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RESEARCH ARTICLE

FACTORS AFFECTING THE USAGE OF PACS IN TERTIARY CARE HOSPITALS IN INDIA: A CROSS-SECTIONAL ANALYSIS

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ABSTRACT

INTRODUCTION:

Picture archiving and communications systems (PACS) enable the electronic administration of digital image evaluation. PACS have been created in an attempt to provide cost-effective storage, quick image retrieval, access to photos taken using multiple modalities, and simultaneous access from various locations. The present study was conducted to identify and assess the various factors influencing PACS use among physicians and radiologists in multi-specialty tertiary care hospitals in Bengaluru, Karnataka, and defence hospitals across India.

METHODS:

A cross-sectional study was conducted between Feb-Sept 2024 among 219 physicians and 58 radiologists across nine hospitals (one private hospital and eight defence hospitals) in India. Three experts conducted face and content validation, and the questionnaire was suitably modified for use prior to data collection. Cronbach's alpha was used to assess internal consistency. Data was collected using a questionnaire, either through paper or Google Forms. Descriptive statistics, ANOVA and Pearson's correlation were performed.

RESULTS:

The benefits most frequently reported by clinicians and radiologists were improved patient care, adequate image quality, and the more frequent use of PACS for prior examinations. Concerns regarding perceived challenges include the unavailability of images at the bedside, downtime exceeding acceptable levels, and inadequate training. Significant relationships and variance were found between user characteristics and interrelated variables. Utilisation rates of radiological equipment differ due to the challenges identified.

CONCLUSION:

The study helps to identify and analyse both the benefits and challenges of PACS usage among physicians and radiologists at private and defence hospitals in India. The findings of this study provide an initial assessment of the radiology department's management strategies regarding the impact of PACS on its users.

KEYWORDS

Picture Archiving and Communication System (PACS), radiologist, physician, patient care delivery, India

INTRODUCTION

Picture archiving and communications systems (PACS) enable the interelectronic administration of obtained digital image evaluation. Pipelining to boost the performance of the central processing unit, client and server design for remote radiology applications, and image file servers are all examples of computer architecture that may be used in radiology. Image compression methods improve digital storage and image transmission rates. Identifying bottlenecks can help boost throughput rates [1] PACS have been created in an attempt to provide cost-effective storage, quick image retrieval, access to photos taken using several modalities, and simultaneous access at many places. PACS can accept input from both digital and analog sources (when the latter have been digitized). PACS is generally composed of an image capture device (an electronic gateway to the system), a data management system (a specialized computer system that manages the flow of information on the network), and image storage devices, A transmission network (which serves local or vast regions), display stations (which contain a computer, text monitor, picture monitors, and a user interface), and equipment for producing hard-copy images (currently a multiformat or laser camera). The aims of PACS are to increase operating efficiency while preserving or increasing diagnostic capability [2].

Purchasing and implementing a PACS is a significant investment with long-term implications for healthcare providers. Consideration of selection variables is crucial for ensuring customer pleasure and quality. Mistakes in decision-making can have negative consequences for a company. Effective decision-making is crucial in healthcare institutions like hospitals to ensure high-quality patient care. Inadequate PACS features can result in medical blunders and jeopardize patient safety [3]. In many industrialized nations, this technology is well-established, and its implications are well recognized. However, in developing nations like India, its application is still in its infancy. The advantages of this technology are not fully recognized. Indicators that may be assessed include the impact of this system on reporting times and the percentage of imaging services used [4].

The areas most impacted by the switch to filmless imaging in radiography examination execution are data access, picture acquisition, and repeating lost exams. It has been demonstrated that there is a significant reduction in the report-generating time (known as the report turnaround time), which is calculated from the conclusion of the examination to the delivery of the film and report. PACS influences report transcription and report dictation times. In one research, the average turnaround time decreased from 87.8 to 32.3 hours, and 71.1% of the reports were available within 24 hours [5]. PACS, traditionally utilised in radiology, has expanded to include medical images from cardiology, oncology, and dermatology. PACS is widely used in hospitals worldwide to enhance patient care. Barriers to using the technology include staff reluctance, downtime, and insufficient training [6,7,8].

