findings of this study reflect the operational experiences of private hospital managers who are directly affected by reimbursement policies, pricing regulations and administrative sanctions. In particular, the urgency of crisis management during the COVID-19 pandemic may have strengthened the centralized decision-making process and reduced opportunities for stakeholders to participate meaningfully in decision-making processes. Therefore, policy processes described as inclusive at the macro policy level may still be perceived as more centralized in operational practice. Especially since health policy requires rapid decisions involving considerable risk, decisions made by policymakers can be dominant. This situation prevents private hospital managers from taking initiative due to sanctions, slowing down the adaptation process for healthcare service provision and negatively affecting innovation capacity.

The perception among private hospital managers that health policymakers adopt an autocratic leadership style serves both as a critique of the leadership style itself and as an indication of the extent to which institutional autonomy and health management professionals are constrained in policy design processes. Despite being the actors most affected by policy decisions in the field, hospital managers' views on 'inability to reach authorities' and 'excessive sanctions' indicate that the top-down management model in the literature is also evident in health policy processes [3-6]. Implementing autocratic decisions based on the assumption that all hospitals (private/public, small/medium/large) have equal conditions, regardless of type, can lead to inequality and inefficiency, especially for private healthcare institutions with

different conditions. This situation highlights the lack of horizontal cooperation and stakeholder participation, which is vital for effectively and efficiently resolving urgent and complex healthcare policy issues (pandemics, technological innovations, etc.) The lack of horizontal collaboration resulting from the autocratic leadership style in Turkish healthcare policy extends the study's findings to a global context. This situation shares conceptual similarities with healthcare governance challenges in other low-to-middle-income countries (LMICs) where policy processes are centralized and top-down. The study provides important empirical evidence supporting these global challenges, demonstrating how autocratic tendencies negatively affect hospitals' capacity for adaptation and innovation on a global scale [15-17]. Consequently, the evidence suggests that health policymakers' adoption of autocratic leadership may negatively affect the work productivity of hospital managers. The lack of decision-making power for managers under autocratic leadership, the inability to take initiative, and feeling disregarded are consistent with the finding of decreased work productivity [18].

The Visionary and Servant leadership types, which are key elements of the blended leadership model proposed by private hospital managers, stem from the unexpected nature of healthcare policy-making needs and the requirement for operational support. The healthcare sector is subject to continuous technological developments and may suddenly face global pandemic crises. Therefore, it is crucial for healthcare policymakers to adopt visionary leadership and develop adaptable strategies to address different problems, enabling them to make the necessary policy decisions to deliver high-quality and efficient healthcare services that can keep pace with technological advancements [1,2]. Furthermore, private hospital managers demand that healthcare policymakers, who embrace servant leadership, prioritise and support the needs of hospitals, thereby countering the criticism of the currently implemented 'top-down' management approach. This expectation supports the approach in the literature that servant leadership contributes to managerial success [19,20]. The adoption of democratic and ethical leadership, other key elements of the blended model, is essential for the quality of health policies and the establishment of trust in the health sector. The hospital managers' statement that 'no opinions were sought' clearly demonstrates the necessity of democratic leadership. Studies in the literature show that democratic leadership requires stakeholder participation and sensitivity to diverse communities to solve complex public health problems [21,22]. Accordingly, involving key actors such as hospital managers in the decision-making processes of health policymakers will also increase the applicability of the decisions taken in the field. On the other hand, the adoption of ethical leadership by health policymakers is imperative due to the risky nature of the healthcare sector [20,23]. However, although ethical leadership is extremely important in management, it should be used in conjunction with different leadership styles as it can be limited in supporting innovation [23]. In this respect, consistency with the research results has been established. The inclusion of these two main elements in the blended model will also create a foundation for hospital managers to feel that their opinions are valued and for the establishment of a sustainable environment of trust in the healthcare sector.

Studies in the literature reveal that adopting a single type of leadership is insufficient in the complex and dynamic field of healthcare governance [7-9,24]. Research findings indicate that current healthcare policymakers adopt an autocratic leadership style; however, this leadership style does not reflect the expectations of private hospital managers or the needs of the sector. The model proposed by private hospital managers is a blended model, as shown in Figure 1. This model consists of a blend of visionary, democratic, ethical, and servant leadership styles. The model aims to ensure that health policies are ethical, increase stakeholder participation, and prepare for crises. This study contributes to the literature by not only presenting the current leadership type but also proposing a leadership model that blends the four main leadership styles. Furthermore, this model is highly valuable from both an academic and practical perspective, as it is the first model to directly present the views and expectations of private hospital managers in Türkiye based on evidence obtained from the field.

Some participants expressed concerns that greater stakeholder involvement in decision-making processes could undermine authority, lead to abuse, or increase the influence of less experienced stakeholders on decision-making. This finding indicates that there is a legitimate tension between inclusivity and decisiveness in healthcare management. However, the proposed blended leadership model aims to balance these risks. In this regard, while visionary leadership ensures the preservation of strategic direction, ethical leadership contributes to strengthening the principles of

accountability and justice. It is believed that the combined use of these leadership styles will help to strengthen, rather than weaken, decision-making authority through broader stakeholder participation in decision-making processes.

CONCLUSIONS

The perceptions of private hospital managers reveal that the current autocratic leadership style of healthcare policymakers is inadequate due to the sector's specific needs. The primary contribution of this research is the conceptualization of a blended leadership model (Figure 1) consisting of Visionary, Democratic, Ethical, and Servant leadership styles that healthcare policymakers should adopt.

In terms of policy implementation, the adoption of Democratic and Ethical leadership should ensure transparent management and stakeholder participation. Managers anticipate that using the proposed model will increase decision-making speed, efficiency, and service quality facilitated by streamlined communication and a first-hand flow of up-to-date data. When the blended model is adopted, policy decisions will be made in a transparent and inclusive manner, improving the quality and efficiency of health policies. This also demonstrates the need for health policymakers to exhibit servant and visionary leadership styles.

In this framework, ethical leadership serves as a safeguard by reinforcing fairness, accountability, and transparency, thereby helping to ensure that broader stakeholder participation strengthens rather than undermines decision-making authority.

This study has some methodological limitations. It is a qualitative research design, and the findings are based on the perceptions of five private hospital managers in the Gaziosmanpaşa district of Istanbul. Therefore, the findings should be interpreted as context-specific and are intended to provide in-depth insights into the experiences and perceptions of private hospital managers within the study setting. Furthermore, it is recommended that the validity of the proposed blended leadership model be tested through mixed-methods research conducted in public and private hospitals in different regions of Türkiye. On the other hand, future research focusing on studies examining the effects of the leadership styles adopted by healthcare policymakers on hospital performance indicators using a quantitative research design could further examine the practical benefits of the model.

CONTRIBUTORS:

The author contributed to all stages of the study, including conceptualization, methodology, data collection, analysis, interpretation, and manuscript preparation. The author approved the final version of the manuscript.

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COMPETING INTERESTS:

The author declares no competing interests.

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RESEARCH ARTICLE

TRANSLATION, ADAPTATION, AND VALIDATION OF SURVEY ON PATIENT SAFETY CULTURE FOR AMBULATORY CARE IN JAPAN

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ABSTRACT

OBJECTIVE

There is no validated questionnaire in Japan to measure the culture of safety in ambulatory care clinics. Therefore, we developed the Japanese version of the Medical Office Survey on Patient Safety Culture (MOSPSC) of the Agency of Healthcare Research and Quality (AHRQ) in the United States with the aim to establish a tool for evaluating and benchmarking the safety culture of outpatient clinics in Japan.

DESIGN AND SETTING

This research uses both qualitative and quantitative approaches to translate, adapt and validate the MOSPSC questionnaire which consists of 62 questions. The process involved seven steps such as translation by two independent bilingual physicians, drafting and reviewing, backtranslation by two separate translation companies, semantic equivalence assessment by AHRQ and revision, pretest, focused discussion, and finalizing the questionnaire after expert review and proofreading. An actual safety culture survey was conducted with mainly online and paper versions at four clinics in Tokyo.

MAIN OUTCOME MEASURES

The survey results were evaluated for patient safety dimensions, reliability and construct validity.

RESULTS

Efforts are made to select appropriate terminology during tool adaptation processes due to different language and medical system between Japan and the United States. The response rate in the actual survey was 66.4% (242/364). Confirmatory factor analysis showed that factor loading and goodness of fit indices were better when 3 items were removed from the original 10-composite model with 38 items. The Cronbach's alpha coefficients of composite measures ranged from 0.62 to 0.78 in the original model and 0.62 to 0.85 in the new model, indicating good internal consistencies.

CONCLUSIONS

Considering the differences in medical systems, culture, and language between the United States and Japan, the instrumented was adapted with a satisfactory content validity and reliability.

KEYWORDS

safety culture, ambulatory care, MOSPSC, validation, adaptation.

BACKGROUND

With increasing complexity and advances in medicine, modern healthcare has become vulnerable to errors. Consequently, fostering a culture of safety has been prioritized in medical institutions in recent years. Safety culture is a sub-facet of the organizational culture that pertains to safety and reflects an organization's commitment to, and effectiveness in, health and safety management [1,2]. According to the Japanese Ministry of Health, Labour, and Welfare, safety culture in healthcare is defined as "A way of thinking or an attitude in which all the staff engaged in medical services give the highest priority to patient safety and strive for its realization, as well as the way organizations work toward that goal"[3].

Dr. James Reason identified five elements of safety culture: an informed culture, a reporting culture, a learning culture, a just culture, and a flexible culture [4]. The outcome of these safety cultures is reflected in medical errors, and it is important to analyze these errors from incident reports, mortality and morbidity conferences, and chart reviews [5-8]. As for a proactive approach to preventing errors, we can evaluate the pre-existing organizational culture in relation to safety, develop action plans for improvements, assess safety interventions and changes over time, and serve as internal and external benchmarking [9-10]. However, measuring safety culture presents several challenges [11]. Measurements include surveys, document reviews, work observations, individual interviews, and focused groups [12]. Among them, surveys are practical and time-efficient and, most importantly, provide ease of benchmarking.

There are different safety culture surveys in healthcare [13]. The most widely adopted international patient safety culture surveys were developed by the Agency of Healthcare Research and Quality (AHRQ). The Japan Council for Quality Health Care has used the validated Japanese version of the Hospital Survey on Patient Safety Culture (HSOPS) by the AHRQ to evaluate the safety culture of hospitals in Japan [14, 15]. Conversely, there is no questionnaire in Japan to evaluate the safety culture of ambulatory medical facilities.

The AHRQ has a safety culture survey called "Medical Office Survey on Patient Safety Culture (MOSPSC)" for ambulatory care. As of September 2022, it has been translated into 15 languages and conducted in 38 countries [16]. Yet, there is no Japanese version of the MOSPSC. Moreover, it is critical to develop a reliable and valid instrument that can be implemented at ambulatory medical institutions in Japan to evaluate safety culture, implement effective measures according to the survey results, and provide benchmarking with other facilities. Therefore, we developed a Japanese version of the AHRQ's MOSPSC to improve medical safety and quality in our group of clinics and expand its use for external benchmarking.

METHODOLOGY

INSTRUMENT

The MOSPSC consists of 62 questions, including free comments, and evaluates the safety culture of the respondents, the team they work for, their immediate supervisor, and the organization in sections A to H [17]. Question items in section A and B are based on a 6-point Likert scale (e.g., 1 = Daily, 2 = Weekly, 3 = Monthly, 4 = Several times in the past 12 months, 5 = Once or twice in the past 12 months, 6 = Not in the past 12 months) . Question items in section C through F are based on 5-point Likert scale (e.g., 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree). In those sections, score 9 refers to "Does Not Apply or Don't Know". Overall rating in section G was based on 5-point Likert scale (e.g., 1 = Poor, 2 = Fair, 3 = Good, 4 = Very good, 5 = Excellent). The details of the questionnaire items in English were provided as the supplementary data file.

FORWARD TRANSLATION

We developed the Japanese version of the MOSPSC in seven steps: Step 1 was the translation of the original MOSPSC questionnaire into Japanese by two bilingual physicians whose native language is Japanese, one of whom knew the purpose of the translation, and the other who did not. In Step 2, these two translations were reviewed by a review

committee consisting of the above two physicians, the principal investigator, and the chief nurse. The review committee identified noticeable differences in the classification and roles of medical professions between the United States and Japan and question items that were difficult to translate due to the use of double negatives. The review committee also referred to question items already included in the validated Japanese version of HSOPS for appropriate wording and structure [14]. After all these considerations, the two translations were modified and integrated into the first Japanese draft (T1).

BACK-TRANSLATION AND SEMANTIC EQUIVALENCE

Step 3 was the back translation into English by two external translators from different translation companies who were native English speakers and did not know the original English version of the questionnaire. Step 4 involved examining the semantic equivalence of the two back-translated versions with the original English version. They pointed out five points and we responded accordingly. The details are described in Supplementary data file. Based on our responses, the AHRQ determined that the items closely followed the original survey, and we proceeded with the next steps in administering the survey at our medical facilities. In Step 5, based on the feedback from the AHRQ, the review committee modified the integrated version (T1) into a revised version (T2).

PILOT TEST AND FOCUSED DISCUSSION

In phase I of Step 6, we created T2 as a web questionnaire using the Microsoft form application. We then conducted a preliminary test with 34 employees at the Tokyo Midtown Clinic in Roppongi. The preliminary test included twelve medical staff, eight nurses, five administrative staff, three clinical technicians, three radiological technicians, two nurse aids, and one manager. In phase II of Step 6, a focused discussion with five staff members from five different professions (i.e., doctors, nurses, clinical and radiological technicians, and administrative staff) was conducted to evaluate the clarity of the questions and the selection of appropriate words. Details are provided in Supplementary data file. The questionnaire edited in accordance with the focused group discussion results was termed T3.

PROOFREADING BY AN EXPERT AND ACTUAL SURVEY

Finally, in step 7, an expert Japanese language proofreader assessed the grammar, style, clarity, pertinence, and understandability of the contents. He suggested changing all sentences from the polite form to the dictionary form in Japanese. We developed the final version of the questionnaire (T4) to conduct an actual survey at four clinics in the Tokyo area: Tokyo Midtown Roppongi, Nihonbashi, Ariake, and Tokyo Bay, all of which belong to the Medical Corporation Midtown Clinic. A survey link was provided to all staff working at these facilities. For those who did not have email addresses or personal computers at the workplace, paper survey questionnaires were distributed, and patients were asked to drop them into a designated internal post box after completion. The survey was distributed and collected between September 21, 2023, to November 30, 2023. The timeline and flowchart for developing the questionnaire are outlined in Supplementary Figure file.

ETHICAL CONSIDERATIONS

The survey was conducted anonymously, in a self-administered manner. After explaining the purpose and other essential contents of the survey on the first page, we asked for consent. Only those who provided consent on the first page were included in the final analysis. The study was approved by the Institutional Review Board of The Midtown Clinic Medical Corporation (Rin-2021-10).

DATA ANALYSIS

First, we entered the data from the paper survey forms into a web form and saved the data file in Microsoft Excel. There was no missing data. We then coded the responses in accordance with the scales in each section: 1 to 5 in sections A and B, and 1 to 6 in sections C to G, with 9 coded for Does not Apply/Don't know. The next step was to check the data file for possible data entry errors using frequency tables for each item to ensure that all responses were within a valid range. We followed the AHRQ's MOSPSC data analysis guidelines to calculate the frequency percentages of positive responses to the single-item measures in sections A and B. We categorized the 38 items in sections C to F into 10 composite measures of patient safety culture and calculated the percent positive response, means, and composite measure scores.

Negatively worded items were reverse-coded, as recommended by the AHRQ. The results were then compared with those from the AHRQ database.

Cronbach's alpha coefficient and the average inter-item correlation (AIIC) were used to analyze reliability. We considered Cronbach's alpha values >0.6 adequate for each composite, and at least 0.9 for the entire questionnaire. AIIC evaluates the correlation of items within each composite, and a value between 0.15 and 0.5 is considered evidence that the items are measuring the same underlying composite [18]. For structural validity, we performed confirmatory factor analysis (CFA) to determine how well the Japanese version fits the composite structure of the original MOSPSC. We did not perform exploratory factor analysis because we aimed to maintain the same factor structure as the original MOSPSC for benchmarking, and the MOSPSC has already been validated across different languages. First, we conducted Kaiser-Meyer-Olkin (KMO) and Bartlett tests of sphericity to evaluate whether our sample size was appropriate for factor analysis. The cut-off value for factor loadings was set to 0.40. We set the criteria for goodness-of-fit indices based on previous studies [19]. CFA was repeated if the factor loadings or model fit indices were not acceptable.

Finally, we calculated polychoric correlations for the 10 composites of patient safety culture to verify construct validity, as the items were ordinal variables. Figures and tables were generated using Microsoft Excel and PowerPoint. Comparison with AHRQ database was conducted using the Medical Office Survey Excel Tool Version 6.2 July 2024.20 Data analysis and statistical tests were performed using the R software (R version 4.4.2). The CFA was performed using the "*lavaan*" package, and the Cronbach's alpha and AIIC calculations were performed using the "*psych*" package. Polychoric correlations and correlation plot were generated using the "*polycor*" and "*corrplot*" packages.

RESULTS

CHARACTERISTICS OF PARTICIPANTS

A total of 242 employees responded to the survey: 165 participated via the online form, and 77 returned the paper questionnaires. The response rate was 66.4% (242/364). Among 242 responders, 20 people did not give consent to participate in the study nor answer any survey questions. Therefore, we analyzed the data of the 222 participants who provided consent to participate in the study and answered the questionnaire (Figure 1). Detailed characteristics of the participants are presented in Table 1. The rates of participation according to occupation were 61%, 27%, 71%, 74%, and 60% for physicians, leaders and managers, administrative or clerical staff, nurses, and other clinical staff or paramedics, respectively.

FIRGURE 1. PARTICIPANT FLOWCHART

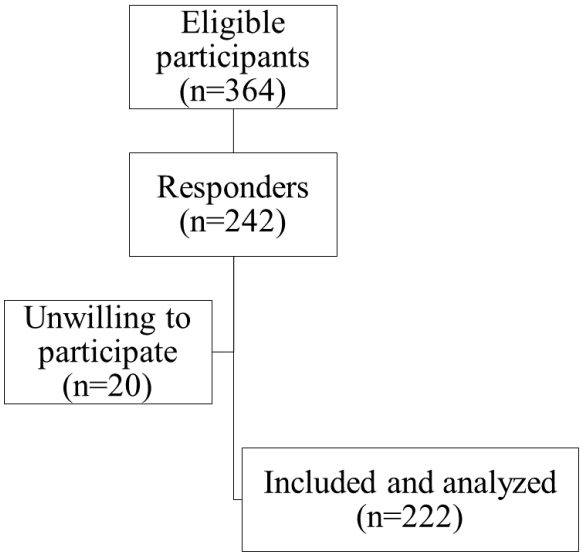


TABLE 1. CHARACTERISTICS OF THE PARTICIPANTS (N=222)

Variable	n	(%)
Years of experience		
Less than 2 months	9	(4%)
2 months to less than 1 year	32	(14%)
1 year to less than 3 years	47	(21%)
3 years to less than 6 years	70	(32%)
6 years to less than 11 years	48	(22%)
11 years or more	16	(7%)
Staff position		
Physician (MD or DO)	22	(10%)
Leaders and managers	15	(7%)
Administrative or Clerical Staff	55	(25%)
Nurse (RN), Licensed Vocational Nurse (LVN), Licensed Practical Nurse (LPN)	69	(31%)
Other Clinical Staff or Clinical Support Staff	60	(27%)
Others	1	(<1%)

SINGLE ITEM MEASURES AND COMPOSITE MEASURES

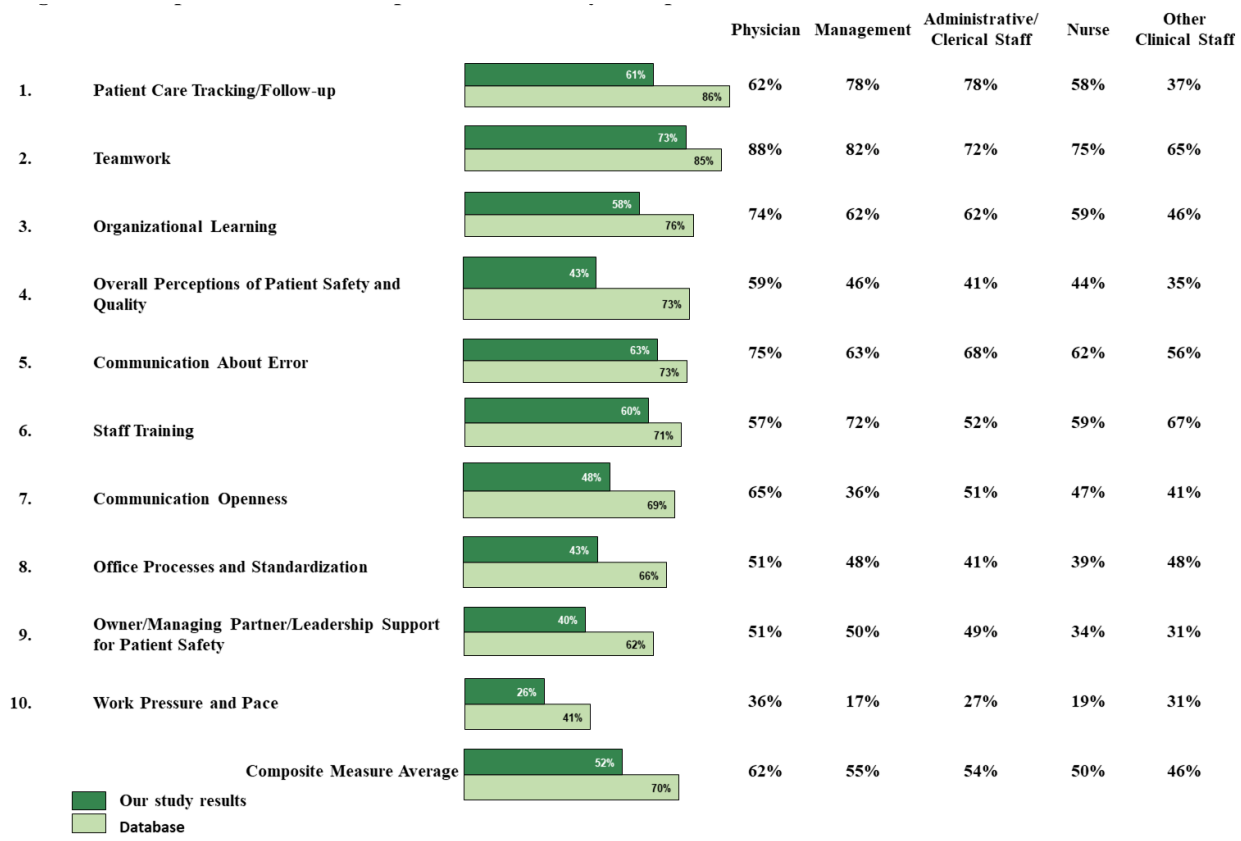
Table 2 shows the positive perception rate of Patient Safety and Quality Issues, information exchange with other settings, and the overall positive rating of quality and patient safety compared to the AHRQ database. The results of the first two measures were superior to those of the AHRQ database, but those of the last two measures were inferior. Figure 2 shows the positive response rates for the composite measures compared to the AHRQ database and among different occupations. The positive response results of the 10 composites were lower than those in the AHRQ database.

TABLE 2. SINGLE ITEM MEASURE COMPARATIVE RESULTS

Note: Database results are based on data from 1,164 medical offices included in the 2024 SOPS Medical Office Database Report; 2) Your medical office's % positive composite measure results are not displayed if 5% or less.	Positive		Neutral		Negative	
	Our study	AHRQ Database	Our study	AHRQ Database	Our study	AHRQ Database
List of Patient Safety and Quality Issues						
A1 A patient was unable to get an appointment within 48 hours for an acute/serious problem.	96%	64%	0%	9%	4%	27%
A2 The wrong chart/medical record was used for a patient.	100%	97%	0%	2%	0%	1%
A3 A patient's chart/medical record was not available when needed.	96%	93%	4%	3%	0%	4%
A4 Medical information was filed, scanned, or entered into the wrong patient's chart/medical record.	97%	97%	1%	2%	2%	1%
A5 Medical equipment was not working properly or was in need of repair or replacement.	94%	88%	6%	6%	0%	6%

A6	A pharmacy contacted our office to clarify or correct a prescription.	64%	61%	10%	13%	26%	26%
A7	A patient's medication list was not updated during his or her visit.	95%	78%	5%	7%	0%	15%
A8	The results from a lab or imaging test were not available when needed.	95%	76%	4%	10%	1%	14%
A9	A critical **abnormal** result from a lab or imaging test was not followed up within 1 business day.	100%	92%	0%	3%	0%	5%
Information Exchange with Other Settings							
B1	Over the past 12 months, how often has your medical office had **problems exchanging accurate, complete, and timely information with:** Outside labs/imaging centers?	97%	73%	2%	12%	1%	15%
B2	Over the past 12 months, how often has your medical office **had problems exchanging accurate, complete, and timely information with**: Other medical offices/outside physicians?	95%	74%	1%	12%	3%	14%
B3	Over the past 12 months, how often has your medical office had **problems exchanging accurate, complete, and timely information with**: Pharmacies?	95%	74%	1%	9%	4%	17%
B4	Over the past 12 months, how often has your medical office **had problems exchanging accurate, complete, and timely information with**: Hospitals?	95%	80%	1%	9%	4%	11%
Overall Ratings on Quality							
G1A	Patient-centered: Is responsive to individual patient preferences, needs and values.	29%	67%	36%	25%	35%	8%
G1B	Effective: Is based on scientific knowledge.	23%	69%	40%	25%	37%	6%
G1C	Timely: Minimizes waits and potentially harmful delays.	24%	54%	32%	28%	43%	18%
G1D	Efficient: Ensures cost-effective care (avoids waste, overuse, and misuse of services).	18%	58%	27%	29%	55%	13%
G1E	Equitable: Provides the same quality of care to all individuals regardless of gender, race, ethnicity, socioeconomic status, language, etc.	33%	81%	33%	15%	35%	4%
Overall Rating on Patient Safety							
G2	Overall, how would you rate the systems and clinical processes your medical office has in place to prevent, catch, and correct problems that have the potential to affect patients?	16%	64%	31%	27%	52%	9%

FIRGUE 2: COMPOSITE MEASURE COMPARATIVE RESULTS BY STAFF POSITION



RELIABILITY

Cronbach's alpha value of each composite ranged from 0.5 to 0.6 in the pilot test and above 0.6 in the actual survey, indicating better internal consistency. Additionally, the actual survey achieved good overall consistency (>0.9). AIIC ranged from 0.31 to 0.71 in the pilot test and 0.33 to 0.49 in the actual survey. Therefore, AIIC improved, indicating that the items measured the same construct. Detailed results are listed in Table 3. It also showed that our adapted version had lower Cronbach's alpha values compared to the AHRQ reliability statistics, which is based on the pilot test data from 202 medical offices and more than 4200 staff [20]. Notably, composite 8, "Staff training," had the lowest internal consistency (0.8 versus 0.62).

TABLE 3. RELIABILITY OF EACH COMPOSITE MEASURE

Composite measures	Number of items	Cronbach's alpha (AHRQ)	Cronbach's alpha (pilot)	Cronbach's alpha (actual)	AIIC (pilot)	AIIC (actual)
1. Communication About Error	4	0.75	0.59	0.63	0.31	0.32
2. Communication Openness	4	0.81	0.71	0.73	0.42	0.41
3. Office Processes and Standardization	4	0.77	0.83	0.69	0.54	0.36
4. Organizational Learning	3	0.82	0.76	0.74	0.52	0.49
5. Overall Perceptions of Patient Safety and Quality	4	0.79	0.83	0.78	0.56	0.48
6. Leadership Support for Patient Safety	4	0.76	0.88	0.75	0.62	0.42

7. Patient Care Tracking/Follow-up	4	0.78	0.87	0.72	0.71	0.41
8. Staff Training	3	0.8	0.58	0.62	0.31	0.37
9. Teamwork	4	0.83	0.69	0.70	0.40	0.38
10. Work Pressure and Pace	4	0.76	0.82	0.68	0.52	0.33
Total	38		0.81	0.94	0.34	0.22

CONSTRUCT VALIDITY

A KMO of 0.74 and the significance of the Bartlett's test of sphericity ($p < 0.05$) suggested that our sample size was appropriate for factor analysis. Standardized factor loadings ranged from 0.09 to 0.9, and some indicators for model fit did not meet the criteria ($X^2 = 1362.6$, df = 620, $p < 0.001$, RMSEA = 0.074 [90% confidence interval: 0.068-0.079], CFI = 0.719, SRMR = 0.108). As some factors (D7, E2, and C3) showed inadequate factor loadings (0.17, 0.09, and 0.26, respectively) and Cronbach's alpha could be improved by dropping these items, we decided to run another CFA after deleting those items.

The new data model of 35 items was also appropriate for factor analysis (KMO=0.81, Bartlett's test of sphericity <0.05). Standardized factor loadings ranged from 0.51 to 0.91, and goodness-of-fit indices were either excellent or acceptable ($X^2 = 1055$, df = 515, $p < 0.001$, RMSEA = 0.069 [90% confidence interval: 0.063-0.075], CFI = 0.814, SRMR = 0.087). Cronbach's alpha values improved, but the average inter-item correlations of the composites marginally increased. Supplementary table shows the CFA results of the 38-item model and the changes in reliability statistics after three items were deleted. The deleted questions are shown in bold.

Figure 3 shows the polychoric correlations of the new 35-item model of the adapted version. Positive correlations were observed among 10 composites of patient safety culture ranging from 0.04 to 0.66. The highest correlation (r=0.66) was found between "Office Processes and Standardization" and "Work Pressure and Pace". Conversely, the lowest correlation (r=0.05) was observed between "Organizational Learning" and "Work Pressure and Pace" as well as "Owner/Managing Partner/Leadership Support for Patient Safety" and "Teamwork".

FIRGURE 3: POLYCHORIC CORRELATIONS OF 35-ITEM JAPANESE MOSPSC



DISCUSSIONS

This is the first study to translate, adapt, and validate the MOSPSC into Japanese. In 2011, Ito et al. culturally adapted the HSOPS for use in Japan. Their instrument had acceptable levels of internal consistency and construct validity, and the composite structures were almost identical to the original HSOPS [21]. Similarly, in our study, both the original 38-item and new 35-item models indicated good internal consistencies with a high overall Cronbach's alpha value (>0.9), and moderate-to-high alpha values in composite measures (>0.6). The AIIC values indicated that the items in the composite measured the same construct, supporting homogeneity and unidimensionality. The model structure with 10 composites was also acceptable when evaluated in the confirmatory factor analysis.

When goodness-of-fit indices were evaluated, the 35-item model had better goodness-of-fit and internal consistency than the original 38-item model. The 35-item model was an adapted version after deleting three items with low factor loadings on composites 1, 6, and 10 from the original model. Two of the deleted items were the only negatively and positively worded items in composites 1 and 6, and the third item in composite 10 was the one we modified the sentence structure as the AHRQ pointed out that it should be tested again as the two back-translations differed. Therefore, it is necessary to investigate the wording or structure of these items in further studies on the MOSPSC in Japan.

Consistent with previous studies on cross-cultural adaptation of MOSPSC in other countries [22-25], our Japanese version of MOSPSC showed a lower internal consistency compared to the AHRQ reliability statistics, especially "Staff training". In this composite, training on new processes, providing on-the-job training, and assigning untrained tasks were evaluated and yielded inconsistent responses, which may be responsible for the relatively low internal consistency. These results also identified areas for improvement in staff training and education.

In our Japanese version, we identified a strong patient safety dimension with regards to access to care, patient identification, availability and completeness of medical records, maintenance of medical equipment, medication updates, and timeliness of test results. Similarly, the positive rating results regarding exchanging accurate, complete, and timely information with labs, imaging centers, other medical offices, outside physicians, pharmacies, hospitals, etc. were high (>95%) and superior to the AHRQ database. However, the overall positive rating of quality was very low (18% to 33%) when compared to the AHRQ database, which ranged from 54% to 81%. The overall positive rating for patient safety was quite low, accounting for only one-fourth of the AHRQ database results (16% versus 64%). These results identified areas for improvement and maintenance of their strengths. They also indicated the need to raise awareness among leaders and staff regarding the results of the MOSPSC survey.

Among the composites of patient safety culture, teamwork was rated highest (73% positive rating), particularly among physicians (88%). "Teamwork" was also identified as the highest safety domain in a patient safety culture survey conducted using the MOSPSC in Yemen (96%), Portugal (76%), and Greece (82%) [22-24]. Conversely, work pressure and pace were poorly rated (26%), especially among leadership (17%) and nurses (19%). This might be due to an imbalance between workload and human resources, particularly among nurses. The shortage of nurses has long been an issue due to the increasing healthcare demand associated with a rapidly aging society. According to the Ministry of Health, Labor, and Welfare (MHLW), there could be a shortage of 60,000–270,000 nurses by 2025 [26]. The healthcare working environment in Japan is also extremely harsh due to free access to the healthcare system. According to 2020 OECD report, the number of outpatient visits per physician per year was 3.5 times that of the United States [27]. "Work Pressure and Pace" was also the lowest scoring dimension on patient safety culture surveys in Portugal (21%), Greece (46%), Slovenia (10.7%), and Yemen (50%) [22-25].

Our study has a few limitations. First, the survey was conducted in only four clinics in the Tokyo area. This could affect the representativeness of the sample and generalizability of the findings to other outpatient clinics. However, since it is the Japanese outpatient version of the medical safety survey questionnaire, whose reliability and validity have been verified for the first time, it will be useful for improving medical safety and quality in our medical group, as well as in other outpatient

medical institutions, serving as a benchmark between facilities. Second, we did not examine other psychometric properties (e.g., convergent validity, discriminant validity, and test-retest reliability) beyond structural validity. As we plan to conduct this survey annually, we can evaluate and improve it in the future.

CONCLUSIONS

We adapted the Japanese version of the MOSPSC and verified that the instrument had good reliability and construct validity. This is the first study to develop an instrument that can be used to measure patient safety culture, benchmark other facilities, and promote patient safety efforts in Japanese ambulatory clinics. Owing to the increasing healthcare demand, shortage of human resources, and sophistication of healthcare in Japan, our tool is very relevant for continuously monitoring safety culture and identifying areas of improvement to focus actions for improvement.

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DECLARATION OF COMPETING INTERESTS

Corresponding authors, on behalf of all the authors of a submission, disclose no conflict of interest regarding this research article.

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SUPPLEMENTARY TABLE (PART 1). CONFIRMATORY FACTOR ANALYSIS RESULTS AND RELIABILITY STATISTICS OF 38-ITEM MODEL BEFORE AND AFTER REMOVING 3 ITEMS WITH LOW FACTOR LOADING

	Item	Mean score	Standard deviation	Standadrized factor loading	α if an item is dropped	AIIC if an item is dropped	α (38-item model)	α (35-item model)	α (AHRQ)
1.	**Communication About Error**						0.63	0.75	0.75
D7.	**Staff feel like their mistakes are held against them. (negatively worded)**	**2.44**	**1.11**	**0.17**	**0.75**	**0.53**			
D8.	Providers and staff talk openly about office problems.	3.23	1.16	-0.52	0.55	0.32			
D11.	In this office, we discuss ways to prevent errors from happening again.	4.12	0.96	-0.84	0.44	0.21			
D12.	Staff are willing to report mistakes they observe in this office.	3.93	0.99	-0.89	0.43	0.21			
2.	**Communication Openness**						0.73	0.73	0.81
D1.	Providers in this office are open to staff ideas about how to improve office processes.	3.30	0.96	0.63	0.74	0.40			
D2.	Staff are encouraged to express alternative viewpoints in this office.	3.10	0.98	0.75	0.63	0.30			
D4.	Staff are afraid to ask questions when something does not seem right. (negatively worded)	2.36	0.99	-0.54	0.68	0.40			
D10.	It is difficult to voice disagreement in this office. (negatively worded)	2.54	1.02	-0.67	0.63	0.30			
	3. Office Processes and Standardization						0.69	0.69	0.77
C8.	This office is more disorganized than it should be. (negatively worded)	3.35	0.99	0.56	0.68	0.43			
C9.	We have good procedures for checking that work in this office was done correctly.	3.55	0.91	-0.62	0.61	0.34			
C12.	We have problems with workflow in this office. (negatively worded)	2.99	0.96	0.64	0.59	0.34			
C15.	Staff in this office follow standardized processes to get tasks done.	3.75	0.76	-0.61	0.62	0.35			
4.	**Organizational Learning**						0.74	0.74	0.82
F1.	When there is a problem in our office, we see if we need to change the way we do things.	4.05	0.65	0.60	0.75	0.61			
F5.	This office is good at changing office processes to make sure the same problems don't happen again.	3.42	0.84	0.77	0.56	0.40			
F7.	After this office makes changes to improve the patient care process, we check to see if the changes worked.	3.36	0.85	0.77	0.62	0.47			

The deleted item in 35-item model was bold.

SUPPLEMENTARY TABLE (PART 2). CONFIRMATORY FACTOR ANALYSIS RESULTS AND RELIABILITY STATISTICS OF 38-ITEM MODEL BEFORE AND AFTER REMOVING 3 ITEMS WITH LOW FACTOR LOADING

	Item	Mean score	Standard deviation	Standardized factor loading	α if an item is dropped	AIIC if an item is dropped	α (38-item model)	α (35-item model)	α (AHRQ)
5.	**Overall Perceptions of Patient Safety and Quality**						0.78	0.78	0.79
F2.	Our office processes are good at preventing mistakes that could affect patients.	3.52	0.83	0.72	0.75	0.51			
F3.	Mistakes happen more than they should in this office. (negatively worded)	2.65	0.99	-0.74	0.68	0.41			
F4.	It is just by chance that we don't make more mistakes that affect our patients. (negatively worded)	2.70	0.95	-0.70	0.74	0.50			
F6.	In this office, getting more work done is more important than quality of care. (negatively worded)	3.09	1.09	-0.64	0.74	0.49			
6.	**Owner/Managing Partner/Leadership Support for Patient Safety**						0.75	0.85	0.76
E1.	They aren't investing enough resources to improve the quality of care in this office. (negatively worded)	2.94	1.21	0.81	0.60	0.33			
E2.	They overlook patient care mistakes that happen over and over. (negatively worded)	2.30	1.06	0.91	0.63	0.35			
E3.	**They place a high priority on improving patient care processes.**	**3.27**	**1.22**	**0.09**	**0.85**	**0.65**			
E4.	They make decisions too often based on what is best for the office rather than what is best for patients. (negatively worded)	2.97	1.28	0.68	0.61	0.34			
7.	**Patient Care Tracking/Followup**						0.72	0.72	0.78
D3.	This office reminds patients when they need to schedule an appointment for preventive or routine care.	4.03	0.90	0.67	0.70	0.46			
D5.	This office documents how well our chronic-care patients follow their treatment plans.	3.63	1.00	0.65	0.62	0.37			
D6.	Our office follows up when we do not receive a report we are expecting from an outside provider.	3.39	1.08	0.58	0.68	0.44			
D9.	This office follows up with patients who need monitoring.	3.69	1.10	0.77	0.63	0.39			

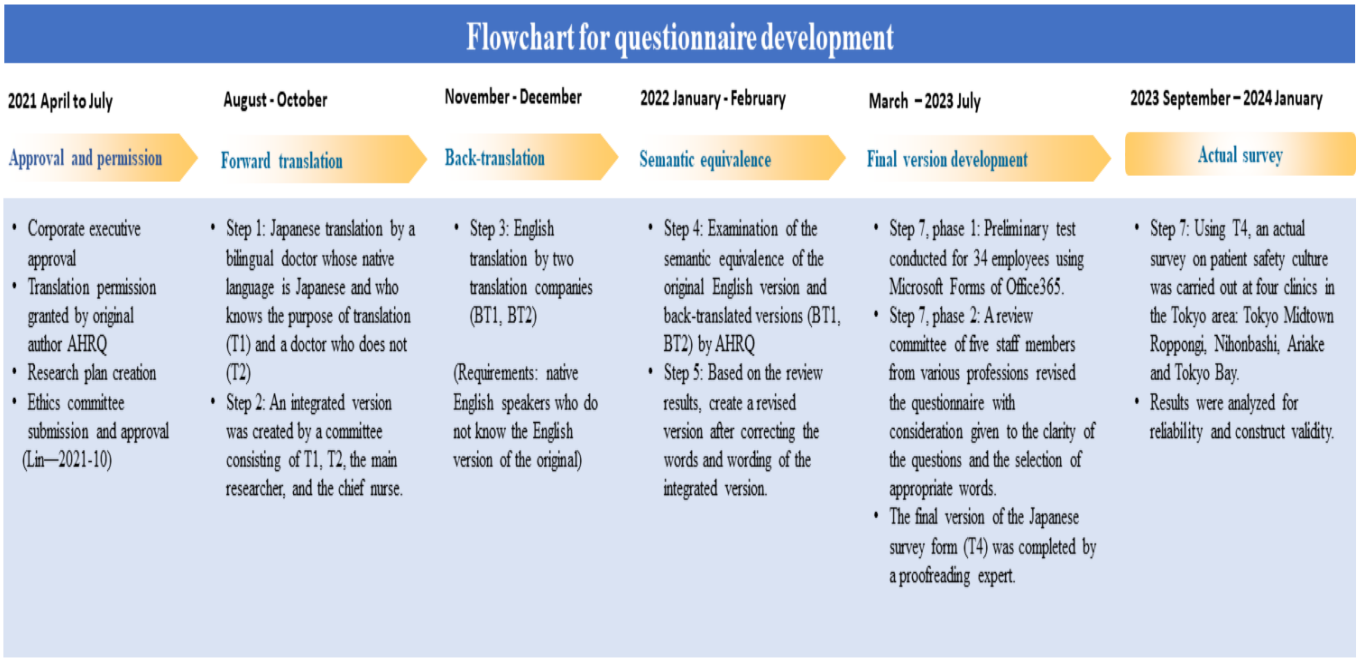
The deleted item in 35-item model was bold.

SUPPLEMENTARY TABLE (PART 3). CONFIRMATORY FACTOR ANALYSIS RESULTS AND RELIABILITY STATISTICS OF 38-ITEM MODEL BEFORE AND AFTER REMOVING 3 ITEMS WITH LOW FACTOR LOADING

	Item	Mean score	Standard deviation	Standardized factor loading	α if an item is dropped	AIIC if an item is dropped	α (38-item model)	α (35-item model)	α (AHRQ)
8.	**Staff Training**						0.62	0.62	0.8
C4.	This office trains staff when new processes are put into place.	3.78	0.83	0.72	0.50	0.00			
C7.	This office makes sure staff get the on-the-job training they need.	3.59	0.91	0.62	0.45	0.00			
C10.	Staff in this office are asked to do tasks they haven't been trained to do. (negatively worded)	2.78	1.10	-0.53	0.63	0.00			
9.	**Teamwork**						0.70	0.70	0.83
C1.	When someone in this office gets really busy, others help out.	4.26	0.72	0.52	0.66	0.40			
C2.	In this office, there is a good working relationship between staff and providers.	3.73	0.75	0.59	0.64	0.38			
C5.	In this office, we treat each other with respect.	3.86	0.78	0.74	0.58	0.32			
C13.	This office emphasizes teamwork in taking care of patients.	3.65	0.94	0.61	0.67	0.41			
10.	**Work Pressure and Pace**						0.68	0.74	0.76
C3.	**In this office, we often feel rushed when taking care of patients. (negatively worded)**	**3.47**	**0.95**	**0.26**	**0.74**	**0.40**			
C6.	We have too many patients for the number of providers in this office. (negatively worded)	3.50	1.08	0.74	0.50	0.20			
C11.	We have enough staff to handle our patient load.	3.06	1.07	-0.49	0.64	0.30			
C14.	This office has too many patients to be able to handle everything effectively. (negatively worded)	3.01	1.07	0.90	0.49	0.20			
					Overall internal consistency		0.94	0.93	

The deleted item in 35-item model was bold.

SUPPLYMENT FURGURE: STEPS INVOLVED IN THE DEVELOPMENT OF MOSPSC JAPANESE VERSION



We developed the Japanese version of MOSPSC through seven steps.

ACHSM Asia-Pacific Journal of Health Management

RESEARCH ARTICLE

VULNERABILITY ASSESSMENT: EVIDENCE FROM A RURAL COMMUNITY-BASED MULTIDIMENSIONAL SURVEY IN JHARKHAND, INDIA

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ABSTRACT

BACKGROUND:

Understanding the health of residents in a given community may not be a new concept but exploring and deriving social factors that determine the health dimensions and its outcomes are very complex. Household vulnerability in rural India is shaped by intersecting residential, social, occupational, and health-related factors. Panchayat-level evidence on multidimensional vulnerability remains limited despite its need for local health planning and primary care delivery. This study assessed the vulnerability status of households across rural communities of Jharkhand.

METHODS:

A community-based cross-sectional survey was conducted among all 1,605 households in one panchayat of Community Health Centre (CHC), Devipur Block, Deoghar District, Jharkhand, India. Sociodemographic information and vulnerability indicators were collected using the NHM vulnerability assessment tool, supported by social maps for systematic field navigation.

RESULTS:

Among the 1,605 households surveyed, 22.1% were categorized as most vulnerable, 40.4% as highly vulnerable, and 37.5% as vulnerable. Multivariable binary logistic regression showed significantly higher odds of severe vulnerability among male-headed households (AOR: 2.40; 95% CI: 1.07–5.35), lower-income households (AOR: 12.09; 95% CI: 5.36–27.26), and scheduled tribes (AOR: 5.52; 95% CI: 3.30–9.23). Whereas Muslim households had lower adjusted odds of severe vulnerability than Hindu households (AOR: 0.46; 95% CI: 0.35–0.62). Marked inter-village variation in household vulnerability was observed across the study villages.

CONCLUSION:

The findings highlight the need for localized, equity-focused strategies that address housing, sanitation, livelihood security, and access to health services, and emphasize the importance of periodic vulnerability assessment to monitor and guide community health action.

KEYWORDS

Assessment, household vulnerability, multidimensional survey, NHM tool, primary health care, panchayat mapping, rural communities, social determinants.

BACKGROUND

Vulnerability is an ever-changing concept. Depending on the interplay of societal, environmental, and personal factors—which can be acquired or innate—people may be more or less at risk of being in a vulnerable circumstance. These factors may provide or deprive individuals from certain types of resources. From a biosocial perspective, social scientists have claimed that vulnerability and poor health have an intricate relationship with historical, cultural, infrastructural, economic, and political environment.[1] Vulnerability assessment in the context of NHM means assessing the level of vulnerability of a slum or household towards ill-health. What factors place a household at a greater risk of illness? Labelling a group as vulnerable is insufficient; we also need to understand the mechanisms that make them susceptible and the individuals who become vulnerable as a result of these processes. Although large-scale assessments of vulnerability contribution to field, vulnerability assessments should also to be conducted at a local level, among groups of people in a more or less limited geographical area.[2]

In developing countries like in India, certain population groups are considered vulnerable. This may be either by nature or because of the deep-rooted factors of culture, beliefs and customs. However, when it comes to health perspective, women, children below 5 years, disabled, elderly, migrant workers, people from low socio-economic groups, individuals with long-term illnesses, sex workers, elderly poor, people with mental illness etc. are considered as vulnerable groups.[3] Describing any one factor of vulnerability towards health/illness in isolation is more intricate because numerous similar factors may directly or indirectly overlap with each other. The community in which people facing the problems of lack of water supply, poor drainage facilities, poor ventilation and housing, inadequate nutrition and poor sanitation, are more prone for diseases. Systematic understanding and documentation of all these issues gives baseline data for effective planning of family health care services. [4,5] Vulnerability assessment is not a onetime activity and should be conducted periodically. The study findings give the baseline and comprehend data about vulnerability status of selected community, which further helps to revise and plan for the appropriate health care services. In Primary Health Care (PHC), the understanding of the individual, family, and community context allows an approximation with the social determinants of health (SDH). [6] Periodic vulnerability assessment at the panchayat level is particularly relevant for strengthening primary health care planning, enabling targeted, equity-oriented interventions aligned with the principles of primary health care and the social determinants of health.

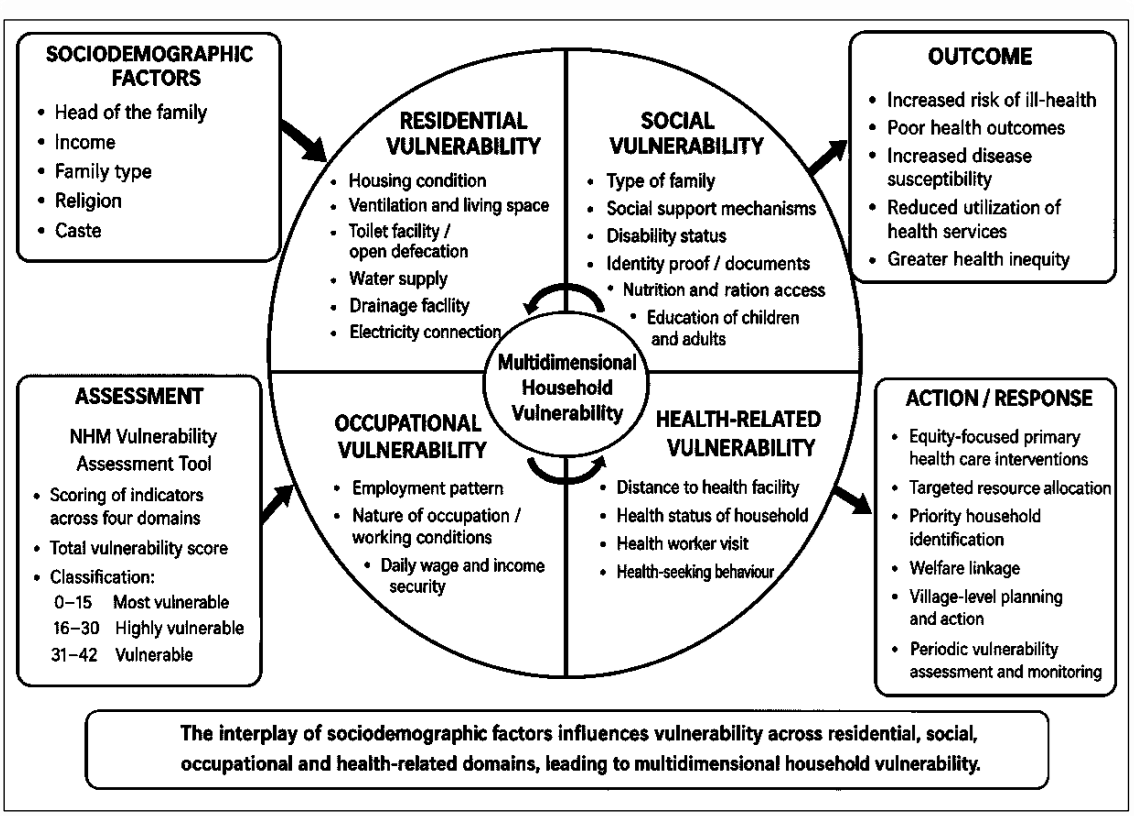
Although multidimensional poverty in rural India declined from 32.59% in 2015–16 to 19.28% in 2019–21, substantial deprivation persisted in nutrition, sanitation, drinking water, and housing across India, highlighting continuing challenges in household living conditions. [7] Vulnerability is closely linked to inequities in access to resources, opportunities, and health services, which differentially affect population groups and influence health outcomes. From a public health perspective, understanding vulnerability is essential for advancing equity and strengthening progress towards universal health coverage.[8] Apart from assessment of vulnerability, regarding the availability and utilization of medical services, the common picture seen in rural community people from low socio-economic groups, they use more emergency services and less of preventive services like immunization and screening. This may be because they perceive health as major crisis [9] rather than as something to be maintained. Vulnerability assessment about health care services of household gives an idea for health care providers to distinguish between provision and use of health care services. [10–12] The nature and dynamics of vulnerability are not adequately captured by checklists of vulnerable groups, despite their importance.[13] Previous studies on vulnerability assessments have often focused on specific vulnerable groups or individual determinants, with limited attention to their combined effects at the household and village levels. [2, 13] The present study addresses this gap by applying multidimensional approach at the household and village levels within a panchayat. It integrates residential, social, occupational, and health-related dimensions using the NHM vulnerability assessment framework, with contextual adaptation to rural settings, while traditional social maps used in community health nursing practice facilitated systematic identification and location of households. The vulnerability assessment findings will facilitate the community health care practitioners in identifying priority households and areas, strengthening micro planning, and guiding ASHA and ANM home visits, screening and follow-up, linkage with welfare schemes, and appropriate allocation of local health

and community resources. Thus, the study extends vulnerability assessment beyond description by generating household- and village-level information that can inform prioritization and planning within primary health care services.

CONCEPTUALIZATION OF VULNERABILITY

In the context of the National Health Mission (NHM), vulnerability refers to the increased susceptibility of certain households or population groups to ill-health due to overlapping social, economic, residential, and occupational disadvantages. Vulnerability extends beyond poverty and includes factors such as inadequate housing, lack of sanitation and safe drinking water, insecure living conditions, hazardous occupations, migration, social discrimination, disability, age-related dependency, and limited access to essential services.[14] Such multidimensional vulnerability contributes to a higher risk of ill-health, poor health-seeking behaviour, increased disease burden, and reduced access to preventive and curative health services. Based on the NHM vulnerability assessment framework, the present study conceptualized vulnerability as a multidimensional condition resulting from the combined effects of residential, social, occupational and health related disadvantages that reduce the capacity of households to maintain health and well-being. The assessment is intended to generate evidence for identifying high-risk households and priority areas, thereby supporting targeted resource allocation and evidence-informed micro-level planning within primary health care services. The conceptual framework depicting the interrelationship between sociodemographic factors, multidimensional vulnerability domains, and vulnerability (Figure 1)

FIGURE 1: CONCEPTUAL FRAMEWORK OF HOUSEHOLD VULNERABILITY

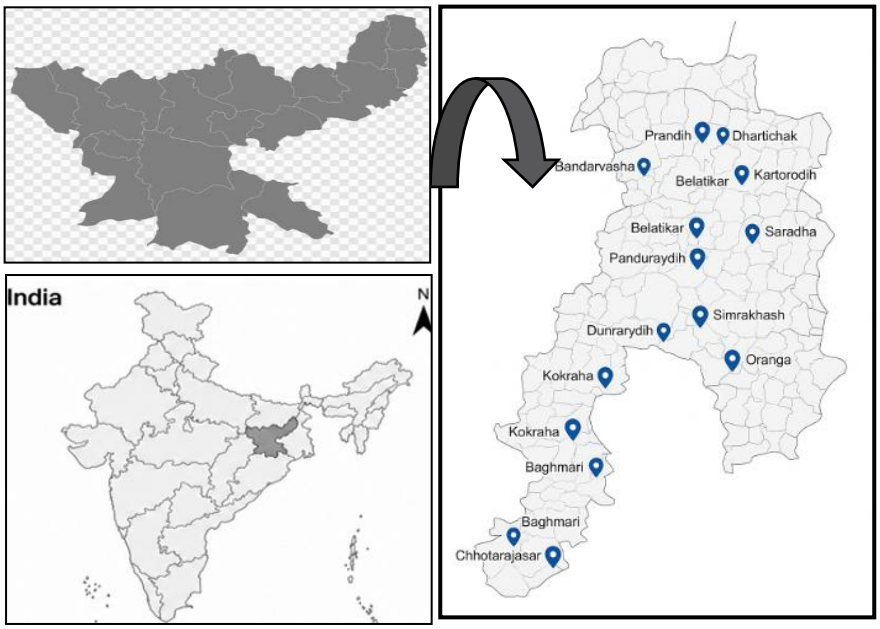


In this context, the present study aims to assess the more prominent and specific factors of multidimensional household vulnerability in selected rural communities of Deoghar district, Jharkhand. The specific objectives were to assess household vulnerability across residential, social, occupational, and health-related domains; to classify households based on overall vulnerability scores; to identify factors associated with severe vulnerability using logistic regression analysis; and to map village-wise variations in vulnerability.

MATERIALS AND METHODS

A community-based descriptive cross-sectional survey was conducted in 17 rural communities belonging to one panchayat (rural local government area) located in Devipur Block, Deoghar District, Jharkhand, India. (Figure 2) The study population comprised all households present in the selected communities during the data collection period. Complete enumeration of the study area identified 1,643 households. However, 38 households could not be included in the study, of which 31 were found locked and 7 had migrated to other places at the time of data collection. Thus, 1,605 households were successfully surveyed and constituted the final sample for analysis, yielding a response rate of 97.7%. The head of the household or an adult representative (≥18 years) was interviewed for each household. Homes locked after two repeated visits were excluded.

FIGURE 2: LOCATION OF THE STUDY AREA WITHIN THE CHC BLOCK, DEOGHAR, JHARKHAND (THE MAP IS NOT IN THE SCALE)



The data collection tool comprised two parts. Part I dealt with the sociodemographic information of households. Part II dealt with vulnerability assessment tool, which was developed by the National Health Mission (NHM), Government of India. Based on the earlier field observations and internal expert review, limited contextual modifications were made to selected items. Specifically, location of the household and occupational conditions, to improve their applicability to the rural socio-environmental setting, while retaining the original domains, items, and scoring framework (Supplementary File 1). The modified tool was reviewed and validated by experts in the field of community medicine and community health nursing. The NHM tool comprises 4 different sections for assessing vulnerability: Residential, Social, Occupational and Health related. The total vulnerability score ranged from 0 to 42 and was computed by summing all domain components. Based on cumulative scoring, households were categorized into three categories: 0–15 as most vulnerable, 16–30 as highly vulnerable, and 31–42 as vulnerable. Lower cumulative scores indicated greater vulnerability.

Data were collected by two trained ANMs, with assistance from eight ASHAs for household identification and field coordination. The investigators trained and oriented the field team on study objectives, administration of the modified NHM vulnerability assessment tool, interviewing, and scoring procedures. Data quality was maintained through investigator supervision and review of completed schedules. Each household was surveyed, visited physically, and face-to-face interviews was conducted with the head of household. Data collection was carried out in two phases from November 2024 to February 2025 and from May 2025 to August 2025, considering the geographical spread of the study communities, manpower availability and feasibility of systematic household coverage. Although the data collection periods differed seasonally, the occupation- and income-related indicators reflected the usual circumstances of permanent household residents, thereby reducing the potential influence of seasonal variation. Prior to data collection, community social maps were prepared with support from, local leaders, residents, and nursing students. These maps

displayed settlement patterns, household clusters, sanitation points, and key resources. They were used as field-guided navigational tools to ensure systematic coverage of all households and to validate the significant indicators during observation.

DATA ANALYSIS

The data thus generated were entered into and analyzed using the SPSS (version 25) software. Descriptive data was presented as frequencies and valid percentages. For inferential analysis, total vulnerability was dichotomized into two categories by combining "most vulnerable" and "highly vulnerable" as severe vulnerability, and comparing it with the "vulnerable" category. To determine the factors associated with total vulnerability, bivariable binary logistic regression was performed by entering each variable separately to estimate crude odds ratio (COR) with 95% confidence intervals (CI). Subsequently, all explanatory variables were entered simultaneously into a multivariable binary logistic regression model using the enter method to obtain adjusted odds ratios (AOR) with 95% CI. All tests were two tailed and p value <0.05 was considered statistically significant. The multivariable logistic regression model yielded Cox–Snell and Nagelkerke pseudo-R^2 values of 0.252 and 0.345, respectively. The Hosmer–Lemeshow goodness-of-fit test was non-significant (chi^2=6.125), df= 8, (p=0.623)), indicating the model is adequately fit. Variance inflation factor (VIF) and tolerance statistics were computed to evaluate multicollinearity among independent variables. All predictor variables showed VIF values close to 1 (range: 1.003–1.037) and tolerance values above 0.96, indicating no evidence of multicollinearity.

ETHICAL CONSIDERATION

Ethical approval was obtained from the Institutional Ethics Committee (IEC) of AIIMS, Deoghar (IEC Code: 2023-109-IND-03). Further permission was sought from the community leaders in the study area and the local authorities. Written informed consent was obtained from all the participants. To ensure confidentiality, unique identification codes were assigned to each village and household, and the data were maintained securely without using personal identifiers.

RESULTS

TABLE 1: DISTRIBUTION OF HOUSEHOLDS ACCORDING TO SOCIODEMOGRAPHIC VARIABLES (N=1605)

Variables	Category	Frequency (f)	Percentage (%)
Head of the family	Male	1573	98
	Female	32	2
Income	Upper	59	3.7
	Upper middle	343	21.3
	Middle	494	30.8
	Lower middle	430	26.8
	Lower	279	17.4
Type of family	Nuclear family	857	53.4
	Extended /Joint family	435	27.1
	Living alone/ Others	313	19.5
Religion	Hindu	1291	80.4
	Muslim	314	19.6
Caste	General	106	6.6
	SC	670	41.8
	ST	326	20.3
	OBC	503	31.3

The sociodemographic profile showed a predominance of Hindus (80.4%), while Muslims accounted for 19.6%. Distribution of caste showed a higher representation of SC (41.8%), followed by OBC (31.3%) and ST (20.3%), while only a small proportion (6.6%) belonged to the general category. A highly patriarchal structure was evident, with 98% of households

headed by men. Most households belonged predominantly to the middle (30.8%) and lower-middle (26.8%) income groups, indicating a largely lower to middle socioeconomic profile. In terms of family composition, most households belong to nuclear families. [Table 1]

Across the surveyed households, the majority (96.9%) lacked drainage facilities and 87.5% lacked piped water supply or they use community taps, while the majority practiced open defecation (81.3%). A substantial proportion lived in kutcha houses (44.5%), and the majority depended on a single earning family member (87.1%) and low-paid daily wage employment (61.6%). Nearly half of the households (47.9%) were located more than 10 km from a health facility, while 52.1% were within 10 km, Furthermore, 80.6% relied on local practitioners, informal providers, medical stores, or no treatment, whereas only 19.4% sought care from government facilities or registered private doctors. These findings highlight economic instability, poor sanitation, and inadequate access to healthcare as key contributors to vulnerability. [Supplementary Table 2]

TABLE 3: FREQUENCY AND PERCENTAGE DISTRIBUTION OF HOUSEHOLDS ACCORDING TO VULNERABILITY CATEGORIES BASED ON DOMAIN AND OVERALL SCORES (N = 1605)

Domain of vulnerability	Most vulnerable n (%)	Highly vulnerable n (%)	Vulnerable n (%)
Residential Vulnerability	0 (0.0)	282 (17.6)	1323 (82.4)
Social Vulnerability	0 (0.0)	136 2 (84.9)	243 (15.1)
Occupational Vulnerability	354 (22.0)	1104 (68.8)	147 (9.2)
Health related Vulnerability	0 (0.0)	291 (18.1)	1314 (81.9)
Total Vulnerability	354 (22.1)	649 (40.4)	602 (37.5)

Across all domains, occupational vulnerability showed the highest level of vulnerability, with 22% of households categorized as most vulnerable and 68.8% as highly vulnerable. Social vulnerability was predominantly high (84.9%), while residential (82.4%) and health-related (81.9%) vulnerabilities were mainly within the vulnerable category. Overall, 22.1% of households were categorized as most vulnerable, 40.4% highly vulnerable, and 37.5% vulnerable, indicating a substantial burden of multidimensional vulnerability within the community. [Table 3]

TABLE 4: BIVARIABLE AND MULTIVARIABLE BINARY LOGISTIC REGRESSION ANALYSIS OF FACTORS ASSOCIATED WITH HOUSEHOLD VULNERABILITY (N= 1605)

Variable	Severely vulnerable (N=1003) n (%^)	Vulnerable (N=602) n (%^)	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	VIF
Head of the family							1.003
Male	991 (63)	582 (37)	2.83 (1.37-5.84)	0.005*	2.40 (1.07-5.35)	0.032*	
Female	12 (37.5)	20 (62.5)	Reference	---	---	---	
Income (BG Prasad scale)							1.031

Upper	9 (15.3)	50 (84.7)	Reference	---	---	---	
Upper middle	190 (55.4)	153 (44.6)	6.88 (3.28-14.47)	<0.001*	5.63 (2.56-12.40)	<0.001*	
Middle	307 (62.1)	187 (37.9)	9.12 (4.38-18.97)	<0.001*	5.86 (2.68-12.79)	<0.001*	
Lower middle	276 (64.2)	154 (35.8)	9.95 (4.76-20.79)	<0.001*	8.86 (3.96-18.97)	<0.001*	
Lower	221 (79.2)	58 (20.8)	21.16 (9.83-45.55)	<0.001*	12.09 (5.36-27.26)	<0.001*	
Type of family							
Nuclear family	558 (65.1)	299 (34.9)	Reference	---	---	---	1.005
Extended /Joint family	213 (49)	222 (51)	0.51 (0.41-0.65)	<0.001*	0.44 (0.34-0.58)	<0.001*	
Living alone/ Others	232 (74.1)	81 (25.9)	1.53 (1.14-2.05)	0.004*	1.22 (0.88-1.67)	0.220	
Religion							
Hindu	862 (66.8)	429 (33.2)	Reference	---	---	---	1.011
Muslim	141 (44.9)	173 (55.1)	0.40 (0.31-0.52)	<0.001*	0.46 (0.35-0.62)	<0.001*	
Caste							
General	52 (49.1)	54 (50.9)	Reference	---	---	---	1.037
SC	323 (48.2)	347 (51.8)	0.96 (0.64-1.45)	0.870	1.15 (0.74-1.79)	0.508	
ST	276 (84.7)	50 (15.3)	5.70 (3.52-9.31)	<0.001*	5.52 (3.30-9.23)	<0.001*	
OBC	352 (70)	151 (30)	2.42 (1.58-3.70)	<0.001*	2.44 (1.56-3.83)	<0.001*	

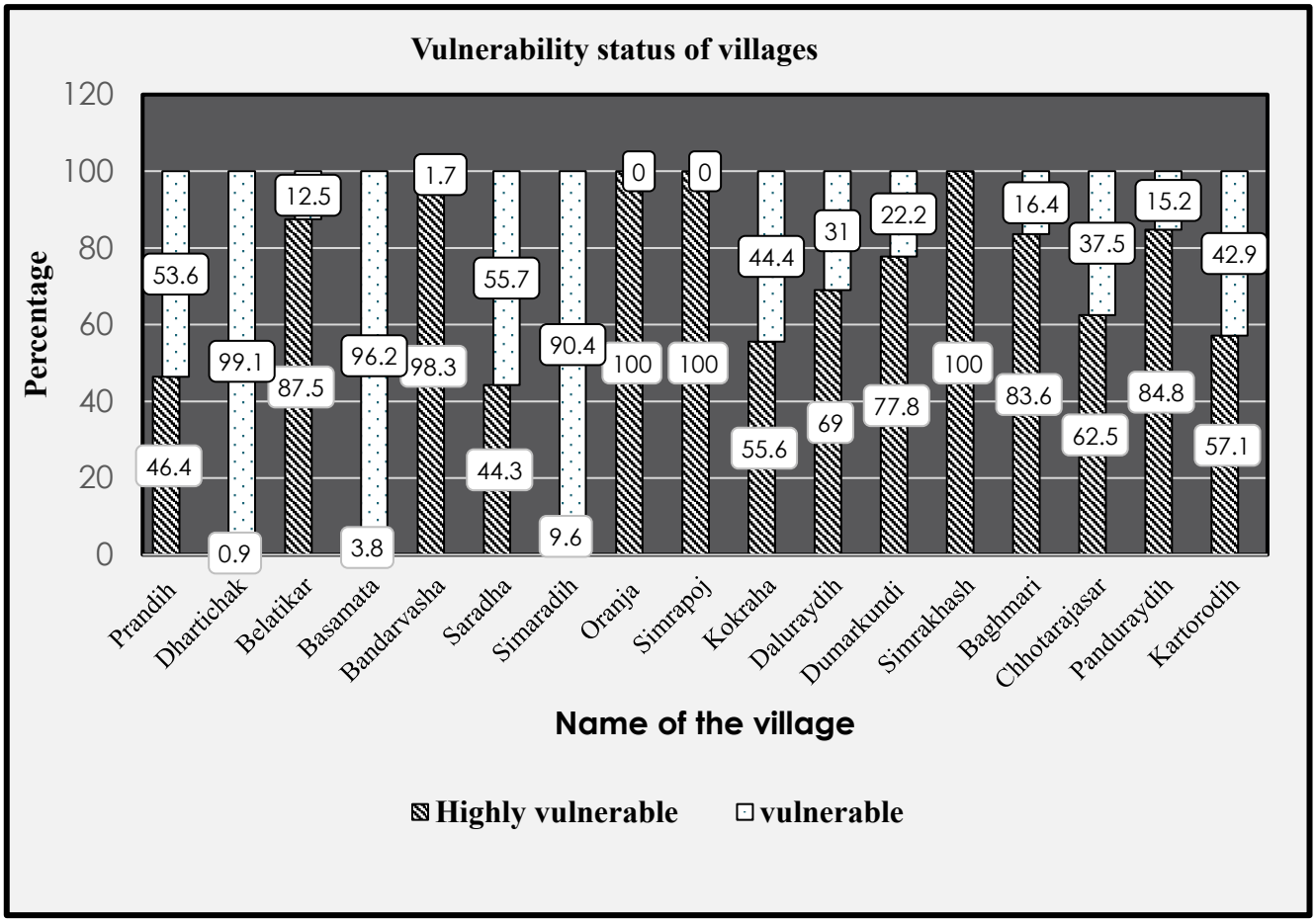
Note: ^ row percentage, OR- Odds Ratio, CI-Confidence Interval, * Statistically significant (<0.05). SC-Scheduled Caste, ST-Scheduled Tribes, OBC-Other Backward Classes, VIF = variance inflation factor

Bivariable logistic regression analysis of 1,605 households showed that 991 (63.0%) male-headed households and 12 (37.5%) female-headed households were severely vulnerable. Male-headed households had 2.83 times higher odds of severe vulnerability than female-headed households (95% CI: 1.37–5.84). Household economic status was classified using the modified B. G. Prasad socioeconomic scale (2024 update) and categorised into five classes: upper, upper-middle, middle, lower-middle, and lower. In the current study lower-income households had the highest proportion of severe vulnerability, with 221 (79.2%) households affected. In the crude analysis, lower-income households had 21.16 times higher odds of severe vulnerability compared to upper-income households (95% CI: 9.83–45.55; p < 0.001). Lower-middle (OR: 9.95; 95% CI: 4.76–20.79), middle (OR: 9.12; 95% CI: 4.38–18.97), and upper-middle income groups (OR: 6.88; 95% CI: 3.28–14.47) also showed significantly higher odds. Households living alone had the highest proportion of severe vulnerability, with 232 (74.1%) categorized as severely vulnerable, and had 1.53 times higher odds compared to nuclear families (95% CI: 1.14–2.05). Compared to Hindu households, Muslim households had 0.4 times lower odds of severe vulnerability (95% CI: 0.31-0.52). Among caste groups, 276 (84.7%) ST households were severely vulnerable. ST households had 5.70 times higher odds of severe vulnerability (95% CI: 3.52–9.31), while OBC households had 2.42 times higher odds (95% CI: 1.58–3.70) compared to the general category. Although 323 (48.2%) SC households were severely vulnerable, the association was not statistically significant.

In the multivariable binary logistic regression analysis, male-headed households remained significantly associated with severe vulnerability (AOR: 2.40; 95% CI: 1.07–5.35; p = 0.032). However, the female-headed reference group contains only 32 households, of which 12 were severely vulnerable. Compared with upper income households, lower-income

households had 12.09 times higher odds of severe vulnerability (95% CI: 5.36–27.26; p < 0.001), while lower-middle (AOR: 8.86; 95% CI: 3.96–18.97), middle (AOR: 5.86; 95% CI: 2.68–12.79), and upper-middle income groups (AOR: 5.63; 95% CI: 2.56–12.40) also showed significantly higher odds. Extended/joint families had lower odds of severe vulnerability than nuclear families (AOR: 0.44; 95% CI: 0.34–0.58; p < 0.001). Muslim households had shown lower odds of severe vulnerability than Hindu households (AOR: 0.46; 0.35-0.62). In caste groups, ST households (AOR: 5.52; 95% CI: 3.30–9.23), and OBC households (AOR: 2.44; 95% CI: 1.56–3.83) had higher adjusted odds than general-category households (both p < 0.001), whereas SC households and households living alone were not significant after adjustment [Table 4]. Given the high prevalence of severe vulnerability (62.5%), the odds ratios may overestimate the corresponding prevalence ratios and should not be interpreted as relative risks.

FIGURE 3: VILLAGE-WISE DISTRIBUTION OF HOUSEHOLD VULNERABILITY LEVELS IN THE STUDY AREA (N = 17)



In the current study, substantial variation in vulnerability was observed across the 17 villages, with several villages including Oranja, Simrapoj, Simrakash exhibiting 100% highly vulnerable households, indicating severe multidimensional deprivation. In contrast, villages like Dharthicak, Basmata, Simradih, show very low levels of high vulnerability, with most households falling in the vulnerable category. Moderate patterns are observed in villages such as Prandih, Saradha, Koraha, Daluraydih, Chotarajasar, reflecting mixed levels of Vulnerability. [Figure 3] Regarding proximity to designated public healthcare facilities, all households in Prandih, Belatikar, Saradha, Simradih, Daluraydih, Kartorodih, Dumarkundi and Baghmari were located more than 10 km away from a health facility. Rest of the villages were located within 10 km. Of these villages, Belatikar, Daluraydih, and Baghmari are tribal communities. Such distance may pose an accessibility challenge for households requiring healthcare.

DISCUSSION

The present study provides a comprehensive assessment of multidimensional household vulnerability, revealing a substantial proportion of families experiencing high levels of residential, social, occupational, and health-related

disadvantages. The principal findings showed that, 22.1% of households were most vulnerable and 40.4% were highly vulnerable. Similar findings were reported by Ravish KS et al. in a study where 45.8% were highly vulnerable and 54.2% were vulnerable, highlighting the widespread burden of vulnerability across Indian communities. [15] A health vulnerability study by Mohapatra S, highlighted poor sanitation, non-functional toilets, open drains, and insufficient water supply facilities, inadequate infrastructure, and limited healthcare access as major contributors to ill-health. Consistent with these findings, our study observed that 96.9% of households lacked drainage and 87.5% lacked piped water supply or they use community taps, while 81.3% practised open defecation, reflecting inadequate sanitary conditions.[16,17] Furthermore, the high proportion of households living in kutcha houses (44.5%), dependence on a single earning member (87.1%), and reliance on daily wage occupations (61.6%) in our study indicate substantial economic insecurity and poor living conditions comparable to the aforementioned study. These findings are comparable to the NFHS-5 Jharkhand report (2019–21).[18] Banerjee et al. report that Scheduled Caste and Scheduled Tribe adults consistently exhibit lower utilization of curative healthcare services. NFHS-5 data show that SC/ST households have 15–20% higher likelihood of living without improved sanitation and 10–18% higher rates of untreated illness compared to general caste groups. These disparities are reflected in our findings where caste was significantly associated with vulnerability.[19,20] A study by Cowling et al. utilized the multidimensional Poverty Index (MPI) to provide a composite indicator of several social determinants of health.[21] The index weights ten indicators across three dimensions: health, education and standard of living. In our study, indicators such as educational deprivation were observed among 33.3% of households where either children had dropped out of school or adults had minimum literacy. Similarly, standard of living deprivation was reflected through lack of improved sanitation facilities, practising open defecation, absence of piped water supply, poor drainage, use of kutcha or semi-pucca housing by the majority of households, and lack of electricity in 9.4% households.

In our study, by domain, 84.9% of households exhibited high social vulnerability and 22.1% showed the highest occupational vulnerability, indicating severe socioeconomic fragility. These findings closely align with national estimates where over 30% of rural households depend on irregular daily wage labour, and over 50% lack secure employment, making them highly susceptible to income-related shocks as per National Health Accounts, MoHFW, 2022. [12] During the survey, it was observed that the majority of households lacked solid waste disposal systems and depended on unsafe water sources. In the current study, 87.5% of households lacked individual piped water supply and 33.3% reported school dropout or illiteracy, whereas the Itanagar study showed comparatively better conditions with 60.7% of households having individual water connections and 79.8% of children pursuing elementary education with minimum literacy among adults.[22] Awasthi et al., conducted a study in Uttarakhand reported that, the proportion of highly vulnerable households ranged from 2.8% to 21.8%, while the majority of households were categorized as vulnerable. In contrast, the present study showed a substantially greater burden of most and high vulnerability categories among households.[23] Reports by Rama Baru et al. and Gupta et al. highlighted that socioeconomic inequities in India are strongly influenced by caste, class, gender, and disparities in the availability, utilization, and affordability of health services. [24–26] These observations are consistent with the findings of the present study, where caste and income emerged as significant predictors associated with severe vulnerability. Previous studies from India has frequently documented greater socioeconomic deprivation among female-headed households, although the relationship varies by region and may be influenced by household-head education, household composition and the definition of poverty.[27–29] In the present study, male-headed households had higher adjusted odds of severe vulnerability; however, this finding should be interpreted cautiously because in our study the female-headed reference group was small. Extended/joint family households had lower adjusted odds of severe vulnerability than nuclear households, consistent with our study linking non-nuclear family structures with lower multidimensional deprivation.[30] Our study revealed Muslim households also had lower adjusted odds of severe vulnerability than Hindu households. This finding contrasts with studies reporting greater deprivation among Muslim populations.[31, 29]

In a study by Wankhade K et al. [32] reported that, in slums of Coimbatore, all slums were categorized as either least vulnerable (scores 11–15) or moderately vulnerable (scores 16–20) with relatively homogeneous vulnerability patterns, In contrast, the present study demonstrated substantial variation in vulnerability across villages. Several villages reported 100% highly vulnerable households, while others had predominantly vulnerable households with very low levels of high vulnerability. These findings indicate marked heterogeneity in multidimensional vulnerability within the study area. The

village-wise variation observed in this study highlights the strong micro-geographic clustering of deprivation. This finding is consistent with evidence demonstrating substantial village-level variation in health and development indicators across India, highlighting the importance of considering local contexts in rural planning and resource allocation. [33] Current study findings collectively support the need for village-specific planning, prioritisation of high-risk clusters, and tailored health and welfare interventions informed by multidimensional vulnerability scores.

STRENGTHS AND LIMITATIONS

The use of complete enumeration minimized selection bias and ensured comprehensive coverage. The use of social maps strengthened systematic data collection. The study provides actionable, village-level evidence for equity-focused primary health care planning. The cross-sectional design limits causal interpretation, and reliance on household-level reporting may introduce reporting bias. As the study was confined to a single panchayat, the findings may have limited generalizability to other rural settings. Although the proportion of non-included households was small, the possibility of selection bias due to household non-availability or migration cannot be completely excluded. Furthermore, the study did not assess the burden of specific morbidities, limiting the interpretation of vulnerability in relation to actual health status. Although households were clustered within 17 villages, village-level clustering was not explicitly accounted for in the primary household-level regression analysis, and potential intra-village correlation may therefore have influenced the precision of the estimated associations.

CONCLUSION AND RECOMMENDATION

The findings highlight the need for targeted, village-specific interventions and routine vulnerability assessments to strengthen equity-oriented rural health planning. Routine vulnerability assessment can support evidence-based planning, prioritization of high-risk households, and equitable delivery of primary health care services. Sharing these results through public forums will facilitate planning and action for appropriate healthcare and welfare services. High-risk households should be prioritized for ASHA/ANM home visits, screening, and government welfare linkage. It is recommended that routine Panchayat-level vulnerability assessments be integrated into primary health care planning to support continuous monitoring and action. Future assessments should also incorporate measures of morbidity and health outcomes to better understand the relationship between vulnerability and ill-health.

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DECLARATION OF CONFLICTING INTERESTS

None

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SUPPLEMENTARY FILE 1

NHM VULNERABILITY ASSESSMENT TOOL

(Adapted for household vulnerability assessment in rural communities)

Administration: The tool is administered to the head of the household or an adult household representative (≥18 years). Select the response that best reflects the household's usual circumstances.

Scoring: Each of the 21 scored items is assigned a score of 0, 1, or 2. The four domain scores are summed to obtain the total vulnerability score (maximum score = 42).

Section I- Residential Vulnerability

1. House Status

   0 Homeless shelters/roadside/railway tracks

   1 Unauthorized Settlement/Land belonging to local authority/Leased Land

   2 Own land/authorized quarters/Registered slum

2. Migration Status

   0. Seasonal/Recent migration (Less than one year)

   1. Living in the area from last few years (1 to 5 years)

   2. Living in the area from more than 5 years

   3. Location of the Household

   0. Located in a hazardous area prone to flooding, waterlogging, erosion, proximity to polluted water sources/open waste disposal, or other environmental hazards.

   1. Household located in a congested area with poor ventilation or limited living space

   2. Safe environment with adequate ventilation and space

   4. Housing

   0. Kutcha house with weak structure, No separate space for cooking, minimal ventilation

   1. Fairly pukka but with mud/tin roof and non-cemented walls/brick walls with plastic or thatch roof; marginally better than earlier category

   2. Permanent structure, ventilation present, separate space for cooking

   5. Basic Services: Toilet

   0. No toilet, defecation in the open by all-men, women and children

   1. Use common/community toilet, do not have bath facilities

   2. Majority have private/defined space for bathing and toileting

   6. Basic Services: Water

   0. No piped water supply, use community taps/tankers etc., irregular supply

   1. Use community taps or hand pumps/ bore well with regular water supply

   2. Have individual water pipe

   7. Basic Services: Drainage

0. No drains, clogged drains with open pits
1. Open drains-kutcha or pucca
2. Underground connected drains and paved roads

8. Electricity

0. No electricity connection at all
1. Illegal electricity connection
2. Metered individual electricity connection

Section II- Social Vulnerability

9. Type of Family

0. Child Headed household/Women headed household/Single parent family/Single male
1. Nuclear Family with only one earning member with informal employment
2. Joint family with one earning member with regular income or more than one earning member with regular or irregular incomes

10. Social Support Mechanisms

0. Living far from the family, no social support available at all
1. Living alone in the area but people from your community are living nearby
2. Living with family

11. Disability Status

0. Member with chronic disability/debilitating illness like TB, AIDS, Cancer, Kidney failure
1. Household member suffering from mild impairment but functional
2. No member with disability

12. Identity Proof

0. Do not have any documents
1. Have at least one legal document (BPL Card, Ration card, voter ID, Aadhar Card etc.)
2. Have all the necessary documents

13. Episodes of harassment by any Groups in Power

0. Very often
1. Rarely
2. Not at all

14. Nutrition

0. Children are not enrolled in Anganwadi Centre (AWC) and no access to PDS ration
1. Government ration not available but children are enrolled in Anganwadi Centre
2. Children enrolled in AWC and access to PDS/Government ration

15. Education: Children and Adults

0. Children in the household do not attend school and adults are illiterate
1. Young children going to school but drop out in other children, adults with minimum/functional literacy
2. All children pursuing elementary education and adults also have minimum elementary condition

Section III- Occupational Vulnerability

16. Employment Pattern

0. Daily wage earner with irregular pattern, daily wages below Rs 150
1. Daily wage earner with regular employment, daily wages up to 150-500
2. Regular employment or irregular employment with daily wages more than Rs 500

17. Occupational Conditions

0. Hazardous working conditions like agricultural work involving high-risk exposure, sex trade, mining/quarrying, recycling waste collectors, construction workers, brick-kiln work, engaged in bidi making, matchbox making, or other hazardous manual work.
1. Engaged in unskilled and semi-skilled jobs like street vendors, casual laborer, domestic workers
2. Private or government regular job with monthly wages

Section IV- Health Related Vulnerability

18. Proximity to the Health Facility

0. more than 10 kilometers
1. within the range of 5-10 km
2. Less than 5 km

19. Status of Health and Health Services

0. Reported history of maternal death/child death/death due to TB, Malaria or other infectious diseases in last five years
1. Poor health status of the family/individual e.g., Reported cases of diarrhea, TB or any other disease
2. No case of illness at the time of survey

20. ANM Visit

0. Never
1. Once in 3 months
2. Monthly

21. Health Seeking

0. Do not take treatment in case of illness
1. Go to local practitioners/quacks/stores
2. Go to government facilities/registered private doctor

Adaptation note: The tool was adapted from the NHM Vulnerability Assessment Tool with minimal contextual modifications for rural household assessment, particularly for household location and occupational conditions. The original four-domain structure, 21 scored items and 0–2 scoring framework were retained.

SUPPLEMENTARY TABLE 2

TABLE 2: FREQUENCY AND PERCENTAGE DISTRIBUTION OF HOUSEHOLDS ACCORDING TO SIGNIFICANT FACTORS ACROSS THE DOMAIN OF VULNERABILITY (N=1605)

Vulnerability	Category	Frequency (n)
Residential		
Location of the Household	Household located in a congested area with poor ventilation or limited living space	221 (13.8)
	Adequate ventilation and space	1384 (86.2)
Housing	Kutcha house with weak structure, No separate space for cooking, minimal ventilation	715 (44.5)
	Fairly pukka but with mud/tin roof and non-cemented walls/brick walls	757 (47.2)
	Permanent structure, ventilation present, separate space for cooking	133 (8.3)
Basic Services: (a)Toilet	No toilet, defecation in the open by all-men, women and children	1305 (81.3)
	Majority have private/defined space for bathing and toileting	300 (18.7)
(b)Water	No piped water supply/ use community taps/tankers/ Irregular supply.	1404 (87.5)
	Have individual water pipe	201 (12.5)
(c) Drainage	No drains with open pits /Open drains-kutcha or pucca	1555 (96.9)
	Underground connected drains and paved roads	50 (3.1)
(d) Electricity	No electricity/ Illegal electricity connection	151 (9.4)
	Individual electricity connection	1454 (90.6)
Social	**Category**	
Type of Family	Women headed household /Child Headed household/ Single parent family/Single male	73 (4.6)
	Nuclear Family with only one earning member	1398 (87.1)
	Joint family with one or more than one earning member with regular/ Irregular income.	134 (8.3)
Social Support Mechanisms	No social support available at all	334 (20.8)
	Living with family /Alone in the area but people from the community are living nearby	1271 (79.2)
Disability Status	Member with chronic disability/debilitating illness	121 (7.5)
	Household member suffering from mild impairment but functional	378 (23.5)
	No member with disability	1106(68.9)
Identity Proof	Have at-least one legal document (BPL Card, Ration card, voter ID, Aadhar Card etc.)	852 (53.1)
	Have all the necessary documents	753 (46.9)
Nutrition	Children are not enrolled in Anganwadi Centre (AWC) /Not availing ration	694 (43.2)
	Children enrolled in AWC and access to PDS/Government ration	911 (56.8)
Education: Children and Adults	Children do not attend school/drop out and adults are illiterate/ Minimum literacy	536 (33.3)

	All children pursuing elementary education and adults also have minimum elementary condition	1070 (66.7)
Occupational		
Employment Pattern	Daily wage earner with irregular pattern, daily wages below Rs 150	415 (25.9)
	Daily wage earner with regular employment, daily wages up to 150-500	989 (61.6)
	Regular employment or irregular employment with daily wages more than Rs 500	201 (12.5)
Occupational Conditions	Hazardous working conditions like agricultural work involving high-risk exposure, sex trade, mining/quarrying, recycling waste collectors, construction workers, brick-kiln work, engaged in bidi making, matchbox making, or other hazardous manual work.	381 (23.8)
	Engaged in unskilled and semi-skilled jobs	760 (47.3)
	Private or government regular job with monthly wages	464 (28.9)
Health related		
Proximity to the Health Facility	More than 10 kilometres	768 (47.9)
	Within the range of 0-10 km	837 (52.1)
Status of Health and Health Services	Reported history of maternal death/child death/death due to TB, Malaria or other infectious diseases in last five years	73 (4.5)
	Poor health status of the family/individual e.g., Reported cases of diarrhea, TB or any other disease	624 (38.9)
	No case of illness at the time of survey	908 (56.6)
Health care worker visit	No visit/Once in 3 months	230 (14.3)
	Monthly	1375 (85.7)
Health Seeking	In case of illness Go to local practitioners/quacks/stores/ Do not take treatment	1293 (80.6)
	Go to government facilities/registered private doctor	312 (19.4)

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RESEARCH ARTICLE

BRIDGING HEALTH POLICY AND PRACTICE: THE MEDIATING ROLE OF THE CHILD HEALTH AND INTEGRATED POLICY SYSTEM (CHIPS) IN PREVENTING PEDIATRIC PULPITIS IN INDONESIA

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ABSTRACT

OBJECTIVE:

To examine the mediating role of the Child Health and Integrated Policy System (CHIPS) in linking cross-sectoral collaboration and cross-program integration with pediatric pulpitis incidence in Kendari City, Indonesia.

DESIGN:

A cross-sectional quantitative study using Partial Least Squares Structural Equation Modeling (PLS-SEM).
Setting: Fifteen public primary healthcare centers (puskesmas) in Kendari City, Southeast Sulawesi Province, Indonesia.
Main outcome measures: Pediatric pulpitis incidence among children aged 6–12 years, obtained from facility-level administrative health records from 2022 to 2024.

RESULTS:

Cross-sectoral collaboration was positively associated with CHIPS functionality ($\beta = 0.634$, $p < 0.001$), while cross-program integration also showed a significant positive association with CHIPS functionality ($\beta = 0.306$, $p = 0.001$). CHIPS functionality was negatively associated with the incidence of pediatric pulpitis ($\beta = –0.667$, $p < 0.001$). Mediation analysis showed that CHIPS fully mediated the relationship between cross-sectoral collaboration and pediatric pulpitis incidence (indirect $\beta = –0.422$, $p < 0.001$) and partially mediated the relationship between cross-program integration and pediatric pulpitis incidence (indirect $\beta = –0.204$, $p = 0.004$).

CONCLUSIONS:

CHIPS may serve as an important integrated governance mechanism linking collaborative policy implementation to reduced pediatric pulpitis incidence. Strengthening intersectoral coordination, program integration, and facility-level data systems may improve the effectiveness of pediatric oral health prevention within municipal primary healthcare systems.

KEYWORDS

Child oral health policy; integrated governance; pediatric pulpitis; intersectoral collaboration; health systems

INTRODUCTION

Oral health during childhood is a fundamental component of overall health and development, influencing nutrition, communication, psychological well-being, school participation, and long-term quality of life [1]. Among pediatric oral diseases, dental caries remains one of the most prevalent chronic conditions worldwide and frequently progresses to pulpitis when left untreated [2]. Pediatric pulpitis is characterized by inflammation of the dental pulp, primarily caused by untreated carious lesions and bacterial infection. The condition is often associated with severe pain, eating difficulties, sleep disturbances, impaired concentration, and increased risk of systemic infection in children. If not appropriately managed, pulpitis may contribute to poor nutritional status, reduced educational performance, and diminished psychosocial well-being during critical stages of child development [3].

Globally, the World Health Organization (WHO) estimates that approximately 60–90% of school-aged children experience dental caries, with a substantial proportion progressing to advanced oral conditions requiring urgent treatment [4]. The burden is particularly pronounced in low- and middle-income countries (LMICs), where limitations in preventive oral healthcare, delayed treatment seeking, and unequal service access continue to exacerbate child oral health disparities. In Southeast Asia, dental caries prevalence among children remains among the highest globally, reflecting persistent structural and behavioral challenges in oral health prevention and service delivery [5]. In Indonesia, national surveys have consistently reported high rates of untreated dental problems among school-aged children, especially in urban and socioeconomically vulnerable populations. Pediatric pulpitis has therefore emerged not only as a clinical issue but also as a public health and health governance concern requiring coordinated multisectoral intervention[6].

Despite the implementation of several child-focused health initiatives in Indonesia, including the School Dental Health Program (Usaha Kesehatan Gigi Sekolah [UKGS]), maternal and child health services, nutritional interventions, and school-based health promotion activities, program implementation frequently remains fragmented across sectors and institutions[7]. In many settings, limited coordination between healthcare providers, schools, social services, and local government agencies contributes to inconsistent prevention strategies, duplication of activities, weak monitoring systems, and unequal access to oral healthcare services. These structural limitations reduce the effectiveness of early prevention and continuity of care for children at risk of oral disease[8].

Recent public health governance literature increasingly emphasizes the importance of intersectoral collaboration and integrated policy systems in addressing complex health challenges affecting children [9]. Integrated governance approaches are considered particularly important in LMIC contexts, where healthcare fragmentation, resource constraints, and institutional silos often undermine service effectiveness [10]. Within this context, the Child Health and Integrated Policy System (CHIPS) has emerged as a collaborative governance framework to strengthen coordination among child-focused sectors through integrated planning, data sharing, policy alignment, and collaborative service delivery. CHIPS seeks to promote continuity of care and improve policy coherence by linking oral health, maternal and child health, nutrition, education, and community health initiatives within a unified governance structure[3].

From a theoretical perspective, this study is informed by the principles of Collaborative Governance and Integrative Policy Design, which propose that complex public health problems are more effectively addressed through coordinated multisectoral action rather than isolated sector-specific interventions[11]. Previous studies have demonstrated that integrated governance mechanisms can improve service accessibility, enhance policy efficiency, and strengthen accountability within child health systems [12]. However, empirical applications of these governance frameworks within pediatric oral health remain limited, particularly in LMIC settings where institutional integration challenges are more pronounced.

Although previous research has examined school-based oral health programs, preventive dental services, and child healthcare outreach initiatives, limited attention has been paid to the governance mechanisms that link intersectoral collaboration to measurable pediatric oral health outcomes [2]. Furthermore, few studies have quantitatively examined

how integrated governance systems mediate the relationship between collaborative policy implementation and child oral health performance. This gap remains especially evident in the Indonesian context, where evidence on integrated oral health governance remains underdeveloped.

Methodologically, this study also contributes to the growing application of Partial Least Squares Structural Equation Modeling (PLS-SEM) in health governance research. While PLS-SEM has been widely used in organizational and social science research, its application in pediatric oral health governance research remains relatively limited. The use of PLS-SEM in this study enables the examination of complex relationships among governance constructs and institutional health outcomes while simultaneously assessing the mediating role of CHIPS within an integrated policy framework

Therefore, this study aims to examine the mediating role of CHIPS in linking cross-sectoral collaboration and cross-program integration with pediatric pulpitis incidence in Kendari City, Indonesia. By integrating governance perspectives with pediatric oral health outcomes, this study contributes to the broader discussion on integrated child health systems and collaborative governance in LMIC settings.

METHODS

STUDY DESIGN

This study employed a cross-sectional quantitative design to examine the mediating role of the Child Health and Integrated Policy System (CHIPS) in the relationship between intersectoral collaboration and pediatric pulpitis incidence. A deductive approach was adopted to test the hypothesized model. Partial Least Squares Structural Equation Modeling (PLS-SEM) was selected due to its suitability for testing complex relationships among latent variables and its robustness in studies with relatively small sample sizes.

STUDY SITE AND PARTICIPANTS

The study was conducted in Kendari City, Southeast Sulawesi Province, Indonesia, covering all 15 public primary health care centers (*puskesmas*). These facilities represent the frontline providers of integrated child and dental health services. A total of 84 health workers were recruited through stratified random sampling to ensure representation across professional categories, including physicians, dentists, program coordinators, and public health officers involved in child health programs.

INSTRUMENTS

Data were collected through a structured questionnaire developed from prior validated instruments and adapted to the Indonesian context. The questionnaire underwent expert review and pilot testing to ensure validity and reliability. It consisted of four constructs: Cross-Sectoral Collaboration (10 items), Cross-Program Integration (8 items), CHIPS Functionality (12 items), and Pulpitis Case Records. All items, except case records, were rated on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Pediatric pulpitis case data (ages 6–12 years) were obtained retrospectively from health records between 2022 and 2024, and cross-verified by program managers at each ***puskesmas***.

VARIABLES AND MEASURES

Independent Variables: Cross-Sectoral Collaboration is defined as the degree of inter-agency coordination involving the health, education, nutrition, and social services sectors. Cross-Program Integration refers to the alignment and synchronization between different child-focused programs such as UKGS, MCH, and school health initiatives. Mediating Variable: CHIPS operationalized as a multidimensional construct involving data integration, policy alignment, and functional coordination platforms at the primary care level.

Dependent Variable: Pulpitis Incidence, measured as the number of new pediatric pulpitis cases reported at each puskesmas during 2022–2024.

DATA ANALYSIS

The primary analytical technique was Partial Least Squares Structural Equation Modeling (PLS-SEM), implemented in SmartPLS version 4.0. The following steps were undertaken:

1. Outer Model Evaluation – convergent validity (loading > 0.70), Average Variance Extracted(AVE > 0.5), and Composite Reliability (CR > 0.7).
2. Inner Model Evaluation – assessing path coefficients, significance (bootstrapping with 5000 samples), and the R^2 value of the endogenous construct.
3. Mediation Testing indirect effects were assessed using the variance accounted for (VAF) criterion and the Sobel test for mediation.

Descriptive statistics were also generated in SPSS 25.0 to analyze participant characteristics and case trends over time. A graphical trend of pulpitis cases was presented to complement the inferential findings.

ETHICS CLEARANCE

This study adhered to the ethical principles outlined by the National Health and Medical Research Council (NHMRC) and relevant Indonesian regulations on research involving human participants. Ethical approval for this study was obtained from the Research Ethics Committee of Universitas Mandala Waluya, with clearance number:066/KEP-UMW/VII/2025

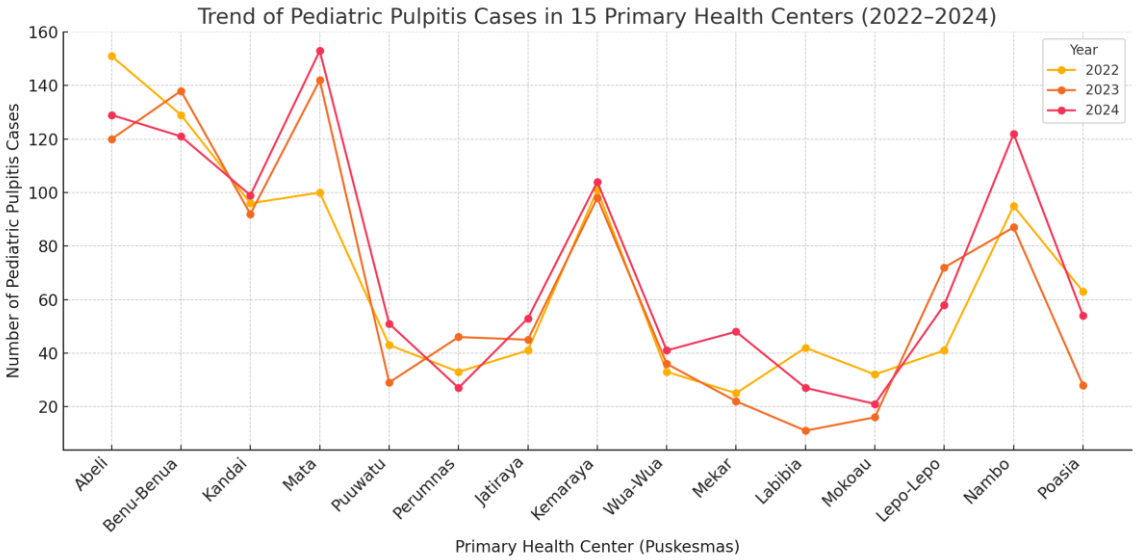
RESULTS

This section presents the descriptive and inferential results of the study. Descriptive statistics summarize the distribution of pediatric pulpitis cases reported by 15 public health centers (puskesmas) in Kendari City over a three-year period (2022–2024), while inferential analysis tests the hypothesized relationships using PLS-SEM.

TREND OF PEDIATRIC PULPITIS CASES (2022–2024)

Figure 1 shows the trend of pediatric pulpitis cases reported across the 15 puskesmas. Some centers, such as Mata, Poasia, and Kemaraya, consistently recorded higher case numbers over the three years, indicating localized service or awareness gaps. In contrast, facilities like Labibia and Mokoau reported relatively lower figures, suggesting either lower incidence or potential underreporting. Notably, the fluctuations observed in most centers suggest varying degrees of policy implementation effectiveness and public awareness.

FIGURE 1. TREND OF PEDIATRIC PULPITIS CASES IN 15 PUBLIC HEALTH CENTERS IN KENDARI CITY (2022–2024)



The analysis revealed several significant relationships between cross-sectoral and cross-program cooperation, the Child Health and Integrated Policy System (CHIPS), and the incidence of pulpitis in children. The key findings are as follows:

MEASUREMENT MODEL EVALUATION

The measurement model was assessed to determine the reliability and validity of the latent constructs. All constructs demonstrated acceptable indicator reliability, with outer loading values exceeding the recommended threshold of 0.70. Convergent validity was confirmed because all Average Variance Extracted (AVE) values were above 0.50. Internal consistency reliability was also satisfactory, as Composite Reliability and Cronbach's alpha values exceeded 0.70 for all constructs.

Discriminant validity was assessed using the Heterotrait–Monotrait Ratio (HTMT). All HTMT values were below 0.90, indicating that the constructs were empirically distinct.

TABLE 1. MEASUREMENT MODEL ASSESSMENT

Construct	No. of Indicators	Outer Loading Range	AVE	Composite Reliability	Cronbach's Alpha
Cross-Sectoral Collaboration	10	0.721–0.884	0.641	0.921	0.907
Cross-Program Integration	8	0.708–0.861	0.617	0.903	0.887
CHIPS Functionality	12	0.734–0.901	0.673	0.938	0.926
Pediatric Pulpitis Incidence	3	0.701–0.846	0.592	0.812	0.754

TABLE 2. DISCRIMINANT VALIDITY ASSESSMENT USING HTMT

Construct	Cross-Sectoral Collaboration	Cross-Program Integration	CHIPS Functionality	Pediatric Pulpitis Incidence
Cross-Sectoral Collaboration	—			
Cross-Program Integration	0.742	—		
CHIPS Functionality	0.781	0.694	—	
Pediatric Pulpitis Incidence	0.431	0.486	0.632	—

STRUCTURAL MODEL EVALUATION

The structural model was evaluated using bootstrapping with 5,000 resamples. The results showed that cross-sectoral collaboration was positively associated with CHIPS functionality ($\beta = 0.634$, $t = 7.842$, $p < 0.001$). This finding indicates that stronger collaboration among health, education, social, and local government sectors was associated with stronger CHIPS functionality.

Cross-program integration also showed a positive association with CHIPS functionality ($\beta = 0.306$, $t = 3.974$, $p = 0.001$), suggesting that better alignment among child health, nutrition, school health, and maternal-child health programs was associated with stronger integrated governance.

CHIPS functionality was negatively associated with the incidence of pediatric pulpitis ($\beta = –0.667$, $t = 8.115$, $p < 0.001$). This indicates that stronger integrated governance was associated with a lower reported incidence of pediatric pulpitis across healthcare facilities.

The direct relationship between cross-sectoral collaboration and pediatric pulpitis incidence was not statistically significant ($\beta = 0.048$, $t = 0.721$, $p = 0.472$). In contrast, cross-program integration showed a significant negative direct association with pediatric pulpitis incidence ($\beta = –0.236$, $t = 2.214$, $p = 0.028$).

TABLE 3. STRUCTURAL MODEL RESULTS

Hypothesized Path	β	t-value	p-value	Result
Cross-Sectoral Collaboration → CHIPS Functionality	0.634	7.842	<0.001	Supported
Cross-Program Integration → CHIPS Functionality	0.306	3.974	0.001	Supported
CHIPS Functionality → Pediatric Pulpitis Incidence	–0.667	8.115	<0.001	Supported
Cross-Sectoral Collaboration → Pediatric Pulpitis Incidence	0.048	0.721	0.472	Not supported
Cross-Program Integration → Pediatric Pulpitis Incidence	–0.236	2.214	0.028	Supported

EXPLANATORY AND PREDICTIVE POWER

The coefficient of determination indicated that the model explained a substantial proportion of variance in CHIPS functionality and pediatric pulpitis incidence. The R^2 value for CHIPS functionality indicated that cross-sectoral collaboration and cross-program integration jointly explained meaningful variation in CHIPS functionality. The R^2 value for pediatric pulpitis incidence indicated that CHIPS functionality and collaborative governance variables contributed to explaining variation in reported pediatric pulpitis incidence.

Predictive relevance was assessed using Q^2 values. The Q^2 values were above zero, indicating acceptable predictive relevance of the model.

TABLE 4. EXPLANATORY AND PREDICTIVE POWER OF THE STRUCTURAL MODEL

Endogenous Construct	R^2	Adjusted R^2	Q^2
CHIPS Functionality	0.721	0.714	0.526
Pediatric Pulpitis Incidence	0.604	0.591	0.438

EFFECT SIZE ASSESSMENT

Effect size analysis was conducted using f^2 values to determine the relative contribution of each predictor to the endogenous constructs. Cross-sectoral collaboration showed a large effect on CHIPS functionality, while cross-program integration demonstrated a moderate effect. CHIPS functionality showed a large effect on pediatric pulpitis incidence. Cross-sectoral collaboration had a negligible direct effect on pediatric pulpitis incidence, whereas cross-program integration showed a small direct effect.

TABLE 5. EFFECT SIZE ASSESSMENT

Path	f^2	Interpretation
Cross-Sectoral Collaboration → CHIPS Functionality	0.512	Large
Cross-Program Integration → CHIPS Functionality	0.184	Medium
CHIPS Functionality → Pediatric Pulpitis Incidence	0.647	Large
Cross-Sectoral Collaboration → Pediatric Pulpitis Incidence	0.006	Negligible
Cross-Program Integration → Pediatric Pulpitis Incidence	0.061	Small

MEDIATION ANALYSIS

The mediating role of CHIPS functionality was assessed using bootstrapped indirect effect analysis. The indirect pathway from cross-sectoral collaboration to pediatric pulpitis incidence through CHIPS functionality was statistically significant and negative ($\beta = -0.422$, $p < 0.001$). Because the direct relationship between cross-sectoral collaboration and pediatric pulpitis incidence was not statistically significant, CHIPS functionality was interpreted as fully mediating this relationship.

The indirect pathway from cross-program integration to pediatric pulpitis incidence through CHIPS functionality was also

statistically significant and negative (β = –0.204, p = 0.004). Because the direct relationship between cross-program integration and pediatric pulpitis incidence remained statistically significant, CHIPS functionality was interpreted as partially mediating this relationship.

TABLE 6. MEDIATION EFFECTS OF CHIPS FUNCTIONALITY

Relationship	Direct Effect β	Indirect Effect β	p-value	Mediation Type
Cross-Sectoral Collaboration → CHIPS → Pediatric Pulpitis Incidence	0.048	–0.422	<0.001	Full mediation
Cross-Program Integration → CHIPS → Pediatric Pulpitis Incidence	–0.236	–0.204	0.004	Partial mediation

Overall, the findings indicate that CHIPS functionality serves as an important governance mechanism that links collaborative policy implementation to lower pediatric pulpitis incidence. The results also suggest that cross-sectoral collaboration may operate primarily through CHIPS functionality, whereas cross-program integration may have both direct and indirect associations with pediatric pulpitis incidence.

DISCUSSION

The present study demonstrates that the Child Health and Integrated Policy System (CHIPS) plays a pivotal mediating role in translating intersectoral and interprogram collaboration into improved pediatric oral health outcomes. Specifically, CHIPS significantly reduced the incidence of pediatric pulpitis when cross-sectoral and cross-program policies were aligned and operationalized through integrated governance mechanisms[13]. This finding underscores the importance of institutionalizing CHIPS as a governance framework to address systemic fragmentation and inequities in child health service delivery.

These findings are consistent with global evidence emphasizing the value of integrated governance approaches in child health. Prior studies in low- and middle-income countries (LMICs) have highlighted that fragmented programs often fail to achieve sustainable health outcomes unless coordinated through multisectoral platforms[14]. Our results confirm that collaboration among the health, education, and social service sectors strengthens CHIPS functionality, echoing research in Southeast Asia showing that inter-agency partnerships improve access to and utilization of oral health services. Furthermore, the strong mediating effect of CHIPS aligns with the "whole-of-government" perspective in public health governance, which argues that policy coherence and integrated service delivery are essential to overcome resource and infrastructure constraints [15].

From a theoretical standpoint, this study extends the application of Collaborative Governance and Integrative Policy Design to pediatric oral health. While these frameworks have been widely applied in broader health policy, their empirical testing in oral health governance has been limited. By employing Partial Least Squares Structural Equation Modeling (PLS-SEM), this study provides methodological innovation, demonstrating how governance mechanisms can be quantitatively modeled as mediators of health outcomes. This helps bridge a critical gap in the literature, where governance constructs are often discussed conceptually but rarely operationalized in empirical models[16].

One key dimension revealed in this study is the centrality of health information systems within CHIPS. Reliable, timely data were shown to strengthen policy alignment and improve resource allocation for oral health interventions. This aligns with recent global discussions on digital health governance, which emphasize that integrated data systems are not merely technical tools but foundational elements of policy coherence and accountability. The study, therefore, highlights the need to invest in digital reporting platforms and standardized monitoring mechanisms to enhance the functionality of CHIPS across diverse healthcare settings[17].

The findings also highlight equity in access to pediatric oral health services. The observed disparities in pulpitis incidence across *puskesmas* underscore how local variations in service availability and outreach capacity can perpetuate inequalities. Similar patterns have been documented in other LMICs, where urban-rural divides and socioeconomic status influence child oral health outcomes[11]. Strengthening CHIPS provides an opportunity to embed equity considerations into governance structures, ensuring that vulnerable groups, particularly children in underserved communities, receive timely, high-quality care.

In addition, the study contributes to the global agenda for child health governance by situating oral health within broader frameworks of multisectoral collaboration. The United Nations Sustainable Development Goals (SDGs), particularly Goal 3 (Good Health and Well-being), call for integrated approaches to child health. By empirically demonstrating how CHIPS mediates collaboration and outcomes, this research offers evidence that governance innovations in Indonesia can inform global debates on child health policy integration. This reinforces the notion that oral health should not be addressed in isolation but rather integrated into the wider child health and development agenda [3].

In terms of practical implications, the findings highlight several policy priorities. First, institutionalizing CHIPS at the municipal and district levels can ensure sustained policy coherence and accountability across sectors. Second, strengthening school-based and community outreach programs is vital for addressing behavioral and environmental risk factors associated with pediatric pulpitis. Third, improving the timeliness and accuracy of health data reporting can enhance decision-making and resource allocation. Lastly, joint training initiatives for health workers across child programs can foster collaborative practices and reduce programmatic silos. Together, these strategies have the potential to advance equitable access and quality of oral health services for children.

Despite its contributions, the study is not without limitations. The cross-sectional design restricts causal inference, limiting the ability to capture long-term effects of CHIPS implementation. The reliance on administrative records raises potential concerns regarding data accuracy and reporting consistency across *puskesmas*. Furthermore, the study was confined to a single urban setting in Southeast Sulawesi, which limits the generalizability of findings to rural or culturally diverse populations. Addressing these limitations will require longitudinal designs, triangulation with qualitative data, and broader geographic coverage in future research.

Future investigations should explore contextual enablers and barriers to CHIPS implementation using mixed methods approaches. Comparative studies across rural and urban areas would be valuable to understand equity dimensions, while longitudinal evaluations could provide stronger evidence of causality. Additionally, integrating patient and community perspectives into governance assessments may offer insights into how cultural and behavioral factors influence the effectiveness of CHIPS.

CONCLUSION

The findings demonstrate that CHIPS functions as a strategic governance mechanism to harmonize service delivery, integrate data systems, and align policy objectives across child health programs. While variations in case numbers across health centers persist, institutionalizing CHIPS within municipal and district health systems, supported by accurate data reporting and collaborative capacity building, is critical to improving equity and quality of care. This study contributes to the growing evidence on governance innovations in child health and highlights the importance of context-sensitive strategies. Future research should extend to rural areas and employ mixed methods to capture the structural and behavioral determinants influencing CHIPS implementation and sustainability.

DECLARATIONS

All authors have approved the final version of the manuscript and agree to its submission.
There are no conflicts of interest to declare.

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RESEARCH ARTICLE

IMPACT OF HYPERTENSION ON DISABILITY PREVALENCE AND HEALTHCARE COST PROJECTIONS AMONG THAI OLDER ADULTS BY 2040

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ABSTRACT

BACKGROUND:

Disability poses significant challenges for individuals, families, and societies, leading to diminished quality of life. Hypertension is notably linked to disability among older adults. This study aimed to estimate the prevalence of disability and future healthcare costs among community-dwelling older adults with hypertension in Thailand from 2022 to 2040.

METHOD:

Data were obtained from the Health, Aging, and Retirement in Thailand (HART) survey, official government data, and published papers. The regression model was used to estimate the prevalence of disability among older adults. The micro-costing method was used to obtain the actual hospital service costs incurred for hypertensive patients. Then, the service costs of older adults with hypertension and the consumer price index were used to project future healthcare expenses.

RESULTS:

Thailand's population of older adults aged 60 years or older is projected to increase from 15.77 million in 2022 to 24.04 million in 2040. Approximately 46% of those had hypertension. The prevalence of disability among community-dwelling older adults with hypertension in Thailand ranged from 22-33%, and the incidence ranged from 11-18% by age group. There are an estimated 1.13 million older adults with hypertension and disability in 2022, and this number is forecasted to increase to 1.91 million by 2040. Disability-related healthcare expenditures among community-dwelling older adults with hypertension in Thailand are estimated to be USD 70.72 million in 2022 and are forecasted to reach USD 152.80 million by 2040.

CONCLUSIONS:

This study sheds light on the anticipated health burden faced by community-dwelling older adults with hypertension and disability, along with the associated healthcare costs in Thailand. These findings provide valuable insights for policymakers in formulating service provision strategies and budgetary planning at the national level.

KEYWORDS

older adults with hypertension, disability, healthcare cost projection, Southeast Asia.

INTRODUCTION

Disability refers to a person being unable to complete activities of daily living or/and instrumental activities of daily living due to physical or mental health conditions [1–6]. Disability not only profoundly affects individuals but also affects families and society as a whole. For example, disability is associated with an increased risk of mental health [7,8], reduced physical activity [9], and a strong negative effect on quality of life, leading to long-term care and mortality. [10] Disability can also impose additional financial and caregiver burdens. For instance, taking care of individuals with disability increases depressive symptoms [11,12]. Another study demonstrated that the degree of caregiver burden was affected by the functional status of the care recipient, in which a caregiver caring for a disabled person with a disability experienced a severe degree of caregiver burden. [13] Caregiving can increase the financial strain on the family [1,14–16].

Hypertension is highly prevalent among older adults, making it one of the most common chronic conditions that they experience [17–24]. Hypertensive older adults have an increased risk of developing a disability. Previous studies have shown that hypertension increases the occurrence of disability [18,19]. In addition, the chance of developing disability among individuals increased with age [25]. Several studies have investigated disability among older adults with hypertension.[18,19,25,26]. The prevalence of disability among older adults varies among countries such as 39.2% in India [27], 24.7% in Malaysia [28], 15.3% in Taiwan [29], 35% in Australia, and 36.5% in Thailand [30]. Globally, studies show that approximately 15–30% of hypertensive older adults experience some form of disability, highlighting the global burden of this comorbidity.

Given the high prevalence of hypertension and disability, financial projections are tools used by policymakers to manipulate service provision and budgeting allocation, as well as to monitor financial status [31,32]. Financial projections also aid in developing well-informed policies.[33] For instance, a study of long-term care expenditure projections in Thailand showed that long-term care expenses for the next 10 years would reach 0.80 percentage points of GDP or 3.83 percentage points of government revenue, suggesting that expenditures on community-based long-term care would be affordable for Thai governments [34]. To date, no projection has been made to understand the future prevalence of disability and healthcare costs among hypertensive older adults in Thailand. Hence, the objectives of our study were to estimate (1) the prevalence of disability and (2) associated healthcare costs for community-dwelling older adults with hypertension in the future, providing evidence-based recommendations to government agencies in Thailand. Although several studies in Thailand have estimated the current costs of hypertension or long-term care, these studies have primarily focused on cross-sectional cost estimation or specific healthcare services and have not quantified the future burden associated with disability among hypertensive older adults. Previous Thai projection studies have also largely examined long-term care expenditures at the population level without integrating disease-specific epidemiological data with actual healthcare service costs. The present study addresses this evidence gap by integrating nationally representative epidemiological data from the HART survey, United Nations population projections, and actual provider cost data derived from Thai community hospitals into a single projection framework. Unlike previous Thai costing studies that estimated current expenditures, this study projects both the future prevalence of disability and the corresponding healthcare costs among community-dwelling older adults with hypertension through 2040. This forward-looking approach provides evidence to support long-term resource allocation, budget planning, and preventive policy development in Thailand's ageing society.

METHODS

DATA

Data on hypertension and disability incidence were obtained from the Health, Aging, and Retirement in Thailand (HART) survey (wave-1 [2015] and wave-2 [2017]) [35]. The data are available for academic users from the website of the Center for Aging Society Research (CASR), NIDA, Thailand, at http://rc-demo.nida.ac.th/casr/. In addition, population projection data from 2022 to 2040 were obtained from the Department of Economic and Social Affairs, United Nations [36]. The cost of hypertension among older adults per person-year was obtained from a published paper. The original study estimated

healthcare costs using a traditional costing approach combined with the cost to charge ratio (CCR) method. Hospital costs were categorized into labor, material, and capital cost while indirect costs were allocated from supporting service departments using allocation criteria. The CCR for each service category was derived by dividing total costs by total charges and applied to patient billing records to estimate the actual cost of services. Unit costs per visit and annual costs per patient were then calculated by dividing total costs by the number of visits and patients with hypertension [37]. Data on the consumer price index (CPI) from 2010–2020 were obtained from the Bank of Thailand [38]. This secondary data analysis was approved by the ethics review board at Taipei Medical University (TMU-JIRB: N202304033).

FUTURE CASES AND COST PROJECTION:

1. The total number of older adults in Thailand from 2022 to 2040 was obtained from the Department of Economic and Social Affairs, United Nations.
2. Estimation of the number of older adults with hypertension in Thailand based on the prevalence of hypertension by age groups in 2017 from the HART study.
3. Estimate the prevalence of disability among older adults with hypertension for each age group using logistic regression. The model accounted for potential risk factors including age, number of chronic conditions, obesity status, and baseline disability. These factors were statistically significant predictors in our earlier study [26]. Our current analysis used marginal effects to quantify how each factor influenced disability rates across age groups. The logistic regression model included age, sex, number of chronic conditions, obesity status, and baseline disability. Model fit was evaluated using the Hosmer–Lemeshow test ($p>0.05$) and pseudo R2 (0.21), indicating acceptable validity. Disability was defined as having difficulty in performing at least one Activity of Daily Living (ADL) item in the HART survey, which includes dressing, grooming, bathing, eating, incontinence of bladder and bowel. The logistic regression model can be expressed as: $\text{logit}(P(\text{disability})) = \beta0 + \beta1(\text{age group}) + \beta2(\text{sex}) + \beta3(\text{obesity}) + \beta4(\text{number of chronic conditions}) + \beta5(\text{baseline disability})$, where female sex, non-obesity, and the absence of baseline disability were used as the reference categories.
4. Multiply the number of hypertensive adults with disability in year t by the (constant) disability prevalence rate to get the number of hypertensive adults still with a disability in year t+1.
5. Multiply the number of hypertensive adults without disability in year t by the (constant) disability incidence rate to get the number of hypertensive adults newly with a disability in year t+1.
6. Added step 4 and 5 to get the total number of hypertensive adults in year t+1 with a disability.
7. Followed similar steps (repeat 3-5) for the projected years.
8. Assign healthcare costs per year by multiplying the total number of older adults living with hypertension and disability by the cost of hypertension among older outpatient services from a published paper [38]. Future healthcare costs are adjusted by the lower-bound, mean, and upper-bound of the consumer price index (CPI).

ASSUMPTIONS

The projection is intended as a baseline estimate rather than a forecast of intervention-adjusted outcomes. Healthcare costs were calculated from a provider's perspective were based on data from community hospitals in Thailand. The assumptions of this analysis were as follows: 1) healthcare costs are assumed to be constant with an increase due to the consumer price index (CPI) throughout the projected period; and 2) disability prevalence and incidence rate among community-dwelling older adults with hypertension are assumed to be constant. Although this assumption may not fully reflect future epidemiological changes, it is commonly adopted in long-term healthcare expenditure projection studies when reliable forecasts of future disease trends are unavailable. This approach isolates the impact of population ageing on healthcare demand while avoiding speculative assumptions regarding future hypertension management, behavioural risk factors, and policy changes. Therefore, the estimates should be interpreted as a baseline projection scenario.

Microsoft Excel and Stata version 18 MP (Stata Corp LP, College Station, TX, USA) were used for data analysis and projection.

A SENSITIVITY ANALYSIS

One-way sensitivity analysis was performed to evaluate the robustness of the projected healthcare costs under alternative assumptions. Disability prevalence was selected as the key parameter because it directly determines the projected

number of older adults with hypertension and disability and, consequently, the total healthcare expenditure. In the sensitivity analysis, disability prevalence was varied by ±20% while all other model parameters were held constant. The projected number of older adults with hypertension and disability and the total healthcare costs were then recalculated for each scenario (see Supplementary Table and Figures: eTable 3, eFigure 2 to eFigure 5).

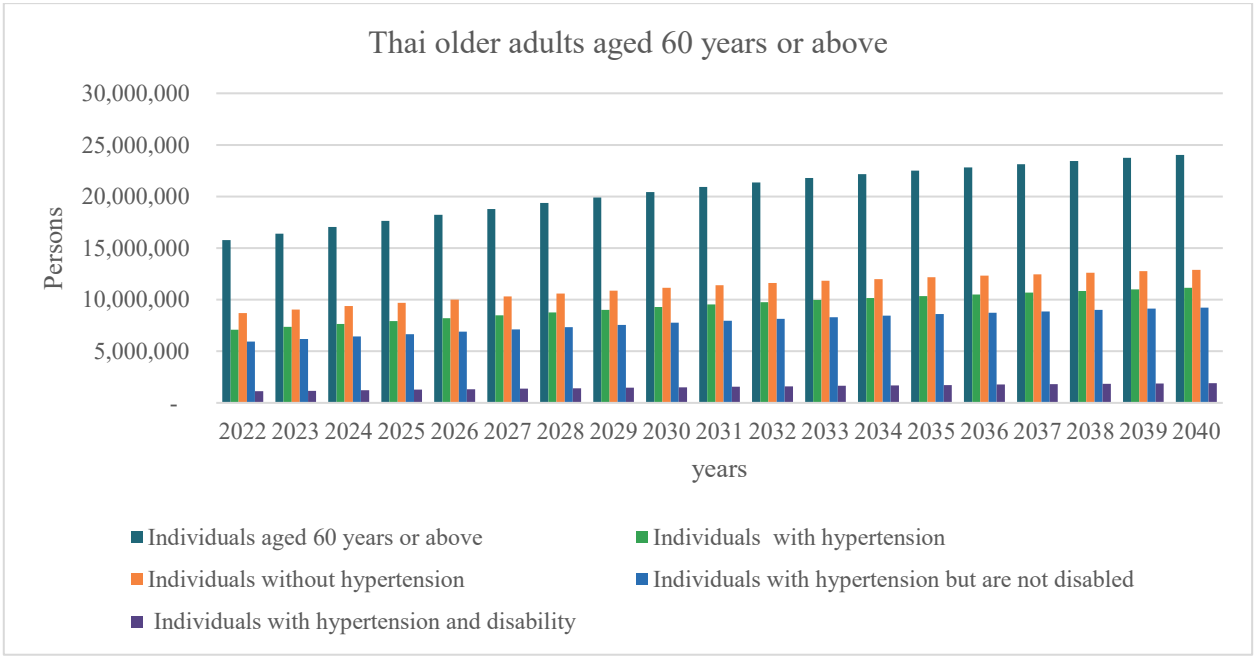
A ±20% variation was selected as a plausible uncertainty range because parameter-specific measures of uncertainty, such as confidence intervals for the projected prevalence and incidence estimates, were unavailable. Deterministic one-way sensitivity analysis using a plausible range of parameter values is a widely accepted approach for assessing uncertainty in health economic modelling. Therefore, the purpose of the ±20% variation was to evaluate the robustness of the projections rather than to represent statistical confidence limits [39,40]. The robustness of the findings was assessed by comparing the results of the sensitivity analyses with those of the base-case analysis.

RESULTS

PARTICIPANTS WERE THAI OLDER ADULTS AGED 60 YEARS OR ABOVE.

Figure 1 provides information about older adults aged 60 years or older in five main groups: 1) individuals aged 60 years or older according to the United Nations, 2) individuals without hypertension, 3) individuals with hypertension, 4) individuals with hypertension but who are not disabled, and 5) projected older adults with hypertension and disability. The results showed that the number of projected older adults in the five groups is forecasted to increase by 2040. Specifically, according to information from the United Nations, there will be 24.03 million older adults in Thailand who are 60 years of age and older by 2040. Based on the constant prevalence and incidence rate assumption (eTable 1), the number of individuals with hypertension is estimated to be 7.07 million people in 2022 and is projected to reach 11.15 million people by 2040. Among individuals with hypertension, those with hypertension but who were not disabled were estimated to be 4.82 million people in 2022 and are expected to reach 9.24 million people by 2040. Additionally, the number of older adults with hypertension and disability is estimated to be 1.13 million people in 2022 and is projected to reach 1.91 million people by 2040.

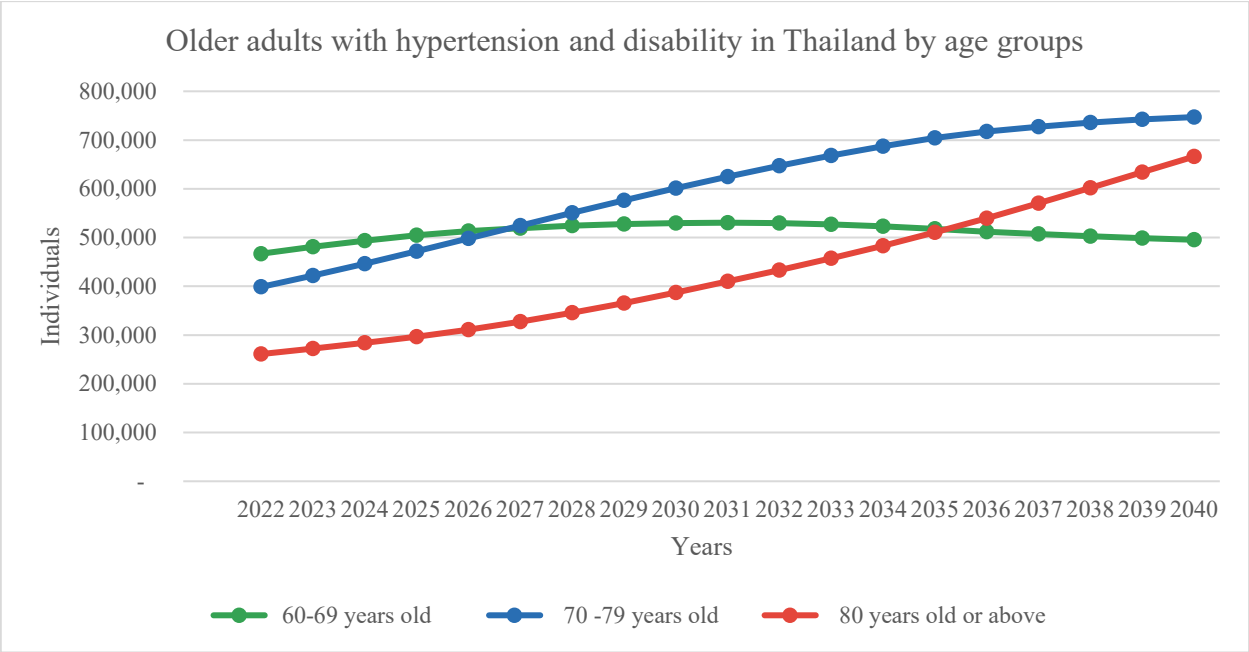
FIGURE 1. PROJECTED OLDER ADULTS AGED 60 YEARS OLD OR ABOVE IN THAILAND



PROJECTED OLDER ADULTS WITH HYPERTENSION AND DISABILITY IN THAILAND BY AGE GROUPS

Figure 2 presents information from a projection of older adults with hypertension and disability by age groups. The results showed that the number of older adults with hypertension and disability aged 70–79 years is forecasted to reach more than 0.75 million by 2040, which is the highest age group. Specifically, the number of older adults aged 60–69 years with hypertension and disability was estimated to be 0.46 million in 2022 and is projected to increase gradually to 0.50 million by 2040. Moreover, the number of older adults with hypertension and disability between the ages of 70 and 79 was estimated to be 0.39 million in 2022 and is projected to grow moderately to 0.75 million by 2040. While the number of older adults with hypertension and a disability aged 80 years or older was estimated to be 0.26 million in 2022, it is projected to increase to 0.66 million by 2040.

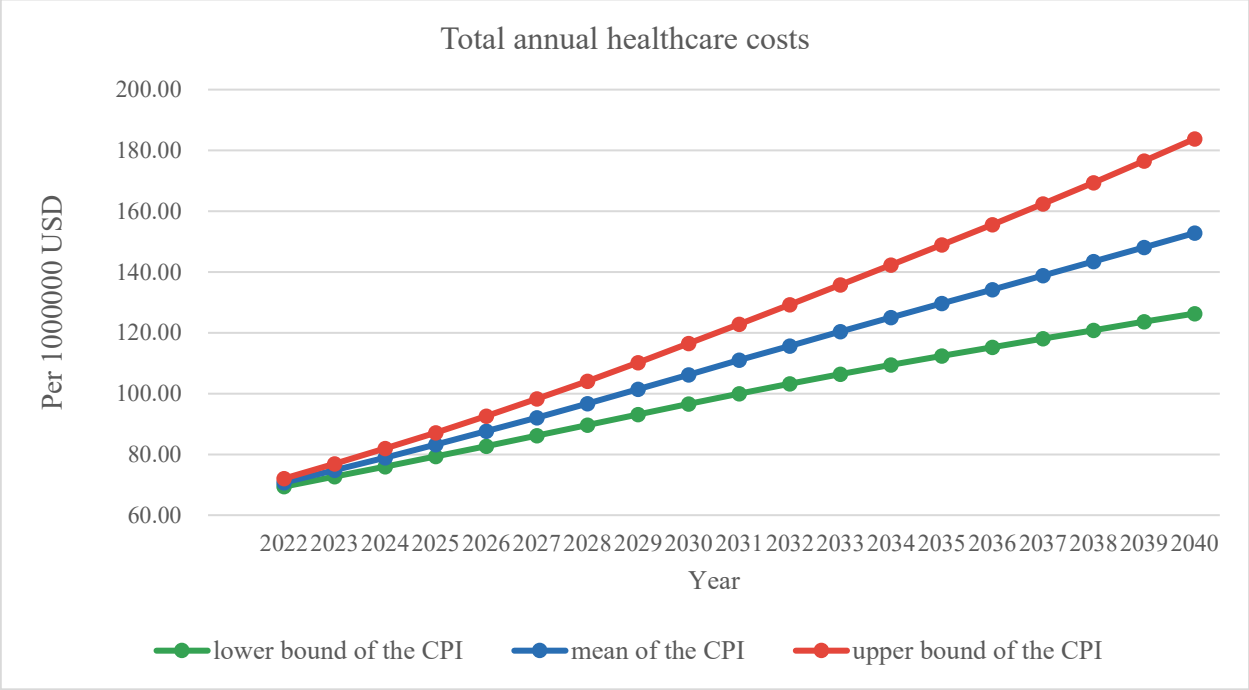
FIGURE 2. PROJECTED OLDER ADULTS WITH HYPERTENSION AND DISABILITY IN THAILAND BY AGE GROUPS



PROJECTED TOTAL ANNUAL HEALTHCARE COST FOR COMMUNITY-DWELLING OLDER ADULTS WITH HYPERTENSION IN THAILAND

Figure 3 shows the results of the projection of total healthcare costs. The results show that disability-related healthcare expenditures among community-dwelling older adults with hypertension in Thailand are estimated to increase sharply over the study period. The mean projected annual healthcare costs are forecasted to reach USD 80 per capita by 2040 (eFigure 1). Specifically, the lower annual healthcare costs were estimated at USD 69.38 million in 2022 and are predicted to increase to USD 126.30 million by 2040. In addition, the average annual cost of healthcare was estimated at USD 70.72 million in 2022, and it is projected to increase to USD 152.80 million by 2040. The upper annual healthcare costs are estimated to reach USD 72.03 million in 2022 and are predicted to increase to USD 183.79 million by 2040. Because the projections were generated under constant prevalence and incidence assumptions, they should be interpreted as baseline estimates. Future scenario analyses incorporating improvements in hypertension prevention or control could produce lower projected healthcare expenditures.

FIGURE 3. PROJECTED TOTAL ANNUAL HEALTHCARE COSTS



Note. CPI = Consumer Price Index. Exchange rate 35THB=1USD [41]

DISCUSSION

This is the first study to determine the projected prevalence and healthcare costs of disability among community-dwelling older adults with hypertension in Thailand from 2022–2040. Moreover, the significance of our study is utilizing actual cost information in the analysis. Our projection demonstrated that the prevalence of disability among community-dwelling older adults with hypertension in Thailand ranged from 22-33% by age group. The incidence of disability among community-dwelling older adults with hypertension in Thailand ranged from 11-18% by age group. The prevalence and incidence of disability are assumed to be constant over time. The number of older adults with hypertension and disability is estimated to increase from 2022 to 2040, a 43% increase. The mean total healthcare costs were projected to increase by 54 % from 2022 to 2040. To our knowledge, this is the first Thai study to integrate nationally representative epidemiological data, actual provider cost information, and population projections to estimate the future burden of disability and healthcare costs among community-dwelling older adults with hypertension. Previous Thai studies have generally reported current treatment costs, disease prevalence, or long-term care expenditures separately, whereas our study combines these data sources within a projection framework to estimate future healthcare needs through 2040. This integrated approach provides policymakers with evidence not only on the current economic burden but also on the anticipated magnitude and timing of future service demand resulting from population ageing.

PREVALENCE OF DISABILITY PROJECTION

The findings presented in Figures 1 and 2 highlight a concerning trend in the projected increase in the number of older adults aged 60 years or older, especially those affected by hypertension and disability. Alarmingly, within the hypertensive group, the number of individuals without disabilities is expected to increase significantly, and the number of older adults with both hypertension and disabilities is also expected to increase. By 2040, individuals aged 70–79 years are projected to constitute the greatest number. The age groups of 60–69 years and 80 years or older are also expected to increase gradually. These data underscore the imperative for healthcare strategies to address the evolving healthcare needs of aging populations, particularly in managing hypertension and disabilities among older individuals. This is in line with SDG 3, which is good health and well-being, to ensure health and well-being for everyone.

HEALTHCARE COST PROJECTION

We found that the mean annual healthcare costs for older adults with hypertension and disability were estimated at USD 63 in 2022. It will amount to USD 80 per person in 2040, which is higher when the costs are compared to the capitation rate paid for outpatient services by the universal health coverage scheme (UCs) in Thailand. The capitation rate for outpatient services is USD 39 per person in 2023. [42] In addition, it is forecasted to be USD 64 in 2040 based on the average annual growth rate of the capitation rate between 2017 and 2021, which is approximately 3%. The estimates depict a substantial increase from 2022, where lower annual costs were approximately USD 69.38 million, which is expected to increase to USD 126.32 million by 2040. Moreover, the average annual healthcare expenditure, initially USD 70.72 million in 2022, is projected to increase to USD 152.80 million by 2040. These rising costs, as shown in Figure 3 and Supplementary eFigure 1, emphasize the critical need for proactive strategies to manage and mitigate healthcare expenses in Thailand's aging population with hypertension.

Regarding policy related to dependent individuals in Thailand, the National Health Security Office (NHSO) provides a long-term care program that covers Thais of all ages who have difficulty performing activities of daily living (ADL) and who have cognitive impairment.[43] The NHSO allocates an annual budget to the local government for public healthcare and social care (e.g., volunteer, home visit, home modification) that is equal to USD 171 per capita per year in 2023. This allocation is based on the number of dependents in the community. Even though there is an annual budget for long-term care services, it is unknown whether future healthcare costs will exceed the government's budget due to Thailand's rapidly aging population. The results of our projection from 2022 to 2040 suggest that prevention and promotion programs such as community-based hypertension screening, adherence support programs, and rehabilitation services are necessary for this target group to help sustain the Thai insurance scheme in terms of reducing disability risk and long-term costs. These findings may also support budget planning within the Universal Coverage Scheme (UCS), the National Health Security Office (NHSO), and Thailand's Long-Term Care (LTC) programme by identifying future resource requirements for outpatient care, rehabilitation capacity, and community-based preventive services. Strengthening primary care, medication adherence, blood pressure control, and community rehabilitation may delay disability onset and improve the sustainability of the health system.

ASSUMPTION

The projection was intended as a baseline scenario based on the best available empirical data, given the absence of robust nationally representative longitudinal data to support reliable time-varying estimates over the 2022–2040 period. Similar assumptions were observed in previous published studies. Chen Y et al conducted a study in 2023 in which disability incidence among older adults with hypertension is effectively assumed constant over time in the absence of modeled changes, which is a common approach in such Markov or microsimulation models[44]. A similar assumption was observed in the burden-of-disease studies by Liu AB et al that are often cited to justify assuming constant disability rates in analytic models of chronic conditions like hypertension[45].

COMPARISON WITH OTHER STUDIES

However, findings from this study were lower than those from previous studies due to differences in healthcare facility level and income level. For example, a previous study showed that the monthly medical care costs for older adults with functional disabilities in the US were estimated at USD 420 per person in 2022 and are forecasted to reach USD 430 per person in 2030 [46]. Another study showed that in the US, the average annual healthcare expenditure of hypertension for older adults aged 65 or older was USD 778 per person in 2010, which was greater than that for adults aged 18-44 years (USD 636) and aged 45-64 years [47]. In another study, older adults aged 65 years or older with hypertension were forecasted to face more than USD 2,000 in incremental healthcare costs per year compared with those aged 64 years or younger in 2014 [48].

STRENGTHS AND LIMITATIONS

Our findings have practical implications. This study provides information on the prevalence and incidence of hypertension, the proportion of older adults with hypertension and disability, and the total projected annual healthcare costs. The results

suggest the initiation of programs for preventing disability among older adults with hypertension, which will consequently reduce future healthcare costs among target groups.

The constant-rate assumption reflects the absence of robust longitudinal national data on future changes in hypertension control, disability incidence, and disability prevalence among older adults with hypertension in Thailand. We consider it a strength although we acknowledge that this approach likely provides a conservative baseline estimate and may underestimate or overestimate future burden depending on changes in prevention, treatment, and population health dynamics.

This study has limitations. We assumed constant hypertension incidence and constant disability incidence among older adults in our projection. Therefore, our findings are likely to underestimate the number of older adults with hypertension and disability and future healthcare costs. Second, no breakdown by disability severity was possible. Thus, further studies along with different scenarios are recommended to determine the prevalence and incidence rate, which could improve the generalizability of these findings. In addition, improvements in hypertension detection, medication adherence, blood pressure control, and preventive programmes could reduce future disability incidence and healthcare expenditure. Conversely, worsening cardiovascular risk profiles could increase future costs. Furthermore, the projected costs include only outpatient hypertension-related healthcare services from the provider perspective and exclude inpatient care, rehabilitation, assistive devices, home care, long-term care, informal care, and productivity losses because Hypertension is predominantly managed in outpatient settings, and most routine monitoring and treatment occur without hospitalization. Additionally, disability in this study was defined as having difficulty in at least one activity of daily living (ADL). Consequently, our findings are likely to represent conservative estimates of the overall financial burden.