Several studies have sought to illustrate the benefits of PACS to users, although many have focused on specific categories of users, such as radiology trainees, users in a particular department, or have been more specialised in their approach [9,10]. Previously published articles have outlined factors recognised during the selection process and critical success factors for implementing PACS in hospitals. During the selection phase, they categorised factors into two categories: specific factors and general factors. Specific factors include usability, leveraging the experiences of leading centres in PACS implementation, interoperability, specialised capabilities for education and research, and compatible hardware. In general, factors include price, domestic or foreign software, vendor presentation, quality, systemic factors, and management factors [3,9,10]. Published articles highlight factors affecting physicians and radiology staff; and have identified and analysed the benefits, such as improved patient care, reduced time for reviewing an exam, better consultation efficiency and challenges of PACS for the participants in their study and imnproved diagnosis accuracy [11,12, 13].

Several research gaps remain regarding the implementation of PACS in hospitals. Most of the studies identified were conducted after the implementation of PACS; therefore, there is a need for pre- and post-studies to be conducted to fully assess the efficiency of PACS. There is also a need to compare the outcomes of PACS across different working environments [6,12, 14]. A scoring system based on a set of criteria is needed to select the PACS with a higher score, which

leads to patient's satisfaction and better efficiency [6, 12]. Previous literature did not consider socioeconomic and cultural variables [11, 15]. Recent literature mentions various quantitative and qualitative factors that significantly affect the use of PACS in hospitals [6,12, 14]. The present study was conducted to identify and assess the multiple factors affecting PACS use among physicians and radiologists across multi-speciality tertiary care hospitals in Bengaluru, Karnataka and defence hospitals in India.

METHODS

This cross-sectional study was conducted among physicians and radiologists in a multispecialty tertiary care hospital in Bengaluru, Karnataka, India, as well as in defence hospitals across the country. Cross-sectional studies are effective for this study because they collect data from a representative sample, providing an overview of the topic under investigation. Furthermore, this technique is suitable for examining the relationships between sociodemographic traits, service outcomes, and personal intentions and hassles [16].

Data collection was conducted in two phases; Phase I was conducted in a multi-speciality hospital in Bangalore between Feb-Mar 2024 with 63 physicians and eight radiologists interviewed face-to-face, and Phase II was conducted across multiple defence hospitals across India between Aug-Sep 2024, with 156 physicians and 50 radiologists contacted for interviews across eight hospitals in the country. Consent was obtained verbally over the phone for personnel who were not physically available, and the call logs and phone numbers were recorded. Google Forms were circulated, and the questionnaire PDF was sent; completion was done at the subject's convenience. Personnel who were available on-site consented directly. Due to security reasons, the exact locations of the defence hospitals cannot be disclosed. However, they were predominantly located in the northeastern and northern parts of India, with a few inputs from the southern military hospitals. Participants included both full-time and part-time physicians and radiologists with a minimum of 6 months of PACS usage experience. Visiting physicians or radiologists were excluded due to their presence in multiple hospitals, which limited their ability to respond to the use of PACS in the hospitals identified for the study.

INSTRUMENTATION

Step 1: Identification of multiple tools from previously published articles

Previous studies employed various tools to assess factors influencing PACS implementation in hospitals. For example, Saghafi et al. (2017) used an interview method to identify Critical Success Factors (CSFs) in PACS implementation [17], while Esfahani et al. (2018) employed a semi-structured interview in their qualitative study [3]. Goodarzi et al. (2016) used a previously validated questionnaire to measure acceptance levels in the emergency departments of three hospitals in Iran [18]. Buabbas et al. (2016) used a questionnaire and interview method to identify PACS impact on radiologists and technologists [19]. Tshalibe et al. (2023) conducted a cross-sectional observational study over five months using a questionnaire to measure both benefits and challenges of PACS from physicians' perspectives [12]. Aldosari et al. (2018) used a questionnaire for a quantitative study at the radiology department in a hospital in Saudi Arabia to examine the PACS impact from the user perspective [11]. Alalawi et al. (2016) used a questionnaire to assess perceived benefits and challenges for physicians and radiologists at three Ministry of Health hospitals in the Riyadh region, Saudi Arabia [14].

Step 2: Selection of appropriate data collection instruments

Studies conducted by Aldosari et al. (2018) and Alalawi et al. (2016) were conducted in the Riyadh region, Saudi Arabia, in a multi-speciality hospital, which is similar to the present study setting [11,14]. Tshalibe et al. (2023) and Alalawi et al. (2016) were more suitable and appropriate for my study, as both papers include benefits and challenging factors together [12,14].