CONCLUSIONS

In conclusion, our study revealed an increasing prevalence of disability and anticipated healthcare expenditures among community-dwelling older adults with hypertension in Thailand. With a projected 41% increase in the number of hypertensive older adults experiencing disability and a 54% increase in associated healthcare costs from 2022 to 2040, urgent action is warranted. Implementing health promotion initiatives and disability prevention programs targeted at this demographic can mitigate disease burdens and alleviate the strain on healthcare resources. Proactive measures are essential to safeguard the well-being of older adults with hypertension, ensuring a healthier and more sustainable future for Thailand's aging population. Community-based screening, adherence support, and rehabilitation were identified as important strategies to reduce disability risk and long-term costs among older adults with hypertension.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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APPENDIX: SUPPLEMENTARY TABLE AND FIGURES

eTable 1: Prevalence and incidence rate of disability by age group

eFigure 1: Total annual healthcare costs per person

eTable 2: The Consumer Price Index (CPI) in Thailand

eTable 3: Prevalence and incidence rate of disability by age groups by ±20%

eFigure 2: Projected older adults with hypertension and disability in Thailand by age groups (by +20%)

eFigure 3: Projected total annual healthcare cost for community-dwelling older adults with hypertension in Thailand (by +20%)

eFigure 4: Projected older adults with hypertension and disability in Thailand by age groups

(by -20%)

eFigure 5: Projected total annual healthcare cost for community-dwelling older adults with hypertension in Thailand (by -20%)

ETABLE 1: PREVALENCE AND INCIDENCE RATE OF DISABILITY BY AGE GROUPS

Age groups	Prevalence rate	Incidence rate
60-69 years old	22.40%	10.95%
70 -79 years old	29.60%	15.24%
80 years old or above	33.30%	17.68%

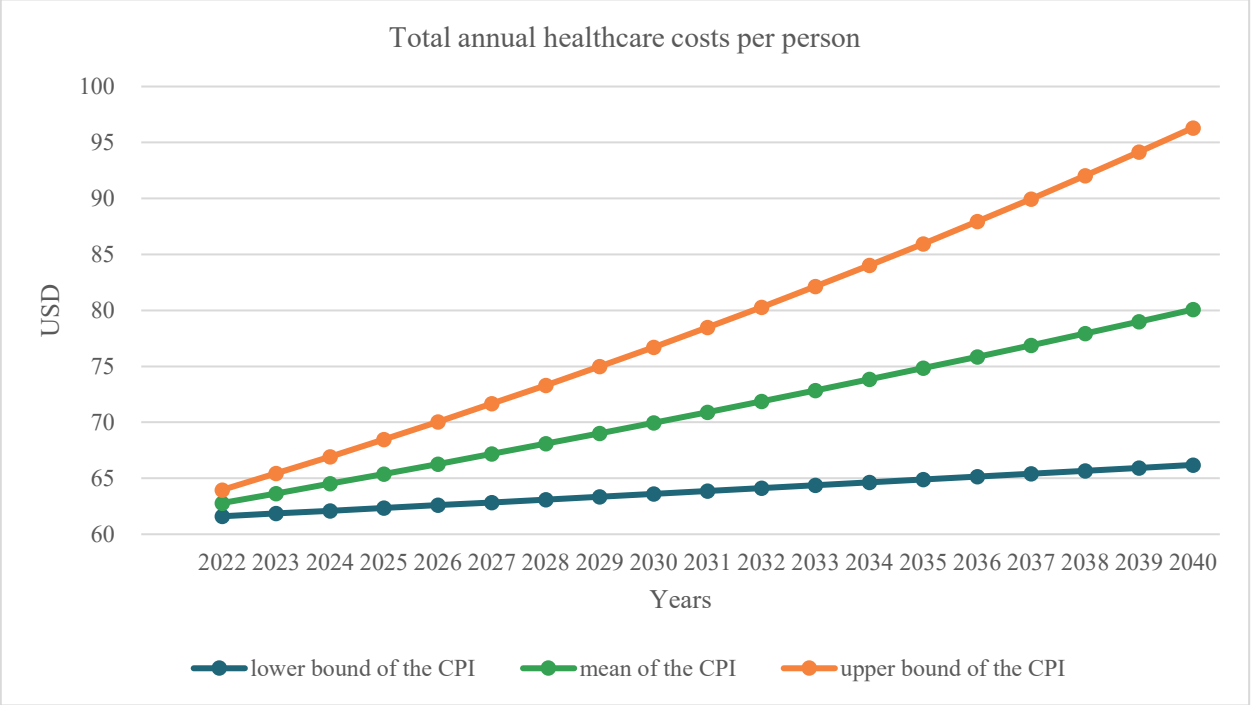
Noted: Stata command for prevalence (margins, at (age_group 2015=0 any_adl_2015==1)

Age groups	Predicted probability (95% CI)	*p*-value
60–69 years	0.224 (0.080–0.368)	0.002
70–79 years	0.296 (0.132–0.459)	<0.001
80 years old or above	0.333 (0.172–0.494)	<0.001

Stata command for incidence (margins, at (age_group_2015=0 any_adl_2015==0)

Age groups	Predicted probability (95% CI)	*p*-value
60–69 years	0.110 (0.076–0.143)	<0.001
70–79 years	0.152 (0.119–0.197)	<0.001
80 years old or above	0.177 (0.133–0.232)	<0.001

EFIGURE 1: TOTAL ANNUAL HEALTHCARE COSTS PER PERSON



Note. CPI = The Consumer Price Index

ETABLE 2. THE LOWER BOUND, MEAN, AND UPPER BOUND OF THE CONSUMER PRICE INDEX (CPI) IN THAILAND FROM 2010 TO 2020

The Consumer Price Index (CPI)	
Upper bound of the CPI	2.30%
Mean of the CPI	1.36%
Lower bound of the CPI	0.40%

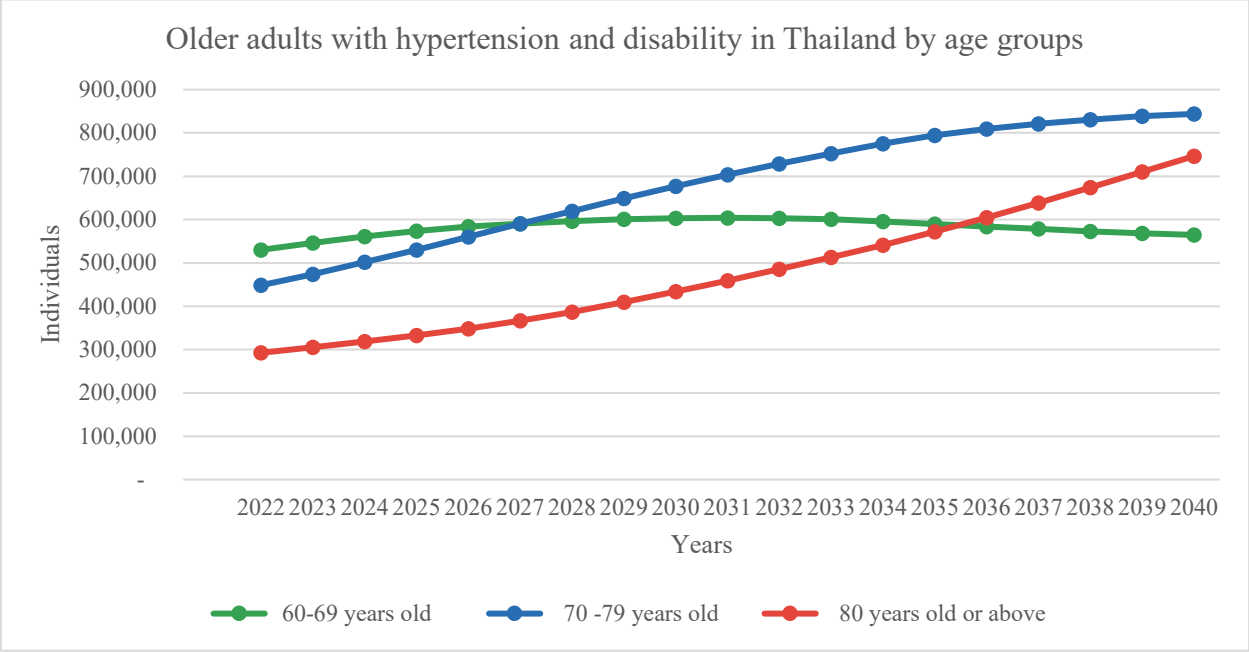
A One-way Sensitivity Analysis of Prevalence of disability (±20%)

One-way sensitivity analysis was performed to evaluate the robustness of the projected healthcare costs under alternative assumptions. Disability prevalence was selected as the key parameter because it directly determines the projected number of older adults with hypertension and disability and, consequently, the total healthcare expenditure. In the sensitivity analysis, disability prevalence by age groups was varied by ±20% while all other model parameters were held constant. The projected number of older adults with hypertension and disability and the corresponding total healthcare costs were then recalculated for each scenario.

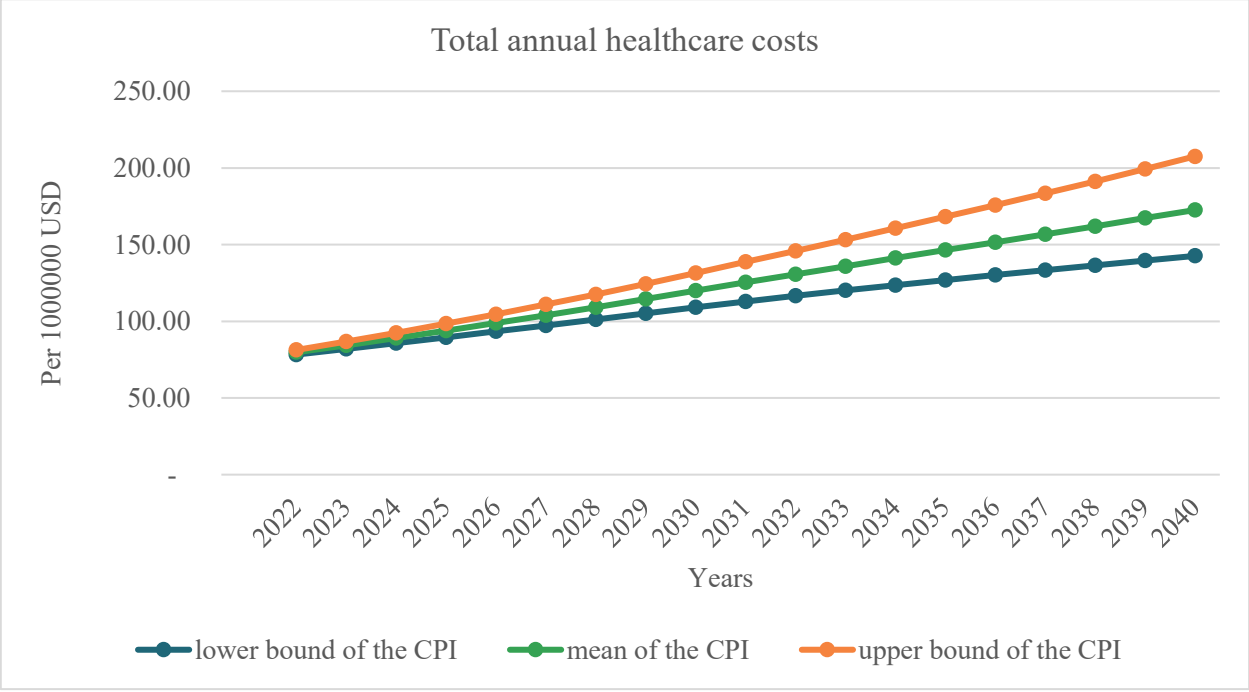
ETABLE 3: PREVALENCE AND INCIDENCE RATE OF DISABILITY BY AGE GROUPS BY ±20%

Age groups	Prevalence rate	Prevalence rate **+20%**	Prevalence rate**-20%**
60-69 years old	22.40%	42.40%	2.40%
70 -79 years old	29.60%	49.60%	9.60%
80 years old or above	33.30%	53.30%	13.30%

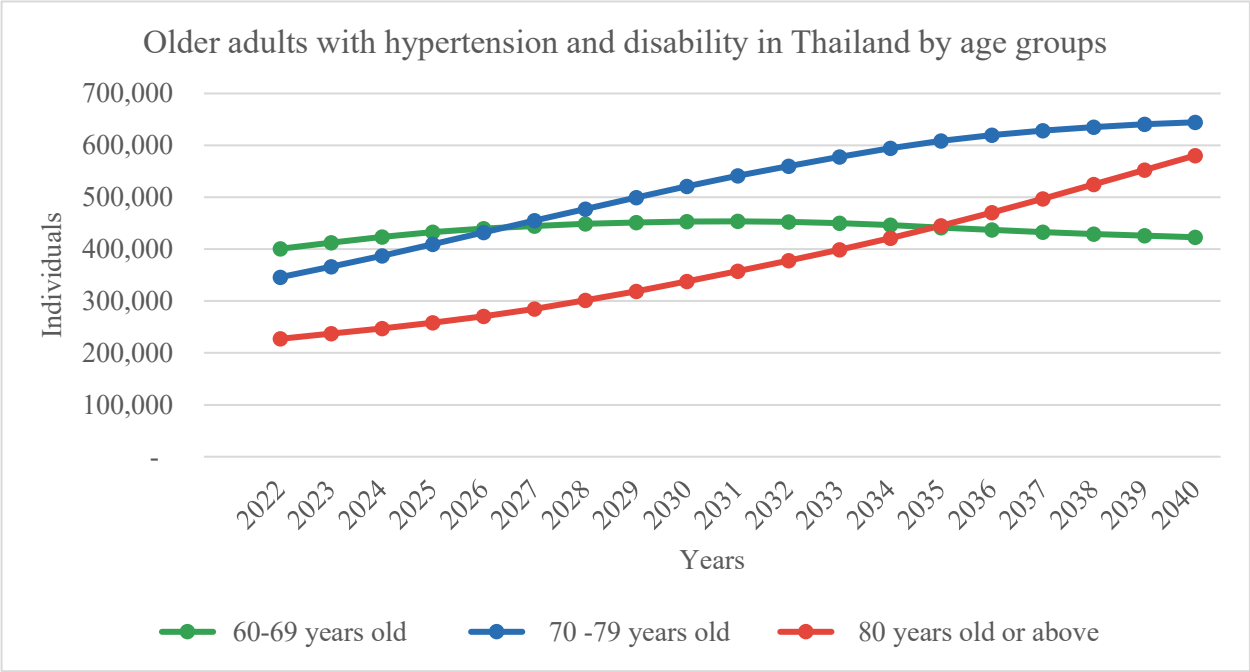
EFIGURE 2: PROJECTED OLDER ADULTS WITH HYPERTENSION AND DISABILITY IN THAILAND BY AGE GROUPS (BY +20%)



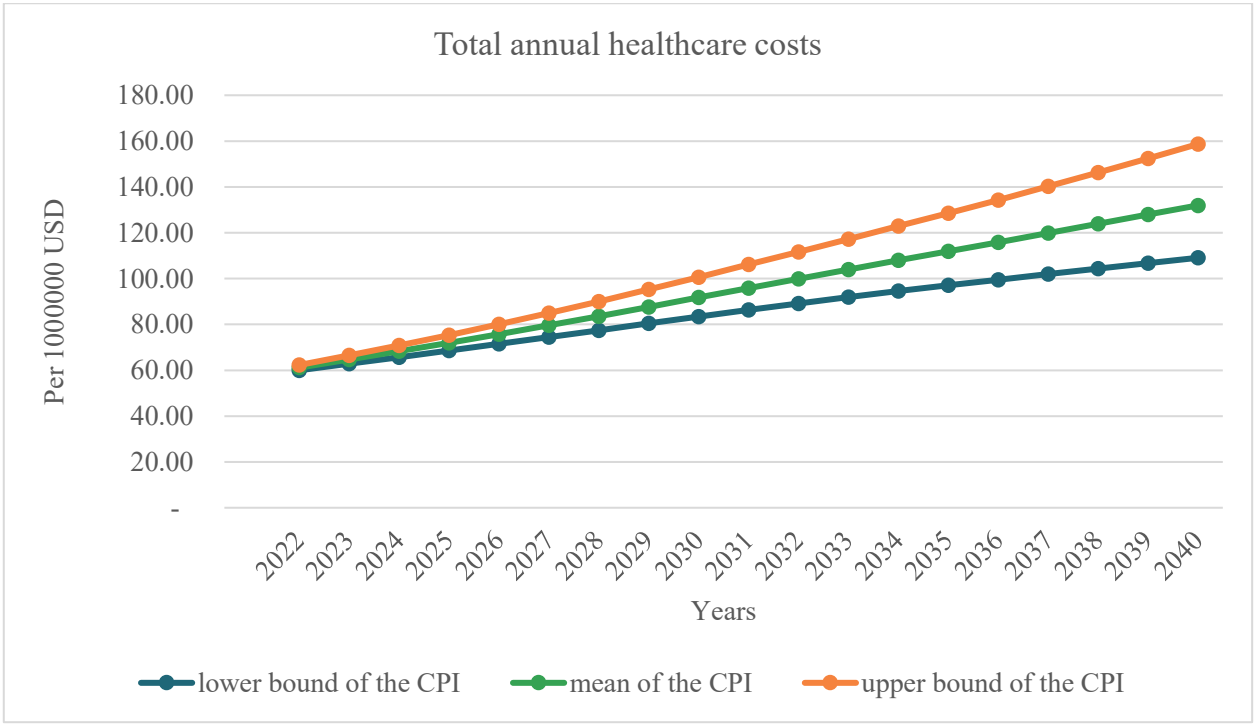
EFIGURE 3: PROJECTED TOTAL ANNUAL HEALTHCARE COST FOR COMMUNITY-DWELLING OLDER ADULTS WITH HYPERTENSION IN THAILAND (BY +20%)



EFIGURE 4: PROJECTED OLDER ADULTS WITH HYPERTENSION AND DISABILITY IN THAILAND BY AGE GROUPS (BY -20%)



EFIGURE 5: PROJECTED TOTAL ANNUAL HEALTHCARE COST FOR COMMUNITY-DWELLING OLDER ADULTS WITH HYPERTENSION IN THAILAND (BY -20%)



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RESEARCH ARTICLE

PHARMACISTS' ROLES IN HYPERTENSION MANAGEMENT WITHIN INDONESIAN COMMUNITY-BASED ELDERLY HEALTH SERVICES: A QUALITATIVE STUDY

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ABSTRACT

OBJECTIVE

This study explores hypertension management within Indonesian Posyandu Lansia (community-based integrated service posts for older people). It aims to identify treatment practices, medication adherence, implementation barriers, and pharmacists' roles to inform health service management and policy development for aged care.

DESIGN

An observational qualitative study was carried out using a phenomenological approach. The data were gathered through semi-structured interviews with a total of 32 participants, including 14 elderly patients, 12 community cadres, and 6 healthcare professionals. The collected narrative data were analyzed using an inductive thematic analysis to identify essential patterns and phenomena.

SETTING

The research was carried out at the Banguntapan II and Piyungan Puskesmas (Community Health Centers) and their affiliated Posyandu Lansia (community-based integrated service posts for older people) in Bantul Regency, Indonesia.

MAIN OUTCOME MEASURES

Qualitative themes were identified regarding the implementation of hypertension treatment, medication adherence patterns, operational management barriers (e.g., funding and administration), and the integration of pharmacists into community-based settings.

RESULT

Posyandu activities primarily focus on routine monitoring and social engagement, yet medication adherence remains low as many elderly patients only take medication when symptomatic. Critical management barriers include restricted village funding and heavy administrative burdens. Regarding the pharmacist's role, their involvement is primarily promotive and preventive, focusing on drug information education, counseling, medication safety monitoring, and stock control. However, these roles are not yet optimized because health center management prioritizes in-facility pharmaceutical services over community outreach.

CONCLUSION

Effective hypertension management in community settings is hindered by operational and policy-related constraints. Pharmacists play an essential role in bridging education gaps and ensuring medication safety, yet their direct involvement remains limited. The practical implications of these findings suggest that strengthening interprofessional collaboration and revising policies to support direct pharmacist participation are vital for optimizing public health programs and improving clinical outcomes for the elderly population.

KEYWORDS

pharmacist, elderly, hypertension, adherence

INTRODUCTION

The role of pharmacists has become a primary focus as a critical component of public health services, particularly in meeting the needs of the elderly population, who are vulnerable to chronic conditions like hypertension [1]. In the Special Region of Yogyakarta, the number of hypertension sufferers aged 15 and over was estimated at 251,100 in 2021, yet only about 51.5% have received health services [2]. Bantul Regency itself recorded a high case burden of 102,807 cases in the same year, making it the most common disease treated at Puskesmas (Community Health Centers), including the Banguntapan II Health Center [3]. This increase in cases aligns with the rising trend of the elderly population, which has reached 14.5% of the total inhabitants in Bantul [4].

Hypertension is often called the "silent killer" because of its deadly impact on vital organs such as the heart, brain, and kidneys without showing obvious early symptoms [5,6]. Medically, the elderly are more susceptible to increased blood pressure due to the natural decline of physical functions, such as reduced blood vessel elasticity and the thickening of heart valves [6].

The greatest challenge in managing this disease is low medication adherence, which in the Yogyakarta region was recorded at only 53.5% [7]. This non-adherence is often triggered by boredom with long-term therapy, memory impairment (dementia), physical barriers to obtaining medication, and drug side effects [8]. Additionally, patients frequently stop taking their medication unilaterally when they feel their physical condition has slightly improved [9].

In this context, pharmacists hold significant potential as a key to improving adherence through education, counseling, and direct support [10]. Posyandu Lansia (Elderly Integrated Health Posts) serves as a highly strategic platform for this intervention due to its ease of access and direct interaction with the community [11]. Optimizing the role of pharmacists at Posyandu Lansia is expected to create more effective and targeted community-based health strategies for hypertension sufferers in Bantul Regency.

While previous research by Wulandari et al. [12] has analyzed pharmacist interventions in community pharmacies and Home Pharmacy Care by Nurfauzi et al. [13], there is a significant gap regarding the pharmacist's role within Posyandu Lansia, a vital community-based platform unique to Indonesia. Furthermore, most existing studies utilize quantitative or quasi-experimental designs to measure clinical outcomes. There remains a lack of qualitative evidence to fully understand how elderly patients, community cadres, and healthcare professionals perceive the integration of pharmacists into this specific setting. This study addresses these gaps by examining the implementation and stakeholder perspectives on pharmacist involvement in community-based hypertension management. Therefore, this study intends to describe the implementation of hypertension treatment and study the specific roles of pharmacists within the Posyandu Lansia program in Bantul Regency.

METHODS

STUDY DESIGN

This study utilized an observational qualitative design with a phenomenological approach. This approach was specifically selected because it enables the researcher to identify and consider the psychological meanings of participants' lived experiences through an in-depth analysis within the context of their daily lives [14]. Phenomenology focuses on these lived experiences, which are subsequently interpreted to derive specific meanings, allowing the phenomena of hypertension management to appear as they are perceived by the individuals involved [15]. This method was chosen to capture the rich, subjective narratives and perspectives of elderly patients, community cadres, and healthcare professionals, providing a deeper understanding of the complexities surrounding hypertension treatment and the professional roles of pharmacists in community-based settings. The reporting of this study follows the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines to ensure methodological rigor and transparency.

LOCATION AND PARTICIPANTS

The study took place from October to December 2023 at Banguntapan II and Piyungan Puskesmas and their linked Posyandu Lansia in Bantul Regency. Participants were recruited through a strategy involving formal recommendations from Puskesmas staff, who then facilitated connections with community cadres serving as gatekeepers at various Posyandu locations.

Purposive and convenience sampling were used in this study to identify informants who could provide valuable information relevant to the study objectives. For the elderly, inclusion criteria were being ≥ 60 years old (or ≥ 45 for pre-elderly), having a confirmed diagnosis of hypertension (systolic blood pressure ≥ 140 mmHg) during the past month, taking prescription antihypertensive medication, and being an active Posyandu participant. Inclusion requirements for healthcare professionals and community cadres include active participation in the Posyandu Lansia program. Exclusion criteria for all categories include physical or mental health issues that prevent participation in the interview process.
The sample size was justified on the basis of suitability and adequacy, resulting in 32 participants (14 elderly patients, 12 community cadres, and 6 healthcare professionals). Throughout the recruitment process conducted by community cadres, all approached individuals consented to participate, resulting in zero withdrawals or non-participation. The data saturation process determined the ultimate participant count, and interviews were repeated until no significant changes in narratives or theme insights were seen, ensuring complete and robust conclusions.

DATA COLLECTION

Data were collected through face-to-face, semi-structured interviews conducted by the primary researcher. The primary researcher had no prior contact with the participants. Through the informed consent process, participants were informed of the researcher's background and the primary objective of the study. This approach allowed flexibility and in-depth exploration of participants' subjective experiences [16]. The interview guides were developed from the research objectives and theoretical framework, then validated through expert review and a pilot test with three elderly individuals and one cadre member to ensure clarity and appropriateness. Community cadres served as gatekeepers for recruitment at Posyandu Lansia locations. Each interview session lasted approximately 30 minutes and was held in a setting comfortable for participants. To ensure confidentiality and encourage open dialogue, all interviews were conducted privately between the researcher and the informant, with no non-participants present. All interviews were audio-recorded with written consent and transcribed verbatim in Bahasa Indonesia to preserve linguistic details and original meanings. To ensure data accuracy, transcripts were returned to participants for member checking before analysis. These narrative data were supplemented by field notes, photographs, and health records to provide contextual reference during inductive thematic analysis.

DATA ANALYSIS

The data were analysed using an inductive thematic analysis to identify recurring patterns and meaningful phenomena emerging from participants' experiences. Interviews were audio-recorded and transcribed verbatim in Bahasa Indonesia to preserve linguistic and contextual nuances. Data analysis was conducted manually by the primary researcher, without

the use of qualitative data analysis software, to maintain close engagement with the original narratives throughout the analytical process. The analysis involved three iterative stages: coding meaningful units from the transcripts, grouping similar codes into broader categories, and generating overarching themes inductively based on conceptual relationships identified within the data rather than from predefined theoretical frameworks. To enhance the trustworthiness and credibility of the findings, several strategies were employed, including source triangulation by comparing perspectives across elderly patients, community cadres, and healthcare professionals; member checking, whereby participants verified the accuracy of interview transcripts and interpretations; and peer debriefing with academic supervisors and peer researchers. An audit trail documenting coding decisions throughout the analytical process was maintained to ensure analytical rigor, minimise researcher bias, and enhance transparency.

ETHICS APPROVAL

This study received ethical approval from the Ethics Committee of Universitas Gadjah Mada (Ref. No. KE/UGM/058/EC/2023), where all participants provided written informed consent voluntarily after receiving a full explanation of the research' purpose and procedures.

RESULTS

SOCIO-DEMOGRAPHIC CHARACTERISTICS

This study involved three distinct groups with firsthand experience in hypertension management: elderly patients, community cadres, and healthcare professionals. Female participants accounted for over 90% of the sample, consistent with local demographic data. The perspectives of the 32 participants provide an understanding of community-based health services through diverse experiences. The study was conducted across several Puskesmas to capture varied perspectives on service delivery. Thematic analysis of participant responses identified key patterns in community-based care. The participant characteristics are presented in Table 1.

TABLE 1. OVERVIEW OF PARTICIPANTS' CHARACTERISTICS

Characteristics	Participants (n)	Percentage (%)
Gender		
Male	3	9.4
Female	29	90.6
Age (years)		
18 - 39	4	12.5
40 - 59	12	37.5
60 - 79	15	46.9
≥ 80	1	3.1
Participant Group		
Elderly Patients	14	43.8
Community cadres	12	37.5
Healthcare professional	6	18.7
Occupational/Role Breakdown (Staff & Cadres)		
Healthcare professional (n=6)		
Doctor	1	16.7
Nurse / Dental Nurse	3	50.0
Midwife	1	16.7
Medical Records Officer	1	16.7
Community cadres (n=12)		
- Head of Elderly Cadres	4	33.3
- Elderly Cadre Officer	8	66.7

Characteristics	Participants (n)	Percentage (%)
Workplace Location (Staff only)		
Puskesmas Banguntapan II	3	50.0
Puskesmas Piyungan	3	50.0
Years of Service (Staff only)		
< 1 year	1	16.7
1 – 10 years	1	16.7
11 – 20 years	3	50.0
> 20 years	1	16.7
Medical History (Elderly Patients only, n=14)		
Hypertension History (Duration 6 mo – 21 yrs)	11	78.6
Comorbidities (Diabetes, Heart, etc.)	3	21.4

Participants noted that healthcare professionals' experience varied significantly, ranging from 6 months to 27 years, with a professional average of 11 years. Older community cadres often received greater recognition than younger cadres [17]. Elderly participants had hypertension for 6 months to 21 years, with a mean age of 64 years, consistent with age-related hypertension risk [18]. Diverse participant backgrounds informed the study's insights are summarized in Table 2. The inductive thematic analysis of participant narratives revealed two major themes: (1) an overview of activities at Posyandu Lansia and (2) pharmacists' roles in Posyandu Lansia.

TABLE 2. SUMMARY OF THEMES AND CATEGORIES

Theme	Category	Subcategory	Sample Quotes
Overview of Activities at Posyandu Lansia	Blood Pressure and Health Examination	Measurement of blood pressure, weight, height, and Provision of Supplementary Food (PMT)	"Posyandu services involve weighing, monitoring blood pressure, blood sugar, height, and waist circumference periodically, complemented by providing limited supplementary food." (Cadre 4)
			"What we do routinely here is just weighing, then blood pressure, giving supplementary food, height, and body circumference, then there's abdominal circumference and waist circumference." (Cadre 6)
		Blood pressure measurement only	"Yes, if there's no other activity, it's necessary, right, they usually check it themselves, here it's just checking blood pressure, for height not really, for more serious diseases they have already checked themselves." (Cadre 12)
	Sources of Hypertension Treatment Information	Healthcare Professionals Puskesmas	"The information is often given to us here from the health center, if hypertension is like this, these are the characteristics, so we tell them it's like this." (Cadre 2)
			"Community cadres obtain hypertension knowledge through official training at the Puskesmas, which provides the crucial medical foundation necessary for them to perform their educational roles. (Cadre 6)
		Electronic and print media	"Knowledge is from, well, reading, reading in the newspaper, it's also on TV, I didn't have time, but now it's even on the phone." (Cadre 12)
	Elderly Patients Understanding	Good elderly patients understanding	"Elderly patients maintain health through regular exercise, diligent reading, and disciplined medication intake every morning right after breakfast." (Elderly 9)

Theme	Category	Subcategory	Sample Quotes
	of Hypertension Treatment		"Elderly patients reported symptomatic medication use, reducing frequency after pain subsided despite being initially instructed to take it twice daily.." (Elderly 13)
		Lack of elderly patients understanding	"As for consuming the medicine, it's rare now, only when I'm exhausted and drink a lot, or when I'm dizzy, then I take it." (Elderly 4)
			"If it's high then I drink it, if not, then no." (Elderly 5)
			"If it runs out and there's no one to take me, then no, but if someone takes me then yes, if no one takes me then I don't get checked." (Elderly 12)
	Enthusiasm of the Elderly Patients and Community Cadres	Presence of community cadres only	"Elderly patients found services provided solely by community cadres unsatisfying, highlighting the need for healthcare professionals to ensure higher quality." (Cadre 4)
			"If someone from the health center is there, at least they have an educational background, at least a health background, Yes, at least if it's just community cadres, I'm less satisfied." (Elderly 8)
		Presence of both community cadres and healthcare professionals	"Healthcare professionals presence offers psychological reassurance, boosting elderly motivation and happiness, which encourages more frequent attendance at health services.." (Cadre 7)
			"I didn't help because I already have medicine, I didn't get checked because I go routinely to the hospital." (Elderly 7)
			"Happy, then happy but not often, it's already rare." (Elderly 13)
	Constraints in Implementing Posyandu Lansia	Budgetary funds and administrative reporting	"The limited funds mean we can't do it, that's the constraint, sometimes we want homecare to also test blood, but it's limited so it didn't happen, only blood pressure was checked." (Cadre 10)
			"Funding facilities, yes the constraint is actually the issue of facilities." (Cadre 8)
		Absence of healthcare professionals	"Yes, if it's the health center, as mentioned before, if possible, please come here." (Cadre 9)
			"The health center doesn't know, they only know about two posyandu whereas they only know there's one health center, only the one at Kembang Tebu that is visited." (Cadre 6)
		Delayed medication delivery from Puskesmas	"This 1 week, I forgot, forgot, until I didn't know where the prescription was, wanted to ask again, this morning, the patient was already disappointed but already healthy, a week and it wasn't given, I forgot." (Cadre 2)
			"Because yesterday there was also a patient with a headache waiting for medicine until the headache was gone before it arrived hahahahha." (Cadre 3)

Theme	Category	Subcategory	Sample Quotes
		Healthcare professionals not bringing medication supplies	"Ceasing on-site medication delivery at Posyandu has caused disappointment among elderly participants who previously valued the convenience of local treatment." (Cadre 10)
	Pharmacist Involvement in Posyandu Lansia	Participation in Posyandu Lansia visits outside Puskesmas working hours	"Pharmacists prioritize in-facility services during regular working hours, limiting Posyandu participation to specific outreach schedules or times outside office hours." (Healthcare Professional 3)
Pharmacists' Roles in Posyandu Lansia	Promotive and Preventive	Promotive and preventive roles without curative services	"Pharmacists focus on promotive and preventive care, while curative services and medication distribution require a doctor's direct presence." (Healthcare Professional 4)
			"Pharmacists join routine Posyandu meetings for promotive and preventive counseling, as these community sessions generally do not include medical treatments." (Healthcare Professional 6)
		Promotive and preventive roles with indirect curative support	" Posyandu Banguntapan II provides limited medication for elderly patients struggling to reach the health center through healthcare professionals or cadre coordination." (Healthcare Professional 1)
	Drug Information Education	Education during Puskesmas visits	"Real education happens when, what's it called, when giving medicine, if the elderly posyandu joins, it means at most adding to going outside, kid." (Healthcare Professional 1)
		Health counseling and education sessions	"If at the usual posyandu there is no treatment, just posyandu eh promotive, preventive only, counseling sessions." (Healthcare Professional 6)
		Ensuring elderly patients health and safety	"Pharmacists are essential for ensuring medication safety, dose management, and stock control, promoting the wise and effective use of medicines." (Healthcare Professional 2)

OVERVIEW OF ACTIVITIES AT POSYANDU LANSIA

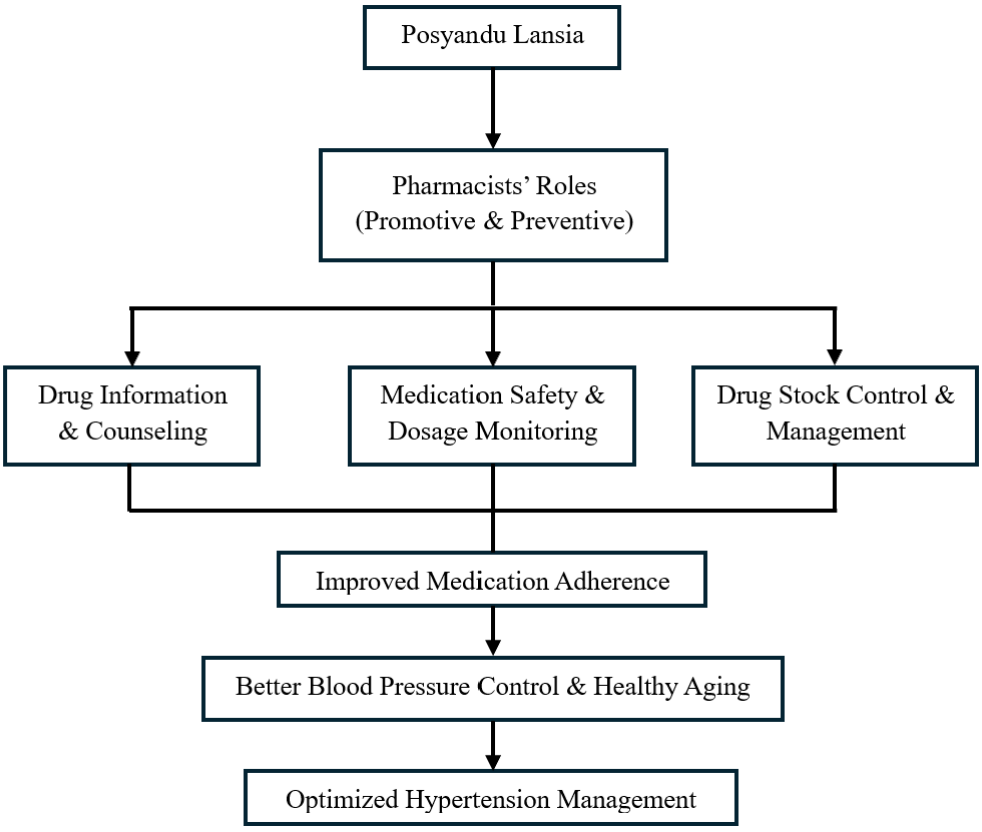
1. Blood Pressure and Health Examinations
   Posyandu Lansia provides health services focused on blood pressure monitoring and physical assessments, complemented by supplementary food. Social activities like group exercise and communal meals are also included to encourage participation and enhance the overall well-being of elderly participants.
2. Sources of Hypertension Treatment Information
   Most participants reported that hypertension information was delivered by Puskesmas staff through training and outreach to community cadres, along with routine meetings on medication management, elderly care, and blood pressure monitoring.
3. Elderly Understanding of Hypertension Treatment
   Elderly patients showed varying adherence to hypertension management. Disciplined individuals maintained consistency through regular medication and routine visits. Other participants practiced irregular habits, taking drugs only when symptomatic.

4. Enthusiasm of the Elderly Patients and Community Cadres
   Enthusiasm of the elderly patients and community cadres decreases when services are managed solely by community cadres. The presence of healthcare professionals significantly boosts motivation and community trust.
5. Constraints in Implementing the Posyandu Lansia
   Limited village funding restricts Posyandu services primarily to blood pressure checks and inadequate facilities. Community cadres struggle with heavy administrative reporting requirements for local authorities. These financial and operational constraints hinder the effective delivery of health programs for the elderly.
6. Pharmacist Involvement
   Some participants reported that Puskesmas prioritized in-facility services to ensure that healthcare delivery could be conducted in a well-organized manner. Others noted that, in accordance with existing regulations, pharmacists may also be involved in Posyandu Lansia activities through Puskesmas Keliling (Mobile Health Service Programs).

PHARMACISTS' ROLES IN POSYANDU LANSIA

1. Promotive and Preventive Roles
   Pharmacists primarily perform promotive and preventive roles in Posyandu Lansia through health education and counseling sessions. Curative services remain at Puskesmas, utilizing multidisciplinary teams of doctors and nurses.
2. Educational Information on Drugs
   Pharmacists deliver drug information and counseling during community health visits. Educational activities enhance medication understanding among elderly participants. Expert guidance ensures patient safety through proper dosage monitoring and risk management. The conceptual framework in Figure 1 was developed based on the themes and categories obtained during the thematic analysis of interview data. It illustrates pharmacists' promotive and preventive roles in Posyandu Lansia and the expected outcome of the roles to improve medication adherence, promote better blood pressure control and healthy aging, and optimize hypertension management.

FIGURE 1. CONCEPTUAL FRAMEWORK OF PHARMACISTS' ROLES IN POSYANDU LANSIA



DISCUSSION

The present study found that pharmacists' roles within Posyandu Lansia remain predominantly promotive and preventive, focusing on medication education and medication safety monitoring. Nevertheless, many elderly patients reported taking antihypertensive medications only when they experienced symptoms, including dizziness or fatigue. This behavior reflects persistent misconceptions regarding the largely asymptomatic nature of hypertension and points to the need for continuous medication counseling by pharmacists and other healthcare professionals [19,20]. Many participants appeared to perceive hypertension as an acute condition requiring treatment only during symptomatic episodes rather than as a chronic disease requiring lifelong management. Such misconceptions are concerning because hypertension is frequently asymptomatic despite progressive target-organ damage, allowing complications to develop even when patients feel well [20,21].

The persistent medication non-adherence observed in this study underscores the critical educational role of pharmacists in community-based hypertension management and aligns with findings from other regions in Indonesia. Research conducted in Bandung found that 53.5% of hypertensive patients in primary care were non-adherent, a trend often linked to the prolonged duration of treatment and the complexity of multi-drug regimens [19]. Similarly, operational barriers in Bantul, such as limited village funding and administrative challenges, mirror evaluations of Posyandu programs in Malang and Pekanbaru, where inadequate facilities and inconsistent medication availability have limited the quality of community-based services [22].

International evidence supports the findings of this study. Qualitative research in Malaysia found that poor medication adherence is linked to limited knowledge of antihypertensive therapy, including its mechanism and potential side effects. Some patients choose herbal or traditional medicines over prescribed antihypertensives, believing them to be safer or more effective [20]. These findings suggest that inadequate health literacy about chronic disease management remains a widespread issue in community healthcare settings in Southeast Asia [23]. Misconceptions about long-term antihypertensive use continue to cause irregular treatment patterns in various healthcare environments.

Pharmacist involvement in Posyandu Lansia remains constrained by several organizational and health system factors, despite its recognized benefits. Pharmaceutical services in Puskesmas continue to prioritize facility-based activities over community outreach programs [13]. In addition, human resource shortages, defined by high pharmacist-to-patient ratios and heavy workloads, often leave only one pharmacist responsible for the entire health center, thereby restricting opportunities to participate in Posyandu activities [24]. Structural barriers, administrative responsibilities, and limited time for community outreach further reduce pharmacists' capacity to provide continuous medication counseling and follow-up for elderly patients with hypertension [25].

Patient-centered pharmaceutical care should be further strengthened to address the gap between patients' medication-taking behaviors and evidence-based hypertension management [13,26]. The evidence suggests that pharmacists can play a greater role in providing Drug Information Services and medication counseling to identify and prevent drug-related problems (DRPs), including inappropriate medication use and incorrect dosing [13]. Previous studies have shown that pharmacist-led counseling improves patient satisfaction, strengthens trust in healthcare providers, and promotes long-term medication adherence [26]. These findings reinforce the importance of expanding pharmacists' clinical roles within Posyandu Lansia [12].

Healthcare policy also plays an essential role in strengthening pharmacists' contributions to hypertension management. The current findings indicate that local policies should attempt to promote the official incorporation of pharmacists into community outreach initiatives, such as Puskesmas Keliling and Posyandu Lansia. Indonesia could benefit from Japan's experience, where implementing a compensation system for community pharmacists delivering patient-centered home care has enhanced pharmacists' clinical responsibilities in drug treatment management [13]. Similarly, prior research in Indonesia has highlighted the significance of compensation in maintaining pharmacist-led pharmaceutical care services

[27]. Based on this information, current statistics suggest that targeted financial assistance may be essential to maintain chemists' involvement in community outreach initiatives such as Posyandu Lansia. These results provide a conceptual basis for broader health service management. By highlighting roles and barriers in Bantul, this study offers policymakers and healthcare managers in other Indonesian regions a framework to improve medication adherence and integrate pharmacists into community-based elderly health services.

Interprofessional collaboration is necessary for improving hypertension management in Posyandu Lansia, as multidisciplinary care has been shown to enhance blood pressure control and the quality of patient care [28]. While community cadres support community mobilization and routine monitoring, pharmacists, alongside physicians and nurses, contribute specialized expertise in pharmaceutical management, medication safety, and patient counseling. Previous evidence indicates that clear and regular communication, experience with collaboration, and understanding each other's capabilities and professional roles are important facilitators of effective interprofessional collaboration [29]. Strengthening these collaborative approaches may improve the continuity, safety, and quality of hypertension management for elderly patients participating in Posyandu Lansia.

STRENGTHS OF THIS RESEARCH

This study considers an important public health issue by exploring hypertension management among elderly patients in the underexplored Posyandu Lansia setting. It delivers practical knowledge of pharmacists' roles, identifies operational and policy-related barriers affecting hypertension management, and offers findings that may shape future community pharmacy practice and healthcare policy. Analytical thoroughness was maintained through continuous consultation with academic supervisors and peer researchers.

LIMITATIONS

There are certain limitations intrinsic to the qualitative design, such as a limited sample size (n = 32). This study was also conducted at a limited number of study sites, specifically two Puskesmas in Bantul Regency, which may limit the transferability of the findings to wider settings or other healthcare systems. Purposive and convenience sampling by community cadres may have introduced selection bias. The lack of direct pharmacist informants limited investigation of the pharmacy perspective. Interviewer bias or subjectivity in interpreting narratives is also possible. Despite these limitations, the research offers valuable insights for future pharmacist-led interventions in Posyandu Lansia.

MEANING OF THE STUDY

The pharmacist's role in Posyandu Lansia provides strategic implications for healthcare managers and policymakers to strengthen interprofessional collaboration at the community level. Program managers must ensure the consistent presence of healthcare professionals in the field to maintain community trust and enthusiasm.

FUTURE RESEARCH

A key challenge for subsequent research will be to identify the most effective and sustainable methods of pharmacist interventions in resource-constrained Posyandu contexts. Future research should be conducted with a larger, more diverse sample and across different areas to improve the transferability of the findings and to better understand perceptions of pharmacists' functions. For a better understanding of collaborative care, comparative studies among different stakeholders, such as elderly patients, physicians, nurses, and pharmacists, are strongly recommended. Further research should explore how digital media, like mobile phones, can support self-education alongside traditional healthcare. Structured pharmacist training and intervention studies should be evaluated for their impact on blood pressure control and medication adherence. These steps are crucial for developing pharmacy guidelines that ensure safe dosing and effective long-term treatment for the elderly.

CONCLUSION

Posyandu Lansia functions as an essential community-based platform for monitoring hypertension, yet medication adherence continues to be a challenge, as many elderly patients consume medication only when symptomatic.

Pharmacists play an essential role through promotive and preventive services, specifically in delivering drug information education and guaranteeing medication safety. To improve these public health programs, health center management should strengthen interprofessional collaboration by integrating pharmacists into Puskesmas Keliling, while policymakers should revise local regulations to support direct pharmacist involvement in community-based settings. This study presents new qualitative evidence on integrating pharmacists into Indonesia's Posyandu Lansia, an underexplored community-based platform. By identifying local barriers and clarifying pharmacists' roles in health promotion and prevention, these findings address a gap in community-based hypertension management.

AUTHORSHIP

All authors participated in drafting and critically revising the manuscript for important intellectual content, approved the final version of the manuscript, and agreed to be accountable for all aspects of the work. ARM performed data collection and analysis and drafted the manuscript. TMA contributed to the conceptualization and methodology of the study, provided supervision, and critically reviewed and edited the manuscript. DE contributed to the methodology, supervised the research process, and reviewed and edited the manuscript draft. NNW provided supervision, conceptualized the study, and reviewed the final draft.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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RESEARCH ARTICLE

CRITICAL ANALYSIS OF THE QUALITY ASSURANCE PROCEDURES OF TIME- AND TEMPERATURE-SENSITIVE PHARMACEUTICAL PRODUCTS IN SELECTED INSTITUTIONS IN SRI LANKA

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ABSTRACT

OBJECTIVE:

This study critically assessed the quality assurance procedures for Time- and Temperature-Sensitive Pharmaceutical Products (TTSPPs) in selected institutions of Sri Lanka.

DESIGN:

A descriptive cross-sectional design was employed, involving direct observation and the use of a validated 99-item tool based on the guidelines of the World Health Organisation. Five domains and 18 subdomains were analysed, and scores were compared across institutional levels.

SETTING:

Medical Supplies Division (MSD) of the Ministry of Health, Regional Medical Supplies Divisions (RMSDs), and selected tertiary and secondary hospitals in the North-Western Province of Sri Lanka

MAIN OUTCOME MEASURES:

The study covered five domains: general storage, indicators for temperature-controlled storage, transport, stock management, and general procedures/record-keeping.

RESULTS:

General storage performed best across institutions (mean score 77.6%), with the MSD showing the highest adherence. However, temperature-controlled storage practices were inconsistent, particularly in hospital wards, due to inadequate monitoring, insufficient equipment, and limited preventive maintenance. The transport of TTSPPs showed the poorest performance (31.1%), with minimal temperature monitoring and calibration procedures in place. Stock management practices were stronger at higher-level institutions, largely due to the support of the Medical Supplies Management Information System (MSMIS).

CONCLUSIONS:

Overall, performance declined progressively from central to peripheral levels. Strengthening infrastructure, providing targeted in-service training, and instituting routine supervision using the assessment tool are recommended to enhance the reliability and sustainability of TTSPPs' quality assurance in Sri Lanka.

KEYWORDS

TTSPPs (Time and Temperature Sensitive Pharmaceutical Products), Quality Assurance, Temperature-Controlled Storage, Medical Supplies Division (MSD), Stock Management, Sri Lanka

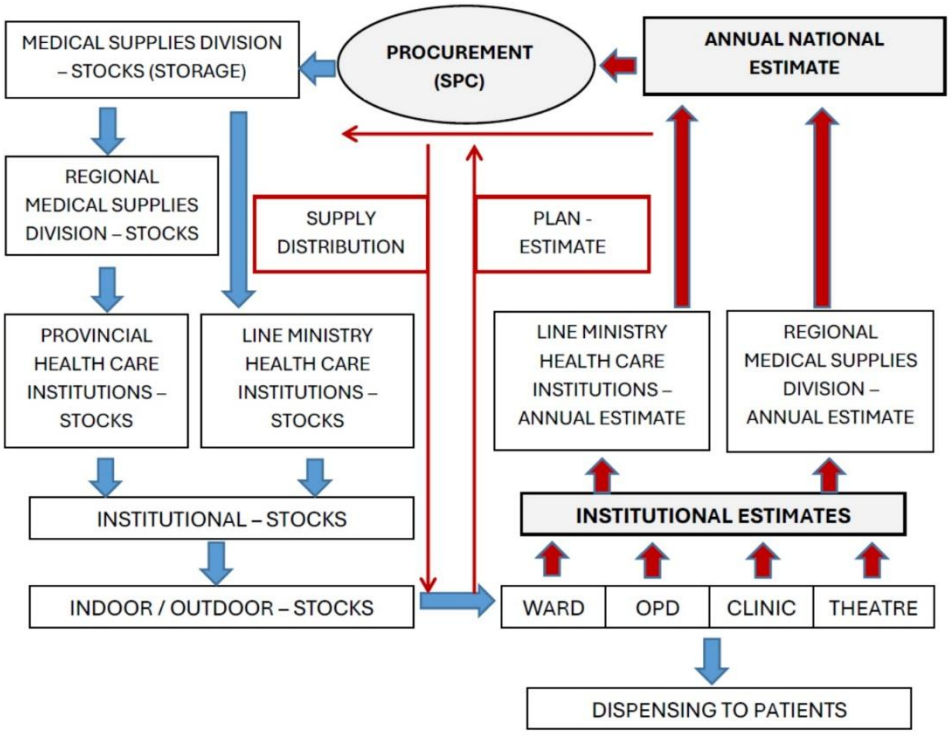
INTRODUCTION

Any health system must ensure adherence to robust systems, processes, and strategies in the supply chain of essential medicines to ensure the quality, safety, and efficacy of medicines are delivered to recipients from the manufacturer. Time and Temperature Sensitive Pharmaceutical Products (TTSPPs) are the most challenging medical products to ensure these quality assurance procedures [1, 2]. TTSPPs are defined as "pharmaceutical goods or products which, when not stored or transported within predefined environmental conditions and/or within predefined time limits, are degraded to the extent that they no longer perform as originally intended" [3]. The "Manual of Management of Drugs" of the Ministry of Health, Sri Lanka, depicts the scope of quality assurance as "the total sum of the organised activities performed with the object of ensuring that pharmaceutical products are of required quality for their intended use" [2].

The Sri Lankan health system is mainly divided administratively and functionally into the curative and preventive health systems, though there are overlaps in the service delivery [4]. There are three levels of care in the curative health system, namely tertiary, secondary, and primary [3]. Sri Lanka is providing free health services at the point of service delivery, including free medicines to all three levels of healthcare. Ensuring the availability of medical supplies is one of the most critical and sensitive issues.

The Medical Supplies Division (MSD) of the Ministry of Health of Sri Lanka is the main central organisation that has the responsibility for the fulfilment of this task, and it should ultimately ensure the right drug is available at the right time at the right place in the right quantity and quality, without any cost to the service recipients [5]. The MSD directly supplies healthcare institutions, including those of the line ministry and provincial healthcare institutions, through the Regional Medical Supplies Division (RMSD). The supply chain of MSD is depicted in Figure 1.

FIGURE 1: SUPPLY CHAIN OF MEDICAL SUPPLIES DIVISION



Source – Manual of Management of Drugs 2008 [2]

In addition to MSD, the National Medicines Regulatory Authority (NMRA) plays a foremost role in protecting and enhancing the healthcare delivery process by ensuring the safety, quality and efficacy of medicines, through the related regulations and the National Medicines Quality Assurance Laboratory (NMQAL), which is under the purview of the NMRA, assigned with the responsibilities of analysing the quality and safety of medicinal products [6]. The "Manual of Management of Drugs" outlines the primary dimensions for ensuring the quality of TTSPPs at the local level, specifically storage and transportation. There are two primary strategies to ensure compliance with these quality assurance dimensions: training and documentation [2].

In Sri Lanka, the expenditure for TTSPPs comprises a notable proportion of the total health expenditure. In 2019, 100 TTSPPs accounted for approximately one-fourth (13 billion) of the total expenditure for medical supplies, which was 54 billion rupees [5]. The 14th International Conference of Drug Regulatory Authorities recommended: "collecting best practices in respect of implementation of quality management systems (QMS) by national regulatory authorities and exploring the possibility of creating a model QMS for medicines regulatory authorities with guidance for its implementation" [7]. There is a lack of comprehensive quality assurance procedures related to TTSPPs in the supply chain management of pharmaceuticals within the Sri Lankan health system. Since TTSPPs represent an essential component of pharmaceuticals, a critical analysis of the quality assurance procedures will help minimise the harm due to the quality failures of TTSPPs, further minimising healthcare costs and improving patient safety.

The present study aimed to conduct a critical analysis of the quality assurance procedures of TTSPPs in the Central MSD, RMSDs, and Tertiary and Secondary Care Hospitals (up to the base hospitals) in the North-Western Province, using a validated tool based on World Health Organisation guidelines and other related guidelines. (Please refer to the Annual Health Bulletin, 2026 regarding the Sri Lankan hospital categorisation, according to the levels of care) [8]. Accordingly, Sri Lankan hospitals are categorised as Tertiary Care, Secondary Care and Primary Care. Tertiary Care hospitals are further classified as Teaching Hospitals, Specialised Hospitals, Provincial General Hospitals and District General Hospitals. Secondary Care Hospitals only include Base Hospitals, and they are the lowest stratum of care, where medical specialists are available. The lowest level is primary care, and we have excluded primary care hospitals from this study.

METHODS

The study was conducted as a descriptive cross-sectional study from September 2019 to November 2019. The MSD in Colombo, as well as the RMSDs, served as the study settings, along with secondary and tertiary care hospitals, i.e. up to Base Hospitals in the North-Western Province, which comprises two districts: Kurunegala and Puttalam. The study sample was "TTSPPs storage and transport components of central level institutions" and "TTSPPs storage and transport components of institutions above Base Hospitals in North-Western Province". The selected institutions for the study are summarised in Figure 2.

Hospitals below Base Hospitals were excluded from this study. These hospitals do not have medical specialists-led clinical care services and are only managed by medical officers. Therefore, the scale of service provision and the range of pharmaceuticals available in hospitals below base hospitals are substantially minimal compared to higher-level hospitals.

North Western Province is one of the nine provinces in Sri Lanka and consists of more than 50 hospitals with in-ward care and more than 75 Primary Medical Care Units (9). According to provincial data sources, these institutions received 487,493 admissions in 2017 (Kurunegala District – 340,217, Puttalam District – 147,276), which is approximately 7.1% of the patient admissions to government hospitals in Sri Lanka. Moreover, these hospitals are responsible for providing 3.1% of outpatient services (1,286,279 in Kurunegala and 416,828 in Puttalam) in Sri Lanka. The distribution of drugs within the province is coordinated by the Regional Drug Stores at the district level.

FIGURE 2: INSTITUTIONS INCLUDED IN THE STUDY SAMPLE

Central level	Regional (district) level	
	Puttalam	Kurunegala
• Central Medical Supplies Division	• Regional Medical Supplies Division- Puttalam • District General Hospital- Chilaw • Base Hospital-A Puttalam • Base Hospital-B Kalpitiya • Base Hospital-B Anamaduwa • Base Hospital-B Marawila	• Regional Medical Supplies Division- Kurunegala • Teaching Hospital- Kuliyapitiya • Provincial General Hospital- Kurunegala • Base Hospital- B Galgamuwa • Base Hospital - B Polpitigama • Base Hospital - B Nikaweratiya • Base Hospital - B Dambadeniya

For the central-level institution (i.e., the Medical Supplies Division), stores and temperature-controlled vehicles were included in the data collection. For the district level, the units (Main drug stores, Indoor dispensary, a randomly selected medical unit, a randomly selected surgical unit, a randomly selected gynaecology and obstetrics unit, a randomly selected paediatrics unit, a randomly selected Intensive care unit, and a randomly selected Operating Theatre) related to the logistical handling of TTSPPs in each of the above district-level institutions were included.

A validated questionnaire based on the World Health Organisation guidelines (3) was used to measure the performance of the quality assurance system. The tool included two sections, i.e., administrative details of the institution and 99 items covering five domains. Each of the 99 items and five domains carried equal weightage. The tool was utilised as an interviewer-administered questionnaire by a panel of three trained experts (including the first author), who visited the relevant institutions and made direct observations. The data were initially entered into a pre-designed Microsoft Excel template, which was then exported into the Statistical Package for Social Sciences version 21. The item scores for each assessment were obtained according to the following scoring guide. When the responses were in dichotomous form, either 0 or 5 marks were given according to the content (i.e. if the response was favourable according to the content of the question, 5 marks were given; if not, 0 was given). For the items with a 3-point Likert scale, either 0,3, or 5 marks were given according to the content. For items with responses on a 6-point Likert scale, a score ranging from 0 to 5 was assigned.

The main domains were further subdivided into 18 subdomains. Scores were calculated for each domain and sub-domain by adding the marks obtained for each item. Each domain and sub-domain score was expressed as a percentage by dividing the added score by the maximum possible score. When any item becomes unrelated according to a setting, the denominator (i.e., the maximum possible score) is adjusted accordingly. For each setting, 18 quality assurance sub-domain scores and five quality assurance domain scores were calculated.

The domain scores were found to be non-normally distributed when assessed for normality using Q-Q plots, Box and Whisker diagrams, and the Kolmogorov-Smirnov test. The mean, median and interquartile ranges were presented for each domain, stratified by setting, and a summary of all units for district-level institutions is presented. The associated categorical correlations of the domain scores (e.g. level of the institution) were determined with the Kruskal-Wallis test. Post-hoc analyses were subsequently conducted. The significance level was set at 5%.

Ethics approval was obtained from the Ethics Review Committee of the Postgraduate Institute of Medicine, University of Colombo (PGIM/ERC/2019/157). Permissions were also obtained from the Deputy Director General (Medical Supplies), Director (Medical Supplies Division) and from the Provincial Director of Health Services of the North-Western Province.

RESULTS

The overall quality domain scores are outlined in Table 1, and the domain scores for each institution and setting are illustrated in Table 2.

TABLE 1: DISTRIBUTION BY OVERALL QUALITY DOMAIN SCORES

Domain	Mean (SD)	Median (IQR)
Domain 1 – General storage	77.6 (3.95)	77.5 (77.5 to 77.78)
Domain 2 – Indicators for Temperature Controlled Storage	46.1 (10.26)	44.0 (41.14 to 49.14)
Domain 3 – Transport of TTSPPs	31.1 (3.83)	30.0 (30.0 to 30.00)
Domain 4 – Stock Management of TTSPPs	55.7 (9.83)	50.0 (50.0 to 60.88)
Domain 5 – General Procedures and Record-Keeping of TTSPPs	65.3 (9.52)	64.0 (60.0 to 67.27)

The practices related to "general storage" (i.e., domain 1) were observed to be relatively well implemented across all institutions, with the highest overall score among all five domains (77.6%). Expected quality performances in relation to have been almost achieved by the MSD (i.e. 95.56%), and the performance of RMSDs, tertiary care and secondary care institutions ranged from 77-78% of that of expected. However, some elements, such as "uninterrupted power supply," were observed to have the near-lowest scores in all the latter institutions.

The "indicators for temperature-controlled storage" domain (i.e. domain 2) demonstrated the second lowest performance among the five main domains (mean score of 46.1), with around 85% adherence to recommendations in general in MSD and RMSDs. The tertiary and secondary care hospitals had lower scores, ranging from 40 to 55%. For tertiary care hospitals, a wide variation in performance was observed between institutions. In most indoor dispensaries, wards, and units, preventive maintenance and contingency plans were not observed, resulting in a score closer to 50%. However, drug stores, indoor dispensaries, and wards complied with FEFO and other requirements by achieving a score above 84 for the subdomain "Arrangement of Stock of TTSPPs".

TABLE 2: MEAN DOMAIN SCORES OF EACH INSTITUTION

Domain	MSD	RMSD	Teaching Hospital		Provincial General Hospital		District General Hospital		Base Hospitals	
	Mean	Mean (SD)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Domain 1 – General storage	95.50	78.89 (7.86)	77.57 (0.13)	77.50 (77.50 to 77.71)	77.29 (0.71)	77.50 (77.50 to 77.50)	77.98 (8.35)	82.50 (68.96 to 82.50)	77.22 (2.52)	77.50 (77.50 to 77.50)
Domain 2 – Indicators for Temperature Controlled Storage	85.41	84.08 (3.41)	50.74 (8.68)	48.29 (43.29 to 58.57)	44.25 (8.94)	42.29 (38.86 to 52.09)	45.43 (3.75)	45.14 (41.71 to 48.57)	43.54 (6.23)	42.86 (40.00 to 46.86)
Domain 3 – Transport of TTSPPs	18.18	44.17 (8.25)	31.04 (2.94)	30.00 (30.00 to 30.00)	31.04 (2.94)	30.00 (30.00 to 30.00)	30.00 (0.00)	30.00 (30.00 to 30.00)	31.14 (2.90)	30.00 (30.00 to 30.00)
Domain 4 – Stock Management of TTSPPs	100.00	75.73 (3.03)	56.37 (8.55)	52.50 (50.00 to 63.11)	55.73 (10.62)	50.00 (50.00 to 67.21)	53.24 (6.19)	50.00 (50.00 to 57.50)	54.42 (7.78)	50.00 (50.00 to 58.33)
Domain 5 – General Procedures and Record-Keeping of TTSPPs	78.46	90.77 (4.35)	75.14 (9.89)	68.00 (68.00 to 87.13)	67.14 (12.09)	60.00 (60.00 to 80.09)	57.17 (5.96)	58.00 (54.05 to 62.00)	63.54 (6.39)	64.00 (60.00 to 64.00)

(MSD – Medical Supplies Division, RMSD – Regional Medical Supplies Division)

The stock management of TTSPPs (i.e., domain 4) had a mean score of 55.7, ranking third among the five main domains. A notable advanced score of 100.00 was seen in the MSD, and a mean score of 75.73 for RMSD. The practices of the tertiary care (55.11) and secondary care (54.42) hospitals were observed to be relatively lower. MSD had a well-planned system of stock management and fulfilled all the considered factors of receiving, issuing and returning procedures through MSMIS, including RMSD and main stores in the tertiary and secondary care hospitals. However, MSMIS had not been introduced to indoor wards and units at the time of data collection.

The overall domain score for "general procedures and record-keeping of TTSPPs" (i.e., domain 5) was 65.3, the second-highest among the main domains. The highest scores were observed in the RMSDs (90.77), followed by MSD (78.46), and the lowest in secondary care institutions (61.87). At the hospital level, drug stores and indoor dispensaries were performing better than the ICU & theatres and wards.

Statistically significant differences were observed in domains 2, 3 and 4 between central (MSD), district-level (RMSDs) and lower-level (institutions up to the Base Hospitals) institutions, as depicted in Table 3. After the significance adjustments, the differences remained for domains 3 and 4. With the post-hoc analyses of domains 3 and 4, differences were observed between MSD and RMSD, as well as between "secondary and tertiary hospitals" (i.e., no significant difference was observed between secondary and tertiary hospitals).

TABLE 3: ASSESSMENT OF DIFFERENCES IN DOMAIN SCORES BETWEEN INSTITUTIONS

Domain score	Difference between the levels
Domain 1 – General storage	P=0.124
Domain 2 – Indicators for Temperature Controlled Storage	P=0.013*
Domain 3 – Transport of TTSPPs	P<0.001*
Domain 4 – Stock Management of TTSPPs	P=0.009*
Domain 5 – General Procedures and Record-Keeping of TTSPPs	P=0.051

*Statistically significant at 5% level

DISCUSSION

This is the first documented research project to explore the quality assurance system of Time and Temperature Sensitive Pharmaceutical Products (TTSPPs) in Sri Lanka. A judgmentally validated quality-assurance assessment tool with 99 items, covering the five main recommended domains, was used in assessing the processes related to the quality assurance of TTSPPs. This tool was used to assess the quality assurance dynamics in three national and district-level stores, as well as in 11 hospitals (including 75 settings within them).

Even with several notable exceptions, it was generally observed that the "transport" domain had relatively lower domain scores while the "general storage" domain had higher scores. To ensure more utility, these five domains were further divided into 18 sub-domains. The domain scores were stratified according to the category of institutions: MSD, RMSDs, tertiary care hospitals and secondary care hospitals. Post-hoc analyses were conducted because significant differences were observed in three domain scores. Once adjusted, there were significant differences in domain 3 (MSD versus RMSD, MSD versus secondary hospitals, RMSDs versus tertiary hospitals, RMSDs versus secondary hospitals) and in domain 4 (RMSDs versus secondary hospitals).

DOMAIN 1 – GENERAL STORAGE

All pharmaceuticals, especially TTSPPs, should be stored under recommended conditions to prevent contamination, deterioration, and to prevent losing their potency and effectiveness [10-12]. A study done in Pakistan reported that the lack of facilities to maintain temperature during power outages was the main drawback of the storage of TTSPPs [13]. Similarly, a study done in Ethiopia reported that only 42.5% of the facilities had the presence of a standby power supply

(14). Both these studies are similar to the findings of our study. This may be a common occurrence, yet it can lead to serious consequences in resource-constrained settings with frequent and prolonged power outages, exposing systems gaps and managerial oversight that need immediate attention.

Out of the study settings, MSD had relatively higher mean scores for domain 1 and 2 (temperature-controlled storage) related sub-domains and maintained systems, as per the recommendations [2, 3, 15] including an uninterrupted power supply (UPS). Despite the operational manual stipulating the requirement of having a UPS system, exposing noncompliance and system defects at the district level, the importance of the UPS is highlighted even in the manual of the WHO under its section 3.9 [3]. As evident from the findings, hospital settings had relatively lower scores compared to central and district-level settings. and were comparable with the results globally, which is observed when the recommendations are not met [16]. Even in the absence of published comparable literature in relation to the government sector in Sri Lanka, a study done in two Sri Lankan districts involving private pharmacies has documented similar substandard performance in storage conditions [7].

DOMAIN 2 – INDICATORS FOR TEMPERATURE CONTROLLED STORAGE

A similar observation of a gradual decline in performance from the central level to the institutional level was also evidenced in this domain. As highlighted by Papiya in 2012, efficient temperature control is crucial, and storage conditions are an important factor in determining its success [18]. Although an Ethiopian study reported 61.7% of the facilities had acceptable cold chain storage, it was noteworthy that approximately 40% had unacceptable cold-chain storage, and participants attributed this weakness to inadequate in-service training [14]. These weaknesses were also noted in our study, particularly in hospital and unit settings, mainly due to the unavailability of thermometers and the non-maintenance of temperature charts, which is an alarming situation regarding the quality assurance of TTSPPs. Similar to the Ethiopian study, this can be attributed to a lack of awareness. Even though in-service training and continuous professional development made a significant contribution to enhancing the management capacity of TTSPPs [9], statutory enforcement of SOPs is a must. Ethiopian participants also emphasised the importance of training in cold chain management, storage, and handling of cold chain medicines, as well as record-keeping [14]. As cold chain monitoring is a fundamental element, providing equipment, other facilities, supervisory vigilance and training is a prerequisite in the pharmaceutical supply chain. These gaps are system errors that have not been attended to by the decision makers, as well as at the managerial level. Hence, all factors mentioned above contributing to this low performance need urgent attention.

DOMAIN 3 – TRANSPORT OF TTSPPS

For a tropical country like Sri Lanka, the temperature during transportation can increase beyond 50 °C, leading to even ordinary medicines losing their efficacy [13]. Therefore, temperature control of medicine during transport is a critical and vulnerable factor, especially in TTSPPs. Our study also reported that performance during transport comparatively showed the lowest out of all five domains. In addition to delays, packaging failures, and incorrect handling, TTSPPs are more prone to deterioration of quality with the extreme variations in temperature, such as freezing of some liquid drugs (insulin) [19]. Holistically, limited available literature on this topic reported that innovative safety packaging, meticulous tracking with reliable information, upgrades to the storage facilities and transportation infrastructure, combined with improved education, training and regulations, can improve logistics management of medications, including TTSPPs, especially during transportation [19, 20). Although education and training are highlighted in many studies as possible interventions, without proper transportation facilities, monitoring mechanisms, and a system to swiftly act on lapses will not be sufficient to improve performance. During transport, monitoring of the temperature was rarely done, which can incur a significant impact when transporting TTSPPs over long distances [21]. Instituting a stringent regulatory framework for cold chain monitoring with designated officers and remote sensing equipment is unlikely to break the current culture of ignorance.

DOMAIN 4 – STOCK MANAGEMENT OF TTSPPS

Accurate record keeping is a vital element for proper stock management of any pharmaceutical and to prevent out-of-stock of medicines [22]. If stock-out or over stoking to be prevented, MIS need to be updated and monitored at each level daily. The system needs to be instituted up to the dispensing point of the medicines and automatically updated with each transaction. At present, Sri Lankan MIS fall short in large hospitals and even in the hospital's main medicines stores. This prevents real-time data from entering the system, preventing actual stock status monitoring. Further, lapses in

monitoring and regular updating of stocks at the institutional level hinder regional and central level forecasting of individual products to be procured to prevent stockouts and overstocking. Hence, for proper supply chain management, systemic issues need to be attended to with upgrading of MSMIS up to the dispensing point and ensuring real-time data entry and remote monitoring. A study conducted in Ethiopia reported 63.1% accurate reports of Logistics Management Information Systems (LMIS), but also reported high product wastage of 55.3% and a stock-out rate of 26.2% [14], which was similar to other settings [22, 23]. However, our study reported better performance in this domain, which can be mainly attributed to the Medical Supplies Management Information System (MSMIS), available at every institution.

DOMAIN 5 – GENERAL PROCEDURES AND RECORD-KEEPING OF TTSPPS

As highlighted by Reddy and others in 2012, a proper system must not only have analysis, measurement, and control facilities, but also validated record-keeping [24]. An Ethiopian study reported that only 44.7% of facilities had accurate inventory records; however, our study reported comparatively better performance in this domain [14]. However, comparatively lower scores were reported in hospitals and units for 'contingency arrangements' and 'ensuring documents, accessibility, safety and retrievability', since responsible staff in the wards and units had not been trained to take appropriate actions in the event of identified emergencies.

The study reported relatively good performance of TTSPPs management in relation to "general storage" (77.6%), "general procedures and record-keeping of TTSPPs" (65.3%), and "stock management of TTSPPs" (55.7%) despite having lower performance scores for "indicators for temperature-controlled storage" (46.1%) and "transport of TTSPPs" (31.1%). Overall, there was a gradual reduction of performance from the central level to the district-level, then to the institutional level and finally to the unit levels.

CONCLUSIONS AND RECOMMENDATIONS

Overall, this study reported a decline in performance across institutional levels, from the central to the regional and institutional levels. For example, although this study was not intended to determine the factors contributing to the limited extension of MSMIS to the ward level, the overall findings suggested that the benefits of digital stock management were more pronounced at the higher levels of the supply chain and did not extend to the point of dispensing, which created a possible discontinuation of information flow. Additionally, strengthening TTSPP quality assurance requires more than the provision of equipment and training; it requires governance arrangements that define responsibilities across MSD, RMSDs, hospital management, pharmacy services and ward-level units, together with mechanisms for information sharing, supervision and accountability across these interfaces. Comparatively, weaker performance at the wards and unit levels indicates that central policies and systems are not necessarily translated into operational practice at the point of care.

It is recommended to provide the necessary infrastructure and equipment for the management of TTSPPs and ensure their proper maintenance in line with the recommended standards. Moreover, many issues can be rectified with improved awareness through in-service training and continuous professional development (20, 25). Additionally, regular monitoring and supervision using the developed tool is recommended to enhance the sustainability of implementing measures (20). Improving awareness through training, monitoring, and supervision does not require additional funds, and a system should be in place at every level.

AUTHORSHIP

HMKW was involved in conceptualisation, data collection, formal analysis, and writing the original draft. DD, LP, and MW contributed to the formal analysis and refining of the methodology, as well as supervision, review and editing of the writing. All authors approved the final manuscript.

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CONFLICTS OF INTEREST:

HMKW was the Director of the Medical Supplies Division, DD was the Director, Medical Services, and LP was the Deputy Director General (Medical Services), Ministry of Health, Sri Lanka, at the time of conducting this study. Additionally, LP was the Former Deputy Director General (Medical Supplies). MW is the current chairman of the Sri Lanka Pharmaceuticals Corporation.

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RESEARCH NOTE

A CONSTRAINED-FLOW LENS FOR EMERGENCY DEPARTMENT CROWDING AND AMBULANCE RAMPING: ANALOGY, QUEUES AND EVIDENCE

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ABSTRACT

OBJECTIVE:

To present a conceptual research note that integrates a constrained-flow analogy, queueing relationships and emergency-care evidence to support investigation of emergency department (ED) crowding and ambulance ramping.

DESIGN:

Evidence-informed conceptual research note.

SETTING:

Australian public hospitals, with Queensland examples where definitions are jurisdiction specific.

MAIN OUTCOME MEASURES:

Candidate measures of demand, census, time, utilisation, variability, boarding, patient off-stretcher time and safety.

RESULTS:

Bernoulli's principle is retained only as an intuitive analogy for restrictions and upstream accumulation. Little's law provides the principal descriptive relationship between average number, effective flow and time; Kingman's approximation explains how high utilisation magnifies variability. Established input-throughput-output models and Australian evidence locate ambulance ramping within whole-of-hospital access block. Intervention evidence is mixed and does not support universal prescriptions.

CONCLUSIONS:

The framework may translate visible congestion into measurable hypotheses, but it is not a predictive hydraulic model. Construct validation, retrospective analysis, queueing analysis, simulation and prospective testing are required before operational use.

KEYWORDS

emergency department; ambulance ramping; access block; patient flow; queueing theory; Little's law; health service management

INTRODUCTION

Emergency department (ED) crowding and ambulance ramping are persistent safety and access problems. Reviews describe interacting input, internal-process and output causes, with output failure – especially boarding and access block – often propagating congestion through the hospital [1-4]. Queensland evidence similarly associates ramping with access block and hospital occupancy rather than ambulance arrivals alone [5,6].

This research note offers a managerial translation framework, not a new law of patient flow. Its contribution is the integration of three layers: an intuitive constrained-flow analogy; established queueing relationships; and empirical measurement followed by local validation. It complements the input-throughput-output model [2], adding questions that connect pathway mapping to measurable operational hypotheses.

METHODS

The framework was tested against foundational queueing scholarship, systematic reviews of ED crowding and interventions, Australian access-block and ramping studies, simulation literature and Queensland operational definitions. Claims were classified as established, evidence-supported interpretation, mathematical relationship, analogy, proposed application or hypothesis. No patient data were analysed and no independent personal technical endorsement is claimed.

FINDINGS

Layer 1 – conceptual analogy. In fluid mechanics, Bernoulli's equation expresses conservation of mechanical energy along a streamline under restrictive conditions, including steady, incompressible and effectively inviscid flow without unaccounted energy losses. Patients are not fluid particles and an ED is not a closed hydraulic system. ED care includes autonomous behaviour, clinical priority, heterogeneous service needs, multiple servers, dynamic staffing, interruptions, blocking and feedback. No claim is made that Bernoulli's equation predicts ED waiting time, patient speed or queue size. Only a limited intuition is borrowed: restrictions can cause upstream accumulation, and usable capacity depends on safely staffed capability rather than physical space alone. 'Pressure' has no direct ED equivalent and is replaced here by congestion, accumulated demand or queue burden. Figure 1 places that intuition within the established input-throughput-output model.

Layer 2 – quantitative discipline. Little's law is $L = \lambda W$. For a defined process and sufficiently stable observation period, L is the long-run average number of patients present, λ is the effective arrival or completion rate per unit time, and W is average time in the process [10]. Units must match, boundaries must be explicit, and flow must be stable enough that average entry and exit rates are comparable. It is a long-run relationship, not an individual forecast or causal model.
For illustration, $L = 60$ patients and $\lambda = 10$ patients/hour gives $W = L/\lambda = 6$ hours. Reducing one component of average time by one hour would be one-sixth of this baseline only if the boundary, demand, completion rate and other delays remained unchanged. It is therefore arithmetic, not a prediction of a 17% ED-length-of-stay improvement.

Kingman's approximation for a stable GI/G/1 queue is $Wq \approx [\rho/(1-\rho)] \times [(ca^2+cs^2)/2] \times E[S]$ [11]. Wq is mean queueing delay; ρ is utilisation; ca and cs are coefficients of variation of interarrival and service times; and E[S] is mean service time. In plain language, bunching of arrivals and variation in clinical work matter increasingly as utilisation approaches full capacity. ED studies have used more suitable time-varying queueing models for staffing [12]. A whole ED is not GI/G/1: it contains parallel servers, acuity priorities, possible pre-emption, abandonment, blocking, time-varying demand and linked downstream queues. Kingman is an explanatory approximation at a carefully defined stage, not a whole-ED calculator.
Layer 3 – clinical evidence and measurement. Clinical priority supersedes first-in-first-out flow. Resuscitation, Australasian Triage Scale urgency, isolation, mental-health and paediatric needs, diagnostic uncertainty, staff skill mix, specialty and intensive-care capacity, interhospital transfer and social discharge complexity alter pathways. Ambulance ramping

should be analysed as a hospital-system signal: Australian studies link access block with crowding, diversion and adverse outcomes [5-9].

Queensland's 30-minute measure is patient off-stretcher time (POST): the interval from presentation at ED triage to transfer from the ambulance stretcher to an ED bed, with the protocol aiming for reception, treatment-area placement and completed clinical handover within 30 minutes [19]. It is a jurisdiction-specific process measure, normally reported as the percentage meeting the threshold – not a universal clinical outcome, median or 90th percentile. Safety, deterioration and handover quality must accompany it.

FIGURE 1. THREE-LAYER CONCEPTUAL PATIENT-FLOW FRAMEWORK.

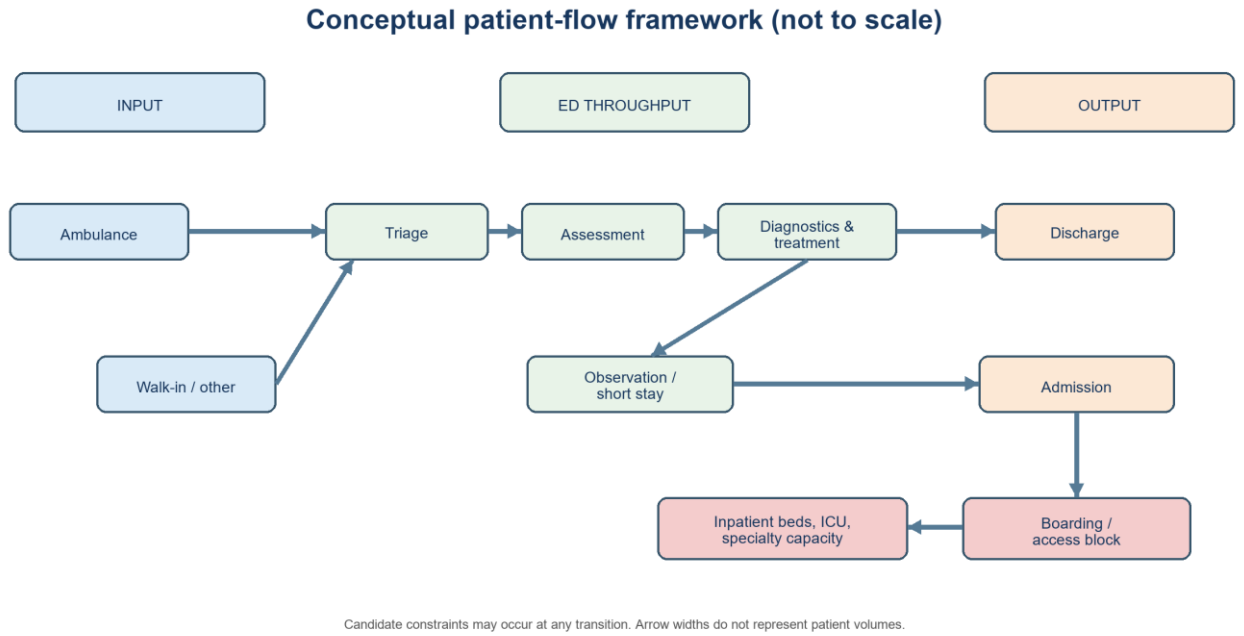


Figure 1. Three-layer conceptual patient-flow framework. The structure complements the input-throughput-output model; arrows and box sizes are illustrative, not measured volumes.

TABLE 1. BOUNDARIES OF THE CONSTRAINED-FLOW ANALOGY

Physical concept	Managerial analogy	Observable ED measure	Important limitation
Flow rate	Patients completing a defined stage per unit time	Stage completions/hour	Patients differ in acuity and service need.
Restriction	Constraint in safely staffed capability	Queue, delay, occupancy, staffing or bed availability	The cause must be established; a visible queue may be downstream driven.
Cross-sectional area	Parallel safe service capacity	Open staffed spaces/servers and skill mix	Physical space without staff is not usable capacity.
Pressure	Upstream accumulation only	No direct physical equivalent; use census, queue size or delay	Not a literal measurable pressure.
Friction/energy loss	Avoidable process delay or variability	Turnaround distributions and interruptions	No one-to-one physical equivalent.

OPERATIONAL INTERPRETATION

Candidate responses must follow diagnosis of the constraint. Fast-track or split-flow may reduce waiting for selected lower-complexity groups, but overall evidence for flow interventions is weak and queues can move elsewhere [14]. Short-stay units require clear eligibility and governance; evidence is insufficient for broad claims [15]. Discharge lounges have heterogeneous, largely descriptive evidence and cannot compensate for inadequate inpatient capacity [16]. Expanding ED beds alone did not improve time-based outcomes in an Australian multisite study, reinforcing the need for whole-system analysis. Timed targets may improve flow, but Australian mortality findings are mixed and targets can distort priorities if safety is not protected [17].

Managers should therefore link theory, evidence and measurement: define the boundary; locate input, internal-process or output constraints; quantify average numbers and times; examine time-of-day demand, staffing and variation; and test whether an intervention relieves rather than relocates delay. Outcome measures may include ED length of stay, boarding, left-without-being-seen, reattendance and patient experience. Process measures may include POST, diagnostic turnaround and admission-to-bed time. Balancing measures include mortality where relevant, deterioration, adverse events, workload, equity, handover quality and downstream congestion.

VALIDATION AGENDA

Stage 1 tests construct validity: do clinicians, ambulance personnel, managers and analysts agree that the framework identifies recognised constraints? Stage 2 uses retrospective data on arrivals, census, POST, ED length of stay, boarding, occupancy, staffing, admissions, diagnostics and ambulance unit-hours. Stage 3 applies Little's law at defined stages and analyses utilisation, variability and temporal patterns. Stage 4 uses discrete-event simulation for interacting queues and high-risk redesign; reviews show promise but weak reporting and limited implementation evidence [13,20]. Stage 5 prospectively pilots one intervention with predetermined inclusion, escalation and stop criteria. Stage 6 compares baseline, intervention and sustainability, including balancing outcomes. Clinical prioritisation and safety remain constraints, not tradeable outputs.

DISCUSSION AND CONCLUSIONS

The framework is accessible and integrates intuition, mathematical discipline and clinical evidence. It is not a literal hydraulic representation, a substitute for clinical judgement, an alternative to established crowding models, or a replacement for detailed queueing, simulation and local analysis. Its main limitations are the imperfect physical analogy, absence of empirical testing of the combined framework, non-stationary and heterogeneous ED operations, data-definition variation and the risk of optimising a visible queue while worsening another.

Bernoulli provides bounded intuition; Little's law provides the principal descriptive anchor; Kingman explains why utilisation and variability interact; ED evidence determines whether candidate actions are clinically plausible; and local analysis determines whether they work. Future research should test construct validity, compare the framework with existing patient-flow methods, assess managerial comprehension, evaluate safety and equity, and establish whether the integration improves operational decisions beyond existing models.

DECLARATION OF CONFLICTING INTERESTS:

The author declares that there is no conflict of interest.

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REVIEW ARTICLE

ALLIED HEALTH LEADERSHIP TRAINING IMPACT ON EMPLOYEE EXPERIENCE: A NEAR-EMPTY SCOPING REVIEW

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ABSTRACT

BACKGROUND

Allied Health practitioners (AHPs) are crucial in improving patient outcomes, reducing mortality and morbidity, and supporting timely discharge in a hospital setting. Despite their importance in the hospital workforce, recruitment and ongoing retention of AHPs remain significant challenges. More recently, leadership development has been a key strategy in enhancing employee capability and wellbeing. While leadership programs show benefits from the leader's perspective, little is known about the impact on employee experience.

AIM

A scoping review was undertaken to determine the impact of allied health leadership programs on employee experience in hospital settings.

METHOD

The Arksey and O'Malley's [1] framework was employed to guide the search. A systematic search across Medline, CINAHL, Embase, and PsycINFO was conducted in May 2025, capturing four concepts: Allied Health, Hospitals, Leadership Training, and Employee Experience. Articles included empirical, peer-reviewed studies, and were individually assessed against the inclusion criteria, ensuring that at least one of the outcomes was the employee experience of those who were being led. Data extracted included study demographics, details of training, and measurement of employee experience.

RESULTS

A total of 3,644 articles were identified, with initial screening reducing this to 72 articles for in-depth review. After further screening the final yield was just one article, resulting in a near-empty scoping review.

CONCLUSION

This review highlights the employee experience and demonstrates the substantial gap in the literature on how allied health leadership programs influence employee experience in hospital settings. Employee experience is a novel and under-researched outcome, yet crucial for a functioning hospital system and allied health retention therefore further research is required in this area.

KEYWORDS

allied health, healthcare, employee experience, leadership, training

INTRODUCTION

Allied Health Professionals (AHPs) encompass a variety of disciplines, including but not limited to physiotherapy, psychology, occupational therapy, social work, dietetics and speech pathology [2]. In Australia, approximately 300,000 AHPs are registered, with hospitals representing the predominant setting of employment [3] AHPs play a vital role in the safe and efficient operating of healthcare services through improving functional outcomes for patients, reducing or preventing hospital related complications, supporting timely discharge, facilitating goal achievement, and supporting transition back into the community [4-6]. Despite the critical role of AHPs, retention and attrition remain significant challenges [4, 7-9]. AH (Allied Health) shortages have been reported due to a variety of attrition triggers including post-COVID-19 burnout, compassion fatigue, inability to be involved with decision making, system and process issues, and dissatisfaction with performance review processes [4, 10, 11].

These workforce retention challenges have prompted healthcare organisations to begin to address high attrition rates and strengthen the AH workforce through implementing a range of strategic initiatives. Career progression has been supported through guiding documents such as the 'Allied Health Career Blueprint' [12], which provides structured pathways for advancement and helps AHPs navigate their careers with clarity and purpose. Professional development frameworks have also been introduced to deliver efficient and effective training aligned with service demands and patient care outcomes [13]. These frameworks aim to build workforce capability, enhance clinical performance, and improve retention, with leadership and management training being a key part of AH practice. Nevertheless, initiatives alone may be insufficient, and a broader cultural focus on leadership and employee experience is increasingly necessary. Effective leadership within the healthcare sector is crucial to foster staff development and has been tied to improved patient and organisational outcomes [14]. Effective leaders can impact clinical safety, quality decision making and ability to sustain organisational change, optimising patient care [15]. They must not only advance the technical aspects of care but also demonstrate active listening, agility, creativity, and balance to maximise patient outcomes, meet organisational requirements, and support staff wellbeing [16]. Within the AH healthcare context, leadership programs have been shown to enhance transformational leadership skills and capabilities [17]. Strong AH leaders are required to facilitate interaction between professions through explicit collaboration opportunities, provide advocacy for all AH professions allowing equitable representation and adapt to the changing healthcare landscape, leading to improved AH workforce retention and improved patient outcomes [18]. However, most evaluations of leadership programs have focused on the leader's perspective, leaving limited understanding of their impact from the viewpoint of those being led [19, 20].

One aspect of leadership that has been gaining increased attention is that of employee experience [21]. Employee experience is an important part of work and can be defined as "the sum of interactions that are influenced by employees' perceptions of the individual and the organizational factors within the workplace" [22 p93] Employee experience and wellbeing are integral to a well-performing and stable healthcare system [23]. Key factors influencing employee experience and satisfaction include opportunities for professional development and career progression [24] and enhanced clinical teamwork with improved clinical outcomes, particularly when healthcare teams are developed with a person-centred focus [15]. For AHPs, employee experience directly influences decisions to remain in or leave the healthcare system, thereby shaping retention and attrition rates [10]. Effective leadership enables employees to flourish by encouraging autonomy, empowerment, and a sense of achievement, which in turn strengthens confidence and positively impacts workplace culture [10, 25].

Given the vulnerability of AHPs in the healthcare labour force and the evolution of leadership philosophy to include employee experience, it is timely to investigate the role of leadership training at influencing employee experience within the AHP workforce. It is essential to understand how leadership programs shape the employment experiences of those being led, ultimately affecting retention, satisfaction, and other workforce outcomes. As a result, this scoping review was conducted to explore what has already been investigated in AH leadership training and employee experience. A scoping review was chosen to summarise what is already known and identify potential research gaps to guide future projects in this emerging area.

AIM

The aim of this scoping review is to examine how AH leadership programs influence employee experience from the perspective of staff being led within healthcare settings.

METHOD

This scoping review was conducted according to the scoping review procedures described by Arksey and O'Malley [1], with guidance and modifications from more recent scoping review methodology [26, 27]. It was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA ScR) guidelines [27]. The protocol for this scoping review was published on Open Science Framework on 5th May 2025, with nil amendments made (doi.org/10.17605/OSF.IO/EAQBX).

SEARCH STRATEGY

A systematic search across four databases was conducted (Medline, CINAHL, Embase, PsycINFO) in June 2025. Additional searching was conducted in Google Scholar (first 200 entries), Trip Database, Clinicaltrials.gov, Scopus, australianclinicaltrials.gov.au, and CDC Wonder. Citation and reference checking were conducted on the final yield. The search terms captured four concepts; Allied Health, Hospitals, Leadership Training, and Employee Experience (See supplementary material for details and example of search). The Allied Health Professionals included in the search (Table 1) typically report under Allied Health directorship [28]. Employee experience terms (Table 2) drew on a broad range of components [10, 15, 21-25, 29]. The concepts and search terms were generated by five authors and were refined through consultations with one academic, one medical librarian, an Allied Health Manager who was not one of the authors, and cross checking with key literature [22, 29, 30]. The research team comprised AH leaders from six disciplines with private and public healthcare experience, across Australia and internationally.

TABLE 1

Allied Health Professionals
Allied Health
Allied Health Assistant
Art therapy
Clinical psychology
Dietetics
Exercise physiology
Music therapy
Neuropsychology
Nutrition
Occupational therapy
Prosthetics and Orthotics
Physiotherapy
Physical therapy
Podiatry
Social work
Speech pathology

TABLE 2

Employee experience terms
Absenteeism
Attitude of health personnel
Employee experience
Employee engagement

Employee health
Employee wellbeing
Flexibility
Inclusion
Innovation
Job autonomy
Job satisfaction
Lifelong learning
Meaningful work
Motivation
Occupational stress
Organisational commitment
Organisational innovation
Personnel turnover
Presenteeism
Professional burnout
Retention
Safety
Staff engagement
Staff wellbeing
Trust
Work engagement

Studies sourced from the searches were exported into Covidence (Veritas Health Innovation, Melbourne, Australia) for review. Duplicates were removed using the automatic feature in Covidence. All authors were involved in screening titles and abstracts, and then full articles against the selection criteria, with each step involving two authors per article. Disagreements were resolved through a third reviewer. All reviewers had a guide outlining the selection criteria in detail, with instructions on how to proceed with the screening tasks, to ensure adherence to the screening process. Group training and calibration activities were conducted.

SELECTION CRITERIA

Table 3 outlines the inclusion/exclusion criteria. No historical timeframe was set. Articles published in English (no funding available for translation), in peer reviewed journals were included. Conference abstracts, theses and opinion pieces were excluded. As we were interested in AH results, papers which included mixed professionals were excluded if they did not separate results for AH from non-AH professionals. Any formalised leadership training programs, either bespoke or commercially available, were included. As we were primarily interested in the outcome of employee experience, one of the outcomes measured had to include any type of measurement about the impact on employee experience from those who the trainees led, as opposed to how the trainees felt about the training.

TABLE 3. INCLUSION/EXCLUSION CRITERIA

Inclusion	Exclusion
Studies which have measured a concept connected with employee experience	Studies that only report the leaders' experience of the training and do not measure any employee experience concept
Studies that report employee experiences of those who leaders lead	Non-English
All countries	Multidisciplinary participants that do not report AH results separately
Hospital/Healthcare network based	

Single or multidisciplinary leadership but must include AH disciplines Any formalised leadership program/s that has run at least once	Conference presentations, opinion pieces, review articles, theses

RESULTS

An initial total of 3,644 articles were identified through database and other source searching. Following title and abstract screening, 72 studies progressed to full-text review, with only one meeting the inclusion criteria (Figure 1). This one study by Bradd et al., 2018 [28], conducted in 2014–2015 across a multisite Australian public healthcare network, examined the development of AH leaders from nine disciplines over a 10-month period. Participants were divided into a control group (n = 16) and an intervention group (n = 14), with three withdrawals overall. The locally developed program was delivered face-to-face, without a formal assessment component, and reported no substantial expenses beyond personnel time. Costs related to course development, staff time (paid or unpaid), and materials were not specified. Training comprised eight sessions covering leadership theory, facilitation skills, leadership styles, critical inquiry, improvement science, and project management, with additional individual coaching provided to the intervention group. Feedback from managers, peers, and subordinates was collected using the Multifactor Leadership Questionnaire (MLQ) [31, 32], though data were not separated to isolate supervisee responses. While the MLQ is not an employee-experience-specific measure, the study was included as it addressed related domains such as workplace culture, engagement, and leadership capability.

FIGURE 1. PREFERRED REPORTING ITEMS FOR SYSTEMATIC REVIEWS AND META-ANALYSES EXTENSION FOR SCOPING REVIEWS FLOW DIAGRAM

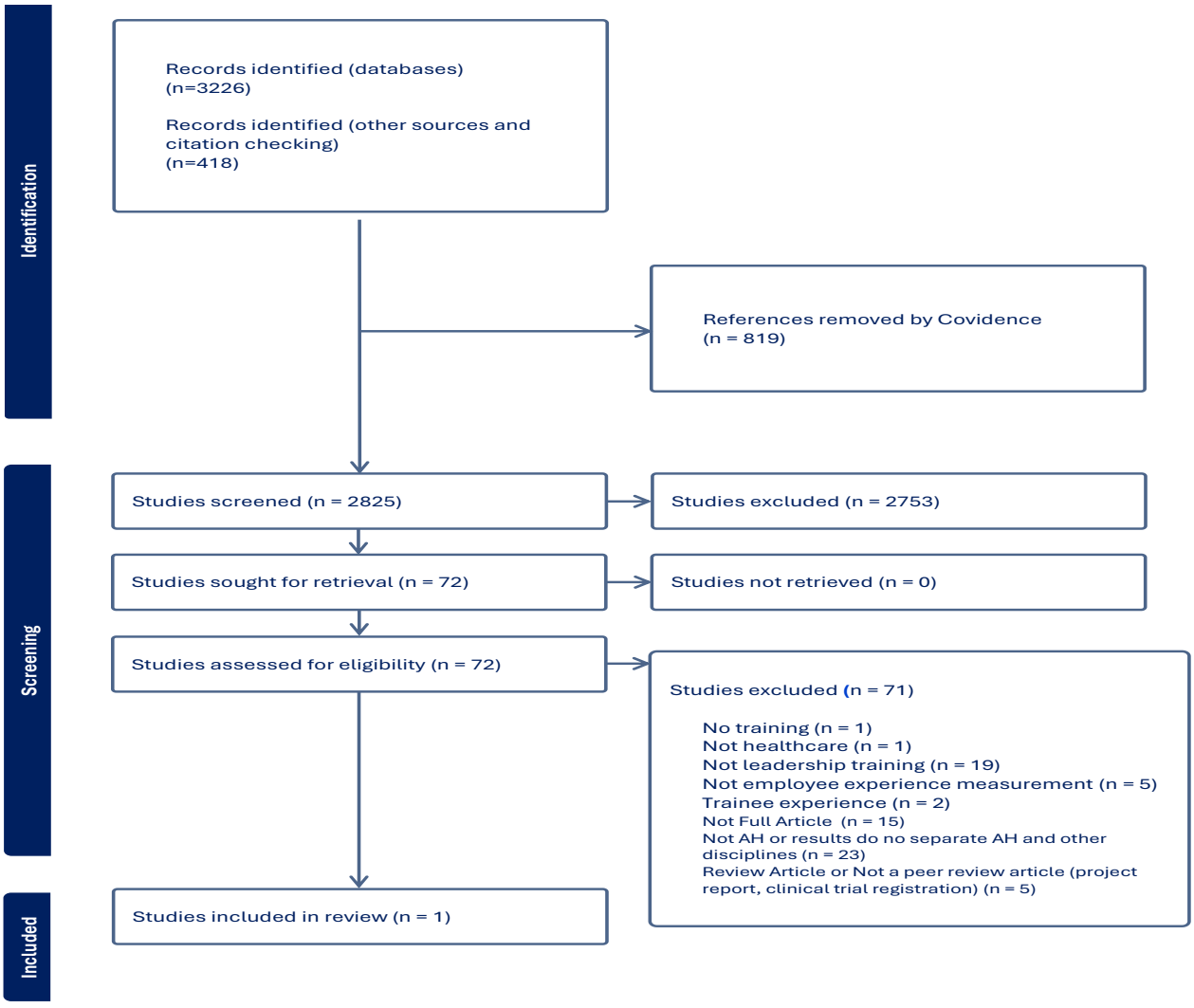


TABLE 4 DATA EXTRACTION

Author, Year published	Country	Course dates/year(s)	Training duration	AH details (# of disciplines)	Attrition rate (number of participants/ number withdrew)	Facilitator background (discipline, in-house vs external)	Setting	Type of training (name of program if stated vs bespoke)
Bradd et al., 2018	Australia	May 2014-March 2015	10 months	9	n=30 Withdrawals – 3 (2/16 intervention and 1/17 control) Attrition rate 3/33=9%	Existing in-house personnel	Public healthcare network (7 sites covering acute, sub-acute and community)	Bespoke program

	Hours of total training (direct and indirect)	Mode of training (face to face/online/independent study)	Course content	Cost	Employee experience area	How employee experience was measured (questionnaires/surveys)	Is there an assessment component?
Bradd et al., 2018	3 days, and four 3-hour action learning sets. Final 3-hr session 4 x 60min individual coaching sessions for intervention group B	Face-to-face	Leadership theory and practice development, facilitation skills, leadership styles, critical inquiry, improvement science and project management	NR	Workplace culture, engagement, & leadership	Other raters including 'subordinates', MLQ	NR

Key. AH = Allied Health; MLQ = Multifactor Leadership Questionnaire; NR = Not Reported.

DISCUSSION

With the aim of understanding the impact of AH leadership programs on employee experience, a robust scoping review was conducted, resulting in one study found that met the eligibility criteria. The paucity of studies indicates the need for more attention in this area to guide both future research and leadership course content. Employee experience remains a novel area as an outcome measure, and we invite future researchers and employers to consider data collection in this area. The single study that met our selection criteria contrasts with the findings of a related scoping review [33]. McKeever & Brown [33] conducted a scoping review to identify the client, organisational and employee-related outcomes of high-quality leadership in the AH workforce. Whilst their scoping review demonstrated the value of AH leadership more broadly, it did not assess the effectiveness of specific leadership programs from the employee perspective. In addition, their scope included the full continuum of care, including community services, whereas this review focuses specifically on hospital (acute and sub-acute) settings. This distinction highlights the unique contribution of the present review: it highlights a critical evidence gap by examining how AH leadership programs affect employee experience in hospital environments.

Low-yield reviews, defined as those identifying no eligible studies (empty) or only a few (near-empty), are often overlooked in academic publishing [34-36] yet 8.7% of Cochrane reviews are empty [36]. Despite limited findings, low-yield reviews remain critical for advancing knowledge and guiding future research. By systematically searching and screening the literature, low-yield reviews reveal areas where research is absent or underdeveloped [34, 37]. This is particularly salient in health sciences, where clinical and policy decisions rely on robust evidence; absence of studies warrants explicit reporting

rather than disregard. Highlighting gaps in AH skills development and employee experience enables future researchers to address these topics and pursue novel yet important concepts.

Failure to report low-yield reviews creates self-imposed publication bias and undermines the transparency and comprehensive reporting that underpin evidence-based practice. To mitigate this bias, low-yield reviews should still be published when pre-registered and conducted with robust methods [34], as in this review. Currently, no specific reporting guidelines exist on low yield reviews (34), hence the reporting of this review still incorporating PRISMA-ScR as per our pre-registration.

The one identified study by Bradd et al. (28) evaluated a bespoke AH leadership program in Australia across seven hospital sites over a 10-month period. Thirty participants from nine disciplines took part, with three withdrawals (an attrition rate of 9%). The program was facilitated internally, delivered 39–43 hours of face-to-face training. Topics covered included leadership theory, facilitation skills, improvement science, and project management. Outcomes focused on workplace culture, engagement, and leadership capability, measured using the MLQ. It is important, however, to note that although the study met our selection criteria, its primary outcome was not captured using a specific employee experience measurement tool. The MLQ includes domains that represent multiple leadership domains. In Bradd et al. [28], trainees themselves rated these, as well as another group comprising managers, peers and subordinates. Additionally, their program did not show significant improvements in how this mixed group rated the leadership skills of the intervention group. This finding, along with the combining of subordinate ratings with others and use of a broad rating tool, mean that it is difficult to further elucidate our research question from this study alone. The study was conducted over ten years ago, so it is understandable that more recent concepts and influences in employee experience were not available at that time to shape the study design.

Salas et al. [38] identified seven evidence-based success factors for conducting training in healthcare. While all are important, two specifically align with this current study's data extraction: determining resources and measuring effectiveness. Bradd et al. [28] reported personnel time and direct training hours but no other resources were identified. To be able to fully consider whether a healthcare organisation can financially implement a full training program, full detailed costings in research studies need to be reported. These include direct personnel time, time and salary for work done in paid hours, unpaid work, materials and licensing, trainer salaries etc. Without such comprehensive reporting, the economic viability of implementing training interventions remain unclear. It is important that future research outlines the financial and non-financial commitments required so organisations can make an economic value assessment.

Although difficult to formulate robust clinical recommendations from the low yield, this study does have important clinical implications. This review has emphasized employee experience as a valuable outcome even though there is little in the literature to guide in terms of AH. Clinicians and researchers are invited to consider employee experience when implementing locally based training initiatives, and to reflect on how such outcomes may be systematically captured. The present study deliberately focused on employee experience as an outcome, as the authors, who are AH leaders, aimed to inform the redevelopment and re-evaluation of their own bespoke, locally implemented AH training program designed for individuals transitioning into AH leadership roles. In the absence of empirical guidance, it is further recommended that AH training, either bespoke or packaged, begins to investigate the impact of such programs on the employee experience of those who AHPs lead. Leadership training programs currently in place may begin to extend their review processes to explore the impact of such training on supervisees. This would then add insight on whether AH leadership training could in fact be an influential factor and strategy for AH workforce capability, clinical performance, satisfaction and retention. However, how to capture such data requires further elucidation.

One of the challenges of measuring employee experience is that it is a multidimensional construct shaped by more than one metric [30]. Therefore, there remains considerable work required on how best to capture employee experience for AH. Despite this, there is potential for future research to bridge this gap. Firstly, further review articles could focus on summarising what standardised outcome measures are appropriate to be used to capture AH employee experience in healthcare settings and further understand the contexts within such measures can be used (e.g., assessing leadership

training outcomes). Such a review will enable researchers and healthcare leaders to be able to select measurements that are relevant to their objectives. Secondly, and related to the first point, is to ensure that employee experience outcome measures are valid for the AH workforce. Pangallo et al. [30] developed an employee experience model from other industries and applied it to two healthcare groups: nurses and physicians. They found that while these two groups had similarities, they also had differences. This illustrates that findings may not be transferable to AH, so therefore AH deserves its own attention. Finally, there is opportunity to engage in qualitative methods to advance our knowledge in aspects of employee experience, which although are not well-represented in AH literature, but have been demonstrated to be insightful tools elsewhere [39, 40]. Qualitative methods have also been used to examine leadership development programs previously, albeit not exploring the impact on employee experience [41].

Despite a broad search strategy and following the PRISMA-ScR protocol, the yield was small. This is not a limit of the review, as a low yield suggests that there requires further work to be done on this topic, but it does limit the breadth of conclusions made. If other studies exist in languages other than English, then they were not represented in this study due to searching in English only with no funding for translation services. Another potential limitation of this paper is that any papers that combined data with other healthcare professionals were excluded, therefore limiting potential multidisciplinary contributions. The PRISMA-ScR reporting suggests 23 studies were excluded for this reason. It is likely, however, that even within this yield, the final yield would be low, as many of these studies also did not report employee experience measures or leadership training programs. Finally, medical radiation sciences, radiography or nuclear medicine were not included, as these disciplines do not report to AH directorships and have different pathways [28], and the exclusion of these professionals may have limited sources being identified.

CONCLUSION

In summary, the present scoping review identified a critical and underexplored gap in the evidence base regarding the impact of AH leadership programs on employee experience within hospital settings. The low yield of only one eligible study underscores that employee experience remains a novel outcome in AH leadership research, despite its clear importance in workforce capability, satisfaction, and retention. While the included study demonstrated the feasibility of evaluating leadership programs, limitations in outcome measurement, conflating of group outcomes, and insufficient reporting of resources limit the conclusions that can be drawn. Importantly, the low yield of this review is itself a meaningful finding, warranting transparent reporting and reinforcing the need for AH and employee experience-targeted research. Future studies should prioritise the development and validation of AH–specific employee experience measures, utilise qualitative data, and report comprehensive resource/cost data to support decisions around implementation. Collectively, these steps are necessary to advance our true understanding of how AH leadership programs influence the employee experience of those they lead.

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CONFLICTS OF INTEREST

The Authors declare that there is no conflict of interest

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SUPPLEMENTARY MATERIAL 1. SEARCH TERMS

Population: Allied Health	Place: Hospitals	Intervention: Leadership Training Programs	Outcomes: Employee Experience
Allied Health	Inpatients (MeSH)	"Leadership development"	"Employee experience"
Allied Health Occupations	Inpatient*.mp	"Leadership train*"	"Staff engagement"
Allied Health Personnel	Hospitals (MeSH)	"Leadership capacity" "Leadership competenc*" "Leadership program*" "Leadership course*" "Leadership education*" "Leadership strengthening"	"Employee engagement"
Allied Health Professions	Hospital*.mp		Work engagement (MeSH)
Art therap*	Subacute care (MeSH)	"Management development"	Job Satisfaction (MeSH)
Clinical Psycholog*	Subacute care.mp	"Management train*" "Management capacity" "Management competenc*"	"Staff wellbeing"
Dietetics	Rehabilitation (MeSH)		"Employee wellbeing"
Dietitian*	Rehab*.mp	"Management program*" "Management course*"	"Employee health"
Dietician*	Rehabilitation Centers (MeSH)	"Management education*" "Management strengthening"	Occupational stress (MeSH)
Nutritionist*			Stress, Occupational (MeSH)
Exercise Physiolog*	Acute Care.mp (Not a MeSH on Medline)		"Professional burnout" (MeSH)
Music Therap*	Hospital Units (MeSH)		Innovation
Occupational Therap*	Health care		Organi$ational innovation (MeSH)
Orthoti*			Safety (MeSH)
Prostheti*			Personnel Turnover (MeSH)
Physiotherap*			"intent to stay"
Physical Therap*			Retention
Podiatr*			Absenteeism (MeSH)
Psycholog*			Presenteeism (MeSH)
Neuropsycholog*			Lifelong learning (MeSH)
Social Work*			Attitude of Health Personnel (MeSH)
Speech Patholog*			"Meaningful work"
Speech Language Patholog*			Inclusion
Speech Therap*			Flexibility
"Allied health assistant"			Trust (MeSH)
			"Job Autonomy"
			"Organizational commitment"
			"Organisational commitment"
			Motivation

Notes:
Growth and development – Removed, as Medline topic is gene/biology.
Career development and agility – Removed, as yield of two irrelevant articles.
Recognition and reward – Removed, as yield of 15 irrelevant articles.
Individual purpose – Removed, as yield of 9 irrelevant articles.
Nutritionist* is a MeSH term for "dietician, dieticians, dietitian, dietitians, nutritionist, nutritionists"

SUPPLEMENTARY MATERIAL 2. SEARCH EXAMPLE.

Database:
Embase <1974 to 2025 May 07>

#	Query	Results from 9 May 2025
1	Allied Health.mp.	18,587
2	Allied Health Occupation*.mp.	114
3	Allied Health Personnel.mp. or paramedical personnel/	17,494
4	Allied Health Professions.mp. or paramedical profession/	2,923
5	art therapy/ or Art therap*.mp.	6,334
6	clinical psychology/ or Clinical Psycholog*.mp.	11,883
7	Dietetics.mp. or dietetics/	10,058
8	dietitian/ or Dietitian*.mp.	26,095
9	Nutritionist*.mp.	7,365
10	Dietician*.mp.	6,355
11	exercise physiology/ or Exercise Physiolog*.mp.	4,380
12	music therapy/ or Music Therap*.mp.	11,030
13	occupational therapy/ or occupational therapist/ or Occupational Therap*.mp.	43,118
14	orthotics/ or Orthoti*.mp.	9,172
15	Prostheti*.mp.	89,404
16	physiotherapist/ or physiotherapy/ or Physiotherap*.mp.	161,585
17	Physical Therap*.mp.	53,387
18	podiatrist/ or podiatry/ or Podiatr*.mp.	6,058
19	psychology/ or Psycholog*.mp.	1,373,041
20	Neuropsycholog*.mp.	150,265
21	social worker/ or social work/ or Social Work*.mp.	56,004
22	Speech Patholog*.mp.	2,687
23	speech language pathologist/ or Speech Language Patholog*.mp.	9,383
24	speech therapy/ or Speech Therap*.mp.	20,137
25	"Allied health assistant".mp.	42
26	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25	1,900,073
27	Inpatient*.mp.	272,292
28	Hospital*.mp. or geriatric hospital/ or private hospital/ or teaching hospital/ or general hospital/ or public hospital/ or mental hospital/ or community hospital/	3,688,269
29	Subacute care.mp. or subacute care/	2,834

30	rehabilitation/	103,630
31	Rehab*.mp.	497,500
32	Rehabilition Centers.mp.	1
33	Acute Care.mp.	44,813
34	Hospital Units.mp.	2,347
35	Health care.mp. or health care/	2,123,503
36	27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35	5,649,456
37	"Leadership development".mp.	2,390
38	"Leadership train*".mp.	1,388
39	"Leadership capacity".mp.	294
40	"Leadership competenc*".mp.	665
41	"Leadership program*".mp.	809
42	"Leadership course*".mp.	201
43	"Leadership education*".mp.	539
44	"Leadership strengthening".mp.	10
45	"Management development".mp.	611
46	"Management train*".mp.	3,724
47	"Management capacity".mp.	623
48	"Management competenc*".mp.	500
49	"Management program*".mp.	25,377
50	"Management course*".mp.	1,016
51	"Management education*".mp.	4,937
52	"Management strengthening".mp.	69
53	37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52	40,951
54	"Employee experience".mp.	49
55	"Staff engagement".mp. or work engagement/	3,851
56	"Employee engagement".mp.	584
57	Job Satisfaction.mp. or job satisfaction/	41,761
58	"Staff wellbeing".mp.	514
59	"Employee wellbeing".mp.	155
60	"Employee health".mp.	2,074
61	Occupational stress.mp. or job stress/	17,908
62	"Professional burnout".mp. or professional burnout/	6,261
63	Innovation.mp.	84,688
64	Safety.mp. or safety/	1,662,545

65	Personnel Turnover.mp.	203
66	"intent to stay".mp.	252
67	Retention.mp.	356,626
68	Absenteeism.mp. or absenteeism/	24,723
69	Presenteeism.mp. or presenteeism/	4,303
70	Lifelong learning.mp. or lifelong learning/	3,499
71	Attitude of Health Personnel.mp. or health personnel attitude/	93,297
72	"Meaningful work".mp.	371
73	Inclusion.mp.	595,957
74	Flexibility.mp.	129,392
75	trust/ or Trust.mp.	98,145
76	"Job Autonomy".mp.	314
77	"Organizational commitment".mp.	1,460
78	"Organisational commitment".mp.	229
79	Motivation.mp. or motivation/	190,640
80	54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79	3,134,814
81	26 and 36 and 53 and 80	1,030

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REVIEW ARTICLE

SUCCESSFUL TRANSITION OF NEW GRADUATE NURSE (NGN) THROUGH MENTORING PROGRAM: AN INTEGRATIVE LITERATURE REVIEW

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ABSTRACT

The transition period for new graduate nurses (NGNs) is critical, with many experiencing challenges due to inadequate preparation for environmental pressures. This study aims to examine NGNs' knowledge, understanding, and experiences, as well as the development of curricula that prepare students for clinical practice. The transition program was evaluated using the Broom methodology for integrative review. The literature review included 15 English-language articles from Scopus, PubMed, and ScienceDirect, published up to August 2025. Structured support programs are necessary to facilitate the transition from a new graduate to a novice nurse. Mentoring, which can be initiated at the university level, has been shown to enhance skills, task performance, professionalism, and patient safety. Mentoring is a vital component in preparing NGNs and represents a concrete strategy to support best practices. No patient or public contribution was involved in this research.

KEYWORDS

Novice; program development; continuing professional development

INTRODUCTION

Newly graduated nurses (NGNs) often face challenges that are beyond their control as they transition from university to professional practice [1]. These challenges stem from a lack of experience and gaps between theoretical knowledge and practical application, coupled with limited environmental support [2]. As a result, many new graduates struggle to adapt to their new roles, leading to a lack of confidence in delivering safe patient care [3], Additionally, some NGNs experience emotional difficulties, including depression, anxiety, and confusion [4].

The role transition from academia to clinical practice is often a difficult and complex process [5]. To ease this transition, there is an increasing need for structured programs, such as mentorship and residency programs, designed to support NGNs and NGNs share their experiences with colleagues [6-8]. Mentorship programs, in particular, have been shown to reduce turnover rates among NGNs in certain hospitals. Studies conducted in China recommend implementing mentorship programs before NGNs are assigned their initial duties [9]. Likewise, residency programs have proven effective in preparing novice nurses for their careers [10]. This review focuses on analyzing research articles that discuss transition programs designed for NGNs.

RESEARCH AIM

NGNs in hospital settings often experience stress, confusion, and feelings of unpreparedness when taking on their roles. These issues not only negatively impact their personal well-being but also pose barriers to their professional growth. To address this, it is crucial to develop strategies that effectively support NGNs during their transition into the workforce. This study seeks to explore the knowledge, understanding, and experiences of NGNs, providing valuable insights for universities to better equip their students and for healthcare institutions to design programs that cater to the specific needs of NGNs. The research question guiding this study is: What knowledge, understanding, and experiences do NGNs gain from university education programs and healthcare providers that help them prepare for their role transition?

METHODOLOGY

DESIGN

This integrative literature review follows the five-step model developed by Toronto and Remington [11] in Table 1: (1) defining research questions, (2) conducting a literature search, (3) evaluating the literature, (4) analyzing the findings, and (5) presenting the results. The Toronto and Remington model serves as a comprehensive framework, guiding researchers in conducting a rigorous and thorough literature review.

TABLE 1. DECONSTRUCTION OF RESEARCH QUESTION FOLLOWING TORONTO AND REMINGTON'S (2020) FRAMEWORK (11).

No	Steps in Toronto & Remington's Integrated Review framework	Deconstruction of the research question
1	Formulate purpose and/or review question(s)	This integrative review aims to examine the available literature on the knowledge and experiences of nurses undergoing transition programs.
2	Systematically search and select literature	The study employs the Participant, Concept, Context (PCC) method to structure the research questions and develop relevant search terms. Keywords and their synonyms were entered into databases such as Scopus, PubMed, and ScienceDirect, while Google Scholar was used to identify any gray or less-defined literature.
3	Quality Appraisal	Literature was evaluated using the JBI Appraisal Checklist for Systematic Review and Research Syntheses (Table 3)
4	Analysis and synthesis	thematic analysis was conducted following Braun & Clarke's six-stage framework (13)
5	Discussion and Conclusion	The study reports and discusses emerging themes and key findings identified through the literature review.
6	Dessimination and finding	• Published journal articles • Theses and Dissertations

SEARCH METHOD

The literature selection process was carried out independently by four researchers. In cases where differences arose, a consensus meeting was held. The first step involved setting the inclusion and exclusion criteria. Articles were included if they focused on programs for NGNs, were fully accessible, and published up to August 2025. Excluded were studies on programs for doctors, pharmacists, or professionals outside nursing, as well as review articles. Databases used included Scopus, ScienceDirect, and PubMed. Search terms were primarily derived from Medical Subject Headings (MeSH), along with English-language titles and keywords from previous research. If PubMed search formula was: ("new graduate nurses OR novice") AND ("program OR training") AND ("transition OR migration"), Scopus and Science Direct was "New Graduate Nurse" and "Transition Program". Participant, context and content (PCC) with Participant : New Graduate Nursing, Nursing student; context : knowledge, experience and understanding; concept:mentoring, preceptorship, residency, Simulated based education and Orientation program in Table 2. The last search of this review was conducted on 30th August 2025.

TABLE 2 . PARTICIPANTS, CONCEPT, CONTEXT (PCC)

Participants	Concept	Context
New Graduate Nursing	Mentoring, Preceptorship	Clinical setting and Hospital
Nursing Student	Preceptorship, residency ,	Clinical setting and Hospital
	Simulated based education, Orientation program	

INCLUSION AND EXCLUSION CRITERIA

Articles were include if they met the following criteria : (1) hospital based, (2) were published in English or Spanish, (3) published between 2019-2025. The exclusion criteria include study protocols, conference papers, in-complete studies or papers that were not primary research were also excluded.

DATA EXTRACTION

The general characteristics of the selected articles were analyzed based on the country of origin, publication year, research methods, and the specific mentoring programs implemented for NGNs (Table 3).

TABLE 3. SUMMARY OF PROGRAM FOR NEW GRADUATE NURSES

No	Author	Country	Method	Program	Result
1	Webb (19)	USA	Quasi-Experimental	Nurse residency Program	Nurse residency programs enhance the quality of nursing care by standardizing evidence-based nursing practices and supporting NGNs as they transition from academic environments to clinical settings.
2	Gautam (16)	Nepal	Qualitative	Mentorship program	New nursing graduates often describe their transition into professional practice as an intense experience. Inductive thematic analysis identified four key themes that encompassed their transition experiences: 'getting hit by reality', 'losing confidence', 'feeling unsupported', and 'gathering strengths.'
3	Siow (20)	Singapura	longitudinal study	Residency Program	The residency program has proven successful in increasing the confidence of NGNs
4	Chen (22)	Taiwan	Quasi-Experimental	Adaptive education program	Adaptive learning programs help NGNs manage their emotions and increase their motivation to work. Statistical analysis revealed significant differences both within subjects (over time and group interaction) and between subjects (across groups) ($p < 0.001$). Those who received gentle care and counseling showed better outcomes compared to those who did not.
5	Hu (17)	China	A Quasi-Experimental	Preceptorship Program	Fifty-three newly graduated nurses (NGNs) completed the program, with their professional identity scores significantly increasing post-intervention—from 111.5 (SD = 16.72) at T1 to 114.2 (SD = 9.12) at T2 (p

					< 0.05). However, scores declined at T3, reaching 105.8 (SD = 9.44), significantly lower than at T1 and T2 (p < 0.05).
6	Abiodun (23)	Africa	Cross-sectional	Peer Support Program with Whatsapp	Interactions with alumni, bridging and bonding social capital, professional integration, and a sense of belonging within a community of practice all showed notable improvement. Among graduate nurses in rural settings, the sense of bonding, professional identity, and theory-practice integrations were significantly higher compared to urban graduates. The findings highlight the value of a WhatsApp community of practice, especially for isolated graduated nurses during critical phases of transition and their professional development.
7	Charette (24)	Canada	Qualitative	competency-based education (CBE)	The competency of NGNs improved with a six-month rotation system and a 12-month orientation phase.
8	Kim (25)	Korea	A Quasi-Experimental	Program Tailored	A tailored nursing practice readiness program significantly reduced the transition shock experienced by newly graduated registered nurses (F = 9.18, p = 0.004), while also improving their practice readiness (F = 19.90, p < 0.001), job satisfaction (F = 4.09, p = 0.049), and retention intentions (F = 6.20, p = 0.016).
9	Jiang (26)	China	Phenomenology	Pre-service safety training program	Three main themes and nine sub-themes emerged from the research: (1) satisfaction with the program's approach and content, (2) personal benefits and growth, and (3) recommendations for future training.
10	Sterner (28)	Sweden	Cross-sectional	Simulated based education	A Wilcoxon signed-rank test revealed that simulation-based education resulted in a statistically significant improvement in nurses' perceptions of their ability to manage acute situations (n = 99; Z = 7877; P < .001).
11	Jangland (14)	Sweden	A Case Study	Mentoring program	Out of 46 hospital units, 14 had implemented one or more components of the mentoring program. This program addressed the needs of newly graduated nurses, provided career development opportunities for senior nurses, and contributed to a more attractive workplace. The overarching theme, Giving NGNs confidence, offering senior nurses a positive challenge, and creating learning opportunities for the organization, reflects the comprehensive value of the mentoring model for nurses and the institution as a whole.
12	Raletooane (15)	Afrika Selatan	Qualitative	Clinical mentoring	Structured clinical guidance is essential to helping newly graduated nurses become competent and confident practitioners. As they come from varied university backgrounds, clinical mentorship is crucial.
13	Horii (27)	Vietnam	Qualitative	a novel clinical training system	The clinical training system was found to enhance the diverse competencies of new graduate nurses, preceptors, and nurse managers while facilitating collaboration among different professions, departments, and organizations and ultimately creating a more supportive learning environment.
14	Clochesy (30)	USA	Cohort Study	Retention and Mentoring (INFORM) Program	INFORM activities can effectively increase faculty knowledge, skills, and productivity early in their careers.
15	Lalithabai (29)	Saudi Arabia	Quasy-Experimental	Orientation program	The results demonstrated statistically significant improvements in overall pre-and post-test scores (P < 0.05) across all dimensions, except for teaching, coaching, and managing complex situations, indicating its effectiveness.

*SD : Standard Deviation

*P : Probability

*n : Number of Sample

QUALITY EVALUATION OF THE LITERATURE

The selected articles were evaluated using the Joanna Briggs Institute (JBI) appraisal checklists [12] in table 4,5,and 6 . The JBI tool adapts to different study designs, and each item on the checklist is answered with "Yes" (Y), "No" (N), "Un Clear (U'Clear), and "not applicable" (N/A). Two researchers independently assessed the quality of each article, comparing their results. Any discrepancies were resolved through discussion to reach a consensus. The study designs of the selected articles included Quasi-Experimental (n=5), Qualitative (n=5), Cohort Study (n=2), Cross-sectional (n=2), and one article with case study design. Result in JBI, fifteen article is Very good rating.

ETHICAL CONSIDERATIONS

This study did not require ethical approval or an ethics reference number, as it was based exclusively on secondary data derived from previously published literature. No human participants, patient data, or identifiable personal information were directly involved in this integrative literature review. Therefore, ethical clearance was not applicable in accordance with institutional and international research ethics guidelines.

TABLE 4. METHODOLOGICAL QUALITY ASSESSMENT OF INCLUDED QUASY-EXPERIMENTAL STUDIES (5 STUDIES)

Question	Webb et al (19)	Chen et al (22)	Hu et al (17)	Kim et al (25)	Lalithabai (29)
Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable comes first)?	Y	Y	Y	Y	Y
Was there a control group?	Y	Y	Y	N/A	Y
Were participants included in any comparisons similar?	Y	Y	Y	Y	Y
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	U'Clear	Y	Y	Y	Y
Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	Y	Y	Y	Y	Y
Were the outcomes of participants included in any comparisons measured in the same way?	Y	Y	Y	Y	Y
Were outcomes measured in a reliable way?	Y	Y	Y	Y	Y

Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Y	Y	Y	Y	Y
Was appropriate statistical analysis used?	Y	Y	Y	Y	N/A

TABLE 5. METHODOLOGICAL QUALITY ASSESSMENT OF INCLUDED QUALITATIVE RESEARCH (5 STUDIES)

Question	Gautam (16)	Charette (24)	Jiang (26)	Raletooane (15)	Horii (27)
Is there congruity between the stated philosophical perspective and the research methodology?	Y	Y	Y	Y	Y
Is there congruity between the research methodology and the research question or objectives?	Y	Y	Y	Y	Y
Is there congruity between the research methodology and the methods used to collect data?	Y	Y	Y	Y	Y
Is there congruity between the research methodology and the representation and analysis of data?	Y	Y	N	Y	Y
Is there congruity between the research methodology and the interpretation of results?	Y	Y	Y	Y	Y
Is there a statement locating the researcher culturally or theoretically?	Y	Y	Y	Y	Y
Is the influence of the researcher on the research, and vice- versa, addressed?	Y	Y	Y	Y	Y
Are participants, and their voices, adequately represented?	Y	Y	Y	Y	Y
Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	Y	Y	Y	Y	Y
Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	Y	Y	Y	Y	Y

Note: Y (Yes); N/A (Not Applicable); N (NO)

TABLE 6. METHODOLOGICAL QUALITY ASSESSMENT OF INCLUDED COHORT STUDY (2 STUDIES)

Question	Clochesy (30)	Sio (20)
Were the two groups similar and recruited from the same population?	Y	Y
Were the exposures measured similarly to assign people to both exposed and unexposed groups?	Y	Y
Was the exposure measured in a valid and reliable way?	Y	Y
Were confounding factors identified?	Y	Y
Were strategies to deal with confounding factors stated?	N/A	Y
Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	Y	Y
Were the outcomes measured in a valid and reliable way?	N	Y
Was the follow up time reported and sufficient to be long enough for outcomes to occur?	N	Y
Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	Y	Y
Were strategies to address incomplete follow up utilized?	N	Y
Was appropriate statistical analysis used?	Y	Y

Note: Y (Yes); N/A (Not Applicable); N (NO)

TABLE 7. METHODOLOGICAL QUALITY ASSESSMENT OF INCLUDED CASE STUDY/REPORT (1 STUDIES)

Question	Jangland (14)
Were patient's demographic characteristics clearly described?	Y
Was the patient's history clearly described and presented as a timeline?	Y
Was the current clinical condition of the patient on presentation clearly described?	Y
Were diagnostic tests or assessment methods and the results clearly described?	Y
Was the intervention(s) or treatment procedure(s) clearly described?	Y

Was the post-intervention clinical condition clearly described?	Y
Were adverse events (harms) or unanticipated events identified and described?	Y
Does the case report provide takeaway lessons?	Y

Note: Y (Yes); N/A (Not Applicable); N (NO)

TABLE 8. METHODOLOGICAL QUALITY ASSESSMENT OF INCLUDED CROSS-SECTIONAL (2 STUDIES)

Question	Abiodun (23)	Sterner (28)
Were the criteria for inclusion in the sample clearly defined?	Y	Y
Were objective, standard criteria used for measurement of the condition?	Y	Y
Was the exposure measured in a valid and reliable way?	Y	Y
Were the outcomes measured in a valid and reliable way?	Y	Y
Were confounding factors identified?	Y	Y
Were strategies to deal with confounding factors stated?	Y	Y
Was appropriate statistical analysis used?	Y	Y
Were the study subjects and the setting described in detail?	Y	Y

Note: Y (Yes); N/A (Not Applicable); N (NO)

RESULT

Fifteen articles were critically analyzed and synthesized to address the research questions regarding the knowledge and experiences of NGNs in both university education programs and the workplace, particularly in preparing them for their transition into professional practice. Braum amd clarke [13] six-step thematic analysis was used to explore the relationships between themes, refining them until no new themes emerged. Two key themes surfaced: (1) Mentoring programs for NGNs and (2) the implications of mentoring on their transition.

SEARCH OUTCOME

The literature search followed the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Articles were collected using EndNote V.21 bibliographic software, then reviewed and classified (Figure 1). Initially, 1,428 articles were identified. After removing duplicate articles, not retrieved and excluded with other reason (example title and abstract) using the inclusion and exclusion criteria = 1,413 articles. The final filtering was conducted based on open access and full-text availability, resulting in 15 articles selected for detailed review.

NGNS MENTORING PROGRAM

Four articles focus on mentoring programs for newly graduated nurses [14-17]. The expectation for new hospital nurses to provide safe and effective patient care remains high [18]. Mentorship can involve direct guidance from colleagues and senior nurses who serve as role models [14]. Often, the mentor, or "supervisor," is selected from among experienced senior staff . This mentoring relationship helps foster professional development, supports career advancement, and provides opportunities for NGNs to demonstrate their skills [19].

Two additional articles discuss residency programs for NGNs [20-21], which are shown to significantly boost their confidence . While the duration of these programs varies, Rush [22] suggest that a minimum of four weeks is necessary to effectively transition NGNs into the residency program.

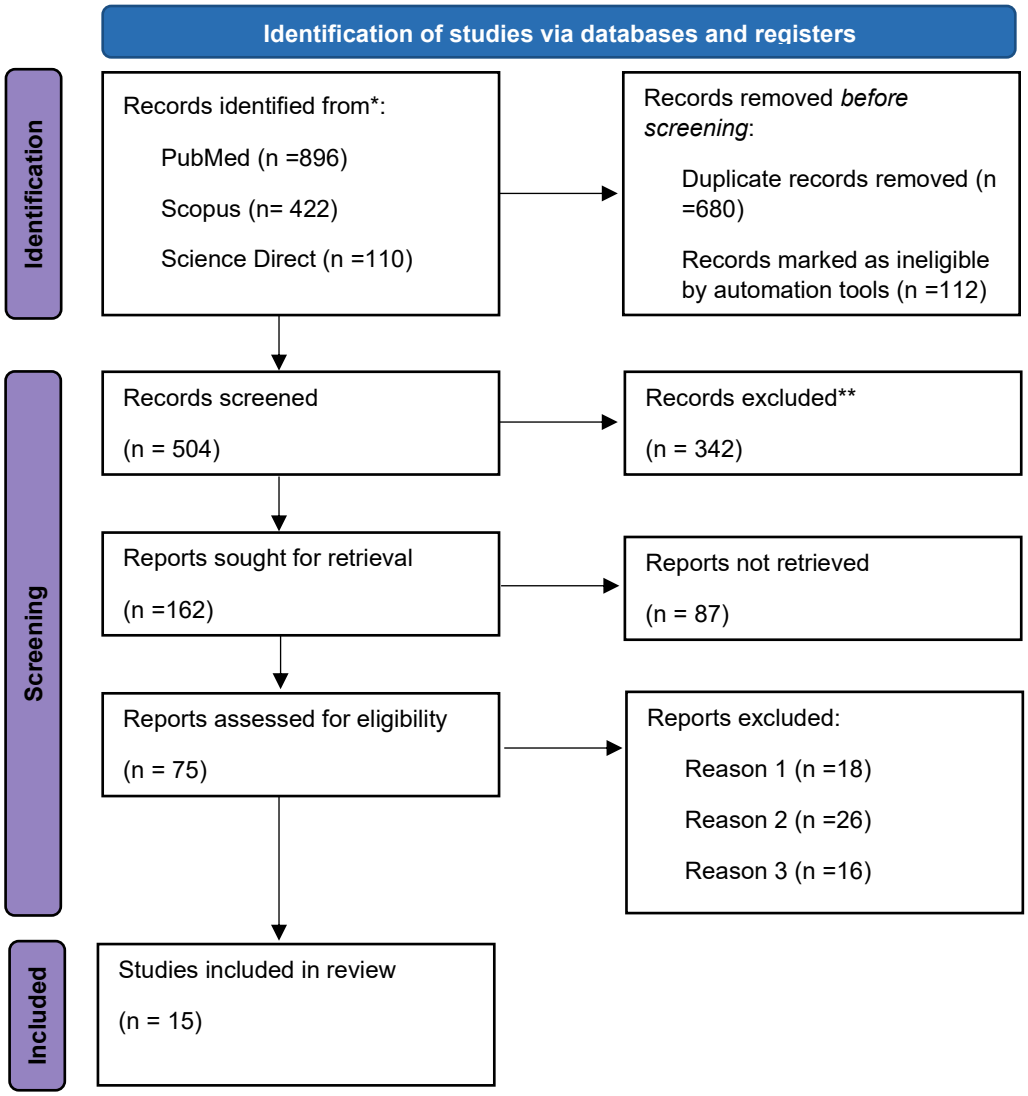
Nine other articles highlight various transition support programs for NGNs, including peer support, competency-based education (CBE), pre-service training, simulation-based education, and orientation programs [23-31]. For instance, Abiodun [24] explored the use of WhatsApp as an eight-week support program, where NGNs were guided through topics like interprofessional relationships and career management. Involving all stakeholders in supporting the transition process accelerates the NGNs' adaptation and helps build their confidence in their new roles and responsibilities.

IMPLICATIONS OF MENTORING PROGRAMS FOR NGNS PERSONAL AND PROFESSIONAL

Mentoring helps NGNs enhance their knowledge and understanding while also alleviating the effects of transition shock [26]. Orientation and mentorship have a direct positive impact on nurses' competence [30. 32, 33]. Competence in NGNs encompasses not only cognitive and psychomotor skills but also affective abilities. While affective skills are more difficult to measure, they can be developed through education and supervised practical training [34].

Mentorship for NGNs should not be limited to routine hospital programs , suggest that mentorship can begin even at the university level, where it helps support students emotionally as they approach graduation, better preparing them for the transition into professional practice. Simulation-based education, a structured form of mentorship, has been proven effective in preparing NGNs for acute clinical situations, as demonstrated in a Swedish hospital study [29].

FIGURE 1 : PRISMA 2020 FLOW DIAGRAM



DISCUSSION

The fiveteen articles analyzed highlighted the critical role of mentoring programs for NGNs. Rather than functioning as a uniform intervention, mentoring programs demonstrate differential effectiveness depending on their design, context, and targeted outcomes. This review reveals that structured, institution-based mentoring (e.g., residency and preceptorship programs) is most effective in improving clinical competence, patient safety, and retention, whereas flexible and peer-supported models contribute more significantly to emotional adaptation and professional identity formation.

Research indicated that the increasing turnover rates among NGNs in recent decades negatively impact patient care. To address this, mentoring programs were recommended as a key strategy to improve retention and support NGNs during their transition [14]. The synthesis suggests that turnover is not merely reduced by the presence of mentoring, but by the quality and continuity of mentoring interactions. Programs that integrate ongoing feedback, reflective practice, and competency evaluation are more successful in retaining NGNs compared to one-time orientation-based interventions.
This transition is a pivotal phase in a nurse's career journey. Importantly, the findings indicate that transition shock is mitigated when mentoring addresses both technical and psychosocial domains simultaneously. Studies that combined clinical supervision with emotional support reported greater reductions in anxiety, improved job satisfaction, and stronger professional commitment [24,31].

University faculty also play a significant role Baharum [35] identification Universities or colleges play an important role in the success of new nurse transition. However, beyond identifying themes, a cross-study comparison revealed that mentoring interventions varied substantially in structure, duration, and delivery mode, which influenced their effectiveness across different outcomes. Structured mentoring programs (e.g., residency and preceptorship models) consistently demonstrated stronger effects on clinical competence and patient safety outcomes, whereas informal or peer-based mentoring (e.g., WhatsApp support groups) showed greater impact on psychosocial adaptation, professional identity, and sense of belonging [22,24].

Programs such as NGNs mentoring are not only implemented during employment or orientation, but the involvement of universities through their own programs can actually shorten the orientation period.

This integrative review emphasizes that mentoring for NGNs is not just another program but a vital initiative that universities should incorporate into their curricula Early exposure to the clinical environment and hands-on experience in hospital settings are essential in preparing nursing students for professional practice . Additionally, enhancing knowledge, experience, and professionalism during the transition period can be achieved through Continuing Professional Development (CPD) programs . CPD equips NGNs with skills that they can immediately apply in their clinical roles [36].

CONCLUSION

Mentoring is essential in preparing NGNs to enter the workforce as competent, professional healthcare providers. It helps bridge the gap between academic learning and direct patient care, enabling a smoother role transition. However, the differences in hospital policies and guidelines present unique challenges. Therefore, there is a need for clear, structured, and sustainable policies to ensure that mentoring programs for NGNs are consistently implemented. Universities are also encouraged to integrate career planning into their curricula, helping students become more prepared for their roles as healthcare professionals upon graduation.

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ACHSM Asia-Pacific Journal of Health Management

REVIEW ARTICLE

A MULTIDIMENSIONAL ANALYSIS OF GREEN HOSPITAL OUTCOMES: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

AIM:

This systematic literature review aims to evaluate the multidimensional outcomes of green hospital practices, specifically focusing on environmental, patient-centered, and organizational dimensions to establish a comprehensive framework for healthcare sustainability.

BACKGROUND:

In recent years, green hospital initiatives have gained prominence as vital strategies for sustainable healthcare delivery. Despite the growing interest, there is a need for a holistic synthesis of how these initiatives impact various facets of hospital management and service quality.

METHOD:

A systematic search was performed across the Web of Science and PubMed databases using the keyword "green hospital" without any temporal restrictions. Following a rigorous screening process based on predefined inclusion criteria, 14 peer-reviewed studies were selected for qualitative synthesis.

FINDINGS:

The analysis indicates a significant surge in research within the last five years, reflecting a global trend. The findings demonstrate that green hospital practices are robustly associated with positive outcomes, including enhanced service quality, increased hospital attractiveness, improved patient satisfaction, optimized waste management, energy efficiency, substantial cost savings, and better environmental health indicators.

CONCLUSION:

Green hospital initiatives provide a synergistic benefit for both environmental sustainability and organizational performance. The study emphasizes that while policymakers must provide the necessary regulatory and financial framework to facilitate the green transition, healthcare managers must assume a proactive leadership role in driving this organizational transformation.

KEYWORDS

sustainability, green buildings, green hospitals

INTRODUCTION

Climate change, with its consequences such as extreme weather events and the rise in infectious and chronic diseases, is identified by the World Health Organization (WHO) as one of the most significant factors threatening global health. The WHO estimates that, as a result of the adverse effects of climate change, there will be 250,000 additional deaths each year between 2030 and 2050. These deaths are linked to various health issues, including heat-related illnesses, malnutrition, vector-borne infections, and water-related diseases. Furthermore, the climate crisis poses a significant threat not only to physical health but also to the systems that determine health, such as access to healthcare and social security [1]. Therefore, it is clear that the health sector, which has taken on an important mission in the preservation and promotion of health, must play a key role in mitigating the effects of the climate crisis. However, the fact that the health sector is currently responsible for 4.4% of global net carbon emissions, and the high level of this rate, creates a significant contradiction [2].

While performing critical functions such as protecting the health of individuals and the community, diagnosing and treating diseases, and providing rehabilitation, healthcare institutions consume significant amounts of energy and water, generate hazardous medical waste, and pose serious threats to the environment and human health. This situation necessitates healthcare institutions to be viewed not only in terms of healthcare service delivery but also as complex organizations that must be addressed within the context of their environmental impacts [3]. This impact of the health sector highlights the significant extent to which the sector contributes to the climate crisis. This situation necessitates a reevaluation of sustainable approaches in healthcare. Consequently, it is clear that the health sector must provide climate-resilient and sustainable healthcare services, reduce its carbon footprint, and adopt cleaner technologies [1]. This necessity has led to the emergence of the "green hospital" concept in the healthcare sector, incorporating many practices that have gained prominence as green buildings in other sectors. These structures have been described by Aini et al. [4] as an environmentally friendly design that enhances and highlights existing natural potential. Indeed, in green-building-certified hospitals, environmentally friendly facility design and service delivery are possible alongside practices such as hazardous material and waste management, as well as the efficient use of water and energy. This makes it possible to reduce service costs, improve quality, and ultimately ensure sustainability [5]. In that sense, green hospitals can be defined as facilities that incorporate environmentally sustainable building features, including the use of green technologies, efficient water and energy conservation practices, strategic locations that minimize transportation costs, the provision of healthy food options, the integration of alternative energy generation systems, and well-designed waste management infrastructure [6], [7].

As the benefits of green buildings—which can be adopted in facilities across various sectors—have become increasingly recognized, green building rating and certification systems have also been developed. These systems subsequently established various criteria to evaluate "green hospitals" based on the green building concept [8]. In a comparative analysis of LEED, BREEAM, and WELL certifications conducted by Tsirovasilis et al. [9], it was noted that these systems go beyond environmental performance to address social sustainability, which also encompasses user well-being. The study found that while LEED and BREEAM are primarily focused on environmental and energy aspects, the WELL certification distinguishes itself by emphasizing human-centered health parameters. Therefore, green hospitals should be evaluated not only in terms of environmental impacts but also in terms of organizational and patient-centered impacts. Indeed, Nurfikri et al. [10] demonstrated in their studies that, alongside growing environmental awareness, patients' preference for green hospitals has become a significant driving force encouraging healthcare institutions to adopt sustainability policies. These findings reveal that the green hospital concept is the result of not only an institutional transformation but also a demand-driven change.

Reducing environmental pollution caused by healthcare services requires preventing the excessive or inefficient use of resources and systematically minimizing the environmental footprint of operational processes. Implementing such measures enhances the efficiency of healthcare services, supports the delivery of higher-value-added services, and

directly contributes to improving public health [11]. In addition to promoting energy and water conservation in hospitals, green initiatives also offer benefits such as providing patients with care in a higher-quality environment and ensuring better hygiene. When the environmental benefits are also taken into account, it is an undeniable fact that the green hospital concept can provide multifaceted benefits [7]. Given the critical importance of the sustainability of healthcare services for global health and social well-being, the multidimensional impacts of green hospital practices must be addressed from a holistic perspective. Accordingly, this study aims to examine the outcomes of green hospital practices from a multidimensional perspective. Studies in the literature generally focus on limited contexts, and no systematic review has been found in the literature that comprehensively examines the multidimensional impacts of green hospitals. This study systematically reviewed studies examining the effects of green hospitals on environmental, patient-centered, and organizational outcomes. In this regard, the study provides an evidence-based framework regarding the impacts of green hospital practices for researchers, healthcare managers, and policymakers, and has the potential to make a significant contribution to the literature.