Step 3: Validation of identified data collection instruments

Aldosari et al. (2018) utilised the Kaplan and Douch data collection instrument, as it was effective in a previous study [11]. The questionnaire was slightly modified and updated to accommodate the study conducted at King Abdul-Aziz Medical City. The instrument was later validated by four experts: two radiologists, a laboratory technologist, and a pharmacist with work experience in health information systems. After their feedback, some adjustments and rewording were subsequently made. Alalwai et. al. (2016) presented Cronbach alpha coefficient with moderate to high internal reliability and consistency; external communication (0.62), service outcomes (0.84), personal intentions (0.53), personal hassles (0.86), and increased blame (0.86)[14]:

The questionnaire used in Alalwai et al. (2016) was identified as the study instrument for this study. However, its face validity was low after internal discussion due to the many questions. Hence, it was decided that this data instrument would be shorted after discussion with the dissertation guide and further validated by experts (medical and IT) from the hospital. The data collection tool used for this study was validated by three experts and divided into three sections: Section 1: Five questions regarding socio-demographic factors; Section 2: Doctors intentions, further subdivided into 3-subscales: (A) Service outcome- 4 questions, (B) Personal intentions- 6 questions, (C) Patient care delivery- 2questions Section 3: Doctor hassles- 5 questions measured on a 5-point Likert scale and the data was collected through the questionnaire. The alpha coefficients of each variable of the original instrument are stated in Table 2.

Table 1: Alpha coefficients of each variable of the instrument

Subcategory	N of items	Alpha value (Physician)	N of items	Alpha value (Radiologist)
Service outcome	4	0.585	4	0.810
Patient care delivery	2	0.670	-	-
Personal intentions	6	0.723	7	0.651
Personal hassle	8	0.645	5	0.795

Data were collected using a questionnaire, either in paper form or via Google Forms, for both participants, and were entered into MS Excel with unique identification numbers and codes. Data was saved on a password-protected personal computer. Data files are stored in the Google Drive and are accessible only to research teams.

STATISTICAL ANALYSIS

All the data was organised using MS Excel and analysed using R software. Descriptive statistics were conducted and reported in frequencies and percentages in MS-Excel. Analysis of Variance (ANOVA) was performed to test the level of impact of the study variables (Service outcome, personal intentions, patient care delivery and personal hassle) on the user characteristics and Pearson's correlation test was conducted to examine the relationship between study impact variables by denoting the correlation coefficient as 'r' and the level of significance as 'p' in R software. All statistical significance was defined as $P<0.05$.

RESULTS

In total, 219 physicians and 58 radiologists agreed to participate in interviews across nine hospitals in the country. 23.28% of physicians were between 30 and 35 years old, compared to 53.40% among radiologists. (Table 2). With the PACS experience, 37.9% of radiologists had more than 6 years of experience compared to 29.68% among physicians. Around 65% of the radiologists had less than 10 years of experience compared to 58% of physicians.

TABLE 2: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE SAMPLE POPULATION

Socio-demographic characteristics	Physician	Radiologist
Age	N, %	N, %
30 -35 years	51(23.28%)	31(53.40%)
36 -45 years	60 (27.39%)	9 (15.50%)
46 -55 years	50(22.83%)	10(17.24%)
Above 55 years	58(26.48%)	8 (13.79%)
PACS Experience		
Below 1years	22 (10.04%)	16 (27.58%)
1-3 years	66(30.1%)	12 (20.68%)
4-6years	66 (30.1%)	14 (24.1%)
More than 6 years	65(29.68%)	22(37.9%)
Years of Experience		
Below 5years	50 (23.1%)	20 (34.48%)
6-10 years	77(35.15%)	18 (31.0%)
11-15years	70 (31.9%)	8 (13.79%)
15+ years	22(10.04%)	12 (20.68%)
Total	219	58

Among physicians, 57.7% strongly agreed that PACS had reduced the time waiting for reviewing an image, and 3.2% strongly disagreed that PACS had reduced the turnaround time (Table 30. Regarding physicians' intentions, 20.5% agreed that PACS produce adequate image quality, and 54% strongly agreed that they access exams more frequently on PACS than on films. Among physicians, 60% strongly agree that PACS has improved their patient care delivery and its process. Among radiologists, service outcome 100% agreed that turnaround time had decreased after PACS implementation, and 87% agreed that PACS tools and functionality improve the quality of exam reports. 100% of radiologists agreed that PACS had reduced their time spent on locating exams for review and improved their quality in patient round (Table 4). 50% and 25% of radiologists agreed that they experience higher PACS downtime than acceptable and experience inadequate workstation speed.