MATERIAL AND METHOD

RESEARCH STRATEGY

This study is a systematic literature review. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed in the design, conduct, and reporting of the study. The PRISMA statement, which serves as both a guide and a checklist, is primarily a reporting guideline used to ensure that systematic literature reviews and meta-analyses are conducted and reported within a standardized framework. It provides a standard framework that includes the selection of study titles, the establishment of the study background, the identification and selection of studies, the assessment of bias, and the reporting of results [12]. The Web of Science (WoS) and PubMed databases, whose credibility is internationally recognized, were selected for the literature review. The keyword "green hospital" was used in both databases to identify relevant studies. The search strategy was tailored for each database to ensure the retrieval of studies aligned with the research objectives. A search was conducted using the relevant keyword in all fields of the Web of Science (WoS) database and in the title and abstract fields of the PubMed database. No time restrictions were applied to the searches.

INCLUSION AND EXCLUSION CRITERIA

The eligibility criteria were determined prior to the literature search. Studies were included if they (i) were published in English or Turkish, (ii) were original research articles, and (iii) investigated the environmental, patient-centered, or organizational outcomes of green hospital practices. Publications that did not meet these criteria were excluded. Specifically, review articles, letters to the editor, conference proceedings, editorials, commentaries, and studies that were not directly related to the outcomes of green hospital practices were excluded from the review.

DATABASE SEARCH AND SELECTION OF THE STUDIES

Duplicate studies were excluded from the pool of studies identified through database searches. The titles and abstracts of the remaining studies were reviewed; after excluding studies identified during this initial screening, the full texts of the remaining studies were examined, and those meeting the study criteria were included. Finally, the selected studies underwent a quality assessment regarding reporting quality and risk of bias. Here, the quality of the studies was assessed within the framework of the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement, which is frequently used in the literature [12]. Since it was determined that all included studies met at least half of the criteria listed in the STROBE statement, no studies were excluded as a result of the quality assessment. The entire screening process was conducted independently by two researchers and subsequently reviewed jointly, and consensus was reached regarding the studies to be included.

DATA EXTRACTION

To compare the results of database searches and exclude duplicate studies, the search results were exported in Excel format. Subsequently, to extract the findings of the studies selected for inclusion, the researchers used an Excel table

containing the authors and years of the studies, their objectives, design, sample characteristics, measurement tools, and main findings. This table was created separately by each researcher and then consolidated.

RESULTS

An initial search of the WoS database yielded 112 studies; after selecting the "article" option, the number of studies was narrowed down to 71. All studies were screened based on their titles and abstracts. Of the studies whose titles and abstracts were reviewed, 18 were selected for full-text review, and the full text of 1 study was unavailable. Following the full-text review, 4 studies were excluded, and 13 studies were ultimately included. A search of the PubMed database yielded 51 results. It was determined that 17 of these studies were duplicates of those obtained from the WoS database, while 34 studies were subjected to a title and abstract review. The remaining 2 studies were included for full-text review. Access to the full text of 1 study could not be obtained. 1 study was included. Ultimately, a total of 14 studies were included from both databases (Figure 1). The findings from the included studies are summarized in Table 1.

FIGURE 1. PRISMA FLOWCHART

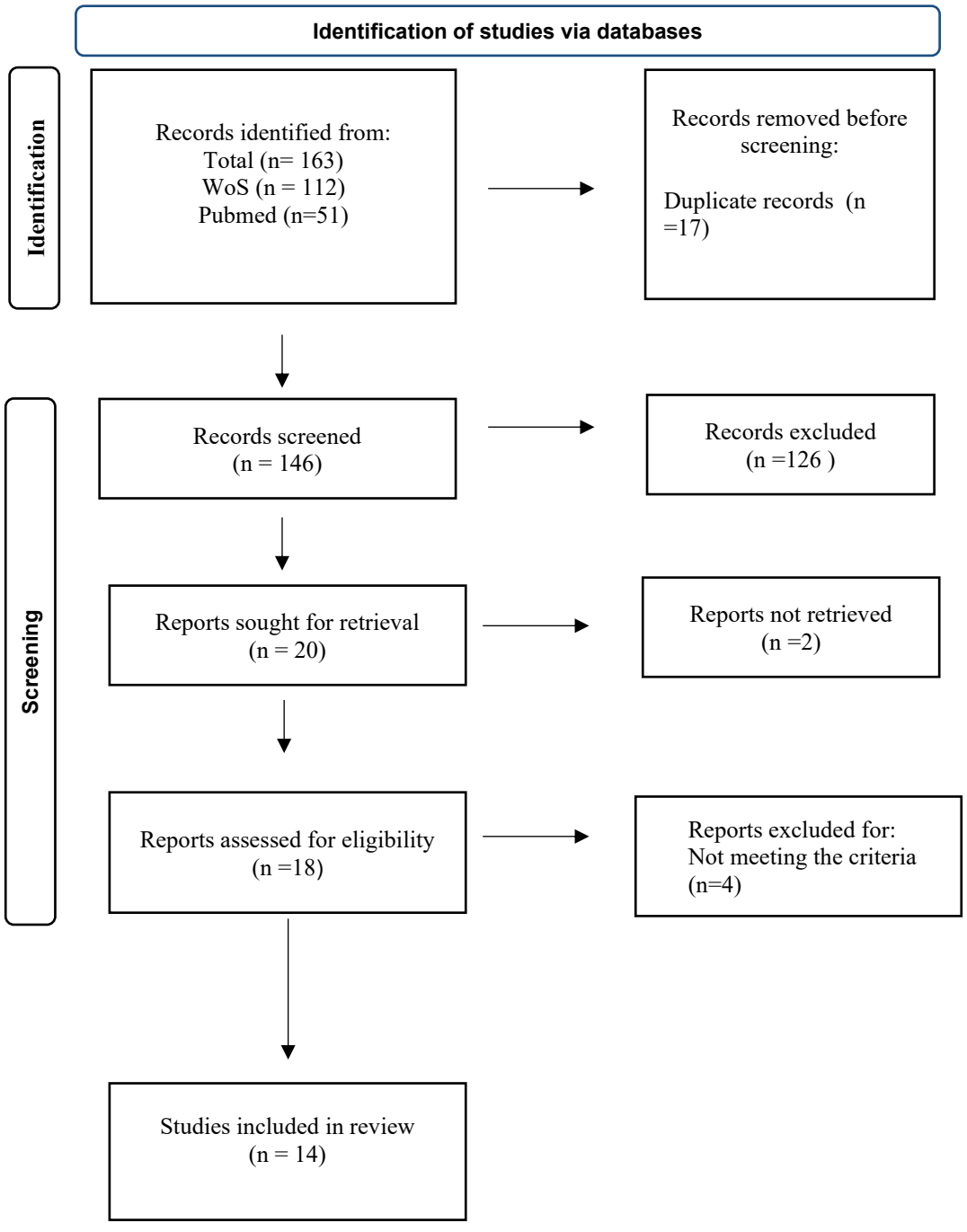


TABLE 1. CHARACTERISTICS AND FINDINGS OF THE INCLUDED STUDIES

Studies	Language	Aims	Design	Sample	Measurement	Main Findings
Nurfikri et al., 2024	English	To analyze the impact of public awareness, attitudes, behaviors, and social norms on shaping the corporate image of green hospitals	Quantitative	400 outpatients receiving care at green hospitals in Indonesia and Taiwan	Survey Form	Green hospital initiatives have been identified as a key factor in increasing patients' choice of hospital and their trust in healthcare facilities.
Aini et al., 2023	English	To develop and analyze a sustainable "eco-friendly hospital" model that integrates the components of green building, green innovation, and green human resource management	Quantitative	A total of 241 participants from a public hospital in Indonesia: 84 staff members, 100 visitors, and 57 residents living in the vicinity of the hospital	Survey Form	Green building, green innovation, and green HR practices each have a meaningful and positive impact on the hospital's environmental performance and organizational sustainability. Green initiatives—such as solar energy, waste sorting, and online systems—reduce costs while creating a cleaner, more comfortable, and safer healthcare environment for patients and the local community.
Wood et al., 2016	English	To identify the needs of patients, visitors, and staff in green hospital design and to develop a "House of Quality" model that translates these needs into technical design requirements	Quantitative	A total of 149 end users from public and private hospitals in Malaysia	Survey Form	It has been determined that the most important green design factors for end-users are "safety in emergencies," "natural ventilation," "use of natural light," and "use of non-toxic materials." Satisfaction with green design among private hospital users was found to be significantly higher than among public hospital users.
Ngatindriatun et al., 2024	English	To analyze the relationship between green hospital initiatives and patient flow issues and service quality, as well as their impact on patient satisfaction in specialized medical departments	Quantitative	572 patients receiving care at five different hospitals in Indonesia that have received the national "Green Hospital" award	Survey Form	Green initiatives have a significant and positive impact on patients' satisfaction with the indoor and outdoor environments, operational procedures, and care services. Green service quality has been identified as a key factor in mitigating the negative impact of disruptions in hospital processes on patient satisfaction.

Kara et al., 2024	English	To analyze the effects of the LEED certification system and hospital expansions on healthcare quality, pandemic management, and environmental performance using mathematical modeling	Quantitative	Two hospitals in Northern Cyprus: Near East University Hospital (Private/LEED Gold Certified) and Dr. Burhan Nalbantoğlu Hospital (Public)	LEED evaluation criteria, LEED Healthcare criteria, and	It has been found that a private hospital with LEED Gold certification significantly outperforms a non-certified public hospital in terms of patient and staff satisfaction and service quality. It has been mathematically proven that hospital expansions facilitate the management of pandemics such as COVID-19 by improving criteria such as water efficiency, indoor environmental quality, and sustainable land use.
Ryan-Fogarty et al., 2016	English	To evaluate the implementation and effectiveness of a systematic environmental management framework that integrates technical infrastructure with staff training, and to improve the hospital's environmental performance in areas such as energy and waste management	Mixed	Cork University Hospital - Ireland	Environmental Review, Sustainability Key Performance Indicators (KPIs), Employee	As a result of systematic green management practices, despite an increase in hospital activity, energy consumption per patient bed was reduced by 14%, and the amount of waste sent to the landfill was reduced by 35%.
Golbazi & Aktas, 2020	English	To determine the priority that green hospitals place on LEED credits that directly impact patient well-being and to compare patient satisfaction levels at these facilities with the national average	Quantitative	140 healthcare facilities certified in the U.S. for LEED scorecard analyses, and 52 green hospitals among these facilities for which patient satisfaction data is available	USGBC LEED Scorecards, Patient-Consumer-Healthcare Provider	Green hospitals were found to have a "General Hospital Score" 3.6% higher than the national average, and a "Recommendation Rate" 5.6% higher. No statistically significant difference was found between green and traditional hospitals in terms of perceptions of cleanliness and quietness.
Dion & Evans, 2024	English	To develop "green hospital" management strategies that integrate energy efficiency and corporate governance in healthcare institutions	Qualitative	10 hospitals—both public and private—operating in the Middle East and North Africa (MENA) region; 29 senior executives included in the data collection process	Interviews and Site Observations	Energy management projects have yielded tangible results, including a 23% reduction in energy consumption at the facility level and an annual cost savings of $85,700.

Bagherian & Mukherjee2025	English	To develop a systematic framework for implementing the "Quality 5.0" approach—which balances technological, patient-centered, and ethical objectives in the healthcare sector—and to analyze the strategic prioritization of patient-centered innovations	Qualitative	43 experts (doctors, nurses, administrators, and clinical pharmacists) with experience in the digital transformation of healthcare; a medium-sized public hospital in southern Germany with 300 beds and approximately 500 employees	Hybrid practice	Green hospital initiatives and sustainable practices have been identified as key strategic approaches for reducing operational and environmental costs.
Fannah et al., 2023	English	To measure the environmental impacts of clinical anesthesia and surgical procedures in healthcare delivery and to develop a data-driven "green hospital" approach for healthcare planning.	Quantitative	A tertiary care hospital in Oman (Royal Hospital)	Secondary data	It has been concluded that environmental sustainability must be managed as part of the quality dimensions of healthcare.
AlShareef et al., 2022	English	To investigate whether designating a "green hospital" during the pandemic ensured the safe and uninterrupted resumption of surgical services	Quantitative	Hospitals designated as "green hospitals" in five cities in the northern regions of Saudi Arabia (experimental group); A large tertiary care hospital in Riyadh that is not designated as a green hospital (control group)	Secondary data	The green hospital model reduced surgical backlogs by 81% in the Al Jawf region, 78% in the Northern Borders, and 74% in Alqurayat. In the control group (non-green hospitals), the backlog reduction rate was found to be only 8%.
Sadatsafavi vd. 2014	English	To compare the financial performance of LEED-certified hospitals with the average performance of non-green facilities	Quantitative	14 LEED-certified hospitals in the U.S. (experimental group) and 3,522 hospitals listed in the Medicare/Medicaid (CMS) database (control group)	Secondary data	Operating costs for green hospitals were found to be approximately 84% higher than those of an average non-green hospital. Green hospitals generated 82% more inpatient revenue, but this increase in revenue was not sufficient to offset the higher operating costs. It was found that a higher LEED certification level (such as Gold or Platinum) does not guarantee better financial performance.

Jannah vd.2023	English	To determine the impact of "Green Brand Image" and "Green Satisfaction" on "Green Brand Value" through "Green Trust" for outpatients	Quantitative	100 outpatients receiving care at the East Java Hospital in Indonesia	Survey Form	The impact of green brand image and green satisfaction on green brand value is mediated by green trust.
Ghersin vd. 2020	English	To examine the entrenched culture of waste and the generation of medical waste in the healthcare sector from an ethical perspective, and to conduct a quantitative analysis of the volume and cost of medical supplies that were opened but never used and subsequently discarded in a pediatric intensive care unit	Quantitative	A 14-bed pediatric intensive care unit at Massachusetts Children's Hospital in the U.S.	Secondary data	During the study, 76 kg of unused medical waste was collected; it was determined that the majority of the waste originated from isolation rooms and unopened packages. While endotracheal tubes, baby diapers, and suction catheters were the most commonly wasted materials, it was emphasized that even high-cost equipment was being discarded without being returned to the system, and that this situation conflicted with principles of environmental sustainability and bioethics.

A total of 14 studies that met the inclusion criteria were analyzed as a result of the systematic review. All studies were published in English, and the vast majority employed a quantitative design. The studies were concentrated within the last 5 years and were conducted in various regions around the world. Additionally, it was determined that the studies were predominantly conducted in the Southeast Asian countries of Indonesia and Malaysia. Studies conducted in the Middle East were found to have been carried out in Saudi Arabia and Oman, while those in European countries were conducted in Ireland and Germany. The findings of the studies focus on three main themes: end-user-focused outcomes, environmental outcomes, and organizational outcomes.

It has been determined that green hospital initiatives are associated with numerous positive outcomes for patients and end-users. Providing clean, comfortable, and safe service areas for patients [4], delivering higher-quality healthcare services [14], and increasing patient satisfaction [15], [16], [17], [14] stand out as the most significant outcomes of green hospitals from the patients' perspective.

Green hospital initiatives are associated with a range of benefits, not only for patients but also for healthcare institutions. In addition to improving patient experience and satisfaction, these initiatives increase the institution's desirability [10], and likelihood of being recommended [16], enhance employee satisfaction [14], and contribute to brand value [18], as well as reducing costs associated with energy consumption and waste volume [19], [4], [20], [21], are among the institutional benefits of green hospitals. Furthermore, being designated as a "green hospital" during crisis periods such as the pandemic ensured the uninterrupted continuation of elective surgeries and significantly reduced surgical backlogs (by up to 81% in some regions) [22]. On the other hand, Sadatsafavai et al. [23], argue that facility operating costs may increase under green hospital practices and that green hospitals do not guarantee cost reductions or better financial performance.

As the third theme, the environmental impacts of green hospital practices are addressed. Energy efficiency and conservation are evaluated as organizational outcomes. In this theme, findings have been obtained that contribute to environmental health and sustainability, such as a cleaner environment [10], reduced waste volumes [24], and lower greenhouse gas emissions [25].

DISCUSSION AND CONCLUSION

The aim of this study was to conduct a multidimensional analysis of the outcomes of green hospital initiatives. To this end, a systematic review was conducted of studies examining the effects of green hospitals on environmental, patient-centered, and organizational outcomes. Within this framework, 14 studies were included. The studies were primarily conducted over the past five years and took place in various regions around the world. Considering the countries where the studies were conducted, it is evident that green hospital practices are being researched more intensively, particularly in developing countries and those undergoing an energy transition. This indicates that green hospital practices remain current in many countries and that the outcomes of such practices in these countries require scientific validation. Research findings indicate that green hospital initiatives are associated with numerous positive outcomes. Across the three themes examined, it was found that these initiatives improve the patient/end-user experience and satisfaction, while often reducing institutional costs and enhancing the hospital's reputation. Furthermore, the contributions of green hospitals to environmental sustainability have been clearly demonstrated in the research. This highlights the importance of integrating sustainability principles into the strategic management processes of healthcare organizations.

A review of the literature indicates that the adoption of environmentally friendly policies, in particular, significantly enhances patients' trust in the institution and boosts brand value [18], [10]. The fact that patients prioritize green design factors such as natural ventilation, natural light, and the use of non-toxic materials when selecting a healthcare facility is a critical finding for healthcare managers [15]. Furthermore, unlike traditional approaches that measure the quality of healthcare solely through clinical outcomes, research findings indicate that a hospital's physical environment and green image are also among the key factors contributing to patient satisfaction. Indeed, the fact that the recommendation rates for green hospitals exceed the average confirms this situation [16].

One of the most significant barriers hospital managers face in the transition to green hospitals is the initial investment cost. Indeed, Sadatsafavai et al. [23] (2014) found that facility operating costs increase in green hospitals. However, the same study reported that while green hospitals may not fully offset these operating costs, they also experience a corresponding increase in inpatient revenue. According to studies reporting energy savings, reduced waste, and lower costs [19], [4], [20], [21], [24], [25], it appears that the initial investment costs can be recouped and significant long-term savings achieved [20]. Furthermore, considering the contributions green hospitals make to environmental sustainability in addition to cost savings, it can be noted that the return on the increased costs is quite high.

This study represents the first systematic literature review to examine green hospital practices from a multidimensional perspective, considering the perspectives of service users, healthcare institutions, and the environment. It is anticipated that the synthesis and reporting of findings from studies included in the literature and indexed in major databases will serve as a key reference point for policymakers, healthcare managers, and researchers regarding the outcomes of green hospital practices. Policy makers can accelerate the green transformation of healthcare institutions by developing financial support mechanisms and sustainability policies that encourage green hospital practices. It is also important for healthcare administrators to consider green hospital practices not only as an environmental responsibility but also as a strategic management approach that increases patient satisfaction, institutional efficiency, and sustainability. In future research, prioritizing comparative studies across different countries and research evaluating long-term impacts will contribute to strengthening the existing evidence base. On the other hand, this study has certain limitations. First, the literature review utilized highly recognized indexes. Consequently, studies not indexed in these databases may have been excluded from the review. Furthermore, only journal articles were included, while theses, books, and conference papers were excluded.

In conclusion, studies in the literature indicate that green hospital practices can provide significant benefits across all three themes. The proliferation of such studies will be important for more frequently comparing the potential benefits of the green hospital concept with actual implementations and for identifying its long-term effects. Additionally, healthcare managers need to consider the potential benefits of green transformation in healthcare institutions and take a leadership

role in institutional transformation processes. It is also important for policymakers to develop policies that encourage this transformation and play a facilitating role in the transformation processes by removing barriers to implementation.

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REVIEW ARTICLE

GREEN HOSPITAL IMPLEMENTATION FOR SUSTAINABLE AND RESILIENT HEALTH SYSTEMS IN LOW- AND MIDDLE-INCOME COUNTRIES: A SCOPING REVIEW

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ABSTRACT

INTRODUCTION

Health care both protects population health and drives environmental harm through energy use, waste, and greenhouse-gas emissions. The Green Hospital concept links environmental sustainability with hospital resilience, but evidence from low- and middle-income countries (LMICs) is fragmented.

OBJECTIVE

To map evidence on Green Hospital implementation in LMICs; identify enablers and barriers; characterize measurement approaches; quantify reporting of health, economic, and equity outcomes; and synthesize a conceptual framework of pathways from governance to population health.

METHODS

Scoping review following PRISMA-ScR, registered on the Open Science Framework (https://doi.org/10.17605/OSF.IO/F2BR5). PubMed/MEDLINE, Scopus, and ScienceDirect were searched for English-language peer-reviewed empirical studies published from January 2009 to October 2025 from countries classified by the World Bank (FY2025) as low-, lower-middle-, or upper-middle-income. Screening and charting were performed in duplicate.

RESULTS

Twenty-nine studies were included, concentrated in lower-middle-income settings (20/29), Sub-Saharan Africa (11/29), and South Asia (7/29). Implementation clustered in waste management, water and sanitation, energy efficiency, and green infrastructure, with limited resilience integration. Leading enablers were leadership commitment, regulatory support, and institutional awareness; leading barriers were financial constraints, weak technical capacity, fragmented governance, and non-standardized indicators. Life-cycle assessment and multi-criteria decision-making predominated. Three gaps were quantified: one study reported a population health outcome, and only as a cross-sectional association; three reported cost data and none a formal economic evaluation; none disaggregated findings by occupational group, rurality, or ownership.

CONCLUSION

The literature maps a Green Hospital agenda concentrated in foundational environmental domains and weakly connected to resilience-oriented governance and performance systems. Because studies were predominantly cross-sectional, pathways from intervention to resilience and health are presented as hypothesized propositions requiring testing. The next priority is to align harmonized environmental key performance indicators with hospital accreditation.

KEYWORDS

green hospital; sustainable health care; hospital resilience; climate change; environmental management; low- and middle-income countries; scoping review

INTRODUCTION

BACKGROUND

Global health systems face compounding pressures from climate change, pandemics, and socio-economic shocks, and are increasingly expected to become both resilient and sustainable. Hospital resilience is the capacity to adapt to, withstand, and recover from disruption while maintaining essential services [1,2]. The COVID-19 pandemic exposed how resource limits and weak coordination undermine it.[3]

Health care also contributes materially to greenhouse-gas emissions. Estimates vary with the system boundary and base year adopted, from about 4.4% of global emissions using 2014 input-output data to about 5.2% in more recent syntheses; across sources, hospital operations and their supply chains account for the largest share of the sector footprint.[4,5]
In response, the Green Hospital concept integrates energy efficiency, waste management, water conservation, and smart technologies into hospital management. Instruments such as environmental key performance indicators (EKPIs) and life-cycle assessment (LCA) support environmental evaluation, [5,6] while implementation-oriented tools for resource-constrained settings, such as the WHO/UNICEF WASH FIT, the WHO guidance on climate-resilient and environmentally sustainable facilities, and the PAHO Smart Hospitals Toolkit, provide a parallel measurement tradition.[7–9] Applying these principles can improve operational efficiency, reduce energy costs, and strengthen crisis capacity.[10]

Evidence remains fragmented, with heterogeneous indicators and limited synthesis of implementation and its constraints. This fragmentation is most acute in LMICs, where hospitals face high climate exposure and constrained investment capacity, and where the applicability of instruments developed in high-income settings has not been systematically examined. This review uses the term LMICs throughout, applying the World Bank country classification for fiscal year 2025, and reports sex- or gender-disaggregated data where available.[11,12] It addresses five objectives: 1) to map the concepts, models and implementation frameworks of Green Hospitals reported in LMICs; 2) to identify enabling and inhibiting factors; 3) to characterise the approaches used to measure sustainability, resilience and efficiency; 4) to quantify reporting of patient or population health outcomes, economic data and equity-relevant disaggregation; and 5) to synthesise an integrative conceptual framework that distinguishes evidenced from hypothesised pathways.

METHODS

REPORTING AND REGISTRATION

This scoping review follows the PRISMA extension for Scoping Reviews (PRISMA-ScR) and the methodological framework of Arksey and O'Malley as advanced by Levac and colleagues.[13,14] It was registered on the Open Science Framework (**https://doi.org/10.17605/OSF.IO/F2BR5**). The method was chosen to map the extent, range, and nature of the evidence rather than to estimate an effect. The PRISMA-ScR checklist is provided as Supplementary File S1.

DATA SOURCES AND SEARCH STRATEGY

Three electronic databases, PubMed/MEDLINE, Scopus, and ScienceDirect, were searched, last updated on 30 October 2025. The strategy combined three concept blocks corresponding to the PCC elements with the Boolean operator AND, with terms within each block combined using OR (Table 1). Truncation and phrase searching were applied; searches were restricted to title and abstract fields; MeSH descriptors were used in PubMed/MEDLINE; and free-text searching was used in Scopus and ScienceDirect. Filters covered publication date, document type, and language. The 2009 start date reflects the WHO and Health Care Without Harm discussion draft that introduced climate-friendly hospitals into institutional debate.[15] Supplementary file S2 provides full strings, run dates, and record counts. No hand-searching, citation tracking, or grey-literature searching was undertaken.

TABLE 1. CONCEPT BLOCKS, CONTROLLED VOCABULARY, AND BOOLEAN STRUCTURE OF THE SEARCH STRATEGY

PCC element	Free-text terms (title/abstract, OR within block)	Controlled vocabulary (MeSH, PubMed only)
Population	"health care system*" OR "healthcare facilit*" OR hospital* OR "health facilit*" OR "health-care facilit*"	Hospitals[Mesh]; Health Facilities[Mesh]; Delivery of Health Care[Mesh]
Concept	"green hospital*" OR "sustainable health care" OR "hospital sustainab*" OR "environmental sustainab*" OR "climate-resilient health facilit*" OR "hospital resilience" OR "life cycle assessment" OR "environmental management" OR "energy efficien*" OR "waste management" OR "sustainable health system*."	Conservation of Natural Resources[Mesh]; Medical Waste Disposal[Mesh]; Climate Change[Mesh]; Green Chemistry Technology[Mesh]
Context	"developing countr*" OR "low-income countr*" OR "middle-income countr*" OR LMIC* OR "least developed countr*" OR "resource-constrained" OR "resource-limited"	Developing Countries[Mesh]
Boolean structure	(Population block) AND (Concept block) AND (Context block), with date, document-type, and language filters applied at the end	-

ELIGIBILITY CRITERIA

Inclusion and exclusion criteria followed the PCC elements (Table 2). Eligible studies were peer-reviewed empirical articles or full conference papers addressing Green Hospital practice, environmental-sustainability domains (energy, waste, water and sanitation, buildings, procurement and supply chain) or resilience strategies with an environmental component, conducted in hospitals or health facilities in LMICs (World Bank FY2025) and published in English between 2009 and 2025. Eligibility focused on the unit of analysis rather than the topic: we included healthcare-waste studies that treated waste as a facility- or organization-level management problem and excluded those that examined it as a treatment process or product alone.

TABLE 2. ELIGIBILITY CRITERIA STRUCTURED BY THE PCC FRAMEWORK

PCC element	Inclusion criteria	Exclusion criteria
P (Population)	Health systems, health-care facilities and hospitals, including teaching, regional and district facilities, and mixed samples that include hospitals.	Studies confined to ambulatory or outpatient clinics only, or to non-health sectors.
C (Concept)	Green Hospital practice; environmental-sustainability domains (energy, waste, water	Product-level or clinical LCA with no organizational dimension; a waste-

	and sanitation, buildings, procurement and supply chain); environmental policy frameworks; or resilience strategies with an environmental component. Health-care-waste studies eligible where waste is a facility- or organization-level management problem; techno-economic studies eligible where facility-level environmental performance is reported.	treatment technology or laboratory process alone; only social or economic sustainability with no environmental dimension; engineering or financial analyses reporting no environmental performance.
C (Context)	Countries classified by the World Bank (FY2025) as low-, lower-middle- or upper-middle-income, including multi-country studies in which all or most settings fall within these categories.	Studies conducted exclusively in high-income countries.
Time and language	Published 1 January 2009 to 31 October 2025; full text in English.	Published outside this window; full text not available in English.
Publication type	Peer-reviewed original empirical research articles and full conference-proceedings papers.	Narrative reviews, systematic reviews, meta-analyses, editorials, commentaries, conference abstracts and study protocols.
Boundary rule	Eligibility turns on the unit of analysis, not the topic. Eleven included studies address health-care waste as a facility- or organization-level management problem with reported environmental performance.	Under the same rule, we excluded 20 full texts because they examined waste as a treatment process or product alone, and we excluded three device- or process-level techno-economic appraisals.

STUDY SELECTION AND DATA EXTRACTION

Records were imported into Rayyan (https://rayyan.qcri.org/) and de-duplicated. Two reviewers (AAL and AM) independently screened all titles, abstracts, and full texts in blinded mode; they resolved disagreements through discussion and, when needed, with a third reviewer (FM). Excluded studies and reasons were documented. The two reviewers charted data into a piloted spreadsheet covering study characteristics, implementation domains, resilience integration, policy frameworks, and LMIC contextual barriers, with dedicated fields for health-outcome, economic, and equity reporting. Screening and full-text disagreements were resolved by discussion and, where necessary, by adjudication with the third reviewer; no formal inter-rater agreement statistic (for example, Cohen's or Fleiss' kappa) was calculated.

DATA SYNTHESIS

Findings were synthesized narratively and thematically against four themes defined a priori from the objectives: concepts and implementation frameworks; enablers and barriers; measurement approaches; and policy implications. The themes were not mutually exclusive; each study was assigned to every theme on which it reported substantive data, so counts are reported against a denominator of 29 and sum to more than 29 (study-by-theme matrix in Supplementary File S3). A gap analysis quantified the reporting of health, economic, and equity outcomes across the included studies.

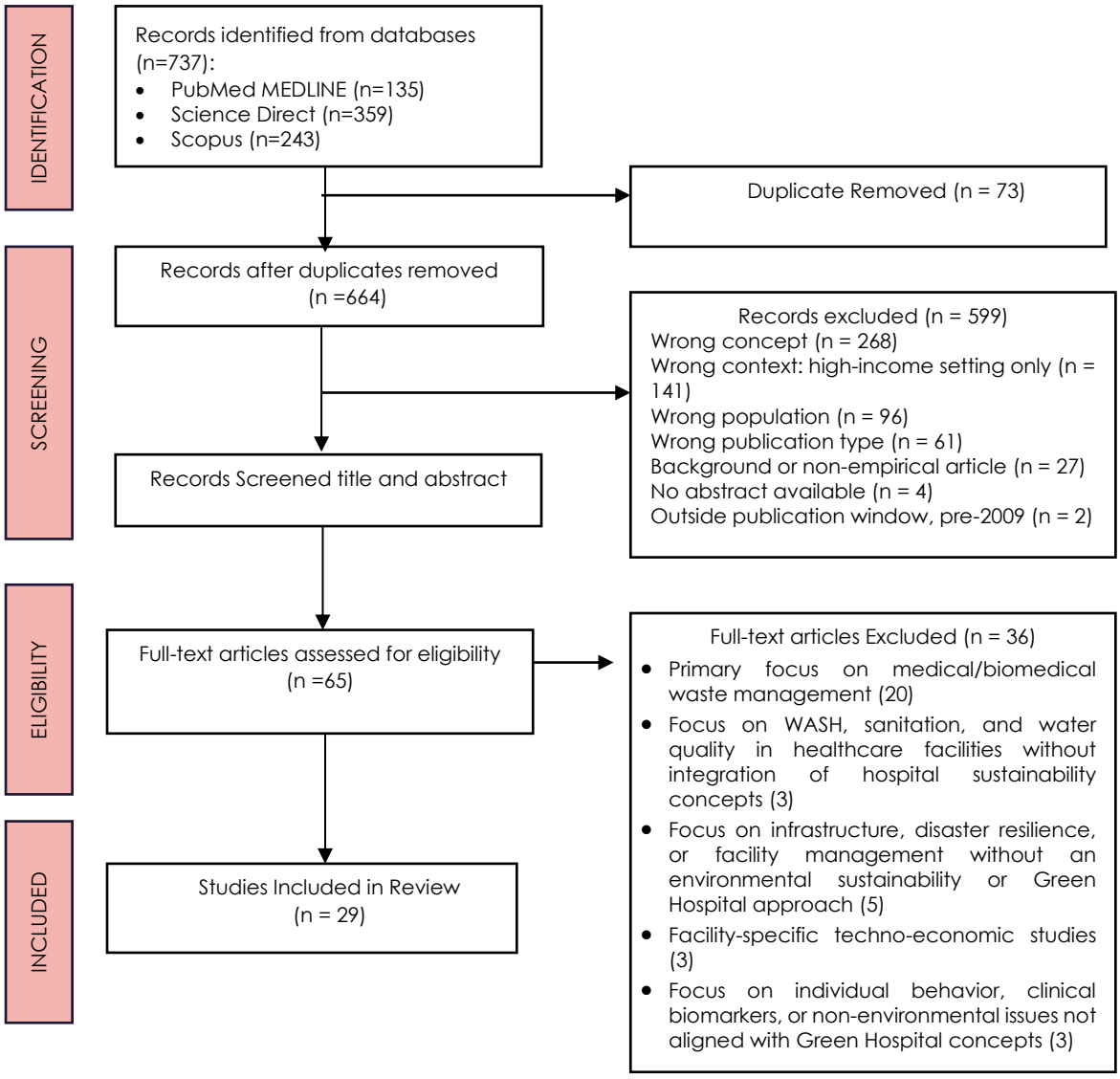
RESULTS

STUDY SELECTION

Database searching in PubMed/MEDLINE (n = 135), ScienceDirect (n = 359), and Scopus (n = 243) identified 737 records. After removal of 73 duplicates, 664 records were screened by title and abstract, and 599 were excluded; 65 full-text articles were assessed, and 36 were excluded, leaving 29 studies included (Figure 1). The 36 full-text exclusions comprised waste examined as a treatment process, technology or product alone (n = 20); settings confined to high-income countries (n = 5); device- or process-level techno-economic appraisals reporting no facility-level environmental performance (n = 3);

studies with no environmental dimension (n = 3); ineligible publication types (n = 4); and full text not available in English (n = 1). Figure 1 and Supplementary File S1 report the same six categories and the same totals.

FIGURE 1. PRISMA-SCR FLOW DIAGRAM FOR THE STUDY SELECTION PROCESS



CHARACTERISTICS OF THE INCLUDED EVIDENCE

The 29 studies were published between 2014 and 2025, with 19 (66%) from 2022 onward. The evidence base was geographically concentrated: Sub-Saharan Africa contributed 11 studies (38%), South Asia seven (24%), and Latin America and the Caribbean only two (7%). By income group, 20 studies (69%) were conducted in lower-middle-income, and eight (28%) in upper-middle-income countries; no single-country study was conducted in a low-income setting, which is represented only within one 46-country modeling study. Central Asia, the Pacific island states, and fragile or conflict-affected settings were absent. Modeling and multi-criteria decision-making dominated the designs (n = 8), followed by cross-sectional descriptive studies (n = 7). Sixteen studies (55%) focused exclusively on hospitals, and none reported findings separately for small or rural facilities (Tables 3 and 4).

TABLE 3. CHARACTERISTICS OF THE 29 INCLUDED STUDIES

Characteristic	n (%)	Detail
World Bank region		
Sub-Saharan Africa	11 (38)	Ghana 4, Nigeria 3, Kenya 2, Namibia 1, South Africa 1
South Asia	7 (24)	India 4, Bangladesh 1, Sri Lanka 1, Pakistan 1
Middle East and North Africa	4 (14)	Iran 3, Morocco 1
East Asia and Pacific	4 (14)	Indonesia 2, Thailand 1, Malaysia 1
Latin America and Caribbean	2 (7)	Colombia 1, Brazil 1
Multi-country	1 (3)	46 UN least-developed countries
World Bank income group (FY2025)		
Lower-middle income	20 (69)	India, Ghana, Nigeria, Kenya, Iran, Bangladesh, Sri Lanka, Pakistan, Morocco
Upper-middle income	8 (28)	Indonesia, Thailand, Malaysia, Colombia, Brazil, South Africa, Namibia
Low income (single country)	0 (0)	Represented only within the multi-country modeling study
Multi-country (low and lower-middle)	1 (3)	46 UN least-developed countries
Study design		
Modeling, MCDM or optimization	8 (28)	DEMATEL, ISM, MICMAC, fuzzy multi-objective, factor analysis, costing model
Cross-sectional descriptive quantitative	7 (24)	Survey, environmental assessment, waste characterization
Qualitative	4 (14)	Policy document review, interviews, document analysis
Life cycle assessment	3 (10)	Waste treatment alternatives
Case study or engineering design	3 (10)	Techno-economic and facility-design studies
Mixed methods	2 (7)	Sequential and concurrent designs
Tool or protocol development	2 (7)	Disaster-preparedness tool; waste-assessment protocol
Setting		
Hospitals only	16 (55)	Public, private, teaching and regional hospitals
Mixed hospital and primary care	6 (21)	Hospitals with clinics, health centers or health posts
Supply chain or off-site treatment	3 (10)	Healthcare supply-chain networks; common treatment facilities
Primary care only	2 (7)	Community health centers; rural dispensaries
System or policy level	2 (7)	National and sub-national policy analysis
Ownership		
Public facilities only	14 (48)	
Public and private facilities	9 (31)	
Not specified or not applicable	6 (21)	Sector- or network-level studies

TABLE 4. SUMMARY OF THE 29 INCLUDED STUDIES ON SUSTAINABILITY, RESILIENCE AND GREEN HOSPITAL IMPLEMENTATION IN LMICS

.	Author	Year	Country	Income group	Study design	Setting	Purpose	Key findings
1	Abu & Elliott [16]	2020	Kenya	Lower-middle	Qualitative policy document review	National and county health systems	Explore country-level commitment to WASH access in health-care facilities within a Universal Health Coverage pilot.	National policy documents lack comprehensive WASH indicators, which the UHC pilot neither measures nor monitors.
2	Lister et al. [17]	2025	Namibia	Upper-middle	Descriptive quantitative survey	Public, private and academic sectors	Identify professionals' knowledge, attitudes, and practices on environmental sustainability.	Professionals held basic knowledge and positive attitudes, but structural barriers prevented them from translating this into practice.
3	Chaitkin et al. [18]	2022	46 LDCs	Low and lower-middle	Modelling study	Public facilities, hospitals and non-hospital facilities, urban and rural	Estimate the cost of full basic WASH and waste-management coverage by 2030.	Full basic coverage requires an estimated US$6.5–9.6 billion, with waste management almost half of that cost.
4	Purwandari et al. [19]	2024	Indonesia	Upper-middle	Cross-sectional, national survey	Government, private, and specialized hospitals	Assess WASH via WASH FIT and its association with patient satisfaction and maternal mortality due to infection.	Most hospitals rated "good" for WASH but only 13% for waste management; specific WASH FIT indicators were associated with maternal mortality due to infection. This is the only study reporting a population health outcome.
5	Embrey et al. [20]	2024	Bangladesh	Lower-middle	Case study and policy analysis	Public and private secondary and tertiary facilities	Analyze integration of IPC and WASH into national quality-of-care guidelines.	National guidance covered only 55% of essential IPC/WASH subconditions; awareness was high, but budget, infrastructure, and training constrained implementation.
6	Chaudhary & Kumar [21]	2021	India (Bihar)	Lower-middle	Cross-sectional quantitative	Public and private hospitals	Examine how innovation and adopter	Relative advantage, simplicity, trialability, and compatibility

							characteristics influence the rate of adoption of environmental sustainability innovations.	significantly predicted adoption of eco-innovations, whereas innovativeness and environmental opinion leadership did not.
7	Regragui et al. [22]	2024	Morocco	Lower-middle	Framework development (fuzzy MCDM)	Public and private hospitals	Develop and test a multi-criteria methodology for hospital sustainability performance.	Thirty-two indicators across six dimensions were established; private hospitals outperformed public hospitals, and both were weakest on the environmental–social and learning–growth dimensions.
8	Rattan et al. [23]	2022	India	Lower-middle	Scale development (factor analysis)	Hospitals and clinics offering traditional medicine	Propose and validate a multidimensional sustainability scale aligned with the SDGs.	A 39-item, seven-dimension scale was validated; traditional medicine promoted low-cost access, but caste and gender exclusion persisted.
9	Ebekozien et al. [24]	2022	Nigeria	Lower-middle	Qualitative interviews	Public hospital buildings	Investigate barriers to green practice in public hospital buildings and propose solutions.	Green building was very limited, constrained by six barrier themes: policy, organizational/leadership, financial, technical, design team, and stakeholder behavior.
10	Sumrit [25]	2025	Thailand	Upper-middle	Hybrid MCDM (DEMATEL–ISM–MICMAC)	Hospitals, sector level	Analyze determinants of net-zero emissions in the health sector.	Top-management commitment and government regulation were the most influential drivers; green innovation and carbon-footprint monitoring were dependent outcomes.
11	Thakur & Anbanandam[26]	2016	India (Uttarakhand)	Lower-middle	Interpretive structural modeling	Facilities and common biomedical waste treatment facilities	Identify and prioritize barriers to health-care-waste management.	Twenty-five barriers formed a 12-level hierarchy; lack of motivation and poor infrastructure were the foundational drivers.

12	Nazari-Shirkouhi & Samadi [27]	2025	Iran	Lower-middle	Hybrid MCDM	Supply chains, hospitals, and pharmaceutical suppliers	Evaluate lean, agile, resilient, and green paradigms.	Green and resilient paradigms were primary causal factors driving supply-chain performance; lean and agile were effect factors.
13	Deepak et al. [28]	2022	India	Lower-middle	Life cycle assessment	Common biomedical-waste treatment facility	Evaluate the environmental burden of biomedical-waste practice.	Incineration was the principal contributor to impact (global warming, terrestrial ecotoxicity), driven by electricity use and direct emissions.
14	Vargas-Muñoz et al. [29]	2025	Colombia	Upper-middle	MCDM (DEMATEL)	Clinics and hospitals	Develop and validate a prioritization framework for circular supply-chain practice.	Management initiative and institutional/legal frameworks were the primary causal factors driving cleaner production and reverse logistics.
15	Sahamir & Zakaria [30]	2014	Malaysia	Upper-middle	Qualitative document analysis	Public hospital buildings	Identify green assessment criteria for public hospital building development.	The study identified six green criteria categories (energy, indoor environmental quality, site planning, materials, water, innovation), adapted for 24-hour operation.
16	Alighardashi et al. [31]	2024	Iran (Kermanshah)	Lower-middle	Cross-sectional environmental assessment	Eight teaching hospitals	Evaluate waste management against sustainable-development objectives.	Separation and collection scored highly, but reduction and disposal were insufficient, yielding moderate performance below circular-economy standards.
17	Munasinghe et al. [32]	2025	Sri Lanka	Lower-middle	Pilot, validation and implementation	Public tertiary and secondary hospitals	Develop and validate an all-hazards disaster-preparedness tool.	The tool was reliable and valid; hospitals scored highest on staffing and communication and lowest on logistics and human resources.
18	Alalade et al. [33]	2025	Nigeria	Lower-middle	Mixed methods	Public and private facilities	Evaluate facility-management approaches	A mixed facility-management approach predominated; inadequate funding, weak

							and maintenance challenges.	maintenance culture, and bureaucratic bottlenecks undermined efficiency.
19	Ala et al. [34]	2024	Iran	Lower-middle	Mathematical modeling and optimization	Supply-chain network: hospitals, laboratories, disposal centers	Develop a multi-objective model balancing cost, environmental impact, and social benefit.	The fuzzy multi-objective model reduced network cost and pollutants while increasing social welfare through accessibility and employment.
20	Asare et al. [35]	2025	Ghana	Lower-middle	Integrated LCA and systems thinking	Five teaching and regional hospitals	Evaluate the environmental impact of medical-waste treatment options.	Autoclaving with effective segregation was the most sustainable option, reducing emissions and terrestrial ecotoxicity relative to incineration.
21	Amos et al. [36]	2020	Ghana	Lower-middle	Sequential mixed methods	Public tertiary and secondary hospitals	Establish and model key performance indicators for waste-management service delivery.	Professional facility management, adequate resources, and defined KPIs (infection control, budget variance) improved waste-management outcomes.
22	Saddari et al. [37]	2025	Ghana (Sunyani)	Lower-middle	Techno-economic feasibility case study	Tertiary teaching hospital	Assess rooftop solar photovoltaic generation under net metering.	A 1,000 kWp grid-connected system could meet ~51% of annual demand with a 4.7-year payback and substantial emissions reduction.
23	Pramana et al. [38]	2023	Indonesia (Pekanbaru)	Upper-middle	Cross-sectional descriptive	Community health centers	Analyze ecological, economic, and social attributes of solid medical-waste management.	The ecological dimension was moderately sustainable, while the economic and social dimensions were less sustainable, indicating the need for a multidimensional model.
24	Oyebode & Otoko [39]	2022	Nigeria (Ado-Ekiti)	Lower-middle	Case study and engineering design	Multi-system teaching hospital	Assess waste practices and design a low-cost incinerator.	Waste generation was 1.15 kg per bed per day; a dual-chamber incinerator (1,200 °C) was

								designed to destroy hazardous waste with minimal emissions.
25	Machate et al. [40]	2021	South Africa (Ehlanzeni)	Upper-middle	Cross-sectional descriptive and inferential	Hospitals, clinics and community health centers	Identify factors influencing health-care-waste generation.	Patient and staff numbers were significant predictors of waste volume, with patient numbers most strongly correlated with daily waste weight.
26	Abu et al. [41]	2021	Kenya (Kisumu)	Lower-middle	Qualitative interviews	Rural dispensaries and an informal-settlement facility	Explore stakeholder experience of WASH implementation and management.	Despite improved access, poor water quality and inadequate sanitation persisted because of finance, climate variability, and corruption, compromising resilience.
27	Oduro-Kwarteng et al. [42]	2021	Ghana (Kumasi)	Lower-middle	Cross-sectional descriptive	Four hospitals and three health centers	Assessed generation rate, composition, and management of health-care waste.	Generation was 0.76–2.92 kg per bed-day with a high hazardous fraction (49.65%) and gaps in segregation, storage, and disposal.
28	Ahmad et al. [43]	2019	Pakistan (Swat)	Lower-middle	Life cycle assessment	Public and private secondary and tertiary hospitals	Compare environmental impact of solid-waste treatment alternatives.	Steam sterilization followed by landfilling was most favorable, outperforming incineration and direct landfilling across impact categories.
29	Moura et al. [44]	2018	Brazil (Rio de Janeiro)	Upper-middle	Protocol development and application	Public maternity hospital	Develop and apply a protocol for assessing health-care-waste management.	A four-phase protocol was validated; the hospital generated 3.39 kg per occupied bed-day, and poor segregation sent recyclables to infectious-waste streams.

CONCEPTS AND IMPLEMENTATION FRAMEWORKS (19 OF 29 STUDIES)

Nineteen studies described Green Hospitals as facilities that integrate environmental sustainability, resource efficiency, and climate resilience into planning, management, and service delivery, most often through green building, energy efficiency, health-care-waste management, and WASH. Three proposed transferable frameworks, rather than describing practice, are: six green assessment criteria for continuous hospital operation in Malaysia, [30] a 32-indicator, six-dimension sustainability model in Morocco, [22] and a validated 39-item, seven-dimension SDG-aligned scale in India. [23] Most others operationalized a single domain, most frequently health-care waste. [28,35]

ENABLING AND INHIBITING FACTORS (17 OF 29 STUDIES)

Common enablers included leadership commitment, supportive regulation, stakeholder engagement, and organizational awareness of environmental and climate risk. The clearest evidence identified top-management commitment and government regulation as the dominant driving factors in the Thai health sector, [25] and management initiative and institutional or legal frameworks as the principal cause-group factors for circular supply-chain practice in Colombia.[29] Reported barriers were high investment cost, limited financial and human resources, weak technical capacity and infrastructure, and weak monitoring: six barrier themes in Nigerian public hospital buildings, [24] a 12-level hierarchy of 25 waste-management barriers in India, [26] and inadequate funding, weak maintenance culture, and bureaucratic bottlenecks in Nigerian facility management. [33] A Study of health professionals in Namibia noted positive knowledge and attitudes alongside structural barriers that prevented translation into practice. [17] At the policy level, national documents neither specified nor monitored WASH indicators within a universal health coverage pilot. [16] Across the 29 included studies, no study applied an integrated framework spanning all five intervention domains; this is a mapping observation of the present review rather than a finding of any single study.

MEASUREMENT APPROACHES (13 OF 29 STUDIES)

Instruments ranged from environmental performance indicators and composite indices to LCA and multi-criteria decision-making (MCDM). LCA appeared in three studies, all applied to health-care-waste treatment alternatives; MCDM and structural modeling were used mainly to prioritize barriers, indicators, or practices rather than to measure performance over time. Only two studies produced an instrument for repeated facility-level application: a validated all-hazards disaster-preparedness tool, [32] and a four-phase waste-assessment protocol. [44] The disaster-preparedness tool is the only measure that directly addresses resilience, and it includes no environmental component; conversely, no environmental measure includes a resilience component.

POLICY IMPLICATIONS (11 OF 29 STUDIES)

Eleven studies argued that clear policy frameworks, institutional guidelines and performance-based monitoring are prerequisites for sustainability and resilience. One costing study estimated US$6.5–9.6 billion to achieve full basic WASH and waste coverage across 46 least-developed countries by 2030, with waste management accounting for nearly half of that total, [18] A Study in Bangladeshi national quality-of-care guidance addressed only 55% of essential infection-prevention and WASH subconditions. [20]

THREE QUANTIFIED EVIDENCE GAPS

A dedicated charting field showed that one of 29 studies (3%) reported a patient or population health outcome: associations between specific WASH FIT indicators and maternal mortality due to infection across Indonesian hospitals. [19] Because that study is cross-sectional, it cannot support attributing a health benefit to an intervention. Three studies (10%) reported quantified cost data, the only payback period, at 4.7 years for a rooftop photovoltaic installation, and none reported a formal economic evaluation.[18,34,37] No study disaggregated its findings by occupational group, rurality, facility size, or ownership; waste handlers, cleaners, informal waste pickers, and residents near disposal sites are absent as units of analysis, even where hazardous waste fractions and incineration emissions are characterized in detail. [28,42] Only one study reported social stratification directly, documenting exclusion by caste and gender. [23] These absences are principal mapping findings rather than review limitations.

DISCUSSION

PRINCIPAL FINDINGS

This review maps a Green Hospital literature in LMICs that is concentrated in foundational environmental domains: health-care waste, water and sanitation, energy efficiency, and green infrastructure, and only weakly connected to resilience-oriented performance and governance frameworks. Global normative guidance requires facilities to sustain essential services and reduce their footprint simultaneously, [7,17,46] but the mapped evidence does not yet operationalize that dual requirement: the single instrument that measures resilience contains no environmental component, and no environmental instrument contains a resilience component. Based on the available evidence, Green Hospital activity is pursued as an environmental program adjacent to, rather than integrated within, hospital resilience.

MEASUREMENT HETEROGENEITY AND THE CASE FOR HARMONIZED INDICATORS

A central contribution of this review is to document the heterogeneity of the indicators and tools applied, from LCA of waste-treatment options to MCDM models and composite indices. [29,35] These approaches yield context-specific insight but limit comparability across facilities and countries and constrain benchmarking. The most relevant comparison is with operational instruments already used in LMIC facilities: WASH FIT and the PAHO Green Checklist collect facility-level environmental data; the PAHO Hospital Safety Index collects resilience data, often in the same facilities; and no instrument spans both (Supplementary S4). A harmonized environmental key performance indicator set is therefore the missing measurement layer.

GOVERNANCE, LEADERSHIP AND FINANCING

Across the included studies, leadership commitment, clear regulation and institutional awareness were the conditions under which interventions were adopted. In contrast, fragmented governance, limited technical capacity and chronic underfunding were the dominant barriers, [24,25,33], consistent with the wider climate-resilient health-systems literature [47]. This should be read as a convergence of reported associations and expert-elicited priorities rather than a demonstrated causal ordering, because the leading analyses model expert judgment rather than implementation outcomes observed over time.

THREE QUANTIFIED EVIDENCE GAPS

Three gaps define the boundary of what this literature can currently support. First, the health consequences of Green Hospital investment are essentially unmeasured: one of 29 studies reported a population health outcome and did so as a cross-sectional association. Second, economic evidence is nearly as sparse: three studies reported cost data, and none provided a formal economic evaluation. Third, no study disaggregated its findings by occupational group, rurality, facility size, or ownership, so the distribution of the environmental health burden across exposed groups cannot be identified; this equity gap is examined in the following subsection. The first two gaps compound each other, because cost-effectiveness analysis requires an outcome to which cost can be referred. Until at least one is closed, the case for Green Hospital investment must rest on environmental and operational arguments.

EQUITY AND ENVIRONMENTAL JUSTICE

The absence of equity-relevant disaggregation is analytically significant, not a reporting deficiency. The environmental health burden of hospital operations falls disproportionately on waste handlers, cleaners and portering staff, on informal waste pickers, and on households near incineration and disposal sites. Studies here characterize hazardous fractions, incineration emissions, and terrestrial ecotoxicity in technical detail.[28,42], yet none identify the exposed population, and the evidence comes overwhelmingly from larger urban facilities. An environmental-justice lens is therefore a substantive requirement of the research agenda, not an optional framing.

AN INTEGRATIVE FRAMEWORK AND ITS TESTABLE PROPOSITIONS

The framework in Figure 2 links governance and system enablers (Band A), Green Hospital intervention domains (B), intermediate operational mechanisms (C), hospital resilience outcomes (D), and population health outcomes (E), with harmonized measurement and an equity lens as cross-cutting conditions. Five propositions follow, each stated with its

evidential status. P1 (evidenced): governance enablers predict intervention adoption, supported by 17 studies. P2 (partially evidenced): interventions produce operational mechanisms, but almost always as a single-domain output measured once rather than a facility-level mechanism observed over time. P3 (hypothesized): operational mechanisms improve resilience outcomes; no included study measures both in the same facility. P4 (hypothesized): resilience outcomes translate into health outcomes; no study addresses this link. P5 (single cross-sectional association): interventions affect health outcomes directly.[19] The evidence supports the front of the pathway, while the links to resilience and to health remain to be tested.

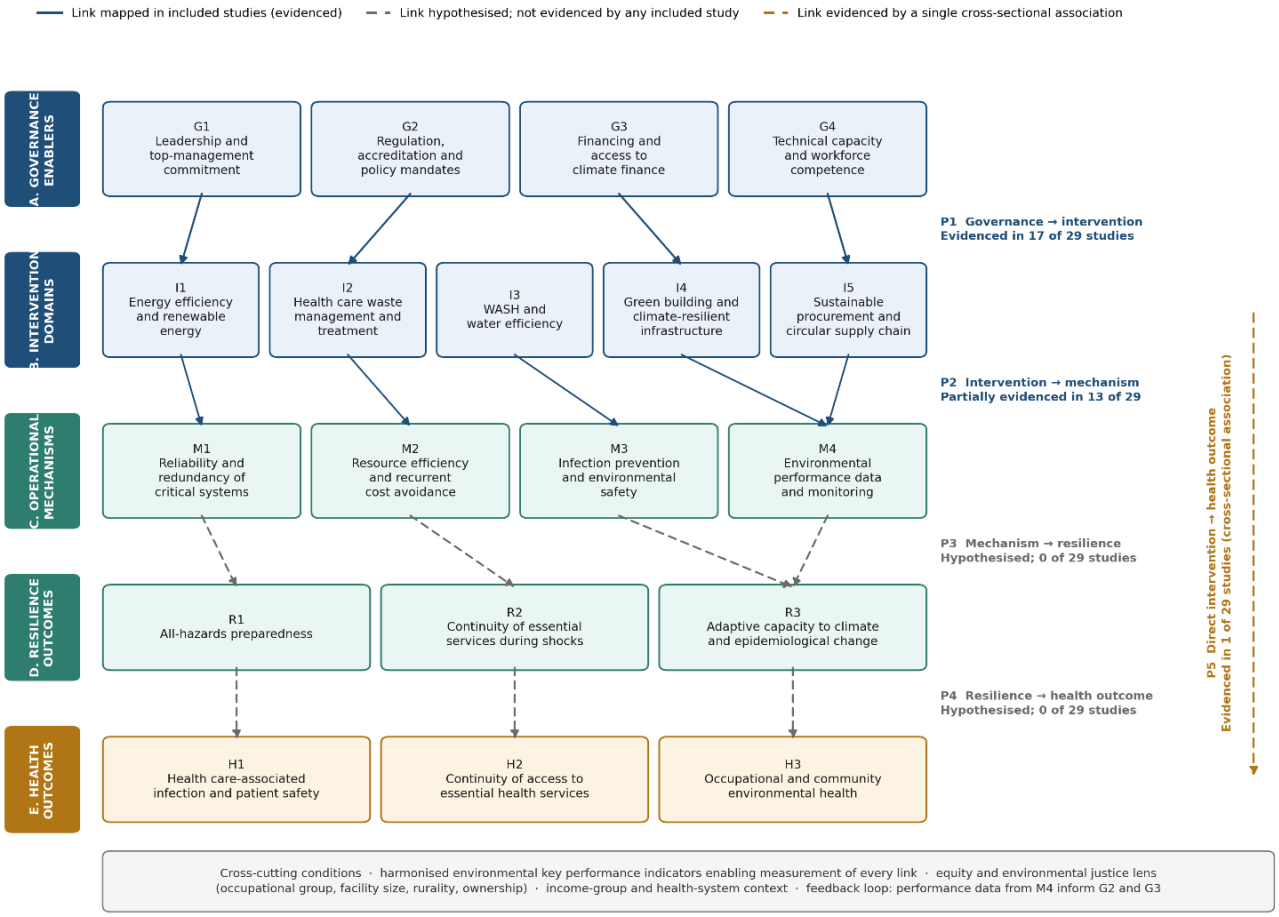


Figure 2. Integrative conceptual framework linking governance enablers, Green Hospital interventions, operational mechanisms, hospital resilience and population health outcomes in LMICs. Solid arrows denote links evidenced by the included studies; dashed arrows denote hypothesized links; a distinct style marks the single link evidenced only by a cross-sectional association (P5). Harmonized measurement and an equity and environmental-justice lens are cross-cutting conditions, with a feedback loop by which environmental performance data inform regulation, accreditation, and financing.

POLICY IMPLICATIONS

Three actions follow. First, embed a feasible minimum environmental indicator set in hospital accreditation the single decision point that already carries managerial accountability and a scoring cycle using data facilities already hold: monthly kilowatt-hours and cubic metres of water from utility invoices, sampled segregation audits, kilograms of waste per occupied bed-day from collection dockets, treatment-technology uptime, and the number of unplanned power or water interruptions, which also indexes the resilience construct at no extra data cost. Reporting should be phased through a voluntary baseline period before scoring any indicator, and facilities should be held accountable only for indicators within managerial reach. [8] Second, connect these indicators to climate finance: the Green Climate Fund, the Adaptation Fund and results-based lending require baseline inventories and monitoring, reporting and verification that most health ministries cannot yet produce, and the same indicator set can serve as that substrate. [4,48] Third, harmonize the environmental and resilience data already collected by WASH FIT, the PAHO Green Checklist and the Hospital Safety

Index into a common minimum core, led by WHO regional offices, making the mechanism-to-resilience link observable in routine data at lower cost than a new instrument.

STRENGTHS AND LIMITATIONS

Strengths include prospective registration, duplicate screening and charting, and an explicit framework distinguishing evidenced from hypothesized pathways. Consistent with the scoping-review method, the authors did not appraise individual studies for quality. The review was restricted to three databases, English-language records, and studies published from 2009. It excluded grey literature, reference-list checking, and citation tracking, so non-indexed LMIC studies are likely under-represented. Heterogeneity in design, outcomes, and tools precluded any comparison of effect sizes; most studies were cross-sectional or single-domain, limiting causal inference; and the evidence is skewed toward Sub-Saharan Africa, South Asia, and larger urban facilities, with no single-country low-income evidence and none from Central Asia, the Pacific, or fragile and conflict-affected settings, to which the findings should not be generalized. Screening and charting were performed in duplicate, but no formal inter-rater agreement statistic was calculated, so the reliability of the selection process is not quantified; this is a reporting limitation.

RESEARCH AGENDA

The priorities follow from the propositions and gaps: a prospective or interrupted-time-series study measuring both an operational mechanism and a resilience outcome such as downtime or service continuity during a documented shock (P3–P4); studies measuring health-care-associated infection, occupational exposure among waste handlers, or service continuity as outcomes; at least one full economic evaluation referring cost to a health or environmental outcome; and comparative research applying a harmonised indicator core across facility types and income groups, with disaggregation by occupational group and facility size as a design requirement.

CONCLUSION

This scoping review maps the Green Hospital literature in LMICs that is oriented toward foundational environmental domains: water and sanitation, health-care waste, energy efficiency, and green infrastructure, and only partially connected to explicit resilience and performance-management frameworks. Indicators and assessment tools are fragmented, with limited use of harmonized EKPIs, which constrains benchmarking, policy learning, and monitoring across facilities and countries. Three gaps are quantified: only one of 29 studies reported a population health outcome, and that as a cross-sectional association; three reported cost data and none a formal economic evaluation; and none disaggregated findings in a way that identifies who bears the environmental health burden. The integrative framework links governance enablers, interventions, operational mechanisms, resilience outcomes, and population health. It states explicitly that the evidence supports the front of that pathway while the links to resilience and health remain hypothesized. The immediate priority for LMIC health systems is not a new sustainability framework but a measurement and accreditation architecture that makes the pathway observable and aligns with national net-zero commitments and Sustainable Development Goals 3 and 13.

SUPPLEMENTARY MATERIAL

S1 PRISMA-ScR checklist with manuscript locators. **S2** Full executed search strategy per database. **S3** Study-by-theme matrix. **S4.** Assessment approaches identified in this review situated against operational sustainability and resilience frameworks used in LMIC health-care facilities

DECLARATIONS

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AUTHOR CONTRIBUTIONS.

Zakiah: Conceptualization; Methodology; Writing – original draft; Writing – review & editing. **Dumilah Ayuningtyas:** Conceptualization; Methodology; Writing – review & editing. **Farida Murtiani:** Methodology; Formal analysis; Writing – original draft; Writing – review & editing. **Annisa Ayu Lestari:** Data curation; Visualization; Writing – review & editing. **Fatimah Fatimah:** Data curation; Formal analysis; Writing – original draft; Writing – review & editing. **Ba'da Febriani:** Formal analysis; Visualization; Writing – original draft; Writing – review & editing. **Amelia Marisa:** Data curation; Writing – original draft. All authors read and approved the final manuscript.

DATA AVAILABILITY.

The completed data extraction for all 29 included studies (Table 4) is openly available on the Open Science Framework at https://doi.org/10.17605/OSF.IO/F2BR5. All other data supporting the findings of this review are contained within the article and its supplementary files.

USE OF GENERATIVE ARTIFICIAL INTELLIGENCE.

We used generative artificial intelligence tools for language editing and draft structuring, and Rayyan's AI features supported reference handling during screening. No tool generated data, charted or interpreted included studies, or made eligibility decisions; the named human reviewers performed all of these. The authors reviewed and edited all resulting text and take full responsibility for the content.

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REVIEW ARTICLE

GLOBAL TREND FOR HUMAN RESOURCE DEVELOPMENT MAPPING FOR PHARMACISTS

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ABSTRACT

Pharmacist workforce planning remains a global challenge, with fragmented evidence and no comprehensive framework across diverse contexts. This paper aims to analyze structures and patterns of knowledge on pharmacist workforce planning and management at the discipline level.

This study employed a systematic bibliometric analysis of 364 Scopus-indexed articles published between 1968 and 2024. The analysis was done using citation analysis, co-occurrence network analysis, and bibliographic coupling to identify key themes, patterns of connections, and directions of knowledge development.

The results indicate that studies on pharmacist workforce planning can be clustered to reflect key dimensions of the workforce system, including strategic workforce management, specialty distribution, supply-demand analysis, and work system and technology design. Existing literature remains constrained by static frameworks and insufficient integration of roles, competencies, technology, and system dynamics.

This study structures global knowledge and identifies future research directions to support forward looking pharmacist workforce planning in complex systems.

KEYWORDS:

Workforce planning, Pharmacist, Bibliometric analysis, Global trend, Human resource

INTRODUCTION

Technological changes, demographic structures, and healthcare systems have made workforce planning a strategic issue in many countries. However, roles, responsibilities, and scopes of pharmacist practices vary significantly depending on each country's context, including legal frameworks, healthcare systems, labor market structures, and technological development levels [1]. These contextual differences mean that pharmacist workforce planning cannot directly rely on a single, unified framework and present a structural challenge to healthcare systems globally.

Although studies on pharmacist workforce planning have been produced in many countries and contexts, the development of knowledge in this field is fragmented. Many studies focus on specific country or contextual problems, such as hospital staff shortages, the expansion of community pharmacist roles, or the impact of technology on service delivery, by studying them in isolation [2,3]. This results in no systematic understanding of how these national differences are managed, interconnected, or reflected in the overall academic knowledge.

This paper does not aim to propose a universal pharmacist workforce model or to offer a global policy conclusion. Rather, it aims to investigate pharmacist workforce planning as a framework of knowledge within a global academic field by analyzing how studies from different countries, healthcare systems, and professional contexts are produced, grouped, and interconnected within the overall knowledge framework. Therefore, national differences are not viewed as limitations to the study, but rather as a crucial element that shapes the style and direction of studies in this field.

Within the context of complex healthcare systems [4], workforce planning based on linear assumptions and a fragmented approach to problem-solving cannot adequately reflect dynamics, delays, and reversals of impacts [5]. Overlooking the structural level of knowledge is therefore a significant limitation that prevents a lot of pharmacist workforce planning from systematically linking workforce issues, policies, and healthcare service structures together.

Although previous studies have employed a wide range of approaches to examine the pharmacist workforce, including statistical analyses, field surveys, and quantitative forecasting models [6-9], these methods have often been applied in an issue-specific manner and have lacked an explanation of the structural limitations of the knowledge base as a whole. As a result, it remains difficult to understand how findings from individual studies are connected to or complement one another at the disciplinary level. This methodological gap highlights the need for an approach capable of systematically exploring patterns, interconnections, and constraints across the entire body of literature, a role that bibliometric analysis is well positioned to address [10-11] (Yoon et al., 2024; Reyes et al.,2024).

To understand these structural gaps, this study used bibliometric analysis as its primary tool to study the field-level knowledge structure of pharmaceutical workforce. This method allows for the revelation of key themes, research trends, and interconnected studies. Even if these studies originate from different countries and contexts, without reducing contextual differences to a single framework, the reflect how these differences are managed and integrated within the academic literature [12].

This study aimed to:
(1) Analyze structures and themes of international knowledge on pharmacist workforce planning;
(2) Identify studies and concepts that influence the formation of the field of pharmacist workforce planning; and
(3) Explain how differences in the roles of pharmacists, healthcare systems, and policies across countries are reflected in the academic knowledge structure.

The results of this study are intended to enhance a systematic understanding of the development of knowledge on pharmacist workforce planning and to provide a conceptual basis for contextual policy interpretation and application at the national level.

RESEARCH METHODOLOGY

RESEARCH DESIGN AND FRAMEWORK

This study was designed as a systematic bibliometric study with the goal of understanding the knowledge structure of international studies on pharmacist workforce planning. The objective of this bibliometric design is to systematically examine the intellectual structure, thematic evolution, and interconnections of studies within the global field of pharmacist workforce planning.

The research methodology framework utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach to ensure transparency, verifiability, and reproducibility in the search, selection, and management of articles as well as integrated various bibliometric analysis techniques to systematically reflect both the conceptual knowledge base and contemporary research themes in this field.

SEARCH STRATEGY

Data retrieval was conducted using the Scopus database, which was selected because it provides broad international coverage of peer-reviewed journals and is widely used in bibliometric research due to its comprehensive citation indexing. The search used the Title, Abstract, and Keywords fields, specifying search terms with Boolean operators as follows: ("Workforce" OR "Human Resource" OR "Manpower") AND ("Planning" OR "Forecasting" OR "Management") AND ("Pharmacist").

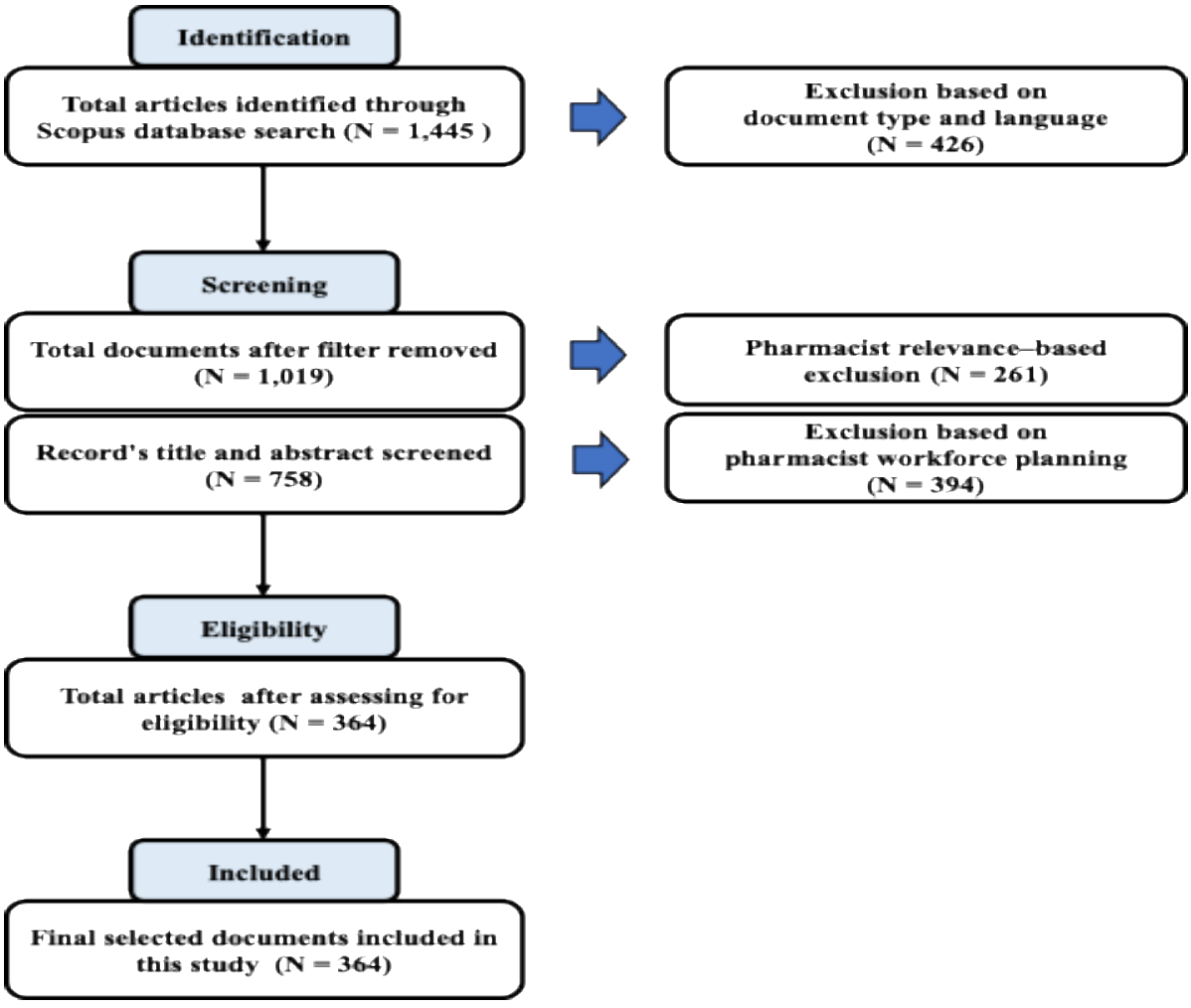
The search scope was limited to English articles to maintain consistency in document type and references, covering the period from 1968–2024. All bibliographic data and reference lists were exported in CSV format for use in the filtering and analysis process according to the PRISMA guidelines.

SELECTION CRITERIA AND REDUCTION OF ARTICLE VARIANCE

To address concerns about content heterogeneity, this study established rigorous article selection criteria, using the workforce-centrality concept as its core. Articles were only included in the analysis if pharmacist workforce planning was the primary focus of the studies, not merely a contextual or secondary mention.

Included articles included studies aimed at analyzing or discussing issues, such as workforce forecasting, workforce planning, supply-demand imbalance, workforce distribution, changing professional roles, and impact of policies or technologies on pharmacist workforce. Conversely, articles that only superficially addressed pharmacists or focused on clinical outcomes without a systematic connection to workforce planning were eliminated. In addition, the screening process followed the PRISMA sequence to ensure the final dataset was conceptually consistent and suitable for knowledge structure analysis, as illustrated in Figure 1.

FIGURE 1 ARTICLE SEARCH, SCREENING, AND SELECTION USING PRISMA DIAGRAM



DATA CLEANING AND PROCESSING

Articles that met the selection criteria underwent initial data processing using Microsoft Excel to remove duplicates, verify the completeness of key fields, and standardize bibliographic data, especially reference lists, which are crucial for bibliographic analysis.

Then, the data was imported into RStudio for initial bibliographic processing. Using packages designed for bibliometric analysis, RStudio was used to (1) examine the reference data structure, (2) verify the completeness and consistency of bibliographic data, and (3) prepare the dataset in a format suitable for relational network construction. Using RStudio in this step reduces the risk of technical errors and acts as a bridge between the raw data and the structural network analysis. Once the data had been examined and prepared in RStudio, the dataset was imported into VOS viewer for use in constructing bibliometric relational networks. This division of roles allows RStudio to handle preparation, while VOS viewer handles network construction, visualization, and clustering in a clear and systematic manner.

BIBLIOMETRIC ANALYSES AND THRESHOLDS

The bibliographic analysis in this study utilized three main techniques that work synergistically to describe the knowledge structure in multiple dimensions. The threshold selection followed common practices in bibliometric studies to ensure that only documents with sufficient citation linkages were included in the network analysis while minimizing noise from weakly connected publications.

Firstly, co-citation analysis was used to identify the knowledge base of the field by considering which documents are frequently cited together in all articles. Co-citations reflect studies that have a conceptual influence and form the foundation for the development of the field of pharmacist workforce planning.

Secondly, keyword co-occurrence analysis was used to analyze research themes and concepts based on the common appearance of keywords within the same articles. This technique helps identify key topics, interconnected concepts, and contemporary research directions in the field.

Finally, bibliographic coupling was used as the main technique for grouping articles based on the similarity of shared citations. The unit of analysis was “documents," and Total Link Strength (TLS) was used as an indicator of the relationship strength. Grouping was performed in VOS viewer using a modularity-based clustering algorithm, which increases the density of links within groups and decreases links between groups.

To enhance methodological clarity, this study set a minimum threshold for including articles in network analysis based on the level of citations and structural linkages. Threshold adjustment was used to reduce noise from articles with low conceptual roles and to test the stability of the network structure. The final threshold was selected from a level that allows the network to be separated into 4 clusters that are conceptually clear and facilitate interpretation in the context of pharmacist workforce planning.

RESULTS

DOCUMENT PROFILES, GROWTH TREND, AND GEOGRAPHIC DISTRIBUTION

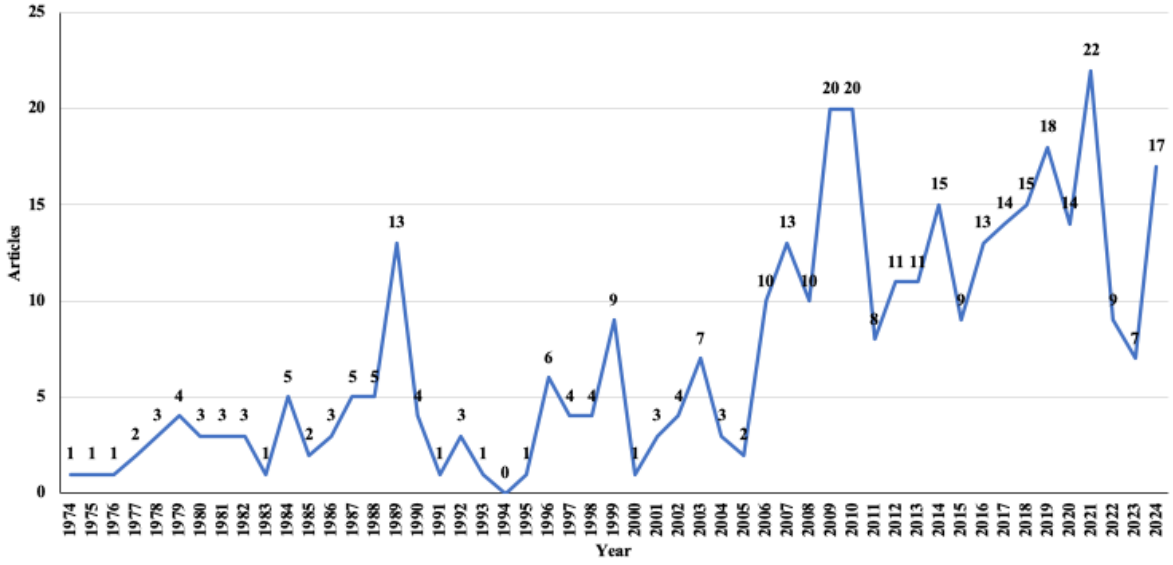
The analysis of document profiles, growth trends, and geographic distribution of studies in this section aims to create a structural understanding of the development of knowledge in pharmacist workforce planning at the international level. This analysis serves as a structural context for interpreting the results of the knowledge network analysis in the next section. It is not intended to evaluate the content quality of individual articles, but rather to explain the pattern of knowledge production at the discipline level.

The data used in the analysis consisted of 364 articles that were selected using the PRISMA approach and the workforce centrality criterion as described in the research methodology section. The analysis of document profiles in this study refers

to the consideration of the bibliographic characteristics of the articles, including the year of publications, the number of citations, the type of documents, and the country of main authors. Using data processing via RStudio and data validation with Microsoft Excel, document profiles were employed to reflect the underlying structure of the academic field, not to provide a substantive analysis of the article's content.

The selected articles from the Scopus database, spanning 1968 to 2024, demonstrate a rising trend in pharmacist workforce planning research. Analysis of 364 documents revealed an average annual growth rate of 5.83% and an average of 15.91 citations per document, reflecting increasing academic and policy relevance. Initially, from 1968–2000, publication numbers were low, averaging fewer than 10 articles annually. Post-2000, publications surged, driven by the growing complexity of healthcare systems and demand for pharmacists in accessibility, drug safety, and workforce management. Particularly during 2020–2024, intensified focus on pharmacists' roles in drug production and vaccine distribution underscored the profession's strategic importance in global health policy, as shown Figure 2.

FIGURE 2 GROWTH TRENDS OF ARTICLES ON PHARMACIST WORKFORCE PLANNING FROM 1968 TO 2024



The top three countries publishing research on pharmacist workforce planning are the United States, the United Kingdom, and Australia.

ANALYSIS OF THE MOST CITED ARTICLES

This analysis of articles with citation influence aims to identify the intellectual influence structure within the academic field of pharmacist workforce planning, with the goal of understanding which articles play a significant role in shaping the directions, concepts, and analytical frameworks of this field in the long term. This analysis is not intended to rank the best articles or select articles for content synthesis, but rather to use the number of citations as a structural indicator of intellectual influence.

This avoids the bias associated with using only total citations, which favors older articles. The results presented in this section are not limited to older articles but aim to reflect both foundational conceptual work and work that continues to influence the development of studies in pharmacist workforce planning.

Top 10 journals publishing pharmacist workforce planning research from 1968 to 2024 are listed in Table 1. Leading journals include the American Journal of Health-System Pharmacy, Human Resources for Health, Research in Social and Administrative Pharmacy, Journal of the American Pharmacists Association, and the International Journal of Pharmacy Practice. The American Journal of Health-System Pharmacy recorded the highest citation count (736 citations from 36 publications), highlighting its influence in hospital pharmacy workforce administration. Human Resources for Health follows

with 683 citations from 25 publications, emphasizing strategic workforce development and healthcare system adaptation. Research in Social and Administrative Pharmacy accumulated 614 citations from 44 publications, focusing on human resource administration, pharmaceutical policy, and community health impacts.

Thus, this analysis suggests that to maximize research visibility and impact, future studies should target these top-tier journals. Research on workforce planning models, pharmacist integration into multidisciplinary healthcare teams, and the role of AI-driven automation is particularly promising. Moreover, fostering interdisciplinary approaches could expand the research scope and enhance citation performance in pharmacist workforce planning literature.

This study does not claim that highly cited articles are qualitatively the most important or encompass all the latest studies, particularly the high-quality works of the U.S. national pharmacist workforce planning researchers. The said studies are reflected in the bibliographic coupling and co-occurrence network analysis in the following section, which is a more appropriate method for detecting emerging trends and contemporary studies that have not yet had time to accumulate citations.

Therefore, the analysis of articles with high citation influence in this section should be interpreted as a reflection of the historical influence structure and core concepts of the field, not as a selection of studies for direct content discussion. In addition, it serves as a basis for understanding the structural connections of knowledge, which will be systematically analyzed through keyword networks and bibliographic coupling later.

TABLE 1 TOP 10 JOURNALS PUBLISHED RESEARCH ARTICLES ON PHARMACIST WORKFORCE PLANNING DURING 1968 TO 2024

Rank	Source	Domain	Total citations	Number of publications	Scopus Quartile (2025)
1	American Journal of Health-System Pharmacy	Health Professions, Pharmacy	736	36	1
2	Human Resources for Health	Public Health, Environmental and Occupational Health	683	25	1
3	Research in Social and Administrative Pharmacy	Health Professions, Pharmacy	614	44	1
4	Journal of the American Pharmacists Association	Health Professions, Pharmacy	290	11	1
5	American Journal of Pharmaceutical Education	Health Professions, Pharmacy	158	12	1
6	American Journal of Hospital Pharmacy	Health Professions, Pharmacy	136	29	1
7	Australian Journal of Rural Health	Public Health, Environmental and Occupational Health	109	7	1
8	BMC Health Services Research	Medicine and Health Policy	92	11	1
9	International Journal of Pharmacy Practice	Health Professions, Pharmacy	84	15	1
10	Hospital Pharmacy	Health Professions, Pharmacy	32	23	1

CO-OCCURRENCE NETWORK ANALYSIS

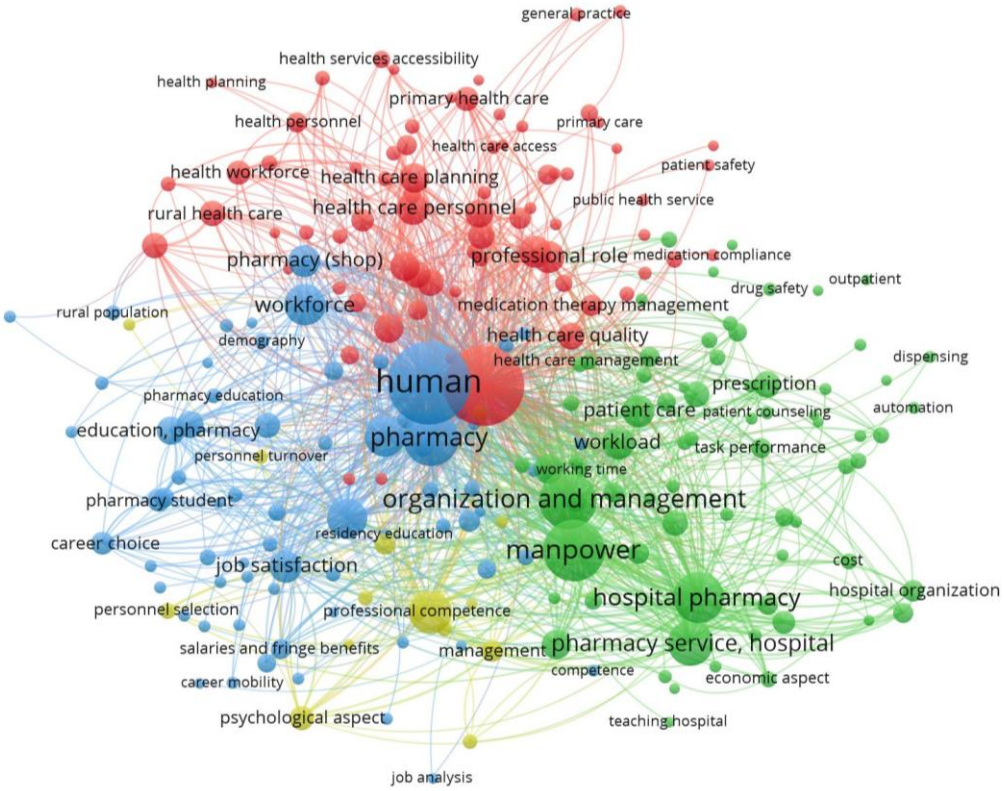
The analysis of keyword co-occurrence networks aims to understand the conceptual structure of knowledge in pharmacist workforce planning as well as to identify which concepts are emphasized in this field, how those concepts are interconnected, and what main themes can be grouped into. This analysis serves as a link between the structural overview of the documents and the network analysis of the articles.

The analysis was performed using author and indexed keywords from 364 selected articles, employing the VOS viewer program to create a co-occurrence network of keywords. A minimum threshold was set at 5 times to select only words with conceptual roles and reduce noise from words appearing only once or twice, which often reflect the specific context of individual articles rather than structural themes.

From the said process, 227 keywords that met the criteria were found and used to create the network, considering the frequency of co-occurrence between words. The size of the nodes in the network represents the frequency of keywords, while the thickness of the edges reflects the strength of the conceptual relationship between words. Keyword clustering was performed using the VOS viewer algorithm, which automatically groups words based on co-occurrence patterns, rather than pre-determining the groups by the researcher.

The co-occurrence network analysis, conducted using VOS Viewer with a threshold of 5 occurrences, examined 227 keywords related to pharmacist workforce planning. Keywords were grouped into four thematic clusters, with node size and line thickness indicating frequency and strength of co-citation links. As can be seen in the map presented in Figure 3. Prominent keywords included "human" (281), "pharmacist" (260), "manpower" (151), "pharmacy" (124), and "workforce" (71), reflecting the focus on workforce management. High-frequency terms such as "hospital pharmacy" (107), "healthcare personnel" (41), and "healthcare planning" (35) highlight the systematic attention required for workforce distribution, addressing the first research question on current workforce planning dynamics. The keywords are grouped into four clusters reflecting key themes in pharmacist workforce management.

FIGURE 3 CO-OCCURRING KEYWORD MAP FOR PHARMACIST WORKFORCE PLANNING (THRESHOLD 5 OCCURRENCES, 227 KEYWORDS)



The knowledge structure of studies on pharmacist workforce planning was divided into four main clusters, which are systemically interconnected but have distinctly different conceptual focuses. Cluster 1 (Red): Healthcare Workforce Planning was the largest cluster, with 72 keywords, focusing on workforce planning at the overall healthcare system level. Keywords, such as "Pharmacist" and "healthcare planning," reflected the study of the roles of pharmacists as a strategic resource in healthcare systems. Studies in this group often analyzes workforce demands, personnel distribution, and alignment between supply and demand in the context of structural changes, such as an aging society, the burden of non-communicable diseases, and the expanding clinical roles of pharmacists.

Cluster 2 (Green): Pharmacist Service Operations, with the same number of 72 keywords, focused on the operational level of pharmaceutical service delivery. Keywords, such as "Workload" and "Scheduling" indicated studies on workload, workforce scheduling, and service efficiency. This cluster reflected efforts to link workforce planning with actual management in service units. Cluster 3 (Blue): Pharmacist Workforce Development had 68 keywords and focused on long-term workforce development, such as "Education" and "Job satisfaction," covering education, competencies, job satisfaction, and personnel retention. Finally, Cluster 4 (Yellow): Strategic Workforce Management, although having the fewest keywords of only 15, clearly reflected policy and strategic management dimensions through keywords like "Personnel management" and "Leadership," emphasizing systemic decision-making and organizational direction setting, and clearly linking pharmacist workforce planning to macro-level health strategies.

In summary, the analysis of keyword co-occurrence networks indicates that the body of knowledge in pharmacist workforce planning comprises multiple systematically interconnected themes, ranging from systematic workforce management, career development, clinical role expansion, to strategic planning. These conceptual groupings serve as the basis for the subsequent analysis of article networks via bibliographic coupling, revealing deeper research directions and structural connections within the body of knowledge.

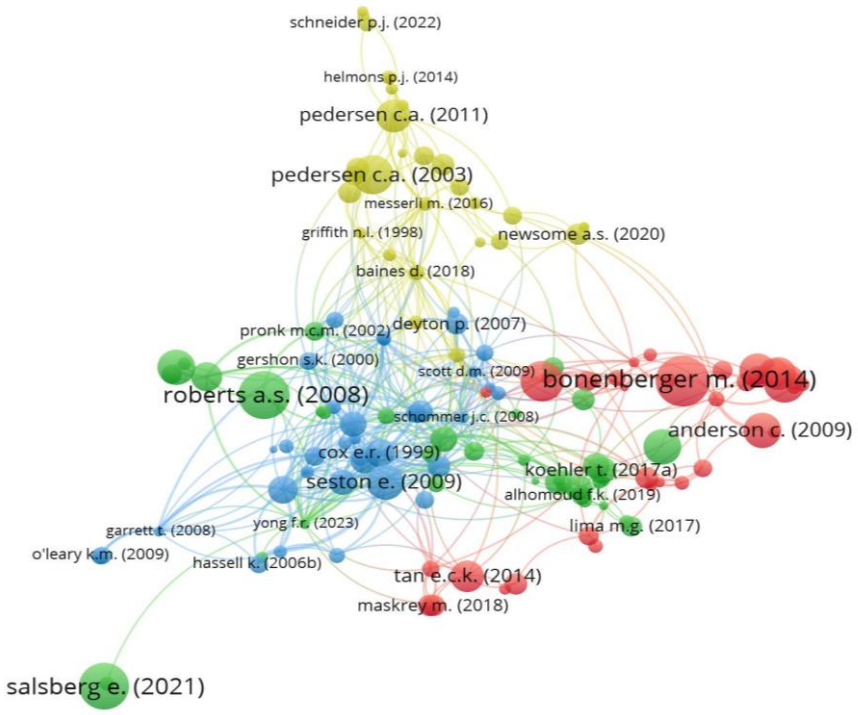
BIBLIOGRAPHIC COUPLING ANALYSIS

Bibliographic coupling analysis was employed to examine relationships between research articles on pharmacist workforce planning. Unlike keyword co-occurrence analysis, which reveals the conceptual structure of the research, bibliographic coupling analysis assessed article relationships based on shared references.

From a total of 364 selected articles, bibliographic coupling analysis was conducted using VOSviewer, applying a minimum threshold of five citations. This criterion resulted in 146 articles being included in the network analysis. Articles were linked based on shared references and clustered using VOSviewer without pre-defining the number of clusters.

The analysis identified four clusters of articles reflecting research trends in pharmacist workforce planning. Figure 4 illustrates the bibliographic coupling network and the relationships between these clusters. These findings, combined with the keyword co-occurrence results, provide empirical evidence for interpretation in the Discussion section.

FIGURE 4 BIBLIOGRAPHIC COUPLING IN PHARMACIST WORKFORCE PLANNING (THRESHOLD 5 CITATIONS, 146 DOCUMENTS)



DISCUSSION

PROFESSIONAL ROLE CONSIDERATIONS (CLUSTER 1; RED)

The first cluster of research reflects the expanding roles of pharmacists, shifting from supportive tasks to medication management, interdisciplinary collaboration, and direct patient care [13, 14]. This transition demonstrates that workforce demand depends on not only the number of pharmacists, but also the specific roles they are expected to fulfill. However, constraints regarding staffing levels, remuneration, and organizational structures may not align with this expanded scope of roles [15, 16]. Consequently, the overall evidence highlights the interconnections among workforce size, professional roles, job design, and team structure [17].

SKILLS AND SPECIALTIES (CLUSTER 2; GREEN)

The second cluster of research highlights imbalances in the pharmacist distribution based on personnel skills and specialties. The rising demand for specialized pharmacists may not align with existing workforce structures and job positions [18], suggesting that the total number of pharmacists alone does not accurately reflect workforce demand [19, 20]. Research concerning skills and specialties also reveals a mismatch between workforce development and health system requirements [21, 22]. These findings underscore the relationships among specialty-based demand, workload, and efficiency gaps in ongoing workforce assessment [23, 24].

WORKFORCE SUPPLY AND DEMAND ANALYSIS (CLUSTER 3; BLUE)

The third cluster of research demonstrates relationships among supply, demand, workload, and workforce sustainability. Workforce shortages may stem not only from the absolute number of personnel but also from shifting demands and the workforce supply adaptability [25]. Furthermore, workload, intentions to leave the job, and pull of the private sector influence workforce availability [26], highlighting the limitations of assessing the workforce solely based on headcount or static staffing ratios [27]. Additionally, evidence regarding workload, stress, turnover, and professional satisfaction illustrates the link between workforce behavior and long-term sustainability [28, 29].

WORKFORCE PLANNING TECHNOLOGIES (CLUSTER 4; YELLOW)

The fourth cluster of research suggests relationships among technologies, work system designs, and pharmacist's roles. Digital technologies, automation systems, and data analytics can transform workflows and job division between operational and clinical tasks [30]. However, the impact on the workforce is also linked to changes in work structures and professional roles [31]. Evidence regarding workload, work environments, and competency gaps further demonstrates that technologies are interconnected with skill mixes, role designs, and workforce development [32]. Thus, technologies represent another dimension linked to the framework of workforce planning.

RESEARCH CLUSTER SYNTHESIS

According to the four clusters of research, pharmacist workforce planning is not only a matter of personnel numbers, but it also is interconnected with professional roles, skills and specialties, supply and demand, workload, workforce sustainability, technologies, and work system design. The key issue emerging from this synthesis is not a lack of workforce planning elements in the literature, but rather that these elements have been examined from disparate perspectives and lack sufficient integration within workforce planning research, affecting the identification of future research gaps.

RESEARCH GAPS

From the synthesis of four clusters of research, three significant gaps were identified. The first gap concerns the time. While past research has examined workforce size, supply and demand, and workload, the linkage between these elements and long-term changes in workforce demand remains limited. Consequently, there is a lack of clear understanding regarding how the relationship between supply and demand might evolve over time.

The second issue relates to workforce skills, specialties, efficiency, and workload emerged as key factors in previous studies, they have not been fully integrated into supply and demand assessments. This gap implies that focusing solely on workforce numbers may fail to reflect the varying demands dictated by specific roles, expertise levels, and work contexts. The final issue concerns technologies. Existing literature demonstrates interconnections among technologies, professional roles, and work patterns, yet relationships between technological change and long-term workforce demand remain unclear, particularly regarding shifts in roles, skill mixes, and job structures.

Taken together, these three gaps reflect a common underlying issue: the integration of time, workforce specialties, and technologies into supply and demand assessments remains incomplete. Consequently, these gaps point toward directions for future research.

THEORETICAL AND MANAGERIAL IMPLICATIONS

This study indicates that assessing the pharmacist workforce involves more than simply determining the correct number of personnel. It is also linked to professional roles, skills and specialties, workloads, technologies, and work patterns. While these elements appear in the literature, they have not been fully integrated into workforce planning studies. Consequently, this study highlights dimensions requiring further research to develop a more comprehensive understanding of workforce demand.

For recruiters and decisionmakers, this study is useful for broadening the interpretation of workforce issues, moving beyond mere position counts to the specific nature of workforce demand. It demonstrates that workforce challenges may stem from staffing levels, the alignment of skills and specialties, workloads, or shifts in roles and work systems driven by technologies. These dimensions can serve as key factors when assessing the workforce situation and identifying information gaps prior to developing specific interventions.

However, as this study focuses on analyzing and synthesizing the structure of existing literature rather than evaluating the effectiveness of specific recruitment methods, workforce management measures, or specific policies, it cannot determine

which approaches are the most effective. Therefore, formulating specific practical and policy recommendations requires additional empirical evidence, particularly studies that address gaps regarding timeframes, workforce specialties, and technologies.

CONCLUSIONS

This study focuses on analyzing research regarding pharmacist workforce planning; therefore, the findings indicate that workforce assessment requires an understanding of the relationships among workforce numbers, capabilities, and changes in work systems to better reflect workforce requirements. A key contribution is the synthesis of knowledge into an interconnected structure, providing a clearer and more comprehensive perspective on workforce planning. This pattern can support decisionmakers in assessing multiple dimensions of workforce requirements and can also serve as a starting structure for workforce planning in other healthcare professions, with appropriate adaptation to the specific characteristics of each profession.

Table 2 was developed from an analysis of structural gaps in knowledge within each cluster, considering issues that are not fully explained in the current literature or are repeatedly identified as limitations in highly correlated articles. Therefore, the global trend for future research direction is the result of a systematic synthesis of the literature across the entire field. However, these research directions require further empirical investigation before specific practical or policy implications can be established. Future studies may also engage relevant decisionmakers to assess the practical relevance and applicability of the resulting evidence to pharmacist workforce planning.

In addition, future research should investigate whether interrelationships among staffing levels, professional roles, specialties, workloads, technologies, and work patterns, as identified in research on pharmacists, also appear in workforce studies concerning other health professions. Such comparative studies may help assess the extent to which this analytical approach is transferable to the contexts of other professions and identify which aspects require adaptation to the specific characteristics of each profession.

TABLE 2 GLOBAL TREND FOR FUTURE RESEARCH DIRECTION

Clusters	Future lines of research
Cluster 1: Pharmacist workforce integration	• Study the impact of increased clinical pharmacist coverage on service quality and patient safety in hospitals. • Study the pharmacist integration in multidisciplinary teams on continuity of care and quality of medication use. • Analyze workforce limitations hindering the expansion of clinical pharmacy services. • Evaluate integrative roles of pharmacists in healthcare system and policy values.
Cluster 2: Workforce capability deployment	• Develop a capability-based workforce planning model to replace headcount planning. • Study the link between competency gaps, patient safety, and workload. • Analyze the allocation of pharmacists based on skill levels in middle-income countries. • Study the use of a competency framework to predict long-term workforce demands.

Clusters	Future lines of research
Cluster 3: Workforce sustainability	• Develop a demand–supply model using workload pressure to assess workforce sustainability. • Analyze the workload of accredited pharmacists on their ability to provide long-term services. • Assess workforce adequacy relative to the population-level polypharmacy burden. • Analyze effects of staffing constraints on continuity of hospital pharmacy services.
Cluster 4: Workforce system design	• Evaluate effects of automated dispensing systems on skill mixes and FTE requirements of pharmacists. • Study workflow design in conjunction with technology to increase productivity without increasing workforce. • Analyze effects of advanced dispensing technologies on system efficiency and workforce allocation. • Evaluate effects of formulary-driven system redesign on workload and workforce costs.

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DISCLOSURE OF INTEREST

The authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

No new data were generated or analyzed in this study. All information used in this research was obtained from publicly available sources.

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REVIEW ARTICLE

A NARRATIVE REVIEW OF THE IMPACT OF TELEMEDICINE ON DIRECT OBSERVED THERAPY IN TUBERCULOSIS

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ABSTRACT

Tuberculosis (TB) remains a major public health challenge, particularly in low- and middle-income countries (LMICs), where conventional directly observed therapy (DOT) places substantial logistical and resource demands on patients and health systems. Telemedicine, particularly video-observed therapy (VOT), has been increasingly adopted to support tuberculosis treatment supervision; however, existing evidence remains fragmented and insufficiently synthesised from a health system and management perspective. This narrative review synthesised peer-reviewed evidence published between 2013 and 2024 on telemedicine-enhanced DOT for tuberculosis, with a focus on treatment adherence, cost and resource implications, patient acceptability, scalability, and equity across diverse health system contexts. Across study designs and settings, telemedicine-enhanced supervision achieved treatment adherence and completion outcomes comparable to, or exceeding, conventional facility-based DOT. Asynchronous and hybrid VOT models demonstrated advantages in reducing patient burden, improving workforce efficiency, and supporting programme scalability. Economic evaluations indicated consistent cost savings for patients and health systems, while qualitative evidence highlighted high patient acceptability, including increased autonomy and reduced stigma. However, persistent digital inequities related to device access, connectivity, and digital literacy limited universal applicability. Overall, telemedicine-enhanced DOT appears most effective when implemented as a complementary component of differentiated tuberculosis care rather than as a uniform replacement for conventional supervision. This review provides policy-relevant insights for health system leaders and programme managers on the strategic integration of telemedicine to balance effectiveness, efficiency, scalability, and equity in contemporary TB care.

KEYWORDS

telemedicine; video-observed therapy; tuberculosis; treatment adherence; health systems; digital equity

INTRODUCTION

Tuberculosis (TB) remains a major global public health challenge, particularly in low- and middle-income countries (LMICs) where health system constraints continue to undermine effective disease control. Despite sustained international efforts, TB remains one of the leading causes of death from infectious diseases worldwide. The World Health Organization estimated 10.6 million new TB cases and 1.6 million TB-related deaths globally in 2021, highlighting persistent gaps in prevention, diagnosis, and treatment delivery [1]. Ensuring sustained treatment adherence remains central to TB control, given the prolonged duration and complexity of standard treatment regimens.

Directly observed therapy (DOT), a core component of the DOTs strategy, has long been adopted to promote adherence by requiring supervised medication intake [2]. While DOT has contributed to improvements in treatment completion and cure rates, its implementation is associated with substantial logistical and social burdens. Patients are often required to attend health facilities frequently, incurring travel costs, income loss, and time away from work or caregiving responsibilities. From a health system perspective, DOT is labour intensive, resource demanding, and difficult to sustain at scale, particularly in settings with workforce shortages and geographically dispersed populations [3].

Advances in digital health have created opportunities to address these limitations. Over the past decade, telemedicine-enhanced approaches to DOT, particularly Digital Adherence Technologies (DATs) which are digital tools and technologies designed to monitor, support, and improve patients' adherence to prescribed treatment regimens, particularly for diseases that require prolonged therapy such as TB. Hence in TB care, DATs serve as alternatives or complements to traditional DOTs. DATs enable treatment monitoring remotely, reducing the burden on both patients and healthcare providers. A more common type of DAT used for TB patients is video-observed therapy (VOT), while DATs represent the broader category of digital adherence interventions This has gained increasing attention as alternatives to conventional in-person supervision. During VOT sessions, patients record or livestream themselves taking their TB medications using a hand held device. Subsequently, healthcare workers review the videos to confirm adherence to the medications. Evidence from randomised controlled trials, observational studies, and implementation research demonstrates that VOT is non-inferior, and in some settings superior, to traditional DOT in terms of treatment adherence, completion rates, and patient satisfaction.

These findings have informed global normative guidance, including World Health Organization recommendations recognising digital adherence technologies as acceptable alternatives to in-person observation under appropriate programmatic conditions. Studies across economically developed and LMIC settings indicate that VOT can reduce patient burden, mitigate stigma, and lower programme costs while maintaining treatment outcomes comparable to conventional DOT [4].

However, integration of telemedicine into TB care presents important challenges. Digital inequities related to smartphone ownership, internet connectivity, and digital literacy remain significant barriers, particularly among socially and economically marginalised populations [5,6]. Concerns regarding data privacy, confidentiality, and patient trust further complicates implementation. In some contexts, cultural preferences for face-to-face interaction and sustained interpersonal support continue to influence patient acceptance of digitally mediated care [7]. These challenges underscore that telemedicine-enhanced DOT is not a universally applicable solution and must be implemented in ways that are responsive to local health system capacity and population needs.

Although a growing body of literature has examined the effectiveness, feasibility, and acceptability of VOT and other digital adherence technologies, existing reviews have largely focused on clinical outcomes or technological performance in isolation.

Consequently, there is a lack of comprehensive synthesis that evaluates how these dimensions interact within real-world health systems. Questions relating to resource allocation, workforce adaptation, scalability across diverse healthcare

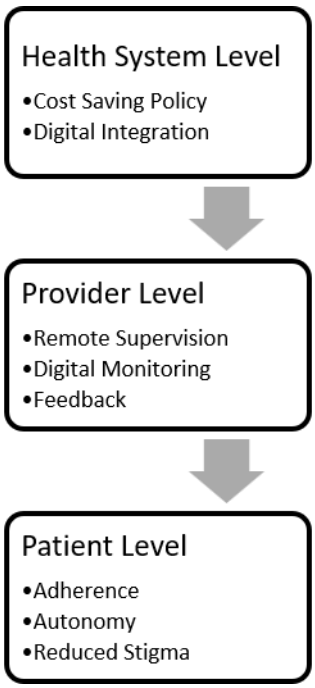
settings, and equitable access to digital services remain insufficiently explored. This gap is particularly important in the post-COVID era, where digital health interventions are increasingly being incorporated into routine TB programmes and require evaluation beyond clinical effectiveness alone.

Furthermore, the rapid expansion of telemedicine during and after the COVID-19 pandemic has reshaped TB service delivery, yet this evolving context is not consistently reflected in earlier reviews. The need for an updated synthesis is further underscored by recent developments in the digital health landscape. Emerging evidence from 2025 has highlighted the growing role of artificial intelligence-assisted VOT systems, updated World Health Organization (WHO) recommendations on DATs, and the expansion of large-scale hybrid care models that combine in-person and remote treatment monitoring. These developments reflect a rapidly evolving telemedicine environment that differs substantially from the early implementation studies that dominate much of the current literature. Despite these advances, there remains a lack of comprehensive narrative reviews that integrate clinical effectiveness, economic considerations, implementation challenges, health-system implications, and equity concerns within the contemporary post-COVID-19 telemedicine era.

In response to this gap, this narrative review synthesises evidence on telemedicine-enhanced DOT for tuberculosis through a health system and programme management lens. Rather than reassessing clinical efficacy, the review examines how telemedicine-supported DOT models have been implemented and integrated within tuberculosis control programmes, with particular attention to treatment adherence, cost and resource implications, patient acceptability, scalability, and digital equity. By identifying cross-cutting patterns, enablers, and contextual constraints across diverse settings, this review aims to provide actionable insights for health system leaders, programme managers, and policymakers on the strategic integration of telemedicine as a complementary component of differentiated TB care.

To support this synthesis, a conceptual framework is presented to illustrate how telemedicine interventions, including VOT and other digital adherence tools, operate across patient, provider, and health system levels to strengthen DOT within tuberculosis programmes. The framework highlights the interdependence of technological capability, workforce readiness, governance structures, and supportive policy environments in determining the effectiveness and sustainability of telemedicine-enhanced TB care.

FIGURE 1: CONCEPTUAL FRAMEWORK OF TELEMEDICINE INTEGRATION IN TUBERCULOSIS MANAGEMENT



METHODOLOGY

This narrative review was guided by the following research question: How have telemedicine-supported directly observed therapy models been implemented across diverse healthcare settings, and what are their impacts on treatment adherence, patient acceptability, service delivery, cost-effectiveness, programme management, scalability, and health equity in TB care?

REVIEW DESIGN AND RATIONALE

A narrative review approach was selected to synthesise evidence on telemedicine-enhanced DOT for TB treatment supervision, with a focus on health system implementation and programme management considerations. This approach was appropriate given the diversity of study designs, intervention models, and contextual settings represented in the literature, including randomised controlled trials, observational studies, qualitative research, and implementation evaluations [3,7].

LITERATURE IDENTIFICATION AND SELECTION

A comprehensive literature search was conducted across PubMed, Scopus, ScienceDirect, ProQuest, and JMIR Publications. Searches were supplemented by manual screening of reference lists from key articles and relevant policy documents from international organisations. Peer-reviewed articles published in English between 2013 and 2024 were included to capture early telemedicine applications in TB care and more recent developments following accelerated digital health adoption during the COVID-19 period [8]. Search terms included combinations of "tuberculosis", "directly observed therapy", "video-observed therapy", "telemedicine", "digital technologies", "implementation", "health systems", and "programme management".

The literature selection process was conducted in three stages. First, titles and abstracts were screened for relevance to telemedicine-supported TB treatment and monitoring. Studies focusing solely on diagnostic technologies, non-TB conditions, or interventions unrelated to treatment adherence were excluded. Second, full-text articles were assessed for eligibility based on their relevance to the review objective and research question. Studies reporting clinical outcomes, patient experiences, implementation factors, economic evaluations, health-system implications, or programme management considerations were prioritised. Finally, selected studies were reviewed in detail and grouped according to a thematic synthesis framework.

As this review included a heterogeneous body of evidence comprising quantitative, qualitative, implementation, and policy-focused studies, a formal risk-of-bias assessment tools were not applied. Instead, the credibility of evidence was considered through critical appraisal of study design and methodology, contextual relevance, and consistency of findings across multiple studies. Particular attention was given to recurring trends, implementation experiences, and areas where evidence remained limited or contradictory.

STUDY SELECTION AND INCLUSION CRITERIA

Studies were included if they examined telemedicine-enhanced approaches to tuberculosis treatment supervision, including synchronous and asynchronous VOT, and reported outcomes or insights relevant to implementation, service delivery, workforce roles, patient acceptability, cost considerations, or health system integration. Both high-income and LMIC settings were included to enable cross-context comparison. Editorials and commentaries without empirical or programme-relevant content were excluded.

DATA EXTRACTION AND ANALYTICAL APPROACH

Data extraction focused on study characteristics, telemedicine modality, health system context, comparator where applicable, and outcomes relevant to programme management. Outcomes of interest included treatment adherence and completion, patient and provider burden, cost implications, workforce efficiency, scalability, and implementation barriers [11-14,17,18]. Included studies were reviewed iteratively to identify recurring concepts and implementation-related insights. An inductive thematic synthesis was undertaken, grouping findings into domains relevant to health system

performance and programme management, including service delivery models, governance considerations, workforce implications, digital infrastructure, patient equity, and sustainability [3,7,9,10]. Themes were refined through repeated comparison across studies.

THEMATIC SYNTHESIS FRAMEWORK

Findings were organised into five thematic domains that informed the Results structure:

1. Models of telemedicine-enhanced DOT implementation
2. Programme integration and governance considerations
3. Health workforce roles and operational implications
4. Patient acceptability, access, and equity considerations
5. Cost, sustainability, and scalability considerations

RESULTS

MODELS OF TELEMEDICINE-ENHANCED DIRECTLY OBSERVED THERAPY IMPLEMENTATION

Across the reviewed literature, telemedicine-enhanced directly observed therapy for tuberculosis has been implemented through three broad service delivery models: synchronous video-observed therapy, asynchronous video-observed therapy, and hybrid models that combine digital supervision with periodic in-person contact. These models differ substantially in operational design, technological requirements, and levels of integration within existing tuberculosis programme structures, reflecting adaptation to local health system capacity and patient needs. Evidence from both high-income and low- and middle-income country (LMIC) settings indicates that implementation choices are strongly shaped by contextual constraints rather than clinical considerations alone [1,3,7]. To facilitate comparison across diverse study designs and settings, key characteristics of the included studies were extracted and summarised in Table 1. Information extracted included study setting, telemedicine modality, population characteristics, methodological approach, thematic contribution, and key findings relevant to treatment adherence, patient acceptability, implementation, scalability, and health-system implications.

Synchronous VOT typically involves real-time video interactions between patients and healthcare providers during medication ingestion, closely replicating conventional in-person DOT while removing the need for physical co-location. This model has been most frequently reported in high-income settings with reliable internet connectivity and established telehealth infrastructure [5,14]. Studies implementing synchronous approaches highlight advantages related to real-time clinical oversight and sustained patient-provider interaction but also report higher workforce time requirements and reduced flexibility for patients compared with asynchronous alternatives [5,14]. These characteristics are summarised in Table 2, which outlines key features, implementation contexts, and system requirements associated with synchronous telemedicine-enhanced DOT.

TABLE 1: SUMMARY OF KEY STUDIES ON TELEMEDICINE AND VIDEO-OBSERVED THERAPY

Author (Year)	Country / Setting	Design	Telemedicine Modalities	Sample Size / Population	Primary Thematic Contribution	Synthesized Key Findings
Story et al., (2019)	United Kingdom	Multicentre RCT	Asynchronous smartphone VOT	226 TB patients eligible for DOT	Adherence effectiveness	Asynchronous VOT achieved 70% vs 31% DOT adherence (OR 5.48; 95% CI 3.10-9.68), showing superior effectiveness and patient satisfaction.
Tello-Cajiao et al., (2023)	Colombia	Quasi-experimental	Synchronous real-time VOT	78 patients (intensive & continuation phases)	Feasibility and acceptability	Adherence 99.8% (intensive) and 98.2% (continuation) with 100% cure; patients preferred remote contact and flexibility.
Kumwichar et al., (2024)	Thailand	Protocol for cluster randomised controlled trial	Asynchronous smartphone VOT	200 patients (urban & rural patients)	Adherence sustainability	Protocol describing planned evaluation of adherence, continuity, and feasibility of smartphone-based asynchronous VOT compared with community-based DOT; outcome data pending.
Abas et al., (2024)	Malaysia	Single-arm intervention	Gamified real-time VOT app (GRVOTS)	71 patients (In continuation phase)	Patient motivation and engagement	90.9% adherence; significant increase in intrinsic motivation (IMI +19.8, $p<0.001$); improved retention and patient satisfaction.
Raj et al., (2024)	United States	Retrospective cohort	Hybrid synchronous + asynchronous VOT	548 patients across 20 TB programs	Scalability and system integration	Treatment completion 97.2% vs 92.3% under DOT; reduced median treatment duration and operational costs.
Donahue et al., (2021)	USA Military Clinics	Implementation case study	Weekly Telemedicine DOT for LTBI	16 LTBI patients	Access and continuity of care	100% completion; reduced travel and improved scheduling flexibility for families.
Fekadu et al., (2021)	Hong Kong	Decision-analytic model	Asynchronous VOT	Simulated 10,000 TB patients	Cost-effectiveness	VOT saved US$1,797 per patient and reduced DALYs by 0.487; 99.4% probability of being cost-effective.
Netto et al., (2024)	Global (systematic review)	Systematic Review	Mixed VOT modalities	12 RCTs (2010-2024)	Adherence, cost, satisfaction	VOT non-inferior to DOT for adherence; improved satisfaction and cost reduction up to 60%.
Olawade et al., (2024)	Multiple LMICs	Narrative review	Telemedicine for MDR-TB	48 articles reviewed	Scalability in resource-limited settings	Telemedicine improved access to remote diagnosis, follow-up, and specialist care; connectivity and culture remain limiting factors.

Author (Year)	Country / Setting	Design	Telemedicine Modalities	Sample Size / Population	Primary Thematic Contribution	Synthesized Key Findings
Browne et al., (2019)	USA	Randomised controlled trial	Wirelessly Observed Therapy (WOT)	77 patients (TB patients in continuation phase)	Precision monitoring	WOT achieved 99.3% positive detection accuracy; confirmed 93% doses vs 63% with DOT; preferred by all participants.
Rabinovich et al., (2020)	Cambodia	Qualitative study	Mobile VOT perception	6 focus groups (urban/peri-urban)	Patient acceptability and equity	High willingness to use VOT; barriers include illiteracy and reduced in-person contact.
Adisa et al., (2021)	Nigeria	Mixed-method cross-sectional	Facility-based DOT (baseline comparator)	140 patients (Drug-sensitive TB patients)	Baseline adherence constraints	Treatment success 81.9%; major barriers were travelling distance and pill burden; baseline for telemedicine potential.
Cross et al., (2019)	India	Implementation evaluation	99DOTS (SMS and phone-call based DOT)	>200,000 TB patients	Scalability in resource-limited settings	99DOTS achieved large-scale digital DOT coverage with >80% adherence, becoming national standard in India.

TABLE 2: IMPLEMENTATION MODELS OF TELEMEDICINE-ENHANCED DIRECTLY OBSERVED THERAPY FOR TUBERCULOSIS

Implementation model	Core characteristics	Level of patient flexibility	Health worker involvement	Typical health system context	Illustrative settings
Synchronous video-observed therapy	Real-time video interaction between patient and health worker during medication ingestion	Low to moderate	High, continuous real-time supervision	Well-resourced systems with stable connectivity and telehealth infrastructure	High-income countries, urban tertiary services
Asynchronous video-observed therapy	Patients record and submit videos for later review by health workers	High	Moderate, batch review of videos	Systems prioritising efficiency and flexibility, often with constrained workforce capacity	Low- and middle-income countries, mixed urban–rural settings
Hybrid telemedicine-enhanced DOT	Combination of asynchronous video submission with periodic in-person or live video follow-up	Moderate to high	Variable, targeted to patient need	Programmes adapting to heterogeneity in patient risk and system capacity	COVID-19 response settings, decentralised TB programmes

Asynchronous VOT emerged as the most frequently described implementation model, particularly in LMICs settings and decentralised tuberculosis programmes [9,11,12,17[. In this approach, patients record and submit videos of medication ingestion for subsequent review by healthcare workers, allowing greater flexibility in dosing schedules and more efficient allocation of staff resources. As shown in Table 2, asynchronous models were consistently associated with reduced patient travel burden and improved convenience, while maintaining acceptable levels of treatment supervision and adherence [3,11-13]. Several studies reported that asynchronous video review enabled healthcare workers to supervise a larger number of patients concurrently, suggesting potential efficiency gains at programme level [12,17].

Hybrid implementation models combine telemedicine-enhanced DOT with periodic in-person contact, either through scheduled facility visits or targeted follow-up for patients identified as having adherence challenges. These models were commonly adopted during the COVID-19 pandemic as adaptive strategies to sustain treatment supervision amid movement restrictions and workforce redeployment [8,15]. As illustrated in Table 3, hybrid approaches were used to balance patient flexibility with clinical oversight, particularly for individuals requiring additional support due to social vulnerability, limited digital literacy, or complex clinical profiles [9,19].

TABLE 3: OPERATIONAL AND WORKFORCE IMPLICATIONS OF TELEMEDICINE-ENHANCED DIRECTLY OBSERVED THERAPY

Operational domain	Synchronous models	Asynchronous models	Hybrid models	Programme-level implications
Health worker time use	High time demand per patient	Reduced per-patient time through batch review	Targeted time allocation	Enables redistribution of workforce effort toward higher-risk patients
Patient travel and opportunity costs	Minimal travel but fixed dosing times	Minimal travel with flexible dosing	Reduced travel with selective in-person contact	Improves patient-centred care and reduces indirect treatment costs
Caseload capacity	Limited scalability due to real-time requirements	Higher scalability with centralised review	Moderate scalability	Supports expansion of treatment supervision without proportional staff increases
Training requirements	Moderate, focused on teleconsultation skills	Moderate, focused on video review and digital platforms	Higher, due to blended workflows	Requires structured training and clear standard operating procedures
Continuity of care	High continuity through frequent interaction	Variable, dependent on review frequency	High for targeted patients	Highlights need for protocols to prevent reduced patient engagement

Across all implementation models, the selection of telemedicine modality was strongly influenced by contextual factors including digital infrastructure availability, smartphone access, regulatory frameworks, and workforce capacity. Table 4 synthesises these determinants and highlights how programme-level decisions shaped the adoption and adaptation of telemedicine-enhanced DOT models across settings [6,7,10]. Importantly, no single model was universally optimal. Instead, successful implementation was contingent on alignment between service delivery design and health system readiness, with flexible and differentiated approaches demonstrating greater potential for sustainable integration into routine tuberculosis care.

TABLE 4: CONTEXTUAL ENABLERS, BARRIERS, AND IMPLICATIONS FOR SCALE-UP OF TELEMEDICINE-ENHANCED DIRECTLY OBSERVED THERAPY

Health system domain	Enablers	Barriers	Implications for scale-up
Digital infrastructure	Smartphone availability, mobile network coverage	Poor connectivity, device instability	Asynchronous and hybrid models more feasible in low-connectivity settings
Governance and regulation	National endorsement of digital adherence technologies	Unclear data governance and medico-legal frameworks	Clear policy guidance required to institutionalise telemedicine-enhanced DOT
Health workforce capacity	Task shifting, centralised monitoring	Resistance to workflow change, digital skill gaps	Workforce engagement and training critical for sustainability
Patient equity and access	Reduced travel burden, privacy benefits	Digital literacy gaps, smartphone ownership requirements	Risk of exclusion necessitates complementary non-digital options
Financial sustainability	Reduced travel and supervision costs	Upfront technology and maintenance costs	Long-term cost-effectiveness depends on integration into routine services

Overall, the evidence indicates that telemedicine-enhanced directly observed therapy should be understood not as a single intervention, but as a set of adaptable service delivery models. Programmes that demonstrated flexibility in selecting and modifying implementation approaches were better positioned to integrate telemedicine-enhanced DOT within existing tuberculosis services, underscoring the importance of context-sensitive design in health system innovation [1,3,7].

INTEGRATION OF TELEMEDICINE-ENHANCED DOT WITHIN TUBERCULOSIS PROGRAMMES AND GOVERNANCE FRAMEWORKS

The integration of telemedicine-enhanced DOT within existing TB programmes varied considerably across settings, reflecting differences in governance structures, regulatory environments, and programme maturity. Across the reviewed studies, successful implementation was most frequently observed when telemedicine-enhanced DOT was embedded within established national or subnational tuberculosis control frameworks rather than introduced as a parallel or standalone intervention [1,3,7]. This integration facilitated alignment with existing treatment protocols, reporting systems, and accountability mechanisms, thereby supporting continuity of care and programme oversight.

In high-income settings, telemedicine-enhanced DOT was commonly integrated through formal policy endorsement and incorporation into routine service delivery workflows, often supported by established telehealth regulations and data governance frameworks [12,14,21]. These settings demonstrated clearer delineation of clinical responsibility, data ownership, and medico-legal accountability, which enabled scale-up beyond pilot phases [12,14]. However, even in these contexts, governance challenges related to data privacy and interoperability with legacy information systems were reported, underscoring the need for ongoing regulatory adaptation as digital adherence technologies evolve [21].

In contrast, integration within low- and middle-income country programmes was frequently characterised by phased or adaptive approaches, often initiated through pilot projects before gradual incorporation into routine TB services [9,11,19]. In these settings, governance arrangements were less formalised, with programme managers relying on locally developed protocols and discretionary decision-making to balance flexibility with oversight. As summarised in Table 4, enabling factors for integration included national tuberculosis programme endorsement, donor or institutional support, and alignment with broader digital health strategies, while barriers included unclear regulatory guidance and limited institutional capacity for digital governance [6,7,10].

Several studies highlighted the role of telemedicine-enhanced DOT in strengthening programme resilience during periods of system disruption, particularly during the COVID-19 pandemic [8,15]. Temporary policy adjustments allowing remote treatment supervision facilitated rapid adoption of telemedicine-supported models, demonstrating the potential for regulatory flexibility to accelerate innovation when supported by clear governance principles. However, the sustainability of such adaptations beyond emergency contexts remained uncertain, particularly in settings where policy changes were not subsequently formalised [8].

Across settings, the degree of programme integration influenced not only operational feasibility but also equity and accountability. Programmes that embedded telemedicine-enhanced DOT within existing monitoring and evaluation systems were better able to identify patients at risk of non-adherence and to deploy targeted support mechanisms [11,17]. Conversely, fragmented implementation approaches risked creating parallel systems with inconsistent reporting and reduced visibility at programme level. Table 3 illustrates how governance clarity and integration affected workforce coordination and continuity of care across implementation models.

Overall, the findings suggest that telemedicine-enhanced directly observed therapy is most effective when conceptualised as a service delivery adaptation within TB programmes, rather than a purely technological solution. Governance structures that provide clear regulatory guidance, define roles and responsibilities, and support integration with routine programme functions are critical to ensuring that telemedicine-enhanced DOT contributes meaningfully to TB control objectives while maintaining accountability and equity [1,3,7].

HEALTH WORKFORCE AND OPERATIONAL IMPLICATIONS OF TELEMEDICINE-ENHANCED DOT

The implementation of telemedicine-enhanced DOT has significant implications for health workforce organisation and day-to-day programme operations. Across studies, shifts in supervision modality altered patterns of health worker time use, task allocation, and patient engagement, with effects varying by implementation model and health system context [3,11,12]. These operational changes were central to the perceived feasibility and sustainability of telemedicine-enhanced DOT at programme level.

Synchronous VOT models generally required sustained real-time engagement between healthcare providers and patients, resulting in time commitments comparable to or exceeding those of conventional in-person DOT [5,14]. While this approach preserved direct clinical oversight and continuity of interaction, it limited scalability in resource-constrained settings where workforce capacity was already stretched. Studies from high-income contexts reported that synchronous models were most feasible when integrated into existing telehealth services with protected staff time and clear role delineation [14,21].

In contrast, asynchronous VOT models consistently demonstrated greater operational flexibility and efficiency [11-13,17]. Health workers reviewed recorded medication ingestion videos in batches, allowing supervision of larger patient caseloads without proportional increases in staffing. This redistribution of effort enabled programmes to prioritise follow-up and counselling for patients identified as having adherence challenges, rather than applying uniform supervision intensity across all patients [11,17]. As summarised in Table 3, asynchronous approaches were associated with reduced travel requirements, improved workflow efficiency, and enhanced capacity for differentiated care.

Hybrid implementation models combined elements of digital supervision with targeted in-person contact, offering a pragmatic balance between efficiency and clinical oversight [9,19]. These models were particularly valuable for managing patients with complex social needs, limited digital literacy, or unstable treatment engagement. Health workers reported that hybrid approaches allowed more judicious allocation of face-to-face interactions, reserving in-person supervision for patients most likely to benefit from additional support [9]. Table 3 illustrates how such models supported continuity of care while mitigating the operational burden associated with universal in-person DOT.

Across all models, the transition to telemedicine-enhanced DOT required new competencies among health workers, including digital literacy, remote patient engagement skills, and familiarity with data platforms [6,7]. Training and change

management emerged as critical enablers of successful implementation, particularly in settings where digital health tools were not previously embedded within routine service delivery. Conversely, resistance to workflow change and concerns regarding increased administrative burden were identified as barriers to adoption in some programmes [19].

Overall, the findings indicate that telemedicine-enhanced directly observed therapy reshapes workforce roles rather than reducing the need for human resources. Programmes that approached implementation as an opportunity to redesign supervision workflows, rather than simply digitising existing practices, were better positioned to achieve operational efficiencies while maintaining patient-centred care. These workforce and operational considerations underscore the importance of aligning telemedicine-enhanced DOT models with broader health system capacity and programme management strategies to support sustainable scale-up [1,3,7].

PATIENT ACCEPTABILITY, ACCESS, AND EQUITY CONSIDERATIONS

Patient acceptability emerged as a key determinant of the effectiveness and sustainability of telemedicine-enhanced DOTs across diverse settings. Overall, studies consistently reported high levels of patient satisfaction with telemedicine-supported supervision, particularly due to reduced travel requirements, increased convenience, and greater autonomy in medication intake [9,11,13,14]. These benefits were especially pronounced among working adults and individuals facing logistical barriers to daily facility-based supervision.

Asynchronous VOT was frequently associated with higher acceptability compared with synchronous models, owing to its flexibility and reduced disruption to daily routines [11-13,17]. Patients valued the ability to record medication ingestion at convenient times without the need to synchronise schedules with healthcare providers. Hybrid models further enhanced acceptability by maintaining periodic in-person contact, which some patients perceived as important for reassurance, relationship-building, and clinical support [9,19]. As reflected in Table 3, acceptability was closely linked to how well implementation models balanced flexibility with ongoing human interaction.

Despite these positive findings, access to telemedicine-enhanced DOT was unevenly distributed, raising important equity concerns. Several studies highlighted the risk of exclusion among populations lacking access to smartphones, stable internet connectivity, or adequate digital literacy [6,10]. Requirements for personal device ownership disproportionately affected older adults, individuals with lower socioeconomic status, and those living in remote or marginalised communities. As summarised in Table 4, digital access constraints and varying levels of technological familiarity were recurrent barriers to equitable implementation across settings.

Privacy and confidentiality considerations also influenced patient acceptability. While some patients reported increased privacy due to reduced clinic visits and avoidance of TB-related stigma, others expressed concerns regarding video recording, data security, and unintended disclosure within shared living environments [9,19]. These concerns were particularly salient in densely populated households and informal settlements, underscoring the need for context-sensitive implementation and clear communication regarding data protection measures.

Across settings, programmes that proactively addressed equity considerations through flexible eligibility criteria, alternative supervision options, and patient support mechanisms demonstrated higher overall acceptability and engagement [6,9,19]. Table 4 highlights how equity-oriented design choices, such as offering non-digital alternatives or providing devices and technical support, mitigated exclusion risks and enhanced inclusivity. These findings suggest that patient-centred and equity-informed approaches are essential to ensuring that telemedicine-enhanced DOT strengthens, rather than inadvertently exacerbates, disparities in tuberculosis care.

COST, SUSTAINABILITY, AND SCALABILITY OF TELEMEDICINE-ENHANCED DOT MODELS

Cost considerations were a central driver of interest in telemedicine-enhanced DOT, particularly in contexts where conventional in-person DOT imposed substantial recurrent expenses related to staff time, patient travel, and facility utilisation. Across studies, telemedicine-supported models were consistently associated with reductions in indirect costs for patients and operational efficiencies for tuberculosis programmes, although the magnitude and distribution of savings varied by implementation model and health system context [3,8,12].

Asynchronous VOT demonstrated the greatest potential for cost savings at programme level, primarily through reduced staff time per patient and the ability to supervise larger caseloads without proportional workforce expansion [12,17]. Studies from both high-income and middle-income settings reported that savings accrued from decreased travel requirements and more efficient supervision workflows outweighed the costs associated with platform maintenance and staff training over time [8,12]. These efficiency gains are reflected in Table 3, which summarises operational implications linked to different telemedicine-enhanced DOT models.

Synchronous VOT, while effective in maintaining close clinical oversight, was generally associated with higher recurrent staffing costs due to real-time supervision requirements [5,14]. As a result, its scalability was more limited in resource-constrained settings unless integrated within existing telehealth infrastructure with protected staffing and funding streams. Hybrid models offered a pragmatic alternative by concentrating resource-intensive in-person or real-time interactions on patients with greater support needs, thereby improving cost efficiency without compromising care quality [9,15].

Sustainability of telemedicine-enhanced DOT depended not only on immediate cost considerations but also on long-term integration within health system financing and governance structures. Several studies highlighted that pilot projects supported by short-term funding or emergency policy adjustments, particularly during the COVID-19 pandemic, faced challenges in transitioning to routine service delivery once external support diminished [8,15]. As summarised in Table 4, sustainable scale-up was more likely when telemedicine-enhanced DOT was embedded within national tuberculosis programme budgets and aligned with broader digital health strategies [1,7].

Scalability was further influenced by equity-related cost considerations. Programmes that required patients to bear the cost of smartphones or data connectivity risked excluding socioeconomically disadvantaged populations, thereby limiting both reach and effectiveness [6,10]. Conversely, models that incorporated device provision, low-bandwidth solutions, or complementary non-digital supervision options demonstrated greater scalability across diverse populations [6,9]. These findings underscore that cost-effectiveness at programme level must be assessed alongside affordability and access at patient level.

Overall, the evidence suggests that telemedicine-enhanced directly observed therapy can offer meaningful cost and efficiency advantages, particularly when implemented through flexible, asynchronous, or hybrid models. However, realising these benefits at scale requires deliberate attention to financing mechanisms, governance integration, and equity safeguards. Telemedicine-enhanced DOT is most likely to be sustainable when positioned as a long-term service delivery strategy within tuberculosis programmes rather than as a time-limited technological innovation [1,3,7].

DISCUSSION

Unlike previous reviews that have predominantly focused on adherence outcomes and technological effectiveness, this review synthesises evidence through a health management and policy lens, highlighting the governance, workforce, scalability, sustainability, and equity factors that determine successful implementation of telemedicine-enhanced DOT within contemporary tuberculosis programmes. Across the reviewed literature, telemedicine-enhanced DOT demonstrated high patient acceptability and considerable potential for scalable implementation, particularly through asynchronous and hybrid models. Nevertheless, persistent challenges relating to digital exclusion, programme integration, and long-term sustainability highlight the need for context-sensitive implementation strategies.

This review highlights five principal findings of relevance to health system management and programme design. First, telemedicine-enhanced DOT has been implemented through diverse service delivery models, including synchronous, asynchronous, and hybrid approaches, with no single model demonstrating universal superiority. Instead, feasibility and effectiveness are strongly shaped by alignment with local health system capacity, digital readiness, and patient needs. Second, successful adoption depends on supportive governance arrangements and regulatory clarity, particularly in relation to data governance, clinical accountability, and integration with existing tuberculosis programme structures.

Third, telemedicine-enhanced DOT reshapes health workforce roles and operational workflows. Rather than reducing workforce requirements, it enables more efficient allocation of staff time when models support differentiated supervision. Fourth, while patient acceptability is generally high due to reduced treatment burden and increased flexibility, access and equity concerns persist, particularly for populations with limited digital access or literacy. Finally, telemedicine-enhanced DOT demonstrates potential for cost savings and scalable implementation, especially through asynchronous and hybrid models, but long-term sustainability requires integration into routine financing and programme planning.

COMPARATIVE INTERPRETATION OF FINDINGS

These findings are broadly consistent with previous systematic reviews demonstrating that video-observed therapy is non-inferior to conventional DOT in terms of adherence and patient satisfaction, while offering operational efficiencies in selected contexts. However, this review extends existing evidence by shifting the analytical focus from efficacy to implementation as a health system intervention. The variability observed across settings underscores that telemedicine-enhanced DOT should not be conceptualised as a standardised technological solution, but rather as a set of adaptable service delivery options that must be matched to programme objectives and system constraints.

A notable strength across the reviewed studies was the consistent demonstration of favourable adherence outcomes and high patient acceptability. Patients frequently reported reduced travel requirements, increased flexibility, and lower treatment burden, while programmes reported improved efficiency in treatment monitoring and supervision. Several studies also demonstrated the feasibility of scaling telemedicine-enhanced DOT within routine tuberculosis programmes, particularly through asynchronous monitoring approaches. However, important limitations were also evident. Many studies were conducted as pilot projects, implementation evaluations, or within relatively well-resourced settings, limiting the generalisability of findings to routine practice. Sample sizes varied substantially, and long-term sustainability outcomes were rarely evaluated. Furthermore, while studies conducted in high-income settings often benefited from established telehealth infrastructure and supportive regulatory frameworks, studies from low- and middle-income settings highlighted ongoing challenges related to internet connectivity, digital literacy, device access, and financing mechanisms. These contrasting findings suggest that implementation success depends not only on intervention design but also on the broader organisational, economic, and policy environment.

Differences between high-income and low- and middle-income settings were particularly evident in governance and integration processes. While high-income settings often benefited from established telehealth regulations and digital infrastructure, lower-resource settings relied more heavily on adaptive, phased implementation approaches. Importantly, several studies demonstrated that flexibility and incremental integration, rather than technological sophistication, were key to sustaining telemedicine-enhanced DOT in resource-constrained environments. These observations reinforce the need to prioritise system readiness and managerial capacity alongside technological considerations.

CONTRIBUTIONS AND IMPLICATIONS FOR POLICY AND HEALTH MANAGEMENT

This review contributes to the literature by explicitly framing telemedicine-enhanced DOT as a programme management and health system innovation, rather than solely a digital adherence tool. By synthesising evidence across implementation models, governance contexts, workforce implications, equity considerations, and sustainability, the review clarifies why outcomes vary across settings and how these variations can be anticipated and managed.

Several practical implications emerge for policymakers, programme managers, and healthcare systems. First, telemedicine-enhanced DOT should be positioned as a complementary component of differentiated tuberculosis care rather than a universal replacement for conventional DOT, allowing supervision intensity to be tailored according to patient risk, treatment phase, and programme capacity. Second, successful implementation requires investment not only in digital platforms but also in workforce training, change management, governance mechanisms, and integration with existing health information systems to maintain accountability and continuity of care. Third, equity considerations should be incorporated into programme design from the outset through the provision of alternative non-digital pathways and targeted support for populations at risk of digital exclusion. Fourth, hybrid models that combine in-person and remote monitoring may provide the greatest flexibility by balancing patient-centred care with programme oversight. Finally, long-

term sustainability depends on embedding telemedicine-enhanced DOT within routine financing arrangements, national digital health strategies, and tuberculosis programme planning rather than relying on short-term pilot projects or emergency-driven implementation.

Unlike earlier reviews that primarily evaluated the effectiveness of video-observed therapy, the present review situates telemedicine-enhanced DOT within the broader 2025 digital health landscape characterised by expanding use of Digital Adherence Technologies, artificial intelligence-supported monitoring systems, hybrid care delivery models, and increasing emphasis on health system integration and digital equity.

FUTURE DIRECTIONS

Looking ahead, further research is needed to examine long-term outcomes of telemedicine-enhanced DOT beyond pilot phases, particularly in low-resource and decentralised health systems also focusing on optimising implementation within rapidly evolving digital health ecosystems. Emerging developments in digital health, including artificial intelligence–supported adherence monitoring and evolving global guidance, warrant careful evaluation to determine how they can be integrated responsibly into tuberculosis programmes without exacerbating inequities. Comparative implementation research focusing on governance models, workforce adaptation, and patient stratification strategies would be particularly valuable in informing scalable and context-sensitive approaches. Additional research is also needed to explore governance frameworks, workforce adaptation, interoperability with national health information systems, and financing mechanisms that support sustainable implementation. Given the increasing emphasis on equitable digital health transformation, future studies should prioritise strategies to reduce disparities in access among rural populations, socioeconomically disadvantaged groups, older adults, and individuals with limited digital literacy. Such work will be critical to ensuring that telemedicine-enhanced DOT contributes to both effective tuberculosis control and equitable healthcare delivery.

LIMITATIONS

This review has several limitations. As a narrative review, it does not employ formal systematic methods or meta-analysis, which may limit reproducibility and introduce selection bias. However, this approach was intentionally adopted to accommodate heterogeneous study designs and to support interpretation through a health system and management lens. The evidence base remains uneven across regions, with limited long-term data from some low-resource settings. In addition, many studies were conducted during periods of system disruption, such as the COVID-19 pandemic, which may affect generalisability. Rapid evolution in digital adherence technologies also means that evidence will continue to develop beyond the scope of this review. As tuberculosis programmes increasingly embrace digital transformation, telemedicine-enhanced DOT is likely to become an integral component of differentiated, patient-centred care. The challenge facing policymakers in 2025 is no longer whether telemedicine can support tuberculosis treatment, but how digital innovations can be implemented sustainably, equitably, and at scale within diverse health system contexts.

CONCLUSION

Telemedicine-enhanced DOT represents a pragmatic evolution in tuberculosis treatment supervision, offering health systems greater flexibility to balance patient-centred care with programme efficiency. This review demonstrates that the value of telemedicine-enhanced DOT lies not in the technology itself, but in how it is governed, integrated, and operationalised within existing tuberculosis programmes. Implementation outcomes vary widely according to health system readiness, workforce capacity, and equity considerations, underscoring the need for differentiated and context-sensitive approaches. For policymakers and programme managers, telemedicine-enhanced DOT should be positioned as a complementary strategy within routine TB care, supported by clear governance frameworks, sustained financing, and inclusive design. When aligned with broader health system priorities, telemedicine-enhanced DOT has the potential to strengthen treatment supervision, enhance resilience to service disruptions, and advance equitable tuberculosis care across diverse settings.

CONFLICTS OF INTERESTS

The authors have no conflicts of interest to declare.

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DATA AVAILABILITY STATEMENTS

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AUTHORS' CONTRIBUTIONS

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RESEARCH ARTICLE

STRENGTHENING WORKFORCE COMPETENCY IN EYE CARE: ALIGNING MALAYSIA'S OPTOMETRY EDUCATION STANDARDS WITH GLOBAL FRAMEWORKS

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ABSTRACT

INTRODUCTION:

Developing a competent eye care workforce requires alignment between national education standards and internationally recognised competency frameworks. In Malaysia, the Optometry Programme Standard addresses local professional and regulatory needs, yet there are opportunities to strengthen its global relevance and policy coherence.

OBJECTIVE:

This review assessed the alignment of the Malaysian Optometry Programme Standard with the World Council of Optometry (WCO) Guide for Optometric Education and identified areas for improvement in competency documentation, curriculum governance, and workforce policy integration.

METHODS:

A narrative review was conducted using documents (2010–2024) related to competency frameworks and optometric education standards. Databases searched included PubMed, Scopus, Web of Science, ProQuest, and Google Scholar, as well as relevant policy documents. A structured screening approach was used to ensure transparency in study selection, including predefined eligibility criteria and iterative reviewer discussions to resolve discrepancies. Findings were synthesised narratively based on thematic relevance rather than statistical aggregation.

FINDINGS:

Both frameworks emphasise core clinical competencies, but differ in structure and specificity. The WCO guide adopts a domain-based model with measurable performance indicators, while the Malaysian standard outlines broader outcomes without explicit competency mapping. Alignment was strongest in ocular health, moderate in refractive error, visual function, and professional practice, and weakest in public health.

CONCLUSION:

Strengthening Malaysia's optometry education through a national, domain-based competency framework would enhance curriculum comparability, accreditation consistency, and workforce readiness. Enhanced alignment with global standards will support health workforce mobility, policy harmonisation, and the long-term quality assurance of optometric education in Malaysia.

KEYWORDS

competency-based curriculum; curriculum mapping; optometric education, quality education

INTRODUCTION

Competency-based education is an outcome-based curricular model that organises a framework of competencies for students to meet healthcare and societal needs.[1] The emergence of competency-based education initiated a global shift in health professions education, with the adoption of standardised competency frameworks to ensure quality and safe healthcare.[2] These frameworks help align professional qualifications across countries, enabling practitioners to possess a minimum set of comparable competencies worldwide.[3] Consequently, global bodies like the World Health Organisation (WHO) promote such frameworks to standardise professional competencies, support global workforce mobility, and enhance the quality of healthcare worldwide.[4]

Within this global context, the World Council of Optometry (WCO) is an international, membership-based, non-profit organisation serving individual optometrists, industry professionals, and optometric organisations. [5, 6] The council facilitates the development of optometry worldwide and supports optometrists in promoting eye health and vision care as a fundamental human right through advocacy, education, policy development, and humanitarian outreach. Recognising the need for consistent competency standards in optometric education worldwide, the WCO developed the Guide for Optometric Education [6], based on the WHO Eye Care Competency Framework [4], to support the advancement of eye care services globally through a unified, competency-driven approach. It is also aligned with the International Labour Organization (ILO 2022) classification of eye care professions.

The WCO Guide for Optometric Education outlines five core curricular domains representing key areas of optometric practice (Table 1).[6] These domains encompass progressive levels of competency development, aiming to prepare graduates for comprehensive, patient-centred care. The curriculum elements are presented as flexible content areas that support multiple competencies, which allow institutions to organise learning into coherent, scaffolded units that facilitate the development of higher-order thinking, clinical reasoning, and professional judgment.

TABLE 1 CORE DOMAINS IN THE WCO GUIDE FOR OPTOMETRIC EDUCATION

Refractive Error: Assessment and Management
Visual Function Assessment and Management
Ocular Health: Assessment and Management
Public Health
Professional Practice

In Malaysia, all higher education providers offering Bachelor of Optometry programmes are required to follow the national programme standard, which serves as a comprehensive framework to ensure consistency, quality, and relevance in optometric education. [7] This standard is enforced through the collaboration of the Malaysian Optical Council (MOC) and the Malaysian Qualifications Agency (MQA), both of which are tasked with maintaining the highest levels of professionalism in optometry practice.

The latest version of the programme standard is Version 2, 2024, titled Code of Practice for Programme Accreditation (COPPA) Undergraduate Optometry Degree/Opticianry Diploma. [7] This revised guideline is designed to help higher education providers develop and continually improve their optometry programs while adhering to both national and international educational requirements. It also provides a structured quality assurance mechanism that encourages institutions to uphold academic excellence and ensure that graduates are capable of meeting the needs of professionals, society, and the healthcare system. The standard outlines seven areas used for programme evaluation: Programme Development and Delivery, Assessment of Student Learning, Student Selection and Support Services, Academic Staff, Educational Resources, Programme Management, and Programme Monitoring, Review and Continual Quality Improvement. Among these, Area 1, Programme Development and Delivery, is particularly significant, as it sets the tone for the overall design of the curriculum.

Within Area 1, the framework outlines the expectation that the Programme Learning Outcomes (PLOs) should define the competencies students are expected to demonstrate upon graduation, and these should align with the Malaysian Qualifications Framework (MQF) domains. The criteria include the ability to examine eyes, detect and manage visual and ocular disorders, prescribe optical devices and vision therapy, deliver low-vision rehabilitation, and engage in research and entrepreneurship. While these competencies reflect key areas of optometric practice, the standard lacks specific, measurable learning outcomes and performance indicators, making it difficult to ensure consistent implementation across institutions. [8,9]

However, this framework grants higher education providers considerable flexibility to design and customise curricula according to their philosophy, available resources, and graduate profile. It implicitly assumes that each institution will independently translate these broad expectations into detailed curricula, incorporating sufficient clinical depth, assessment strategies, and educational approaches to achieve the intended learning outcomes. While such flexibility encourages innovation and contextual relevance, it may also introduce challenges. Without well-defined national benchmarks or measurable indicators, ensuring consistency, comparability, and comprehensive competency coverage across programmes becomes difficult. [10]

Although the Malaysian Optometry Programme Standard covers a broad range of learning outcomes and curriculum areas, it differs in structure, focus, and competency articulation from the WCO Guide for Optometric Education. Published in 2024, the WCO Guide for Optometric Education introduces a detailed, domain-based competency structure to standardise optometric education globally. [6,11] In contrast, the Malaysian Optometry Programme Standard, last revised in 2024, predates the publication of the WCO Guide for Optometric Education. Therefore, differences in emphasis and domain categorisation are expected.

The scope of this review is specifically focused on Malaysian undergraduate optometric education standards, with particular attention given to competency frameworks. The review seeks to answer the following key questions:

1. How do the competency domains outlined in the WCO Guide for Optometric Education align with those specified in the Malaysian Optometry Programme Standard?
2. What are the gaps or inconsistencies between the two frameworks that may impact the international relevance and comprehensiveness of optometric education provided in Malaysia?
3. How do global trends in optometric education, particularly competency frameworks and educational practices from selected countries, provide context for international benchmarking and inform Malaysia's position within the global landscape?
4. To what extent is the WCO framework relevant and applicable within the Malaysian context, and what are the implications for curriculum development?

Contributions from six countries, namely India, Vietnam, Australia, the United Kingdom, Singapore, and Malaysia, were included based on the availability of published documents identified during the search. These countries were selected based on the availability of relevant published documents and their curricular alignment. In particular, several Asian countries included in this review (India, Australia, Vietnam, Singapore, Malaysia) have optometry education systems historically influenced by or aligned with the United Kingdom model, resulting in similarities in curriculum structure, competency frameworks, and training approaches. [7, 12-16] Australia also demonstrates strong historical and structural alignment with the United Kingdom model, particularly in competency-based optometric education and accreditation systems. [17-18] The inclusion of the United Kingdom, therefore, provides an appropriate benchmark for comparison, while Australia offers an additional established international perspective with a similarly mature competency-based regulatory framework influenced by UK educational traditions. [13, 14] Collectively, this selection supports meaningful contextual comparison while reflecting the current evidence base.

METHODS

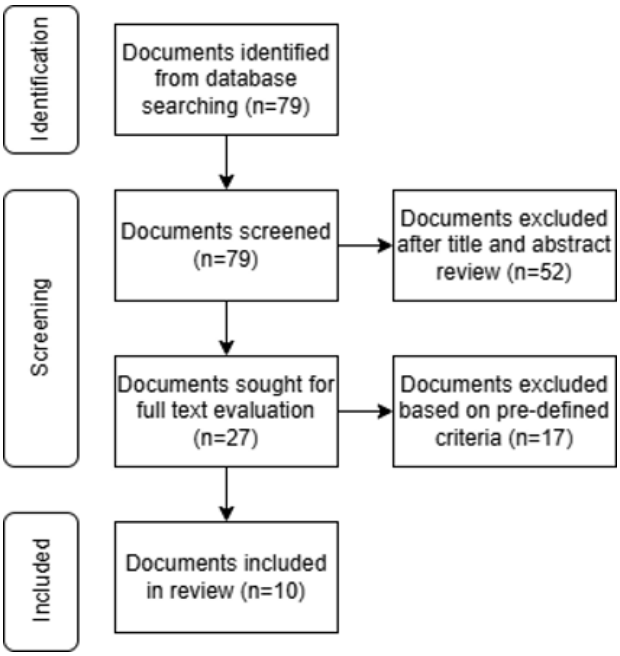
A search for related articles on undergraduate optometric education standards was conducted across the following databases: Google, Google Scholar, PubMed, Scopus, Web of Science, ProQuest, and ResearchGate. A combination of relevant keywords and search strings were used to identify pertinent document, including: "WCO ECCF" OR "World Council of Optometry ECCF", "WHO ECCF" OR "World Health Organization competency framework", "WCO Guide for Optometric Education" OR "WCO education guideline*", "MQA" OR "Malaysian Qualifications Agency", "MQF" OR "Malaysian Qualifications Framework", "COPPA" AND "optometry", "COPPA" AND ("curriculum" OR "program standard*"), "Optometry program standard*" OR "optometry education framework*", "Competency-based optometry curriculum" OR "CBE in optometry", "Optometric education" AND ("India" OR "China" OR "Australia" OR "United Kingdom" OR "UK"), "Optometry education standard*" AND ("India" OR "China" OR "Australia" OR "UK"), "International comparison of optometry education", "Healthcare curriculum mapping" OR "educational alignment in health professions", and "Curriculum mapping" AND "optometry".

A total of 79 records were identified through the database and supplementary searches. These included policy documents, competency frameworks, and curriculum standards; therefore, the term "documents" is used consistently throughout the review rather than referring to empirical studies. A structured screening approach was applied to enhance transparency. Eligibility criteria included relevance to optometric competency frameworks, curriculum mapping, and educational standards (2010–2024). A flow diagram illustrating the study selection process is provided to enhance transparency (Figure 1).

During screening, all 79 records underwent title and abstract review, resulting in the exclusion of 52 records. Inclusion criteria encompassed publications dated between 2010 and 2024; studies focused on optometric or allied health professional education; content addressing competency frameworks, curriculum mapping, or educational standards; inclusion of empirical studies, descriptive reports, policy documents, or document reviews; relevance to undergraduate, postgraduate, or continuing professional development (CPD) education; written in English; and full-text availability. Duplicate publications, articles lacking methodological clarity, studies with no clear relevance to competency-based education models, and non-English language publications were excluded.

Following screening, 27 full-text documents were assessed for eligibility; 17 were excluded based on predefined criteria. A total of ten documents were ultimately included in the final synthesis.

FIGURE 1: FLOW DIAGRAM OF DATABASE SEARCH AND DOCUMENT SCREENING



Document selection was conducted independently by two of the authors. Disagreements were resolved through structured consensus discussions among the authors rather than through formal focus group methodology. This process was conducted iteratively to ensure consistency in study inclusion and thematic synthesis.

RESULTS AND DISCUSSION

Ten main documents were analysed. These comprised two international competency frameworks, six professional or accreditation guidelines, and two educational curriculum sources. Table 2 presents the documents included in this review.

TABLE 2 INTERNATIONAL COMPETENCY FRAMEWORKS, PROFESSIONAL GUIDELINES, AND EDUCATIONAL DOCUMENTS INCLUDED IN THE REVIEW (N=10)

Category	Document/Framework	Country/Region	Citation
International competency framework	WHO Eye Care Competency Framework (WHO ECCF)	International	[4]
	WCO Competency Framework for Optometry	International	[6]
Accreditation guideline	GOC Accreditation and Quality Assurance Handbook (2015)	United Kingdom	[18]
	Indian Entry Level Optometry Competency Skill Standard (IELOCS)	India	[12]
	Model Curriculum Handbook for Optometry (2015–2016)	India	[13]
	Entry-Level Competency Standards for Optometry	Australia	[17]
	Optometry Programme Standard (MQA, 2024)	Malaysia	[7]
	The Global Optometry Resources	Vietnam	[14]
Educational curriculum source	Course subjects taught in Singapore Polytechnic	Singapore	[15]
	Course subjects taught in Ngee Ann Polytechnic	Singapore	[16]

The selected documents represented contributions from six countries: India, Vietnam, Australia, the United Kingdom, Singapore, and Malaysia, reflecting diverse educational systems and competency development approaches. This mix of sources provided a comprehensive view of both global and national perspectives on competency-based optometric education. The documents from WHO ECCF, WCO, India, Vietnam, Australia, the UK, and Malaysia defined optometry as the award of a bachelor's degree or higher from a tertiary education institution. Meanwhile, Singapore Polytechnic and Ngee Ann Polytechnic offer optometry education at the diploma level rather than the bachelor's degree level, reflecting a different entry qualification pathway compared to the international competency frameworks and other university-based optometry programs.

Alignment and Divergence Between the WCO Guide for Optometric Education and the Malaysian Optometry Programme Standard

The analysis shows partial to moderate alignment between the WCO Guide for Optometric Education and the Malaysian Optometry Programme Standard (Table 3). Both aim to prepare entry-level optometrists. However, the WCO framework is more structured, as it provides clearly defined competency domains, detailed skill expectations, and measurable performance indicators for curriculum delivery and assessment. [6] In contrast, the Malaysian standard uses broader programme learning outcomes and competency descriptions aligned with the Malaysian Qualifications Framework and national higher education requirements. [19] This leads to differences in clarity and measurability rather than core content. [1,2]

In the three clinical domains (refractive error, visual function, and ocular health), there is strong conceptual overlap. Both frameworks include refraction, binocular vision, ocular disease management, and contact lenses. However, the WCO framework defines skills in more detail and shows clearer progression of competencies [6]. For example, it outlines specific competency elements, performance criteria, and related curriculum content for each clinical skill. The Malaysian standard remains general and does not clearly define performance levels or a structured skill development framework, especially in advanced areas such as myopia management and rehabilitation. [7] This indicates that while clinical intent is aligned, the depth of competency articulation differs significantly between the two frameworks.

Divergence between the WCO framework and the Malaysian standards is found in the non-clinical domains. The WCO framework explicitly includes public health, epidemiology, health systems, communication, teamwork, and digital health [4,6]. In the Malaysian standard, these areas are either absent or only indirectly mentioned. Although the Malaysian standard includes ethics, professionalism, and community service, these areas are not clearly structured as competencies. [3,11] This reduces clarity in assessing graduate capability in these non-clinical domains and highlights a gap in the formal recognition of broader professional roles.

Overall, the competency domains in the WCO Guide for Optometric Education show partial to moderate alignment with those in the Malaysian Optometry Programme Standard. Both frameworks cover core clinical domains such as refractive error management, visual function assessment, and ocular health, indicating strong conceptual agreement in preparing entry-level optometrists. However, the WCO framework presents these domains in a more structured and detailed manner, with clearly defined competencies and performance criteria, whereas the Malaysian standard presents them through broader programme learning outcomes without explicit performance indicators. Non-clinical domains such as public health, communication, and professional practice also align with intent but are more comprehensively and explicitly articulated in the WCO framework.

TABLE 3: MAPPING OF THE WCO GUIDE FOR OPTOMETRIC EDUCATION TO THE MALAYSIAN OPTOMETRY PROGRAMME STANDARD

WCO Domain	WCO Competencies	Corresponding Elements in Malaysian Standard	Alignment Level	Identified Gaps
Refractive error: assessment and management	Subjective & objective refraction, prescribing and dispensing spectacles/contact lenses, myopia management	Refraction, dispensing, contact lenses, and low vision care	Moderate	No explicit emphasis on individualised corrective plans or structured myopia management approaches
Visual function assessment and management	Binocular vision, oculomotor function, accommodation, visual perception, low vision, workplace vision care	Binocular vision, paediatric optometry, low vision, community optometry	Partial	Limited documentation of training in oculomotor function, visual perception, and structured rehabilitation protocols
Ocular health: assessment and management	Evaluation of anterior/posterior ocular structures, OCT, therapeutic pharmaceutical agents, ocular emergencies	Diagnostics, ocular disease, pharmacology, basic ocular therapeutics	Contextually aligned	Competency in pharmacological management is limited by national scope (per the Optical Act 1991)
Public health	Social determinants of eye health, epidemiology, community outreach, health systems	Community optometry, public health projects, limited outreach training	Low to Moderate	No defined public health competencies; lacks epidemiology, systems-based practice, and measurable population health outcomes

Professional practice	Ethics, patient communication, record-keeping, legal compliance, interprofessional collaboration	Governance, legal and ethical topics, professionalism	Partial	Absence of explicit competencies in patient communication, empathy, interprofessional teamwork, and digital health readiness

Gaps Between the WCO Framework and the Malaysian Standard: The Impact on Malaysia's Global Standing in Optometric Education

Table 4 summarises the curriculum gaps between the WCO framework and the Malaysian standard. The WCO framework groups competencies into defined domains with performance expectations, which supports standardised assessment. [6,17] This would lead to a more structured curriculum planning, competency-based teaching, and uniform assessment across different training institutions and clinical settings. In contrast, the Malaysian system allows interpretation at the institutional level, enabling Malaysian universities to adapt curriculum delivery to local educational priorities, available resources, and clinical training environments. [3,10]

Another gap is the limited definition of public health and professional skills in the Malaysian standard. The WCO framework includes population eye health, epidemiology, communication, teamwork, and digital readiness as core competencies. [4,6] In the Malaysian standard, these areas are present in teaching but are not clearly defined as measurable outcomes. [7] Although this provides Malaysian institutions with the flexibility to integrate professional and public health elements into their curricula through diverse teaching and assessment approaches, the absence of a clear domain-based structure and measurable indicators in the Malaysian framework may result in differences in how competencies are implemented and assessed across institutions. It could also make these competencies less visible within graduate competency profiles and curriculum evaluation processes.

In addition, the Malaysian regulatory scope also influences the design of the optometry curriculum. In Malaysia, the Optical Act 1991 limits the scope of clinical practice; Section 31 of the Act restricts the use of drugs for vision examination to medical practitioners, although registered optometrists may use selected drugs for refraction, provided they are approved by the Malaysian Optical Council. [20] This limits the extent to which clinical competencies can be developed in the Malaysian optometry curriculum compared to countries such as the UK and Australia, where the scope has expanded alongside education reforms [5, 21]. Such regulatory differences highlight how policy environments directly shape educational outcomes and expectations for competency frameworks.

Overall, the main gaps between the two frameworks lie in differences in structure, measurability, and regulatory framing rather than in core clinical content. While Malaysia demonstrates strong coverage of fundamental optometric competencies, the WCO framework provides a more explicit domain-based structure with clearly defined performance indicators that support consistent assessment and international comparability. The Malaysian framework relies more on broader outcome statements and institutional interpretation, which may lead to variation in how competencies are operationalised and assessed. In addition, public health and professional practice skills are less explicitly defined as measurable outcomes in Malaysia, reducing their visibility within competency profiling. Regulatory constraints also shape the extent of clinical competency development, particularly in therapeutic practice. Collectively, these differences may influence the international comparability and comprehensiveness of Malaysian optometric education, particularly regarding standardisation and holistic competency documentation.

Global Trends and Benchmarks for Malaysian Optometric Education

Globally, optometric education is moving towards competency-based models that focus on measurable skills, aiming to improve workforce readiness and standardisation. Competency-based education is widely supported in health

professions, although implementation varies across systems. [1,2] This global shift provides important context for interpreting national differences.

Countries such as the UK and Australia have well-developed competency systems in which education, accreditation, and professional practice are closely linked (Table 5). [18,21] These systems also show that education reforms have supported expansion of clinical roles over time, including advanced practice and prescribing rights. [5,11] This reflects a strong integration between competency frameworks and workforce evolution.

In contrast, India, Vietnam, and Singapore show developing or transitional systems, meaning that their optometry education frameworks are evolving towards more competency-based and standardised models, but implementation is still being refined across institutions and regulatory structures. For example, in Vietnam, optometrists are generally trained at the Bachelor's degree level within university-based programmes, although the profession is still in its early stages and is undergoing ongoing structural and regulatory refinement. [22] These countries also include core clinical competencies but have less consistent coverage of public health and professional practice domains. This may affect the extent to which graduates are uniformly prepared in areas such as interprofessional collaboration, population eye health, communication, and healthcare systems practice when compared with more fully standardised international competency frameworks.

Implementation also varies across institutions due to differences in resources and regulations, as well as the adoption of competency-based education principles. [12,15,22] For example, differences in clinical training facilities, access to specialised equipment, faculty expertise, institutional priorities, and national regulatory requirements may influence how competency-based education is delivered and assessed across programmes.

In addition, regulation plays a major role in shaping optometry education and professional training. Scope-of-practice laws influence the range of clinical skills that can be taught, assessed, and practised within each country. In Malaysia, the Optical Act 1991 limits certain aspects of clinical practice, particularly the use of drugs for vision assessment and related procedures. [20] As a result, educational programmes are designed within these legal boundaries. In contrast, countries such as the United Kingdom and Australia have gradually expanded optometric practice roles through regulatory developments that evolved alongside educational advancement and competency training [17-18]. This demonstrates the close relationship between education and policy, where educational frameworks not only respond to existing regulations but may also support future professional development and scope expansion.

Across systems, benchmarking is most useful as a tool for improvement rather than direct adoption, meaning that international frameworks are better used to identify strengths, gaps, and areas for curriculum enhancement rather than implemented unchanged within another educational system [19,23]. Global frameworks provide guidance but must be adapted to local contexts, as differences in healthcare systems, scope-of-practice regulations, educational structures, workforce needs, and available resources influence how competencies are taught and applied in each country [10,23]. Therefore, international standards function more as reference points than prescriptive models.

Globally, optometric education is increasingly shaped by competency-based frameworks that emphasise measurable outcomes, structured skill domains, and integration with clinical practice, providing a clear basis for international benchmarking. These global trends provide a comparative reference that helps position Malaysian optometric education within the international landscape. As a result, international frameworks may inform Malaysia's curriculum development by highlighting areas for refinement and reinforcing its ongoing progression towards a more structured competency-based education system.

TABLE 4. STRUCTURAL AND CONTENT GAPS BETWEEN THE WCO GUIDE FOR OPTOMETRIC EDUCATION AND THE MALAYSIAN OPTOMETRY PROGRAMME STANDARD

Identified Gap	Description	Implications
Absence of domain-based structure	The Malaysian standards adopt a flexible structure that is not explicitly aligned with clinical or functional domains.	Reduces clarity in curriculum planning, delivery, and assessment; hampers direct benchmarking.
Lack of performance indicators	Learning outcomes in the Malaysian framework are presented in broad terms, allowing for adaptable interpretation.	Hinders objective assessment of student competency; reduces transparency in meeting minimum standards.
Underdeveloped public health focus	Community service is acknowledged, providing a foundation for expanding structured content in epidemiology and health systems.	Limits graduate preparedness for population-based care, health promotion, and multidisciplinary collaboration.
Limited emphasis on professional soft skills	The current framework provides an opportunity to further develop areas such as communication, empathy, and digital readiness.	May result in graduates lacking essential readiness for workplace and patient care in modern clinical settings.
Scope-of-practice constraints	The WCO competencies extend beyond current legal prescribing rights in Malaysia, highlighting areas for future policy alignment.	Necessitates local adaptation of the WCO framework; may affect recognition of its full scope in international settings.

TABLE 5. NATIONAL OPTOMETRY COMPETENCY FRAMEWORKS IN SELECTED COUNTRIES AND THEIR ALIGNMENT WITH WCO GUIDELINES

Country	National Framework	Source	WCO Domain Coverage	% Domains Covered	Key Features
India	Model Curriculum Handbook for Optometry (2015–2016) – Ministry of Health and Family Welfare, India.[13] Ministry of Health and Family Welfare. Allied Health Section. Model curriculum handbook: optometry. New Delhi: MoHFW; 2016. Indian Entry Level Optometry Competency Skill Standard (ASCO 2021) – Association of Schools and Colleges of Optometry.[12] Association of Schools and Colleges of Optometry. Indian Entry Level Optometry Competency Skill Standard (IELOCS). 2021.	Developed by ASCO; partially adapted from WCO model	Refractive Visual Ocular Health	60%	Competency-based education; partial standardization across institutions
Vietnam	Optometry training programme via international	Brien Holden Foundation, Pham	Refractive Visual	60%	WCO-informed with global expert input;

	collaboration. Brien Holden Foundation. [14] Global Optometry Resources [Internet]. Sydney (NSW): Brien Holden Foundation.	Ngoc Thach University, HCMC Eye Hospital; WCO-informed	Ocular Health		local adaptation required
Australia	Entry-Level Competency Standards for Optometry.[17] Hamlyn BR, Hart KM, Kiely PM, et al. Entry-level competency standards for optometry 2022. Clin Exp Optom. 2025;108(3):380–393.	Developed with stakeholder feedback; submitted to WCO for review	Refractive Visual Ocular Health Public Health Professional Practice	100%	Detailed guidance; aligned to WCO; includes independent prescribing
United Kingdom	Accreditation and Quality Assurance Handbook (General Optical Council 2015).[18] General Optical Council. Accreditation and quality assurance handbook: routes to registration in optometry. London: GOC; 2015.	Overseen by General Optical Council; WCO-informed	Refractive Visual Ocular Health Public Health Professional Practice	100%	Comprehensive national standards; detailed public health & professional skills documentation
Singapore	Singapore Polytechnic. Optometry course information.[15] Ngee Ann Polytechnic.[16] Diploma in Optometry programme information.	Public documentation limited; domain-oriented	Refractive Visual Ocular Health	60%	Domain-based, partial WCO alignment; prescribing restricted
Malaysia	Optometry Programme Standard (MQA 2024).[7] Malaysian Qualifications Agency. Code of practice for programme accreditation: optometry programme standards. Petaling Jaya: MQA; 2024.	MQA 2024	Refractive Visual Ocular Health	60%	General learning objectives; lacks unified entry-level competency framework; institutional QA varies

Relevance of the WCO Framework to the Malaysian Context and Implications for Curriculum Development

The WCO competency framework is a globally recognised reference for entry-level optometric competencies and is relevant as an aspirational benchmark for Malaysia. [6] Its domain-based structure provides a clear view of modern optometric practice, covering clinical care, public health, and professional responsibilities. In Malaysia, the framework is relevant in principle as it supports global standardisation and workforce mobility. However, direct adoption is limited by differences in education structure and national regulatory requirements. The Malaysian Optometry Programme Standard follows an Outcome-Based Education (OBE) model aligned with the Malaysian Qualifications Framework, focusing on local healthcare needs rather than global benchmarking. [7]

A key limitation to the direct use of the WCO framework is differences in the scope of practice across countries. In Malaysia, the Optical Act 1991 restricts therapeutic prescribing and certain advanced clinical tasks. [20] In contrast, countries such as Australia and the United Kingdom have expanded optometric roles through regulatory changes, enabling broader clinical responsibilities within competency-based education systems. [5,21] In these countries, changes in education have often come before changes in regulation, supporting the gradual expansion of practice. Overall, Malaysia's approach reflects a regulation-aligned education system that ensures safe, standardised practice while providing a stable foundation for future competency and scope development.

This creates a gap between training and clinical practice. Although Malaysian students may learn competencies aligned with global expectations, not all skills can be fully applied in practice due to legal limits. This may lead to underuse of graduate abilities and limit the development of advanced clinical roles. It also shows the need to align both curriculum design and regulatory frameworks so that education translates into actual workforce capability. Without this alignment, competency-based education may remain strong in theory but limited in practice. [3,11]

From a curriculum perspective, the findings support adapting the WCO framework rather than adopting it directly. A hybrid approach is more suitable, where WCO domains are mapped onto the Malaysian OBE structure, rather than fully replacing one with the other. This can improve clarity, consistency, and international comparability. Priority should be given to strengthening areas that are less clearly defined in the Malaysian standard, such as public health optometry, digital health, and interprofessional collaboration. [6,11] Adding clear performance indicators would also improve assessment and make competency achievement more consistent across institutions. [17]

Future changes should be introduced in stages. The first step is to map the curriculum and identify gaps. The next step is refining learning outcomes and assessments based on competency principles. The final step involves working with regulatory bodies and professional stakeholders to ensure that any curriculum changes align with potential scope-of-practice updates. This gradual approach allows improvement without disrupting existing systems while moving towards international alignment. [10,23]

A wider implication of this study is that education can influence future policy. In countries such as the United Kingdom and Australia, developments in competency-based education have supported the later expansion of optometric roles and regulatory change [5,21], showing that education can help drive policy development. In Malaysia, strengthening competency-based education may similarly support future discussions on scope expansion and workforce development.

In summary, the WCO framework is relevant to Malaysia as a reference for improving optometric education. However, its use must consider the local education structure and regulatory limits. A contextualised alignment approach is more appropriate than full adoption. Mapping global competencies into the Malaysian framework can improve clarity, strengthen graduate readiness, and support gradual progress towards international standards.

LIMITATIONS

Although this review provides a structured competency mapping, certain limitations should be acknowledged. It employed elements of narrative synthesis to interpret the findings, introducing subjectivity. It is also focused on policy documents and official guidelines, which may have excluded non-English or unpublished materials. Consequently, the findings represent a structured synthesis of policy-level evidence rather than an exhaustive account of global optometric education standards.

CONCLUSION

With its domain-based design, clearly defined performance indicators, and international alignment with the WHO Eye Care Competency framework, the WCO Guide for Optometric Education serves as a practical tool for curriculum planning, assessment, and accreditation. The Malaysian Optometry Programme Standard, while aligned with national regulatory and professional requirements, would benefit from enhanced clarity in defining competencies and stronger

structural alignment with international benchmarks such as the WCO guideline. This review provides a foundational step toward reform, offering direction for future curriculum revisions, institutional benchmarking, and regional collaboration.

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REVIEW ARTICLE

ARTIFICIAL INTELLIGENCE BASED PREDICTION OF EMERGENCY DEPARTMENT REVISITS AND HOSPITALIZATION: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

BACKGROUND AND AIM:

Short-term emergency department readmission is one of the major challenges in resource management and quality of clinical care. The aim of this study was to evaluate the performance of artificial intelligence models in predicting patients' frequent emergency department visits and to investigate the effect of the data type and algorithm used on the sensitivity and specificity of prediction.

METHOD:

The international databases PubMed, EMBASE, and Web of Science were searched using keywords aligned with the study objective between from January 2015 to 10 December 2025. In the present study, 27 studies were included in the meta-analysis. Data analysis was performed using the stata. v17 software and analysis was performed using a random effects model (DerSimonian–Laird) to determine sensitivity and specificity.

RESULT:

The overall sensitivity of the models was 0.61 [95% CI; 0.54 to 0.68] and the overall specificity was 0.83 [95% CI; 0.78–0.89]. Subgroup analysis showed that the type of AI algorithm had a significant effect on diagnostic accuracy; Ensemble and XGBoost models performed better.

CONCLUSION:

Artificial intelligence models can be a useful tool for identifying high-risk ED patients, especially using multi-source data and hybrid algorithms.

KEYWORDS

Artificial Intelligence, Emergency Department, Diagnostic accuracy, Revisit, hospitalization.

INTRODUCTION

Unnecessary patient readmissions and hospitalizations following emergency department (ED) visits represent one of the most significant challenges facing healthcare systems worldwide[1]. According to global statistics, about 15 to 20 percent of patients return within a month after being discharged from the ED, and more than ten percent require re-hospitalization[2, 3]. Repeated visits impose significant direct and indirect costs on the healthcare system, and studies have also reported an increased risk of hospital complications, reduced quality of patient care, and reduced patient satisfaction[4]. Studies have shown that more than 50 million ED readmissions occur annually in the United States, approximately 15 to 20 percent of which result in readmissions within 30 days, and the direct cost of these visits is estimated to be $3 to $5 billion[5]. Identifying high-risk patients at the first visit to the ED to prevent readmissions can reduce the burden on healthcare systems, and accurate prediction of these events allows for the design of preventive interventions and evidence-based clinical decision-making[6, 7]. These challenges highlight the need for more advanced predictive approaches beyond traditional statistical methods.

Over the past decade, the use of artificial intelligence (AI) has emerged as an advanced tool in predicting clinical outcomes and managing big data[8, 9]. Evidence has shown that models based on machine learning and neural networks have the ability to extract complex patterns and accurately predict emergency department revisits and hospitalizations[10-12]. Systematic reviews have highlighted the increasing use of mobile and AI-based applications in supporting decision-making processes and vulnerable populations, highlighting the scalability and adaptability of AI-based models across diverse real-world settings in diverse real-world contexts[13]. In addition to clinical applications, recent evidence from higher education has shown that AI systems can achieve acceptable levels of reliability, validity, and fairness in complex assessment tasks, although concerns regarding alignment with human judgment remain[14].

The importance of using artificial intelligence models in predicting and reducing unnecessary readmissions can reduce the economic burden, decrease hospital complications, improve healthcare quality, and enhance satisfaction among patients and emergency department staff[15]. Therefore, the development and application of artificial intelligence can have a significant impact on the efficiency, safety, and economics of healthcare systems[16, 17]. Despite the growing number of studies investigating AI-based prediction models in emergency care, the reported diagnostic performance of these models remains heterogeneous, and the influence of algorithm type and data source on predictive accuracy has not been comprehensively synthesized. Therefore, this systematic review and meta-analysis aimed to evaluate the diagnostic performance of AI-based models for predicting emergency department revisits and hospitalizations and to examine the impact of algorithm type and data source on model accuracy.

METHOD

STUDY DESIGN AND REPORTING STANDARDS

The present study was designed as a systematic review and meta-analysis to evaluate the performance of artificial intelligence models in predicting ED readmissions and hospitalization. The reporting process was conducted according to the PRISMA 2020 guidelines[18]. As this study was based exclusively on previously published data, ethical approval was not required. Ethical considerations were addressed according to the requirements reported in the original studies. All steps, including search, screening, data extraction, and analysis, were performed independently by two researchers, and disagreements were resolved with a third reviewer. The international databases PubMed, EMBASE, and Web of Science were evaluated for articles using keywords from January 2015 to 10 December 2025. In addition, a search for grey literature sources in Google Scholar and a review of the reference lists of the included studies were also conducted. The research question was defined based on the PICO framework (population, intervention, comparison, and outcome). The study protocol was developed at the beginning to clarify the purpose, inclusion and exclusion criteria, evaluation method, and data analysis method.

MESH TERMS USED TO RETRIEVE LITERATURES:

((((((((((((((((("Emergency Service, Hospital"[Mesh] OR "Emergency Room Visits"[Mesh]) OR "Emergency Service, Hospital"[Majr]) OR "Emergency Room Visits"[Majr]) OR "Emergency Medical Services"[Mesh]) AND ("Patient Readmission"[Mesh] OR "Patient Admission"[Mesh])) OR "Patient Readmission"[Majr]) OR "Hospitalization"[Mesh]) OR "Hospitalization"[Majr]) OR "Patient Admission"[Majr]) AND "Artificial Intelligence"[Mesh]) OR "Artificial Intelligence"[Majr]) OR ("Artificial Intelligence/classification"[Majr] OR "Artificial Intelligence/statistics and numerical data"[Majr])) OR "Machine Learning"[Mesh]) OR "Deep Learning"[Mesh]) AND "Data Accuracy"[Mesh]) OR "Area Under Curve"[Mesh]) AND ("Sensitivity and Specificity"[Mesh] OR "Parasitic Sensitivity Tests"[Mesh])) AND "Large Language Models"[Mesh]) AND "Diagnosis"[Mesh].

STUDY INCLUSION AND EXCLUSION CRITERIA

Studies that met the requirements of the PICO strategy were included:

Population (P): Patients presenting to the ED without age or diagnostic restrictions.

Intervention (I): Artificial intelligence

Comparison (C): Traditional method/lack of comparator.

Outcome (O): Diagnostic accuracy, sensitivity, specificity

Animal studies, use of non-algorithmic methods, review articles, letters to the editor, conferences, duplicate articles, studies published in languages other than English, failure to provide complete data, and studies that did not have specific objectives were excluded from the study.

DATA EXTRACTION

Data from each included study were independently extracted by two investigators using a standard data extraction form; disagreements between the investigators were discussed and settled by a third researcher. The following data were extracted from each study: first author, publication year, sample size, revisit interval, data source, and AI technique.

QUALITY ASSESSMENT

In the present study, the Predictive Model Bias Assessment Tool (PROBAST) was used to assess the risk of bias in predictive model studies. This tool has 20 questions in four areas (Participants, Predictors, Outcome, and Analysis)[19].

STATISTICAL ANALYSIS

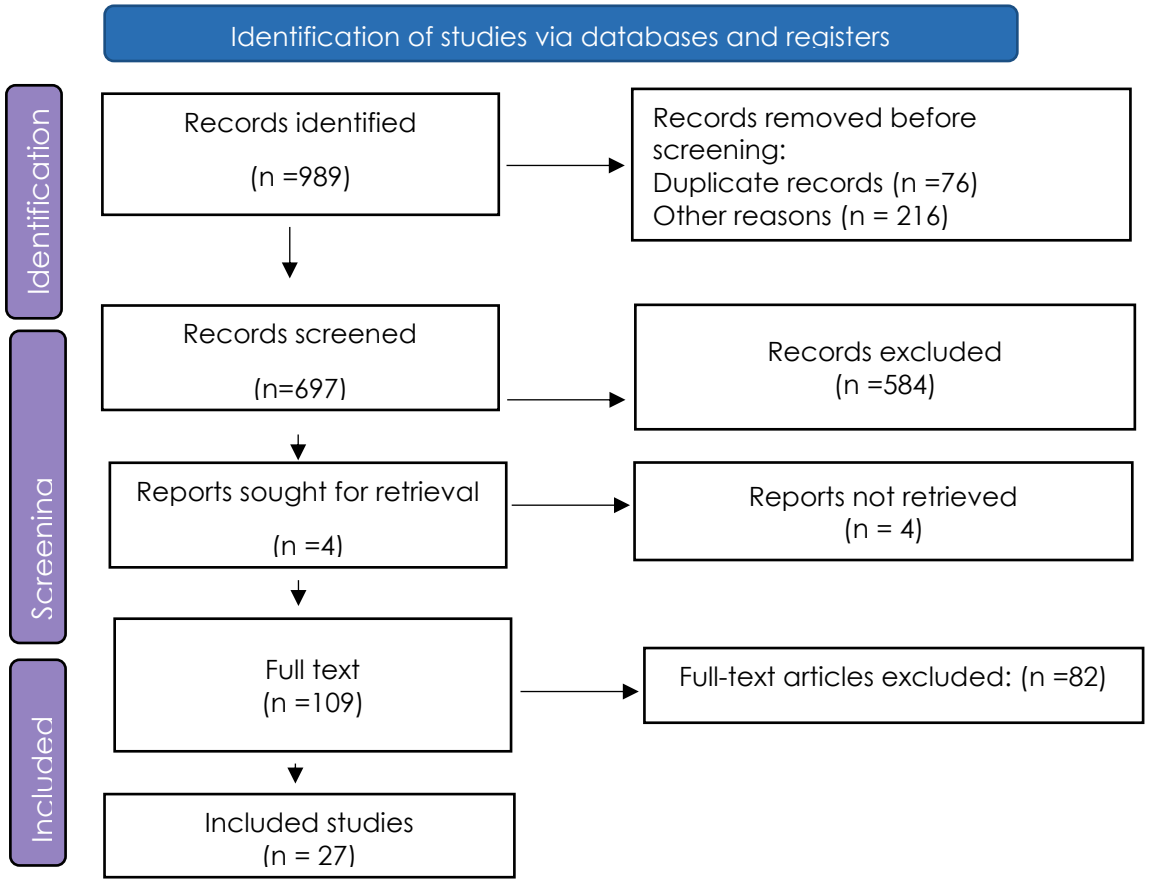
Data analysis was performed using STATA/MP.v17 (College Station, Texas, USA). $p<0.05$ was considered as statistically significant difference. Pooled sensitivity and specificity were calculated using a random-effects model based on the DerSimonian–Laird method. Statistical heterogeneity was assessed using Cochran's Q test and the I^2 statistic: No heterogeneity: $0.0\% < I^2 < 24.9\%$; low heterogeneity: $25.0\% < I^2 < 49.9\%$; Moderate heterogeneity: $50.0\% < I^2 < 74.9\%$; High heterogeneity: $75.0\% < I^2 < 100\%$.

RESULT

LITERATURE SEARCH

The database search identified 989 records, as shown in Figure 1 . After reviewing the titles, 292 of these articles were excluded based on duplication and inconsistency with the inclusion and exclusion criteria; the abstracts of 697 articles were reviewed and studies that did not meet the study selection criteria were excluded at this stage (n=584), and the full text of 109 articles was reviewed by two blind and independent authors. Finally, after removing irrelevant articles, 27 articles were included in the meta-analysis.

FIGURE 1. PRISMA 2020 FLOW DIAGRAM



STUDY CHARACTERISTICS

In the present study, the total sample size was 3,052,833 patients, which included a wide range of data based on electronic health records (EHR/EMR), insurance databases (NHIRD), and multicenter data. Revisit intervals varied substantially across studies. In most studies, 72 hours have been considered, while in others, up to 9 days, 30 days, 120 hours, 7 days, and even three months have been reported. Overall, the heterogeneous nature of the time interval for re-visits, the diversity of clinical characteristics, and the differences in algorithms used across studies highlight the need for a comprehensive meta-analysis to combine results and provide an accurate estimate of the performance of AI models. Collectively, the included studies provided data from more than three million patients, enabling robust quantitative synthesis. Table 1 shows a summary of the study data.

BIAS ASSESSMENT

Of the 27 studies, 14 were assessed as low risk of bias and 13 as having a moderate risk of bias. Most studies had a well-defined population or sufficient sample size, but some had incomplete reporting, which made their status unclear. (Table 2).

TABLE 1. SUMMARY OF DATA EXTRACTED FROM STUDIES

No.	Study. Years	Number of patients	ED revisit interval (Hour)	AUC	Source	AI model
1	Avendano et al., 2025 [20]	3591	72, 216, 720	0.85	EHR	ML
2	Oh et al., 2025 [21]	12977	72	0.74	EHR	ML
3	Liu et al., 2025 [22]	38797	72	0.81	CETAT	MLP

4	Bians et al., 2025 [23]	8969	72	0.84	EHR	ML
5	Sadek et al., 2025 [24]	2023	72	0.75	EHR	XGBoost
6	Watson et al., 2024 [25]	174393	72	0.84	EHR	ML
7	Cohen et al., 2024 [26]	213	3 months	0.71	EHR	ML
8	Hsu et al., 2024 [27]	25225	72	0.71	EHR	Voting
9	Chen et al., 2024 [28]	128848	72	0.64	EHR	BERT
10	Zhang et al., 2024 [29]	62154	72	0.87	EHR	LR
11	Sung et al., 2024 [30]	6282	72	0.82	EMR	stacking Ensemble
12	Saggu et al., 2024 [31]	4473	720	0.70	EHR	GNN
13	Davazdahemami et al., 2022 [32]	657752	72	0.74	EHR	DNN
14	Aldhoayan et al., 2022 [33]	77906	168	0.61	EHR	CatBoost
15	Li et al., 2021 [34]	436810	72	0.93	EHR	XGBoost
16	Hsu et al., 2021 [35]	25151	72	0.74	EHR	Voting
17	Chmiel et al., 2021 [36]	44294	72	0.74	EHR	XGBoost
18	Chen et al., 2021 [37]	49252	72	0.76	NHIRD	C4.5
19	Artetxe et al., 2020 [38]	99858	72	0.64	EHR	Bagging
20	Vest et al., 2019 [39]	279611	720	0.73	EHR	DT
21	Meng et al., 2019 [40]	328733	72	0.73	EMR	DA
22	Hong et al., 2019 [41]	330631	72	0.76	EHR	XGBoost
23	Bergese et al., 2019 [42]	28341	120	0.81	EHR	CT
24	Hu et al., 2017 [43]	125940	120	0.72	EMR	RF
25	Artetxe et al., 2017 [44]	99858	72	0.60	EMR	RF
26	Artetxe et al., 2016 [45]	360	720	0.88	EMR	SVM
27	Besga et al., 2015 [46]	391	720	0.72	EHR	SVM

ED = Emergency Department; EHR = Electronic Health Records; EMR = Electronic Medical Records; CETAT = Clinical Emergency Triage Assessment Tool; DNN = Deep Neural Network; SVM = Support Vector Machine; NHIRD = National Health Insurance Research Database.

TABLE 2. RISK OF BIAS OF PREDICTION MODEL RISK OF BIAS ASSESSMENT TOOL

Study. Years	Participants	Predictors	Outcome	Analysis	Overall
Avendano et al., 2025 [20]	L	L	L	L	Low
Oh et al., 2025 [21]	L	L	L	L	Low
Liu et al., 2025 [22]	L	L	L	L	Low
Bians et al., 2025 [23]	L	L	L	L	Low
Sadek et al., 2025 [24]	L	L	L	L	Low

Watson et al., 2024 [25]	L	L	L	L	Low
Cohen et al., 2024 [26]	L	L	L	L	Low
Hsu et al., 2024 [27]	U	L	L	L	Moderate
Chen et al., 2024 [28]	U	L	L	L	Moderate
Zhang et al., 2024 [29]	L	L	L	L	Low
Sung et al., 2024 [30]	U	L	L	L	Moderate
Saggu et al., 2024 [31]	U	L	L	L	Moderate
Davazdahemami et al., 2022 [32]	U	L	L	L	Moderate
Aldhoayan et al., 2022 [33]	L	L	L	L	Low
Li et al., 2021 [34]	L	L	L	L	Low
Hsu et al., 2021 [35]	L	L	L	L	Low
Chmiel et al., 2021 [36]	L	L	L	L	Low
Chen et al., 2021 [37]	U	L	L	L	Moderate
Artetxe et al., 2020 [38]	U	L	L	L	Moderate
Vest et al., 2019 [39]	L	L	L	L	Low
Meng et al., 2019 [40]	L	L	L	L	Low
Hong et al., 2019 [41]	L	L	L	L	Low
Bergese et al., 2019 [42]	L	L	L	L	Low
Hu et al., 2017 [43]	U	L	L	L	Moderate
Artetxe et al., 2017 [44]	U	L	L	L	Moderate
Artetxe et al., 2016 [45]	L	L	L	L	Low
Besga et al., 2015 [46]	U	L	L	L	Moderate

L: Low risk of bias; U: Unclear risk of bias; H: High risk of bias

SENSITIVITY OF ED REVISIT

The overall sensitivity of the AI models was reported to be 0.60 with a 95% confidence interval between 0.52 and 0.68 (Figure 2). This value indicates that the predictive AI models were able to correctly identify about 60% of actual patient returns to the ED. This sensitivity level is in the medium range, indicating that a significant percentage of repeat visits are still not identified by artificial intelligence models and that there is a need to optimize and improve the algorithms.

Subgroup analysis was performed to investigate the differences in performance of AI models based on the Revisit timeframe. The results showed that the sensitivity was different in different groups, such that after 72 hours the sensitivity was estimated to be 0.60 (95% CI: 0.52–0.70) with very high heterogeneity (I^2 = 89.4%). Revisit timeframe after 30 days was estimated with a sensitivity of 0.59 (95% CI: 0.46–0.71) and high heterogeneity (I^2 = 79.3%), which showed the performance of AI models slightly lower than the 72-hour prediction. Sensitivity was estimated to be 0.66 and 0.91 after 7 days and 3 months, respectively. The AI prediction of readmission after 3 months showed high performance, but its generalizability is limited due to being a single study. The sensitivity after nine days was estimated to be 0.438 (95% CI: 0.046–0.830) with very high heterogeneity (I^2 = 97.3%). The test of difference between groups (Q_b = 29.30, $p < 0.001$) showed that there was a significant difference between subgroups.

The overall heterogeneity of the studies was very high (I^2 = 91.9%). This high level of heterogeneity is due to differences between studies; type of AI algorithms, sample size, length of patient return interval, data quality and study design.

SPECIFICITY OF ED REVISIT

The overall specificity was reported to be 0.84 with a 95% confidence interval between 0.79 and 0.90, the AI models were able to correctly identify more than 84% of non- revisits patients, indicating a relatively good performance of the AI models (Figure 3).

FIGURE 2. FOREST PLOT SHOWED SENSITIVITY OF PREDICTING ED REVISIT

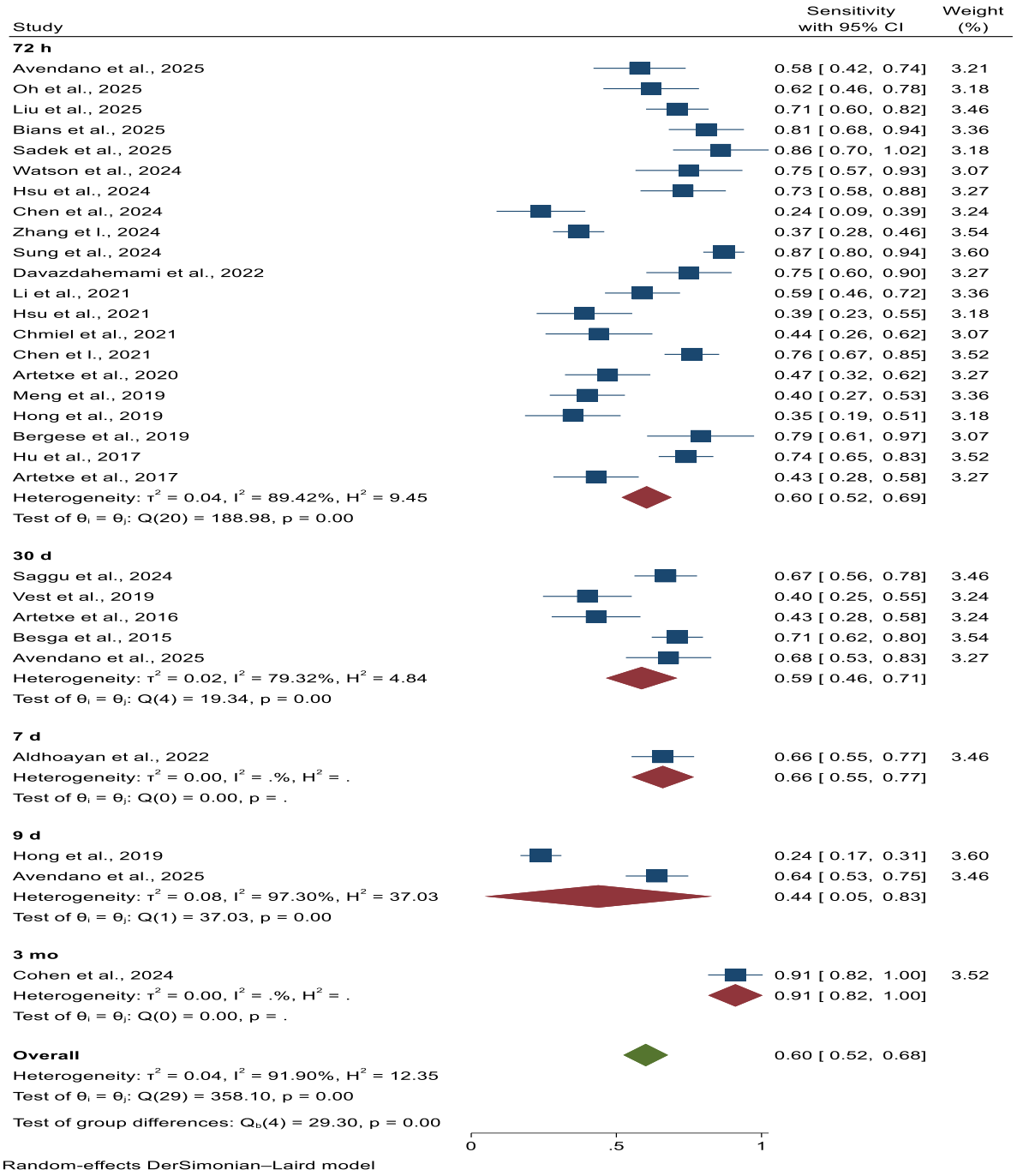
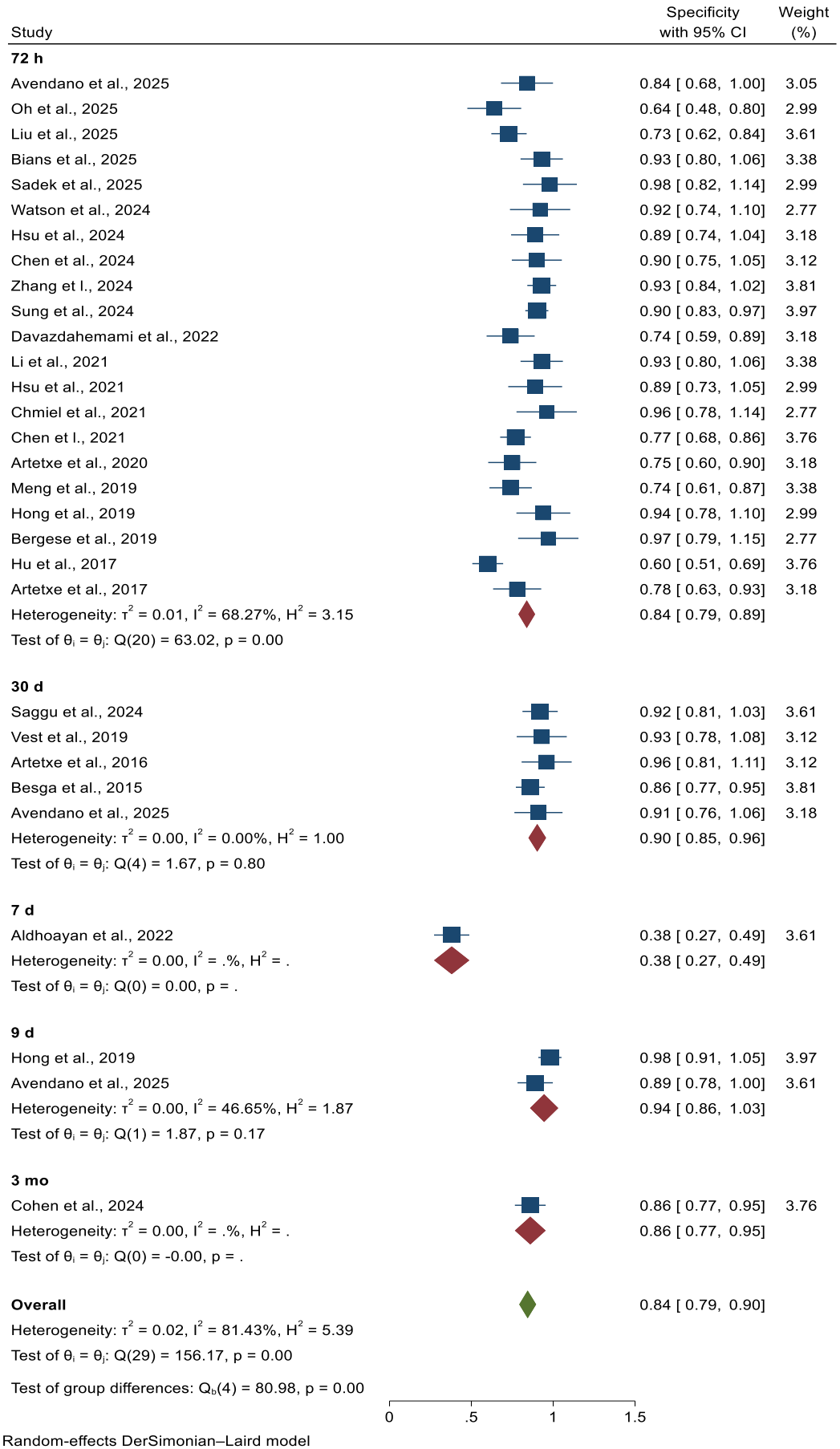


FIGURE 3. FOREST PLOT SHOWED SPECIFICITY OF PREDICTING ED REVISIT



Subgroup meta-analysis was conducted to determine the performance of AI models based on the Revisit timeframe (Figure 3). After 72 hours, the specificity was estimated to be 0.84(95% CI: 0.79–0.89) with high heterogeneity (I^2 = 68.3%). After 30 days, specificity was 0.90 (95% CI: 0.85–0.96) with very low heterogeneity (I^2 = 0.0%). This group had consistent performance, indicating that the models in this group were able to correctly identify approximately 90% of non- revisits patients. After 7 days, the specificity was 0.38, which is relatively low and indicates poor performance of the AI model. After 9 days, specificity was estimated to be 0.95 (95% CI: 0.86–1.031) with moderate heterogeneity (I^2 = 46.7%), indicating very good performance of the models in this group. Specificity was also estimated to be 0.86 after three months, indicating good and reliable performance of the AI model. The difference between groups test (Q_b = 80.98, $p < 0.001$) showed that there were significant differences between subgroups and that the performance of AI models differed based on Revisit timeframe. Overall heterogeneity between studies was high (I^2 = 81.4%), indicating significant differences between algorithms, sample size, patient return timeframe, and data quality.

Due to the high heterogeneity between studies, a subgroup analysis of meta-analysis was performed based on data source and type of artificial intelligence algorithm (Figure 4, 5 and Table 3, 4). Subgroup meta-analysis by data source showed that there was no statistically significant difference between subgroups (Qb = 6.82, p = 0.08) (Figure 4). The highest sensitivity was for national structured databases such as NHIRD (ES: 0.76 95% CI, 0.67 to 0.85) and CETAT data (0.71 95% CI, 0.60 to 0.81). AI Models that relied on EHR (0.60 95% CI, 52 to 0.69) and EMR (0.58 95% CI, 0.37 to 0.78) data showed lower sensitivity (Figure 4), which could reflect the high heterogeneity in clinical data recording, differences in definitions of ED readmission, and the quality of input variables. Although subgroup analysis showed higher pooled sensitivity for AI models using the NHIRD dataset compared to EHR- or EMR-based studies, these findings should be interpreted with caution, as only one study used NHIRD and CETAT data. EHR-based AI models were used in twenty studies, despite lower overall sensitivity and significant heterogeneity reflecting real-world variation in clinical documentation and healthcare systems. Subgroup analysis based on AI algorithms showed a significant difference (Qb = 147.35, $p < 0.001$) (Table 3), indicating the determining role of AI model selection on Sensitivity.

The highest sensitivity was for Stacking Ensemble (0.87 95% CI, 0.799 to 0.941), indicating that combining multiple algorithms can significantly increase the identification of high-risk patients. Also, C4.5, Classification Tree, DNN, and ML models had high sensitivity. The low sensitivity of BERT (0.24 95% CI, 0.087 to 0.393) was notable and could be due to the model's focus on textual data without effective integration of structured clinical data (Table 3).

FIGURE 4. FOREST PLOT SHOWED SUBGROUP META-ANALYSIS OF SENSITIVITY ACCORDING TO DATA SOURCE

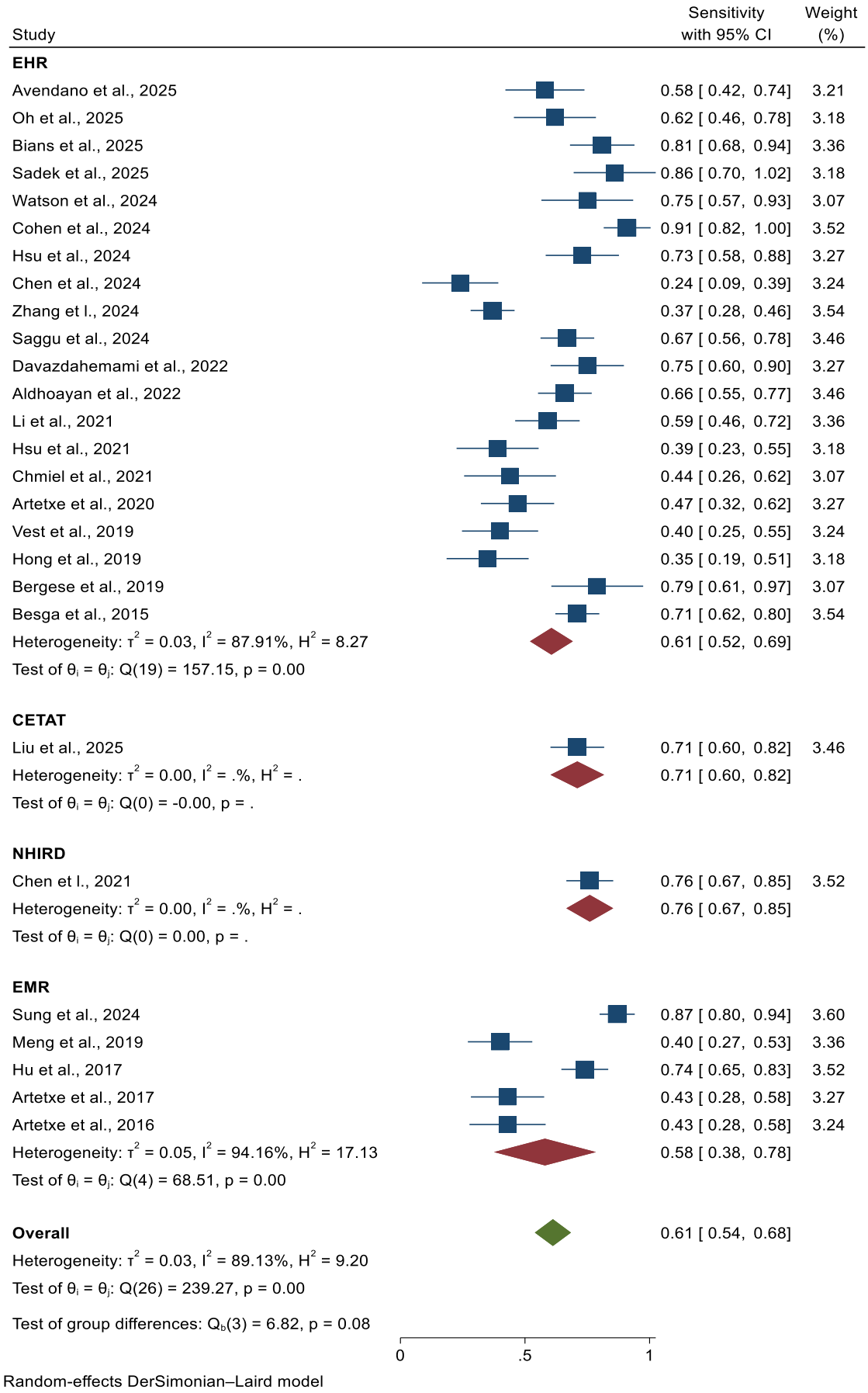
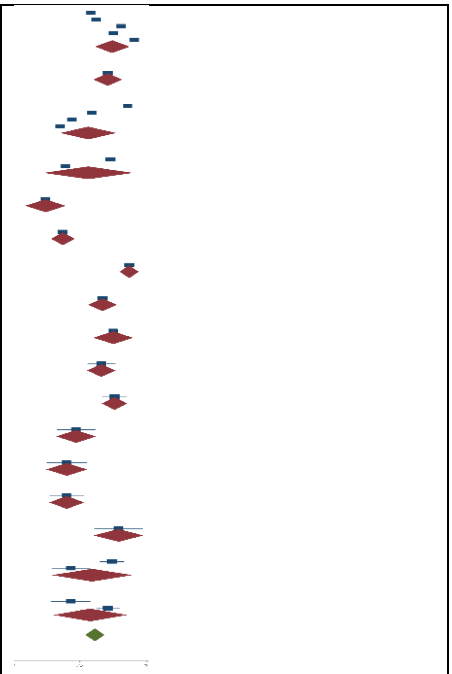


TABLE 3. SUBGROUP META-ANALYSIS OF SENSITIVITY ACCORDING TO ARTIFICIAL INTELLIGENCE ALGORITHM TYPE

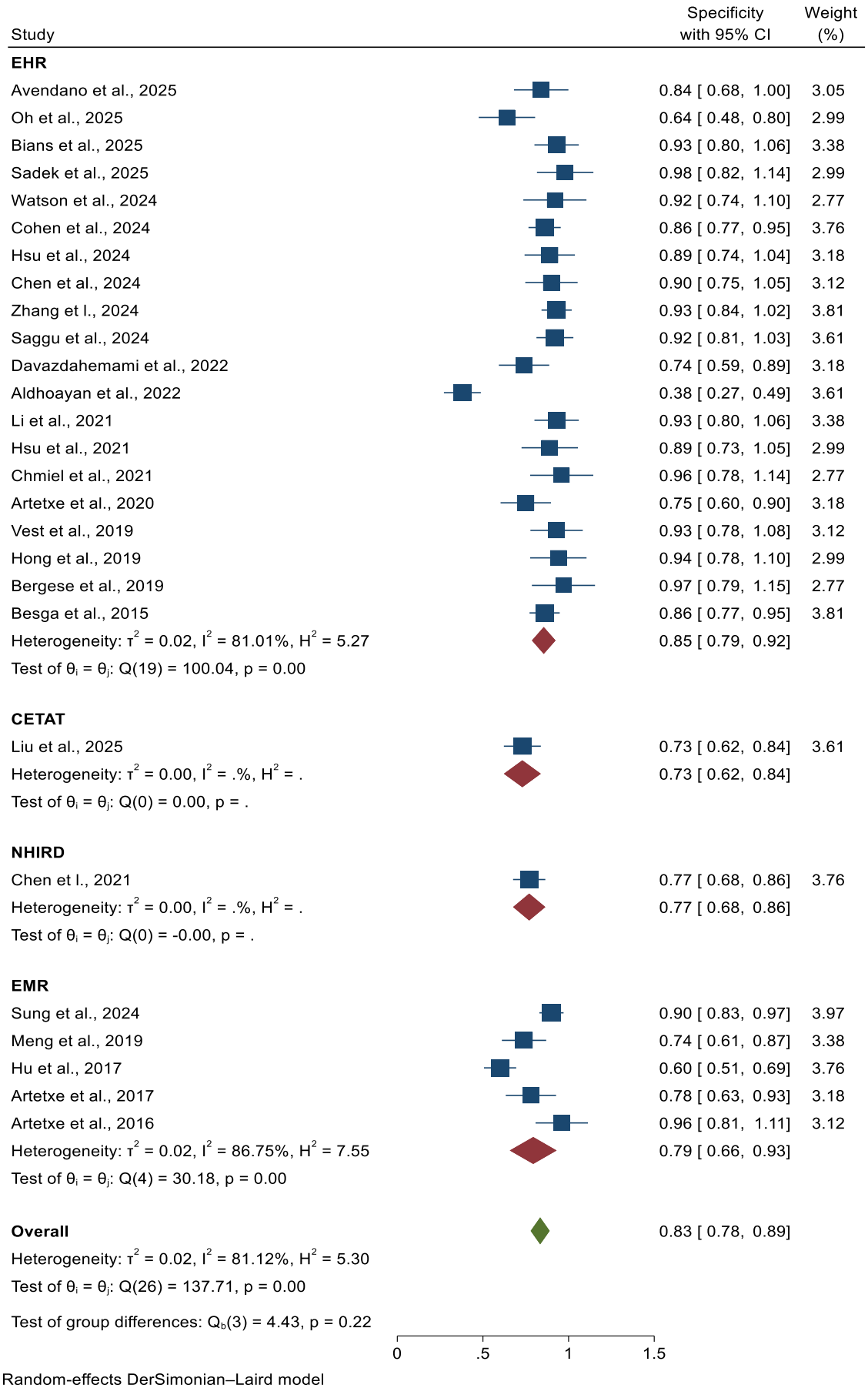
AI algorithm	Number of studies	Pooled Sensitivity	95% Confidence Interval
BERT	1	0.240	0.087 – 0.393
Bagging	1	0.470	0.323 – 0.617
C4.5	1	0.760	0.666 – 0.854
CT	1	0.790	0.606 – 0.974
CatBoost	1	0.660	0.552 – 0.768
DA	1	0.400	0.271 – 0.529
DNN	1	0.750	0.603 – 0.897
DT	1	0.400	0.247 – 0.553
GNN	1	0.670	0.562 – 0.778
LR	1	0.370	0.282 – 0.458
ML	5	0.743	0.612 – 0.874
MLP	1	0.710	0.602 – 0.818
RF	2	0.590	0.287 – 0.894
SVM	2	0.577	0.303 – 0.851
Stacking ensemble	1	0.870	0.799 – 0.941
Voting ensemble	2	0.562	0.229 – 0.895
XGBoost	4	0.562	0.352 – 0.771
Overall	27	0.612	0.539 – 0.685
Tests of group differences	df:16	Q_b= 147.35	P<0.001



In a subgroup meta-analysis by data source type, models developed using electronic health records (EHRs) showed the highest specificity (0.85; 95% CI: 0.78 to 0.92). This was followed by EMR-based studies with a pooled specificity of 0.79 (0.66–0.93) (Figure 5). The difference between subgroups in terms of data source type was not statistically significant (Q_b = 4.43, P = 0.219). These findings indicate that data source type alone did not have a decisive impact on the specificity of AI models.

Subgroup meta-analysis based on AI algorithm type showed significant differences in specificity. The difference test between subgroups in this section was statistically significant (Q_b = 106.76, P<0.001), indicating the important role of AI algorithm choice in model performance (Table 4).

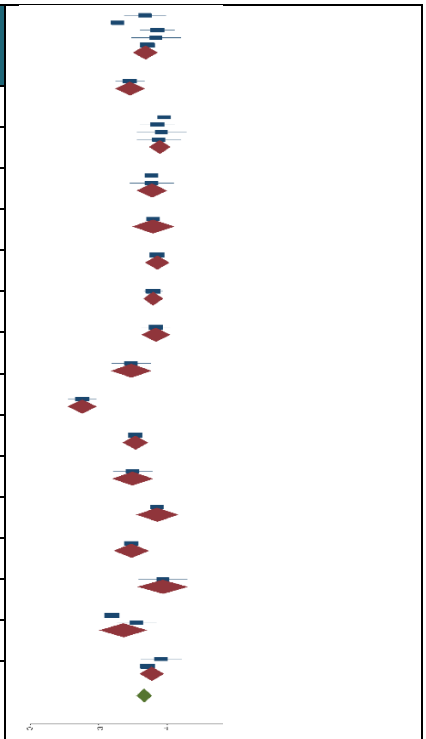
FIGURE 5. FOREST PLOT SHOWED SUBGROUP META-ANALYSIS OF SPECIFICITY ACCORDING TO DATA SOURCE



The highest specificity was related to algorithms based on gradient boosting and ensemble models, with XGBoost showing the best performance with a specificity of 0.95 (95% CI; 0.871 to1.027) and Stacking Ensemble models showing the best performance with a specificity of 0.90 (95% CI; 0.829 to 0.971). Also, some classical algorithms such as logistic regression (LR), decision tree (DT), and graph networks (GNN) also had high specificity (Table 4).

TABLE 4. SUBGROUP META-ANALYSIS OF SPECIFICITY ACCORDING TO ARTIFICIAL INTELLIGENCE ALGORITHM TYPE

AI Algorithm	No. of Studies	Pooled Specificity	95% CI
BERT	1	0.900	0.747–1.053
Bagging	1	0.750	0.603–0.897
C4.5	1	0.770	0.676–0.864
CT	1	0.970	0.786–1.154
CatBoost	1	0.380	0.272–0.488
DA	1	0.740	0.611–0.869
DNN	1	0.740	0.593–0.887
DT	1	0.930	0.777–1.083
GNN	1	0.920	0.812–1.028
LR	1	0.930	0.842–1.018
ML (unspecified)	5	0.843	0.752–0.934
MLP	1	0.730	0.622–0.838
RF	2	0.681	0.505–0.856
SVM	2	0.890	0.800–0.979
Stacking Ensemble	1	0.900	0.829–0.971
Voting	2	0.890	0.780–1.000
XGBoost	4	0.949	0.871–1.027
Tests of group differences	df:16	Q_b= 106.76	P<0.001



DISCUSSION

The findings of the present meta-analysis show that AI models have high specificity (≈0.83) in predicting patients' return to the emergency department, meaning that AI models are able to correctly identify patients who will not return to the emergency department. These results are consistent with the results of previous meta-analyses[47]. A recent meta-analysis that examined the performance of artificial intelligence algorithms in predicting emergency department readmissions showed that the average specificity in these models was about 0.92[47]. One of the notable points in the present meta-analysis was that the source of data used did not significantly affect the diagnostic specificity of AI; this finding suggests that patients who are unlikely to revisit the emergency department are generalizable across different data environments, provided that the data are standardized and reliable. However, heterogeneity between studies was high, which could be due to differences in the type of data recording, the quality of clinical variables, and the study definition of follow-up. Meta-analysis showed that specificity was consistently higher than sensitivity, with sensitivity reported at around 0.56, indicating that the models are less effective in correctly diagnosing patients with readmissions (True Positive) [48]. This observation aligns with the results of the present study; however, sensitivity was estimated to be higher in the present study. Therefore, artificial intelligence models need to improve in detecting actual patient revisits. A pooled sensitivity of 0.61 indicates that approximately 39% of patients who subsequently revisit the emergency department may not be identified by current AI models. From a clinical standpoint, such false-negative predictions may result in missed opportunities for preventive interventions, inadequate discharge planning, insufficient post-discharge follow-up, and suboptimal allocation of healthcare resources for high-risk patients. Consequently, exclusive reliance on AI-based predictions may pose potential risks to patient safety, particularly among vulnerable individuals and those with complex medical conditions.

Despite this limitation, the models included in this study demonstrated consistently high specificity, reflecting a strong capacity to accurately identify patients at low risk of emergency department revisit. Therefore, AI-based predictive models should be considered complementary clinical decision-support tools rather than replacements for physician judgment. When integrated with clinical assessment, triage findings, and professional expertise, these models may contribute meaningfully to risk stratification, optimization of resource utilization, reduction of unnecessary interventions, and enhancement of overall emergency department efficiency. Several studies have shown that using a combination of structured and unstructured data (such as clinical notes) can improve prediction performance, although its operational complexity is high and requires natural language processing skills[49]. Studies show that the use of ensemble algorithms and more complex models is preferred over simpler techniques[50, 51]. In the present study, XGBoost, Stacking Ensemble, and other hybrid approaches demonstrated superior predictive performance. This observation is consistent with previous studies suggesting that ensemble-based methods can better capture the complexity of clinical data[30, 52-56]. Many previous meta-analyses and systematic reviews on the use of AI in the emergency department have generally addressed the broad applications of AI without emphasizing quantitative measurements of the model, focusing on the transformative role of this technology in patient diagnosis and management[57]. This indicates that the field of predicting patient return to the emergency department is still relatively new and requires further studies with better reporting standards.

There were several important limitations in the present study that should be considered; high heterogeneity was observed between studies, which could be due to the AI algorithms, the criteria for defining ED revisits, and the duration of patient follow-up. Therefore, the present findings should be interpreted with caution. The number of studies in some algorithms and data sources was limited, which resulted in estimates of sensitivity and specificity with lower precision and wider confidence intervals. Therefore, more studies are needed to provide stronger evidence. Many studies used data from a single center, which limits the generalizability of the results to other populations or health systems. Also, some studies lacked full reporting of validation or multi-stage modeling, which may have led to overestimation of the true performance of the models. Finally, differences in data quality and handling of missing values between studies could also have affected the accuracy of the estimates. Furthermore, a significant geographical imbalance was observed among the included studies, with a heavy concentration of data from specific Asian healthcare databases. Future research should include more studies from Western healthcare systems would be essential to ensure the findings are generalizable to different healthcare infrastructures and patient populations.

Future research should focus on improving the identification of patients at genuine risk of emergency department revisit and utilize clinical features, textual data, and composites. To increase the generalizability of models, studies should examine multicenter data. Using structured and unstructured data simultaneously can increase predictive performance. Future research should be reported according to TRIPOD or PROBAST guidelines to allow for accurate assessment of quality and risk of bias. Based on the present results, hybrid and ensemble algorithms performed better; therefore, it is recommended to use these approaches in designing prediction models.

CONCLUSION

The present study showed that AI models demonstrated good performance in identifying patients who were unlikely to revisit the emergency department, and the overall specificity was estimated to be about 0.83. However, the sensitivity of AI models was reported to be moderate, indicating that AI models need to be improved in detecting real revisits. The type of data used did not have a significant impact on specificity and sensitivity, but the type of AI algorithm played a significant role in model performance, especially the Ensemble and XGBoost models, which provided higher performance. These findings emphasize that integrating multi-source data and using advanced hybrid algorithms can improve prediction accuracy.

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REVIEW ARTICLE

FROM ALGORITHMS TO EMPATHY: EMOTIONALLY INTELLIGENT AI COMPANIONS IN ELDER MENTAL HEALTH CARE: A SCOPING REVIEW

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ABSTRACT

BACKGROUND

The increased mental illness of the older individuals caused by loneliness, memory loss, and the absence of an emotional support system require innovative solutions. This review examines the ways in which emotional intelligence would be implemented in virtual companions to assist in improving mental health outcomes in elder care centres.

OBJECTIVE

The primary goal of this study is to examine the current applications and theoretical principles in order to understand how the emotionally intelligent virtual companions can enhance the traditional eldercare through appropriate emotional assistance.

METHODS

The PRISMA-ScR guideline was used to conduct a scoping review. Peer-reviewed literature published between 2010 and 2026 was identified from the Scopus, Web of Science, and PubMed databases. Studies that talked about emotional intelligence, virtual companions, mental health outcomes, or the design or implementation of eldercare services were included. A total of 32 studies were included using a PRISMA-ScR–guided scoping review approach. The data was organized using the themes to identify common ideas and patterns in how virtual agents are used to help older people's mental health.

RESULTS

The results show that there are six main themes: Emotional Responsiveness, Conceptual Frameworks, Psychological Outcomes, Usability and Acceptance, Ethical/System Integration, and Health System Integration. The results show that virtual companions with emotional intelligence may help older people feel less lonely (e.g., most studies reported short-term reductions in loneliness, though effect sizes varied across heterogeneous study designs"), improve their mood, and make them more mentally strong. Major limitations in the current collection of studies are: most studies are small, short-term, and heterogeneous, which limits generalizability as well as the precluded meta-analysis.

CONCLUSION

This paper emphasizes the possibility of emotionally intelligent virtual companions as an aid in mental healthcare for the elderly. It describes the relevance of uniform conceptual models, thorough research, and moral requirements of the creation of emotionally intelligent virtual companions which displays a flourishing and emerging front for innovations that can better present-day methods of provision of elder mental health treatment. They need to be properly introduced into

health-care systems, but the introduction must be backed by the cautious interpretation of the existing data, well-defined ethical standards, and the robust long-term scientific and economic analysis.

KEYWORDS
emotional intelligence, mental health, elder, elder care services, virtual companion

INTRODUCTION

One of the most recent and the most critical demographic trends of the twenty-first century is population aging. This creates numerous issues for global healthcare systems. Physical illnesses become more common as individuals grow old, but with that there is emerging evidence that mental and emotional health issues, such as loneliness, depression, and cognitive loss, are equally damaging to older people health [1]. This demonstrates that older people still require interventions that can be raised up and that benefit them. For example, loneliness is linked to an increased risk of death, heart disease, and cognitive decline. As a result, fixing these issues has become a high priority for public health [2, 3].

Emotional intelligence (EI) generally refers to the capacity to perceive, interpret, and regulate one's own emotions as well as those of others.[4]. In eldercare, interventions that improve emotional awareness and regulation have shown promise in reducing depressive symptoms and increasing life satisfaction [5]. However, it is still difficult to use EI-based programs in real-world eldercare settings because of staffing issues, scalability issues, and differences in caregiver training.

New developments in artificial intelligence (AI) offer a new way to close this gap. AI-powered virtual companions that can understand and respond to users' emotions can provide individualized emotional support [6]. Emotional intelligence, when applied to artificial intelligence systems, does not include subjective emotional experience or consciousness, because it was initially described as a human cognitive-emotional capacity. Instead, EI-informed AI refers to a functional and design-oriented application of emotional intelligence concepts, such as emotion identification, affective response development, and adaptive interaction based on emotional cues from users. These agents can be chatbots on a screen, voice assistants, or real-life social robots. They are made to read users' emotions and change their responses based on what they see [7, 8]. Research on AI prototypes such as the 'Ryan' robot suggests that emotion-aware systems may improve mental health and subjective well-being in elderly people suffering from depression and dementia [9,10]. Existing reviews indicate that AI-powered virtual companions are associated with decreased loneliness and perceived improvements in emotional well-being among older persons, mainly in short-term and exploratory research [6,12].

This field is still new, though. Different types of empirical studies use different methods, such as randomized controlled trials and exploratory qualitative designs, and they often have small sample sizes and short durations [13]. Also, the current conceptual frameworks for EI-informed virtual agent design are not standardized or rigorously validated. Cultural adaptation of these systems is rarely discussed, even though there is evidence that culturally appropriate emotional expressions are important for caregiver interactions [14,15]. The term "emotionally intelligent AI" is used in this review to refer to systems that simulate empathic responsiveness using affective computing techniques rather than having human-like emotional capacities a distinction that is widely debated in the social robotics and ethics literature [15,17]. Ethical discussions about data privacy, emotional dependency, and the authenticity of AI companionship are also new, which means that these are important issues that need to be looked into before they can be used more widely [16,17].

Mental health issues go beyond taking care of the elderly and are closely linked to how systems are set up to be helpful and emotionally responsive. These results highlight the need to incorporate the concept of emotionally intelligent design into technologies, which strive to enhance the psychological well-being, e.g., by creating virtual companions that help the elderly.

To address these issues, this paper reviews peer-reviewed articles on virtual emotionally intelligent companions applied in the elderly care. The key aims of the study are:

- To explore the extent of empirical and conceptualizing research, which has explored the EI-integrated virtual companions in senior mental health care with consideration of how their study designs and purposes vary.
- To define and outline the current conceptual models that guide the integration of the elements of emotional intelligence in the design of virtual agents.
- To investigate ethical, usability and system-integration issues that have been documented to be pertinent in real-life situations involving eldercare.
- To present major opportunities and challenges in the future study, such as the improvement of methods and the creation of policy-relevant recommendations.

By integrating perspectives from gerontology, affective computing, psychology, and ethics, this study examines emotionally intelligent virtual companions in terms of their reported benefits, limitations, and opportunities for further refinement.

Such information is necessary to health care administrators, aged care facility managers and policymakers who may wish to incorporate some emotionally sensitive technology solutions to the eldercare systems.

Considering the emergent and cross-disciplinary character of the emotionally intelligent virtual companions in elderly mental health care, the available literature is very heterogeneous which incorporates exploratory trials, qualitative research, conceptual framework, and pilot applications. To accomplish this a scoping review methodology was chosen to provide a systematic mapping of the breadth, nature and gaps in the current body of evidence, not to provide an estimate of pooled intervention effects or make conclusive statements about effectiveness.

METHODS: SCOPING REVIEW DESIGN

This study used a scoping review technique based on the PRISMA Extension for Scoping Reviews (PRISMA-ScR) framework [18]. The primary goal was to collect peer-reviewed research on emotionally responsive virtual companions for older individuals, with a special focus on mental health outcomes and elder healthcare service contexts. The review looked at how to make, operate, and evaluate virtual agents with emotional intelligence (EI) features.

SEARCH STRATEGY

A complete literature search was done using some major electronic databases to identify interdisciplinary and high impact studies. The search was restricted to articles which were published between 2010 and 2026; The date range (2010–2026) was selected because key methodological and technological advances in affective computing—particularly artificial emotional intelligence, emotion-aware socially assistive robots, and virtual companions—began to emerge and mature after 2010, enabling their application in eldercare settings [10,14].

Boolean operators (AND/OR) were used to connect the main objectives of the paper which are:

1. AI Companions/Robots
2. Emotional Intelligence/Affective computing
3. Older people/adults

DATABASE SEARCH STRATEGIES

Scopus:("emotional intelligence" OR "affective computing" OR "emotional responsiveness" OR "emotion-aware AI") AND ("AI companion" OR "virtual companion" OR "digital companion" OR "social robot" OR "humanoid robot" OR chatbot OR "AI assistant") AND ("older adults" OR elderly OR "older people" OR ageing OR gerontology OR "geriatric care") Web of Science: TS=("emotional intelligence" OR "affective computing" OR "emotion-aware AI" OR "empathic AI") AND TS=("virtual companion" OR "AI companion" OR "social robot" OR "conversational agent") AND TS=("older adults" OR elderly OR ageing OR gerontology) PubMed[MeSH] : ("Artificial Intelligence" OR "Affective Computing") AND ("Emotion Recognition") AND

("Aged" OR "Older Adults") AND ("Companion Robots" OR "Conversational Agents" OR "Virtual Assistants"). Searches were conducted between January 2025 and August 2026 and were limited to peer-reviewed English-language publications.

ELIGIBILITY CRITERIA

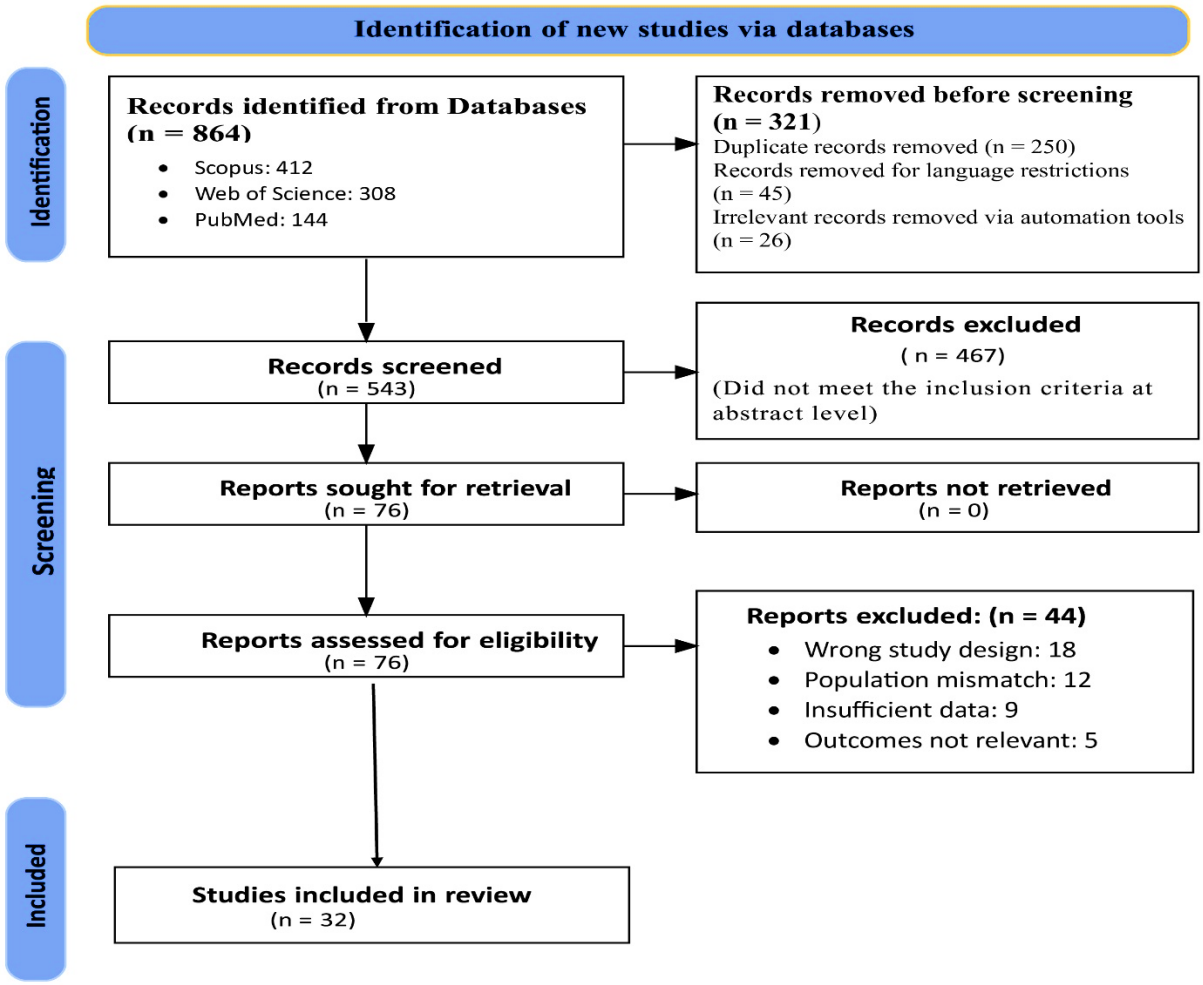
TABLE 1: INCLUSION AND EXCLUSION CRITERIA FOR STUDY SELECTION

Inclusion Criteria	Exclusion Criteria
Provided conceptual frameworks, experimental results, or qualitative insights relevant to elderly care	Focused solely on technical or engineering aspects without user-centred evaluation
Focused on virtual agents, chatbots, or robots integrating emotional intelligence for use with older adults (aged 60 years)	Did not report findings in relation to mental or emotional health
Addressed outcomes related to mental health, loneliness, emotional well-being, or social connectedness	Were not in English, or were opinion pieces or articles without any evidence

STUDY SELECTION PROCESS

After finding 864 publications (Scopus: n=412; Web of Science: n=308; PubMed: n=144), 321 records were removed before screening (Duplicate records removed: n=250; Records removed for language restrictions: n=45; Irrelevant records removed via automation tools: n=26). Two independent reviewers then looked at the titles and abstracts of the remaining 543 articles. Following full-text assessment of 76 articles, 44 reports were excluded (wrong study design: n=18; population mismatch: n=12; insufficient data: n=9; outcomes not relevant: n=5). Ultimately, 32 studies met the inclusion criteria and were included in the scoping review. The differences in selection were addressed, as recommended by scoping reviews [18], either through discussion or by seeking assistance from a third party. A comprehensive study-level evidence-charting table summarizing key characteristics for all 32 included studies is provided as Supplementary Material.

FIGURE 1: PRISMA-SCR FLOW DIAGRAM SHOWING THE STUDY SELECTION PROCESS FOR THE SCOPING REVIEW [18].



DATA EXTRACTION AND ANALYSIS

A standard data extraction form to collect the following information was developed: the study's goal, the type of virtual companion, the sample population, the emotional intelligence features used (like recognizing emotions and giving empathetic feedback), the outcome measures (like loneliness scores and affective response), the study design, and the main results. Emotional intelligence concepts were identified and analyzed in terms of functional application (e.g., emotion recognition, empathic dialogue, adaptive feedback) rather than just psychological qualities. Narrative synthesis and thematic categorization were used to look at the data. The studies were put into groups depending on the type of design (qualitative, quantitative, or mixed-method), the platform (robotic, voice, or text-based), and the outcome categories (emotional well-being, cognitive engagement, or user satisfaction). A lot of attention is given to the conceptual frameworks that guided the construction of these themes. Data extraction was conducted independently by two reviewers, and discrepancies were resolved through consensus.

QUALITY APPRAISAL

Of the 32-research considered, 18 were empirical intervention or observational studies, which were evaluated using the relevant JBI critical evaluation procedures. Rather than assigning overall categorical quality scores, the JBI appraisal was used descriptively. Small sample sizes, limited intervention durations, reliance on self-reported outcomes, lack of blinding, and short follow-up periods were among the most common methodological drawbacks. Conceptual articles and past reviews were not subjected to strict quality assessment, but were used to inform theoretical framework and context interpretation. Quality evaluation results influenced the careful interpretation of findings but did not decide study exclusion, which is according to the scoping review approach [18,20]. A formal review procedure (e.g., PROSPERO) was not registered because the major goal of this scoping review was to map concepts, evidence types, and research gaps rather than analysing intervention effect sizes.

RESULTS

For synthesis and interpretation, included studies were divided into three broad categories: (1) empirical intervention studies (randomised and quasi-experimental designs), (2) qualitative and observational studies investigating user experiences and perceptions, and (3) conceptual papers and prior reviews that informed design frameworks, ethical considerations, and system-level implications. Empirical studies were the primary source of effect-related interpretations, while qualitative and conceptual works provided contextual and explanatory insights, in accordance with scoping review methodology and evidence review recommendations [18,19].

STUDY DESIGNS AND METHODOLOGIES

The 32 studies that were considered showed a broad methodological context.

1. Randomized Controlled Trials (RCTs): A small number of studies examined emotionally responsive AI companions through controlled experimental designs [8,43,44].
2. Pilot, Cross-sectional, and Survey studies: A large portion of the literature utilized pilot studies, cross-sectional designs, and surveys (e.g., PLS-SEM) to explore user acceptance, ease of use, and emotional supportiveness [10, 31, 32, 40, 41].
3. Qualitative and Case studies: Interviews, qualitative frameworks, and long-term case series provided a detailed description of the experiences of older adults as they used chatbots and social robots in home-care settings [7, 15, 17, 27, 28, 36, 37, 38].
4. Prior reviews and evidence syntheses: Numerous systematic and scoping reviews have comprehensively examined AI companions, chatbots, and socially assistive robots [6, 12, 13, 14, 22, 29, 35, 42].
5. Conceptual / theoretical papers: Previous work on foundation models, participatory design, and ethical frameworks provided the conceptual base for interpreting engagement and addressing issues like deception and data privacy [16, 24, 26, 34].

Geographically, studies were conducted across North America, Europe, and East Asia, reflecting a diverse research context.

THEMATIC ANALYSIS

The data have been thematically organized and presented in tables in order to emphasise key features such as emotional responsiveness, conceptual frameworks, psychological outcomes, usability and acceptance, ethical considerations, and health system integration. A meta-analysis was not performed due to heterogeneity in research designs, evaluations, and intervention types, in accordance with scoping review methodology and reporting guidelines [18,19]. Across studies, emotionally intelligent behaviour was operationalised through affective computing mechanisms such as sentiment analysis, vocal tone recognition, facial expression analysis, and rule-based or adaptive empathic response generation [7,10,15].

TABLE 2.1: EMOTIONAL RESPONSIVENESS

Virtual Companion Feature	Effect/Outcome (Specific Data)	Study Type
Voice-based emotional AI	Reported reductions in loneliness scores over a short-term intervention period, measured by using the UCLA Loneliness Scale [8, 12]	Randomized Controlled Trial/ Experimental
"Ryan" social robot with multimodal emotion detection	Reported increases in user engagement and perceived mood improvement among older adults with dementia [9,10, 31]	Pilot/Experimental study
Conversational AI providing empathic responses	Users reported better emotional comfort and support [11, 30, 34]	Observational/User study

Note: Reported results are study-specific findings and should not be considered as pooled or generalisable effect estimates.

TABLE 2.2: CONCEPTUAL FRAMEWORKS

Model/Framework	Key Elements / Application in Design
Mayer–Salovey Emotional Intelligence model	Provides core EI components—emotion perception, understanding, regulation—used for designing emotionally intelligent companions [4]
Social-Robot Relationship-Building	Explains user attachment, trust formation, and long-term acceptance of companion robots [15]
Affective computing + self-regulation	Hybrid framework combining affective computing with self-regulation theory to guide dialogue management and emotional feedback [7]

Note: In the studies that were included, emotional intelligence models were primarily employed as conceptual or functional design frameworks to inform emotion-aware system behavior, rather than as representations of human emotional cognition.

TABLE 2.3: PSYCHOLOGICAL OUTCOMES

Outcome	Effect/Change (Specific Data)	Study Design
Loneliness	Most studies reported short-term reductions in loneliness scores over intervention periods ranging from 4 to 12 weeks, although outcome measures and effect magnitudes varied across studies [8, 10, 12, 13, 22, 23, 33]	RCTs and quasi-experimental trials and Literature reviews
Depression & Anxiety	Several studies reported short-term improvements in depressive and anxiety-related symptoms as measured by geriatric mental health scales [10, 11, 22, 41].	Pilot and observational studies
Emotional Well-being	Participants reported feeling less alone, more empathetic, and better after interacting with the agent [7, 15, 17, 23, 32, 37]	Qualitative interviews/user reports
Social Interaction & Cognition	Exploratory findings suggested modest changes in social interaction and cognitive engagement; however, results were inconsistent and not statistically robust [10,31]	Pilot study

TABLE 2.4: USABILITY AND ACCEPTANCE

Factor/Metric	Observation / Findings
Adoption Rate	Most studies reported moderate to high levels of user uptake and sustained engagement, influenced by factors such as age, digital literacy, and platform design [11, 24, 32,39]
Platform Preference	Voice-based agents were more accepted than robotic platforms (due to ease of use and lower cost) [12,13]
Emotional Expressiveness	Social robots exhibiting human-like emotional cues (gaze, gesture, empathic communication) fostered stronger user attachment [15]

TABLE 2.5: ETHICAL/SYSTEM INTEGRATION

Aspect	Details / Example
Data Privacy	Use of sensitive emotional profiles by companions raises user privacy concerns (requires safeguarding emotion data) [16, 17, 27, 28]
Emotional Dependency & Authenticity	Risk that users may form emotional dependence or be deceived if AI companions are perceived as sentient; underscores need for transparency, user control, and informed consent [16, 17, 27, 28]
Human Oversight	Older adults prefer AI support with human involvement rather than full automation [11]

TABLE 2.6: HEALTH SYSTEM INTEGRATION

Integration Strategy	Description	Examples/Findings
Medication Reminders and Monitoring	Virtual companions embedded in home-care systems to remind users of medication and monitor health status. [6, 31, 34].	Joy TV companions were designed to prompt medication adherence and monitor health metrics through integration with caregiver platforms.
Supplement to Human Support in Home Care Packages	Pilots integrated virtual companions to fill emotional gaps when human caregivers were unavailable. [11, 13, 31, 34].	Initial studies noted reduced caregiver burden and improved adherence to routines when EI-based virtual agents were used as supplemental tools in home-based eldercare settings.
Preliminary Outcome Evidence	Preliminary implementations show potential for emotional and behavioral engagement; nevertheless, evidence is mostly qualitative or exploratory, with little long-term or economic evaluation [13].	While qualitative feedback is positive, no studies provided full-scale economic analysis or long-term outcome data to justify system-wide integration.
Workflow Enhancement Potential	EI companions have been proposed as a tool that might reduce burnout among staff by automating routine emotional check-ins and referrals, though this requires prospective evaluation. [6,13].	Systems capable of monitoring emotional status could escalate care alerts, potentially reducing emotional labour on clinical staff.
Barriers to Integration	Lack of policy, infrastructure, and trained personnel to manage AI agents in eldercare settings [6].	Yang et al. highlighted that without caregiver training and digital infrastructure, system-level adoption of emotionally intelligent companions remains difficult.
Scalability and Cost-effectiveness	No current large-scale trials with cost-benefit assessments; needed to validate widespread implementation [11,13].	Although promising in pilot phases, broader studies with financial and clinical outcomes are essential before health systems can adopt these tools on a large scale.

DISCUSSION

STATEMENT OF PRINCIPAL FINDINGS

This scoping review combined findings from 32 studies on emotionally intelligent virtual companions in elder mental health care. Across multiple reviews and pilot interventions, emotionally responsive virtual companions were linked to short-term improvements in loneliness and depressive symptoms, though study designs, outcome measures, and effect magnitudes varied significantly, and many long-term studies showed mixed results [8, 10, 12, 22, 23, 33]

In addition, qualitative narratives backed up these quantitative advantages, with users saying that they had a real emotional connection, their mood improved, and they felt more capable of doing things when they interacted with sympathetic virtual agents [7, 27, 36, 37]. However, preliminary dementia trials indicated promising indicators of more social interaction and a little cognitive gain, although these results were not statistically significant [10].

Many of the research studies that were included used parts of Mayer and Salovey's EI model, like emotion perception, understanding, and regulatory feedback, to help develop the system [4, 15]. Technology acceptance models indicate that factors such as perceived empathy, ease of use, and user optimism influence the adoption of emotionally intelligent technologies [13]. Across the reviewed literature, recurring ethical concerns were identified, particularly in relation to data privacy, emotional dependency, and the potential for deception arising from simulated empathic behaviour [16, 17, 27,

28]. The first projects of integrations such as voice-based agents in a home-care system suggest they may have potential for the improvement of the workflow; however, there is scanty information on the cost-efficiency and scaling challenges in the long run [6, 11, 13].

CONCEPTUALISING EMOTIONAL INTELLIGENCE IN AI SYSTEMS

The idea of emotional intelligence has long been considered to be a human cognitive-emotional skill that implies emotional awareness, knowledge, and management [4]. In a system based on artificial intelligence, though, EI is usually deployed as a functional or symbolic design characteristic and not as a psychological characteristic of the system under consideration [7,15]. The AI systems mentioned in this review are emotionless, but reproduce affectively responsive behaviour, through affective computation techniques, which is also important in limiting the anthropomorphic interpretations and unrealistic expectations of AI behaviour [15,17].

Some of this researche involved some popular models of EI, such as Mayer-Salovey model, to make a choice in terms of system design [4,7]. Such applications primarily used EI models as design heuristics that enable the organisation of processes, such as emotion recognition, response selection and adaptive interaction, rather than offer statements about the machine-based emotional cognition [7,15]. The simulated empathy raises the question of authenticity, transparency and emotional dependency ethically and discusses the importance of not trying to deceive users into thinking AI companions are human beings [16,17].

STRENGTHS AND WEAKNESSES OF THIS REVIEW

The inclusion of interdisciplinary coverage of the research is one of the strengths of this review because the research study in the domain of gerontology, affective computing, psychological, and ethics are covered and considered, and both empirical and conceptual research are taken into consideration. Compared to the earlier test that was mainly concerned with technical performance or viability, this synthesis can be able to test design structures, usability issues, incorporation of health-system and any other reported mental health outcome such as loneliness. In that way, the review adds to the previous literature on AI efficacy, including that by Yang et al. (2025) [6], since the study specifically targets the implementation of emotionally intelligent strategies to design and ethical and systemic barriers to implementation. In addition to it, the fact that the studies included in the Scopus journals are ranked in the Q1-Q4 category, and the PRISMA-ScR recommendations are adhered to makes the review process more transparent and publicized. In the case, the quality appraisal of the methodological methods was used to support evidence-informed interpretation with the help of JBI tools in case empirical data were used [20].

Nevertheless, some limitations are to be taken into consideration. Many of the included RCTs and pilot studies included small samples (mostly less than 60 participants), brief-intervention periods (4-12 weeks) and no or limited, long-term follow-up. The observed effect sizes can be, therefore, partially attributed to novelty effects and not long-lasting positive changes in mental health outcomes. Furthermore, in comprehensive systematic reviews evaluating interventional designs, effect sizes tend to be lesser or inconsistent due to methodological heterogeneity and a high risk of bias [6,21,22].

MEANING OF THE STUDY

Based on the findings of this scoping review, emotionally intelligent virtual companions may have the potential to serve as an addition of supplementary services to the existing elder mental health and aged care services [6,13]. The technologies are to be viewed as the emerging tools that could hold some value in terms of providing health management, but not as the established or independent care solutions [16,17]. It has some initial signs of potential usefulness in terms of assisting to ensure emotional engagement and continuity of care - particularly in the environment that is affected by workforce constraints the existing body of research is too young to warrant extensive implementation until further research is conducted to confirm these results [6,13,17].

The co-design solutions with the older adults, caregivers, and clinicians, therefore, are likely to be the key to meaningful adoption and realize the virtual companion capabilities, which are being aligned with the actual care processes and emotional objectives. Simultaneously, ethical AI use, emotional authenticity and data protection education of employees will be needed in order to support safe deployment. At the policy level, regulatory/governance framework policies

addressing transparency, informed consent, emotional boundary management and data protection should take precedence and be integrated with mental health and broader digital health policies. Collectively, these findings highlight implications for health management practice, including the need for digital literacy development, clearer implementation guidance, and the careful integration of EI-based technologies into existing aged care workflows [6,11,13].

The virtual companions can also be used in the face-to-face therapy at the health system level to ensure that the people are engaged emotionally between therapy sessions. One such instance is that trust can be developed through the use of caring speech agents that will encourage people to embrace remote behavioural health services, especially among patients of advanced age that live in rural areas or underserved communities [11,13].

Any managerial or policy adoption of emotive intelligent virtual companions, in turn, must be preceded by properly designed pilot programs to be developed with older adults, care givers and clinicians and any systematic analysis of the outcomes, the costs and ethical implications [6, 16,17].

RESEARCH GAP AND FUTURE RESEARCH

Although the first results in this direction are promising, there are multiple gaps in the research that should be filled in before the introduction of emotionally intelligent virtual companions becomes an ethically viable solution. Majority of studies that are in place are of short duration and thus, there is no enlightenment on whether benefits observed are achieved over time or fade away by repetition. The future research would then be benefited by better conceptualizations of how emotional intelligence elements are connected to particular AI capabilities and mental health results. It is also evident that because of the extensive use of samples in Western nations and East Asia, the cross-cultural research is necessary, especially in low- and middle-income settings, to learn more about the differences in the expression of emotions, communication patterns, and social norms among older adults.

The necessity to create ethical frameworks in collaboration with stakeholders and test them with the assistance of the user-centred design research is proposed, even though the ethical concerns are under-researched, especially, when it comes to the emotional dependency. In addition, outcome measures are not the same in all studies, and it is not an easy task to compare the outcome, this is why more standardised methods of assessment ought to be discussed, including ecological momentary assessment and real-time engagement measures. Finally, the AI autonomy should be compensated with the right human supervision in future systems, e.g. human-in-the-loop designs, however, the aspects related to adaptive learning systems (e.g. bias and transparency) should be considered.

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SUPPLEMENTARY MATERIAL: CHARACTERISTICS OF THE INCLUDED EVIDENCE (N=32)

No.	Author/ Year	Study Design	Sample (n)	Setting	AI / Virtual Companion	Emotional / Affective Functions	Outcomes	Principal Findings
1	Yang et al. (2025)	Systematic review	N/A	Older-adult care/community	AI applications / virtual companions	Emotional support, companionship	Loneliness	AI applications showed potential to reduce loneliness, although technological and systemic barriers remained.
2	Rodríguez-Martínez et al. (2024)	Qualitative study	NR	Older adults	Conversational chatbot	Adaptive/empathic responses	Loneliness, emotional health	Participants reported feeling less alone and experiencing emotional benefits following interaction with conversational chatbots.
3	Robinson et al. (2013)	Randomized controlled trial	40 randomized; 34 analyzed	Residential care facility	PARO companion robot	Social interaction, companionship, responsive interaction	Loneliness, depression, quality of life	Significant reduction in loneliness compared with the control group. The robot also stimulated conversation and social interaction.
4	Abdollahi et al. (2017)	Pilot/experimental study	NR	Elder-care/dementia care	"Ryan" social robot	Multimodal emotion detection, responsive interaction	Mood, engagement	Reported increased engagement and perceived mood improvement among older adults with dementia and depression.
5	Lee et al. (2025)	Observational /user study	NR	Mental-health context	Conversational AI	Empathic responses	Emotional comfort, support	Users perceived potential for emotional support but preferred human involvement in mental-health care.
6	Boumans et al. (2022)	Systematic review	N/A	Older adults with amnesia	Voice-enabled intelligent virtual agents	Conversational/emotional support	Cognitive and memory support, acceptance	Identified applications and acceptance of voice-enabled intelligent agents for older adults with amnesia.
7	Marziali et al. (2024)	Literature review/bibliometric analysis	N/A	Older adults	Voice assistants	Emotional/social support	Loneliness, social isolation	Identified potential for voice assistants to reduce loneliness and social isolation.
8	Momand et al. (2023)	Systematic literature review	N/A	Older-adult/virtual-companion contexts	Immersive virtual companions	Emotional and social support	Social connection	Explored immersive technologies and virtual companions for emotional and social support.
9	De Graaf et al. (2015)	Qualitative/exploratory	NR	Social interaction context	"Harvey" social robot	Gaze, gesture, emotional/social cues	Attachment, relationship-building	Human-like social cues supported attachment and relationship-building with the robot.

10	Olumide (2024)	Critical review	N/A	Loneliness/emotional-support context	AI/virtual companions	Emotional support, companionship	Emotional support	Highlighted potential benefits alongside ethical and functional concerns surrounding AI companionship.
11	Berridge et al. (2023)	Qualitative/perceptual	NR	Older-adult companionship	Companion robot	Emotional/social support	Loneliness, perceived benefit, deception	Identified perceived benefits of companion robots while highlighting risks of emotional deception.
12	Guevara et al. (2026)	Systematic review	121*	Elderly care	Socially assistive robots	Emotional/social support	Quality of life, loneliness, depression	Reviewed evidence suggesting benefits of socially assistive robots for quality of life and psychological outcomes.
13	Luan & Li (2026)	Cross-sectional study	NR	Later-life/AI companionship	AI smart companions	Emotional/social support	Psychological well-being	Examined relationships between AI technology perceptions, usage demand and psychological well-being.
14	Irfan et al. (2024)	Participatory/co-design study	28	Older-adult context	Conversational companion robot	Empathy, personalization, engagement	Loneliness, well-being	Older adults wanted robots to express empathy, personalize interactions and provide active engagement.
15	Liu et al. (2025)	Empirical study	NR	Older-adult virtual travel	GenAI-enabled virtual avatars	Emotional engagement, supportive interaction	Well-being, confidence	Virtual travel experiences guided by GenAI avatars enhanced well-being and confidence.
16	Peng (2026)	Theoretical/design exploration	N/A	Ageing/healthcare	Age-adaptive emotional virtual human	Empathic support, adaptive interaction	Emotional/health support	Proposed an ageing-adaptable virtual human capable of empathetic support and health-related reminders.
17	Portacolone et al. (2020)	Ethical/conceptual analysis	N/A	Older adults with cognitive impairment	Artificial companions	Simulated companionship/emotional interaction	Ethics, autonomy, privacy	Highlighted concerns regarding deception, surveillance, informed consent and social isolation.
18	Hung et al. (2025)	Qualitative/conceptual synthesis	NR	Long-term care	Social robots	Emotional/social support	Loneliness, well-being, ethics	Identified ethical concerns including consent, equity, substitution of human care and infantilization.
19	Chen et al. (2026)	Scoping review	12*	Older-adult mental-health care	AI conversational agents	Emotional support, conversational interaction	Mental-health outcomes, acceptance	Most included studies reported positive acceptance/usefulness while identifying barriers to implementation and interaction.

20	Pita et al. (2025)	Pilot study	7	Older-adult medical/home-care context	Integrated social robot + virtual assistant	Social/emotional interaction	Well-being, medical management	Participants generally completed medical-management tasks and basic conversations, although interaction challenges occurred.
21	Jegundo et al. (2020)	Survey	46	Older-adult care provision	Virtual companion	Emotional/social support	Usefulness, satisfaction, ease of use	Participants reported high usefulness and ease of use; care providers viewed the companion as a supplementary tool.
22	Li & Pan (2026)	Empirical study	90	Older-adult emotional support	AI agents	Emotional support, social engagement	Loneliness, social engagement, cognitive load	AI-based interaction was associated with reduced loneliness, increased social engagement and lower cognitive load.
23	Karegoudra et al. (2025)	Mixed-methods evaluation study	28 older adults (aged 65–84 years)	Elderly care	Caregiving AI Chatbot (voice-based conversational agent)	Social support, virtual companionship, reducing social isolation and loneliness	User preferences, technology adoption, well-being, social connectivity	Older adults identified appointment/medication reminders (89.3%), emergency assistance (78.6%), and health monitoring (75.0%) as top desired AI features. Voice-based conversational AI acted as a key tool for daily routine management and emotional companionship.
24	Luu et al. (2026)	Scoping review	17*	Older-adult chatbot adoption	AI chatbot	Emotional trust, personalization	Adoption barriers	Identified barriers involving physical condition, interaction design, technology literacy and emotional trust.
25	Haque & Rubya (2023)	App-description/user-review analysis	NR	Mobile mental-health apps	Chatbots	Personalized/human-like interaction	Mental-health support, safety	Users valued personalized interactions but identified poor crisis identification as an important concern.
26	Wang et al. (2026)	Qualitative study	NR	Older-adult AI companionship	AI companions	Emotional/social support	Mental well-being	Autonomy, ease of use and competence were associated with better mental well-being.
27	Nagata et al. (2026)	Five-case series	5	Home care	Conversational companion robot	Conversational/emotional support	Psychological support, satisfaction, usability	Eighteen-month home use showed high satisfaction and usability, although standardized psychological outcomes were mixed.

28	Shin et al. (2025)	Q methodology	NR	Older-adult care/caregiver context	AI-based care technologies	Emotional support	Caregiver perceptions	Identified distinct caregiver perspectives regarding acceptance and improvement of AI in older-adult care.
29	Treder et al. (2024)	Survey/overview	NR	Dementia care/research	Large language models	Conversational/emotional assistance	Well-being, usability, ethical concerns	LLMs were viewed positively, while bias and data privacy were important concerns.
30	Imkome et al. (2025)	Pilot experimental study	44	Older-adult mental-health context	"Ai-Aun" chatbot	Emotional support, conversational intervention	Mental health, satisfaction	Mental-health outcomes differed between groups after intervention, with reported satisfaction and efficacy.
31	Shu et al. (2026)	Scoping review	83*	Healthcare populations	Embodied/socially assistive robots and virtual agents	Emotional/social interaction	Healthcare outcomes	Mapped applications of embodied intelligence in healthcare, including humanoid and virtual agents.
32	Murayama & Takase (2025)	Randomized controlled trial + qualitative analysis	73 randomized; 68 completed	Community-dwelling older adults living alone	BOCCO emo humanoid social communication robot	Empathetic communication, emotional support, psychological connection, social interaction	Loneliness, psychological well-being, depression, self-rated health	Loneliness decreased significantly more in the intervention group (DID −3.1; 95% CI −5.9 to −0.4), while psychological well-being improved (DID 1.9; 95% CI 0.1–3.7). Qualitative findings indicated emotional support, psychological connection, social interaction and cognitive/mental stimulation.

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CASE STUDY

EVALUATION OF INTERNAL QUALITY CONTROL PRACTICES IN A BLOOD CENTER AFFILIATED TO A TERTIARY CARE HOSPITAL: COMPLIANCE WITH WHO AND NACO STANDARDS

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ABSTRACT

BACKGROUND:

Blood transfusion is indispensable in trauma, surgery, cancer therapy, and anemia management. Because transfusion carries the risk of infection and immune reaction, blood banks must maintain strict quality control (QC).

OBJECTIVE:

To evaluate the quality control performance of a tertiary care blood bank and determine its compliance with World Health Organization (WHO) and National AIDS Control Organization (NACO) standards.

METHODS:

A one-year observational study was performed at the Blood Bank, Sree Balaji Medical College and Hospital. Data were collected from donor screening, component preparation, infectious-disease testing, storage, equipment monitoring, and transfusion-reaction surveillance. QC was assessed according to NACO (GSR 166-E, 11-03-2020) domains: infrastructure, donor screening, post-phlebotomy, test processing, bag quality, bag thawing, and discard.

RESULTS:

During the three - month study period, 250 donors were screened, of whom 5 (2%) were deferred based on NACO donor selection criteria. A total of 245 blood units were collected and processed into blood components. One hundred quality control (QC) samples comprising packed red blood cells (PRBCs), random donor platelets (RDPs), and fresh frozen plasma (FFP) were evaluated. Serological screening revealed HBsAg positivity of 2.3%, HCV positivity of 0.7%, syphilis positivity of 0.3%, and no HIV-reactive donations. Among the QC samples, 98% of PRBCs, RDPs, and FFPs complied with WHO/NACO quality standards. Storage temperatures remained within recommended limits, all equipment passed scheduled calibration, and only mild transfusion reactions (2%) were observed.

CONCLUSION:

Comprehensive QC practices in this blood bank achieved 97.5 percent compliance with WHO/NACO requirements. Effective infrastructure, donor screening, and component monitoring ensure high product quality and safe transfusion outcomes.

KEYWORDS

blood transfusion, quality control, NACO, WHO, PRBC, platelet concentrate, fresh frozen plasma

INTRODUCTION

Blood transfusion remains a cornerstone of modern medical care essential in trauma, obstetrics, oncology, and chronic anaemia management. The safety of transfusion, however, relies entirely on the quality of blood components produced and stored by blood banks. Globally, the World Health Organization (WHO) has set stringent norms for ensuring quality and safety in transfusion services, requiring systematic quality control (QC) programs for all components. In India, the National AIDS Control Organization (NACO) and the National Accreditation Board for Hospitals and Healthcare Providers (NABH) have adopted these recommendations, mandating that at least 1 % or a minimum of four units per component each month undergo QC testing [3,4].

Recent Indian studies affirm that structured QC programs and automation significantly improve component quality. Das et al. (2022) from a tertiary center in Eastern India reported that 98–100 % of PRBC, platelet, and plasma components met WHO specifications after implementing automated extraction and quadruple bag systems [1]. Similarly, Patel et al. (2022) observed that two years of structured QC monitoring in Ahmedabad yielded consistent compliance across all blood components [3].

Across India, findings have been largely encouraging. Upadhyay & Pangtey (2016) in Uttarakhand and Akhtar et al. (2021) in Aligarh both found QC conformity above 95 % for PRBC and platelets, demonstrating reproducibility across regions and institutions [2,4].

Moreover, innovations in component processing like the top-and-bottom or buffy coat extraction systems have shown to enhance leukocyte removal and hematocrit uniformity [5,10]. Bhardwaj et al. (2021) compared triple versus quadruple bag systems and found the latter produced higher plasma yields and platelet recovery, aligning with WHO performance benchmarks.

These findings collectively underscore that rigorous QC implementation is both feasible and essential in Indian blood banks. This study builds on that evidence by assessing the QC outcomes at the blood bank of Sree Balaji Medical College and Hospital, Chennai, and comparing them with WHO, NACO, and published Indian data.

MATERIALS AND METHODS

STUDY DESIGN

Descriptive cross-sectional study conducted for three-months at the tertiary care blood bank.

QC Domains and Protocol (NACO GSR 166-E 11-03-2020) and Process

Internal quality control was performed in accordance with the National AIDS Control Organization (NACO) Standards for Blood Centres (GSR 166(E), 2020). Approximately 5–10 quality control samples were evaluated each week, depending on blood component production, resulting in a total of 100 quality control samples comprising Packed Red Blood Cells (PRBC), Random Donor Platelets (RDP), and Fresh Frozen Plasma (FFP) during the three-month study period. Overall, 100 QC samples comprising PRBC, RDP, and FFP units were analyzed during the three-month study period. The quality control process was evaluated across the following domains:

- Infrastructure
- Donor screening and selection
- Post-phlebotomy procedures
- Laboratory testing and component processing
- Blood bag quality
- Component thawing and storage

- Blood component discard procedures

INFRASTRUCTURE

The blood centre consisted of approximately 1,200 sq ft dedicated to whole blood collection and 650 sq m allocated for component preparation, storage, and quality control activities. Dedicated areas were available for donor registration, counselling, blood collection, component separation, storage, record maintenance, stores, and washing and sterilization.

DONOR SCREENING AND COLLECTION AREAS

Separate screening and phlebotomy zones with pre-donation medical examination forms.

STUDY POPULATION

A total of 250 prospective blood donors who fulfilled the donor eligibility criteria according to the National AIDS Control Organization (NACO) guidelines were screened during the three-month study period. Of these, 5 donors (2%) were deferred because of temporary medical or behavioural risk factors, including anaemia, recent medication use, and travel history. Consequently, 245 blood units were collected and processed for component preparation.

BLOOD COMPONENT PREPARATION

Whole blood was collected using CPDA-1 quadruple blood bags and processed by the Platelet Rich Plasma (PRP) method using refrigerated centrifugation. Blood components prepared included Packed Red Blood Cells (PRBC), Random Donor Platelets (RDP), and Fresh Frozen Plasma (FFP). Component preparation and quality assessment were performed according to institutional Standard Operating Procedures (SOPs), WHO recommendations, and NACO Standards for Blood Centres (GSR 166(E), 2020).

EQUIPMENT

The blood centre was equipped with blood collection monitors, refrigerated centrifuges, plasma extractors, blood bag tube sealers, ELISA and CLIA analysers, platelet incubators with agitators, blood bank refrigerators, plasma freezers, and calibrated temperature monitoring systems.

TESTING PROCEDURES

1. Donor screening for infectious risk.
2. Serological testing for HIV, HBsAg, HCV, syphilis.
3. Component separation by centrifugation and QC for hematocrit, platelet count, and fibrinogen.
4. Storage at PRBC 2–6 °C, RDP 22–24 °C with agitation, FFP −40 °C to −80 °C.
5. Compatibility testing by ABO/Rh typing and crossmatching.
6. Reaction monitoring for every transfusion.

INTERNAL LABORATORY PARAMETERS

PT 11–13.5 s, aPTT 21–35 s, Fibrinogen 200–400 mg/dL, Hematocrit (M 40–54%, F 36–48%).

MICROBIOLOGICAL QC

Culture on nutrient agar, blood agar, and MacConkey agar for sterility.

DATA ANALYSIS

Data were entered into Microsoft Excel and analysed using descriptive statistical methods. Continuous variables are presented as mean ± standard deviation, whereas categorical variables are expressed as frequencies and percentages. Quality control compliance was calculated according to WHO and NACO quality standards for blood components.

QUALITY CONTROL STANDARDS

Internal quality control was performed according to the National AIDS Control Organization (NACO) Standards for Blood Centres (GSR 166(E), 2020) and World Health Organization (WHO) Guidelines.

The quality criteria adopted were:

- PRBC hematocrit: 55–70%
- RDP platelet yield: ≥5.5 ×10^{10}/unit
- RDP pH: ≥6.2
- FFP fibrinogen: ≥200 mg/dL
- Factor VIII: ≥0.7 IU/mL
- PRBC storage: 2–6°C
- RDP storage: 20–24°C with continuous agitation
- FFP storage: ≤−30°C
- Quality control frequency: minimum 1% or four units/component/month

RESULTS

The results highlight a comprehensive evaluation of the blood bank's internal quality control system, with each QC domain meeting or exceeding WHO/NACO benchmarks. The following section synthesizes these quantitative outcomes and interprets their significance in the context of blood transfusion safety and operational excellence.

DONOR SCREENING AND SEROLOGICAL SAFETY

A total of 250 prospective blood donors were screened, of whom 5 (2%) were deferred because of temporary medical or behavioural risk factors, primarily anaemia, medication use, or travel history. Consequently, 245 blood units were collected and subjected to mandatory transfusion-transmitted infection (TTI) screening.

The serological profile obtained from laboratory records indicated HBsAg positivity of 2.3%, HCV positivity of 0.7%, and syphilis positivity of 0.3%, while no HIV-positive donors were detected.

TABLE 1: DONOR SCREENING AND INFECTIOUS TESTING

Parameter	Total Samples Tested (n)	Result	Comment
Total donors screened	250	—	Prospective blood donors
Donors deferred	250	5 (2%)	Deferred for temporary illness or risk history
Blood units collected	245	245	Eligible donations
HBsAg positive	245	2.30%	Reactive units discarded
HCV positive	245	0.70%	Reactive units discarded
Syphilis positive	245	0.30%	Reactive units discarded
HIV positive	245	0%	None detected

These findings mirror the infection burden reported by other Indian tertiary centers such as those in Ahmedabad and Uttarakhand [2,3,8]. The absence of HIV reactivity reflects the success of stringent pre-donation screening and confidentiality protocols. The low rates of TTI positivity demonstrate an effective donor deferral and counseling program, ensuring that only low-risk donors contribute to the blood supply.

COMPONENT QUALITY CONTROL

Internal quality control was performed **monthly** according to NACO guidelines. The number of QC samples evaluated each month varied between **5 and 15**, depending on blood component production. During the study period, **100 QC samples** comprising PRBC, RDP and FFP were analysed.

The analysis revealed that **98% of PRBCs, 98% of RDPs, and 98% of FFPs** met WHO/NACO criteria.

- PRBCs consistently achieved hematocrit between 55–70%, indicating adequate red cell recovery following **Platelet-Rich Plasma (PRP) method** component preparation.
- RDPs maintained platelet yield above **5.5×10^{10}/unit** with optimal pH (6.2–7.4).
- FFPs demonstrated satisfactory fibrinogen and Factor VIII levels, confirming preservation of coagulation factors during freezing.

TABLE 2: COMPONENT QUALITY CONTROL

Component	Parameter	Compliance (%)	Remarks
PRBC	Hematocrit 55–70%	98	2% discarded for low hematocrit
RDP	Platelet yield ≥5.5 × 10^{10}/unit; pH ≥6.2	98	All units showed swirling
FFP	Fibrinogen ≥200 mg/dL; Factor VIII ≥0.7 IU/mL	98	No deterioration seen
QC frequency	Monthly	—	5–15 samples/month
Total QC samples	100	—	PRBC, RDP and FFP

Overall component compliance – 98 %.

These outcomes indicate stable component production efficiency. The marginal 2% discard rate suggests minimal technical variability during centrifugation or bag sealing. The high compliance also reflects skilled staff operation and timely QC testing.

STORAGE AND EQUIPMENT MONITORING

All three major components were maintained within prescribed storage temperatures (PRBC 2–6°C, RDP 22–24°C, FFP −40°C to −80°C). Equipment logs showed no temperature excursions, and calibrations were validated monthly.

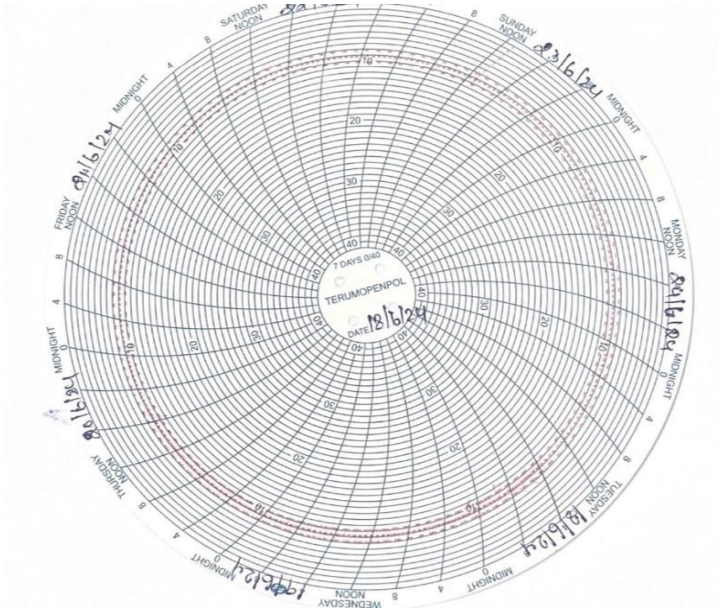
TABLE 3: STORAGE AND EQUIPMENT MONITORING

Component	Temperature Range	Observation	Compliance
PRBC	2–6 °C	Within range	100%
RDP	22–24 °C (agitated)	Stable	100%
FFP	−40 to −80 °C	No fluctuations	100%

All equipment was calibrated monthly with no failures.

Maintaining stable storage conditions is critical to prevent hemolysis, pH drift, and platelet deterioration. The 100% compliance underscores robust cold-chain management and well-maintained infrastructure. This finding confirms that both environmental and technical control systems function optimally, matching WHO standards for blood storage.

FIGURE 1: TEMPERATURE CHART



COMPATIBILITY TESTING

All donated blood units underwent forward and reverse ABO blood grouping, Rh(D) typing, antibody screening, and major crossmatching before issue according to institutional standard operating procedures. Crossmatch compatibility was assessed by concordance between donor and recipient ABO/Rh blood groups, absence of agglutination or haemolysis during crossmatching, and successful completion of compatibility testing before transfusion. During the study period, all compatible units were correctly matched, and no ABO/Rh mismatches, incompatible crossmatches, or acute haemolytic transfusion reactions were recorded, resulting in 100% compatibility accuracy.

TABLE 4: COMPATIBILITY TESTING AND CROSSMATCHING

Parameter	Observation
Forward ABO grouping	Performed for all donations
Reverse ABO grouping	Performed for all donations
Rh(D) typing	Performed for all donations
Antibody screening	Performed before issue
Major crossmatch	Performed for all issued units
ABO/Rh mismatch	None detected
Incompatible crossmatch	None detected
Acute haemolytic transfusion reaction	None observed
Compatibility accuracy	100%

The perfect compatibility record demonstrates the precision of testing and adherence to SOPs. This is a critical indicator of transfusion safety, as crossmatch accuracy directly affects patient outcomes. Compatibility accuracy was determined

by the absence of ABO/Rh discrepancies, negative incompatible crossmatch results, and the absence of haemolytic transfusion reactions among all issued blood units during the study period.

ADVERSE REACTION MONITORING AND LABORATORY

Among 245 transfusions monitored, 5 (2%) produced mild adverse reactions, including three (1.2%) febrile non-haemolytic reactions and two (0.8%) allergic urticarial reactions. No haemolytic or anaphylactic events occurred.
Internal laboratory parameters, including hematocrit, PT, aPTT, and fibrinogen, remained within normal ranges, and all bacterial cultures (nutrient agar, blood agar, and MacConkey agar) were sterile.

TABLE 5: ADVERSE REACTIONS

Reaction Type	Frequency (%)	Severity	Outcome
Febrile non-haemolytic	1.2 (3/245)	Mild	Resolved
Allergic urticaria	0.8 (2/245)	Mild	Resolved
Haemolytic/Anaphylactic	0	None	None

Total adverse reaction rate – Total adverse reaction rate: 5/245 (2%), all mild and self-limited.

The low incidence of transfusion reactions (2%) mirrors global data, where reaction rates typically range between 1–3% (10,14). The absence of severe reactions demonstrates the safety of the transfusion process and the precision of pre-transfusion compatibility testing. The sterile culture results validate aseptic processing, while normal coagulation parameters confirm component stability and the reliability of internal quality systems.

INTERNAL QUALITY PARAMETERS

Across all QC domains, the overall compliance rate was 98%. Donor screening and infectious testing achieved near-total compliance (98–100%), component QC maintained between 96–98%, and equipment and storage domains achieved 100%. Laboratory QC remained stable, and adverse reactions were minimal.

TABLE 6: INTERNAL QUALITY PARAMETERS

Parameter	Reference Range*	Result	Interpretation
Hematocrit (M)	40–54%	Within range	Normal
Hematocrit (F)	36–48%	Within range	Normal
PT	11–13.5 s	12.8 ± 0.5	Normal
aPTT	21–35 s	28.6 ± 2.1	Normal
Fibrinogen	200–400 mg/dL	312 ± 18	Normal
Culture	Blood, Nutrient and MacConkey agar	No growth	Sterile

**Reference ranges adapted from the World Health Organization (WHO) Laboratory Quality Management System Handbook (2011), National AIDS Control Organization (NACO) Standards for Blood Centres (2020), and Clinical and Laboratory Standards Institute (CLSI) guidelines. [11,12,17,18]*

Internal quality control parameters were evaluated using representative quality control samples from Packed Red Blood Cells (PRBC), Random Donor Platelets (RDP), and Fresh Frozen Plasma (FFP). Hematocrit was assessed in PRBC units,

coagulation parameters including fibrinogen were evaluated in FFP units, while microbiological sterility testing was performed on representative blood component samples using nutrient agar, blood agar, and MacConkey agar.

TABLE 7: OVERALL QC SUMMARY

QC Domain	Compliance (%)	Remarks
Donor Screening	98	Effective deferral
Infectious Testing	100	TTI risk minimized
Component QC	96–98	Within WHO limits
Storage & Equipment	100	Fully compliant
Compatibility Testing	100	No mismatch
Adverse Reactions	2	Mild only
Lab QC	100	All within normal range
Overall Compliance	98%	Meets WHO/NACO standards

TABLE 8. COMPARISON OF PRESENT STUDY FINDINGS WITH WHO/NACO STANDARDS

Parameter	WHO/NACO Standard	Present Study
Donor screening	Mandatory	Performed for all donors
TTI screening	Mandatory	Performed for all collected units
PRBC hematocrit	55–70%	98% complied
Platelet yield	≥5.5 × 10^{10}/unit	98% complied
FFP fibrinogen	≥200 mg/dL	98% complied
PRBC storage	2–6°C	100% compliant
RDP storage	20–24°C with agitation	100% compliant
FFP storage	≤−30°C	100% compliant
Equipment calibration	Monthly	Monthly
QC frequency	Monthly	Monthly
Overall QC compliance	≥95%	98%

The consolidated compliance rate of 98% exceeds NACO's minimum threshold of 95% and aligns with reports from Surat [8] and Eastern India [1], confirming that structured internal QC programs are both effective and reproducible. This high

level of conformity demonstrates institutional maturity in transfusion governance, ensuring both product quality and patient safety.

SUMMARY

The synthesis of these results reveals a blood transfusion service that performs at an advanced level of quality assurance, achieving near-perfect alignment with WHO and NACO standards.

Key interpretations include:

- High component compliance (98%) confirms robust technical capacity.
- Stable storage and equipment function (100%) prove infrastructural reliability.
- Minimal TTI positivity (3.3% combined) demonstrates successful donor selection.
- Low reaction rate (2%) validates safe transfusion practice.
- Sterility of all components highlights effective infection control measures.

Overall, the data confirm that Sree Balaji Medical College and Hospital's Blood Bank operate as a model for national transfusion safety, integrating automation, staff competence, and documentation discipline to achieve sustainable quality.

DISCUSSION

In the present study, the blood bank demonstrated a high level of compliance with WHO and NACO quality standards across all quality control domains. Overall quality control compliance was **98%**, with PRBC, RDP, and FFP compliance rates of **98%, 98%, and 98%**, respectively. These findings indicate effective donor screening, blood component preparation, storage, compatibility testing, and haemovigilance practices.

DONOR SCREENING AND TTIS

The 2.3 % HBsAg and 0.7 % HCV positivity rates are consistent with data from Uttarakhand and Ahmedabad centers [2,3,8]. Zero HIV positivity and complete discard of reactive units demonstrate effective screening practices aligned with national guidelines [4].

COMPONENT QUALITY AND AUTOMATION

PRBC compliance (98 %) matches that reported by Das et al. [1] and Bhardwaj et al. [5], who attributed improved hematocrit and yield to quadruple bag automation. Platelet quality (98 %) was comparable to results by Sahoo et al. [6] and Warke et al. [9], confirming that buffy-coat and PRP methods can achieve WHO standards when agitation and pH are maintained. Plasma quality (98 %) aligned with Bala et al. [7], who observed >95 % compliance for Factor VIII and fibrinogen.

STORAGE AND CALIBRATION

No temperature excursions and routine equipment validation ensured component stability, similar to findings by Patel et al. [3] and Akhtar et al. [4]. These studies underline that monitoring systems and periodic maintenance are vital for sustained quality.

ADVERSE REACTIONS

The 2 % reaction rate corresponds to international data [10,14], with only febrile and mild allergic responses reported. This reflects effective cross-matching and antibody screening protocols.

MICROBIOLOGICAL QC

The absence of bacterial contamination across all media confirms aseptic collection and processing. Routine culture testing adds credibility to internal sterility assurance [11,12].

OVERALL PERFORMANCE AND COMPARISON

A 98 % compliance rate places this center within the top range of Indian transfusion services. Integration of automated systems and continuous training has made quality monitoring routine practice. These results affirm that well-structured IQC frameworks can maintain global-standard safety [1,3,5,6,8,9,13].

CONCLUSION

The findings indicate that the blood bank maintained a structured internal quality assurance programme and achieved a high level of compliance with WHO and NACO standards during the study period. Automation, effective donor screening, and continuous monitoring produced safe and reliable blood components while minimizing transfusion risks.

RECOMMENDATIONS

1. Maintain monthly QC audits following NACO guidelines.
2. Strengthen automation and data recording systems.
3. Conduct regular calibration and staff training programs.
4. Expand hemovigilance reporting and digital traceability.
5. Participate in external quality assurance programs for benchmarking.

LIMITATIONS

This study was limited to a single center and did not include molecular-level TTI screening. External QC participation and multicentric comparison would strengthen generalizability.

ETHICAL CLEARANCE

Approved by the Institutional Ethics Committee, Sree Balaji Medical College and Hospital (**Ref: SBMC/IEC/2023/Path-021**). All procedures complied with WHO ethical standards.

Artificial intelligence tools were used exclusively for proofreading and improving linguistic clarity. AI did not influence the study design, data extraction, analysis, interpretation, or conclusions. All scientific judgments and final content remain entirely the authors' own.

CONFLICT OF INTEREST

No conflicts of interest declared.

FUNDING

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CASE STUDY

ETHICAL DILEMMA IN A PATIENT WITH A DO-NOT-RESUSCITATE ORDER (DNR): A CASE REPORT

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ABSTRACT

Adhering to professional ethics is fundamental in-patient care. The primary ethical principle is to respect the patient's autonomy in decision-making. However, in many clinical settings, particularly in jurisdictions like Iran, this principle faces significant barriers due to legal and religious interpretations of the "sanctity of life." This article argues that the concept of autonomy, specifically the patient's right to refuse treatment, must be the foundational framework before discussing complex end-of-life decisions like "Do-Not-Resuscitate" (DNR) orders.

We report a case of a 91-year-old patient who returned to Iran with a pre-existing DNR request. The subsequent conflict between his autonomous wishes and local clinical mandates resulted in a traumatic outcome for both the patient and the nursing staff. We analyze how the lack of clear legal guidelines regarding DNR, combined with systemic resource allocation issues, creates profound moral distress for nurses.

This paper advocates for a transition from a reactive clinical approach to a proactive, ethics-based legal framework that honors patient autonomy while safeguarding healthcare providers.

KEYWORDS

Ethical principles, principle of independence, cardiopulmonary resuscitation, ethical challenge, nurse

INTRODUCTION

Nurses are the largest group of healthcare service providers globally. The mission of this profession is to provide necessary healthcare, treatment, and rehabilitation services at the highest standard level to ensure the promotion and maintenance of society's health [1]. In order to achieve these goals, nurses must adhere to ethical principles. Beyond simple technical competence, the moral agency of the nurse is tested in the crucible of end-of-life care, where personal values, religious beliefs, and professional obligations often collide [2]. To navigate these dilemmas, one must first establish a hierarchy of ethical discourse. At the apex is the Principle of Autonomy, which dictates that competent individuals have the absolute right to self-govern, including the right to accept or refuse any medical intervention [3]. A DNR order is not a request for euthanasia, nor is it an abandonment of care; it is the exercise of a patient's right to refuse a specific, highly invasive medical intervention when it contradicts their personal goals of care [4].

Independence comes from the Greek root "Auto-Nomos," where "Auto" means self and "Nomos" means law. In general, it means that a person establishes their own rules and makes decisions about their affairs [5]. Independence is the right that a person has to determine their destiny, rooted in society's respect for recognizing people's informed decisions about their issues [6].

Autonomy in bioethics refers to respecting a patient's decision and choice. Patient autonomy is the patient's right to choose treatment without the intervention of health authorities [7, 8]. Patients with incurable diseases or fear of injuries caused by the CPR process may choose not to receive it when their condition deteriorates [9]. CPR includes all basic and advanced treatment measures in cardiac or respiratory arrest due to various clinical reasons [10].

The Iranian legal and ethical landscape presents a unique challenge. While the ethical principle of autonomy is globally recognized, its implementation in Iran is constrained by a legal system that views the withdrawal of life-sustaining treatment as a potential liability. Currently, under Iranian law, the duty to preserve life is so paramount that a patient's prior refusal of CPR might be interpreted by courts as a form of "intentional homicide" or "abandonment," regardless of the patient's documented wishes [11]. This legal rigidity forces clinicians into a defensive medical practice, where they prioritize legal compliance over the ethical duty to honor patient choices. This creates a double bind for nurses, who are trained to be patient advocates but are legally shackled by a system that refuses to acknowledge the legitimacy of DNR order [12].

Crucially, the moral distress experienced by nurses in these scenarios is not solely due to the violation of patient autonomy. It is deeply rooted in the structural failures of the healthcare environment. For instance, when resources are scarce such as the limited availability of ICU beds or the inequitable allocation of life-support equipment nurses often feel the moral weight of being forced to perform futile CPR on patients who have expressed a desire for a peaceful death [10, 12]. This not only exhausts physical resources but also causes moral injury to the nurse, who feels complicit in a process that they know is medically futile and ethically discordant with the patient's dignity [13].

This presents a moral challenge for nurses; what should be done in opposing the law and religious teachings while respecting the patient's wishes and decisions for their treatment process?

CASE INTRODUCTION

In March 2023, a 91-year-old male with a history of hypertension, osteoporosis, and previous percutaneous coronary interventions was admitted to an intensive care unit (ICU) in Tehran, Iran, due to decreased consciousness and hypoxemia (O2 sat <80%). The patient had been recently treated for aspiration pneumonia in Los Angeles, where he had signed a formal DNR document.

Upon admission, the family presented these documents. They explained the patient's desire to avoid the trauma of intubation and CPR, preferring a peaceful end-of-life. However, the hospital administration and the treating physicians, guided by a conservative interpretation of Iranian law, clarified that such documents carry no binding legal weight in the ICU. The team felt they had no choice but to follow standard resuscitative protocols to avoid professional and legal repercussions.

Two days post-admission, the patient's condition worsened. Despite the vocal objections of the family, the patient was intubated. When cardiac arrest occurred, the staff initiated full resuscitation measures. The patient died shortly thereafter. In the aftermath, the nursing team reported a profound sense of moral distress. This was exacerbated by several factors:

1. The feeling of powerlessness in failing to protect the patient's bodily integrity;
2. The cognitive dissonance of witnessing a traumatic, futile intervention that ran counter to the patient's stated goals;
3. The systemic frustration of a work environment where defensive medicine is prioritized over compassionate, patient-centered care. The nurses felt that their role had been reduced to mechanical function, stripped of the ethical capacity to advocate for a dignified death.

DISCUSSION

The implementation of a DNR order is a fundamental expression of human autonomy. The failure to honor it in this case underscores a systemic void in Iranian healthcare [14]. To bridge this gap, we must reconsider how we integrate ethical principles into clinical practice:

1. Prioritizing Autonomy: Clinical decision-making must move away from the assumption that saving life at all costs is the only ethical imperative. Respect for patient autonomy includes the right to a dignified death, which necessitates the formal recognition of DNR requests [3].
2. Addressing Legal-Ethical Friction: It is time for Iranian lawmakers and clinical ethics committees to move beyond the traditional binary of Resuscitate vs. Murder and develop a legal framework that recognizes the validity of Advanced Directives (Ads). This would provide the necessary safe harbor for clinicians to act in accordance with patient wishes without fear of litigation [2,3].
3. Broadening the Scope of Moral Distress: Moral distress is not merely a philosophical byproduct; it is a clinical hazard. As demonstrated by the scarcity of resources, when nurses are forced to perform futile procedures, it compromises the overall efficiency and humanitarian quality of the ICU. Healthcare institutions must implement structural support mechanisms, such as ethics consults and debriefing sessions, to address these issues before they lead to nurse burnout and moral injury [15,16].

In conclusion, the case of this patient is not an isolated event but a call to action. By aligning our legal mandates with global ethical standards, educating staff on the nuances of autonomy, and acknowledging the environmental triggers of moral distress, we can ensure that patients like the one described in this report receive care that respects their dignity rather than merely prolonging their suffering [17,18].

ETHICAL CONSIDERATION

The ethical considerations and scientific value of the report were discussed with the late H.SH.'s wife and children, who have given their consent for the publication of the results. Additionally, this study was conducted in compliance with the standards of the Organizational Ethics Committee of Tehran University of Medical Sciences and the 1964 Declaration of Helsinki.

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