TABLE 3: PHYSICIAN'S RESPONSES ACROSS VARIOUS DOMAINS

Service outcome	SA	MA	N	MD	SD	Mean	STD
PACS has reduced the time I must wait to review an exam/image	95 (57.7%)	49 (31.4%)	12 (7.7%)	2 (1.3%)	3 (1.9%)	4.42	0.839
I believe that report turnaround time has improved since the implementation of PACS.	55 (35.3%)	57 (36.5%)	34 (21.8%)	5 (3.2%)	5 (3.2%)	3.97	0.993
I believe that PACS tools and functionality improve the quality of the report.	66 (42.3%)	57 (36.5	26 (16.3%)	4 (2.6%)	3 (1.9%)	4.00	.870
PACS has reduced the number of exams reordered because	61 (39.1%)	66 (42.3%)	22 (14.1%)	4 (2.6%)	3 (1.9%)	4.00	.870

the exams are not available (lost or located elsewhere) when I need them							
Total	277	229	94	15	14		
Personal intentions	**SA**	**MA**	**N**	**MD**	**SD**	**Mean**	**SD**
I access exams more frequently with PACS than I did with film	61 (57.7%)	49 (31.6%)	12 (7.7%)	2 (1.3%)	3 (1.9%)	4.42	.839
PACS has facilitated consultation between myself, other clinicians and/or radiologists at other healthcare locations	84 (53.8%)	45 (28.8%)	22 (14.2%)	2 (1.3%)	3 (0%)	4.32	.897
My efficiency has improved because of PACS.	46 (29.5%)	67 (42.9%)	34 (21.8%)	6 (3.8%)	3 (1.9%)	4.31	.897
PACS has reduced the amount time it takes me to access exams/reports	26 (41.2%)	29 (46%)	8 (12.7%)	0 (0%)	0 (0%)	4.3	.682
PACS produces adequate image quality on the hospital workstation	32 (20.5%)	79 (50.6%)	29 (18.6%)	9 (5.8%)	7 (4.5%)	3.77	0.986
Total	249	269	105	19	16		
Patient care delivery	**SA**	**MA**	**N**	**MD**	**SD**	**Mean**	**SD**
PACS has improved my ability to make decisions regarding patient care	49 (31.4%)	65 (41.7%)	38 (24.4%)	1 (0.6%)	5 (3.2%)	4.17	0.907
PACS meets my expectations for patient care delivery.	83 (53.2%)	44 (28.2%)	18 (4.76%)	6 (3.7%)	5 (3.2%)	4.24	1.015
Total	132	109	56	7	10		
Personal Hassle	**SA**	**MA**	**N**	**MD**	**SD**	**Mean**	**SD**
PACS have difficulty finding images when needed	3 (4.76%)	7 (11.1%)	7 (11.1%)	27 (42.8%)	19 (30.1%)	2.17	1.129
I experience inadequate workstation performance (speed)	3 (4.76%)	8 (12.7%)	10 (15.8%)	20 (31.7%)	22 (34.9%)	2.21	1.194
I have inadequate access to PACS viewing stations (PCs with Web or workstations).	1 (1.59%)	6 (9.52%)	12 (19.0%)	24 (38.1%)	20 (31.7%)	2.11	1.018

I have difficulty logging on to the system	0 (0%)	3 (4.76%)	5 (7.94%)	25 (39.6%)	30 (47.6%)	1.70	.816
PACS downtime is higher than acceptable	3 (4.76%)	2 (3.17%)	8 (12.7%)	19 (30.1%)	31 (49.2%)	1.84	1.081
I experience a lack of availability of system support	2 (3.17%)	0 (0%)	11 (17.4%)	19 (30.1%)	31 (49.2%)	1.78	.958
I received insufficient training in the new technology	6 (9.52%)	6 (9.52%)	12 (19%)	15 (23.8%)	24 (38.10 %)	2.29	1.325
I am unable to view images at the patient's bedside	33 (52.38%)	12 (19.05%)	12 (19.05%)	4 (6.35%)	2 (3.17%)	4.11	1.123
Total	51	44	77	153	148		

SA- Strongly Agree, MA- Moderately Agree, N- Neutral, MD- Moderately Disagree, SD- Strongly Disagree and STD- Standard deviation

TABLE 4: RADIOLOGIST'S RESPONSES ACROSS VARIOUS DOMAINS

Service outcome	**SA**	**MA**	**N**	**MD**	**SD**	**Mean**	**SD**
I believe that report turnaround time has improved because of PACS.	19 (38%)	26 (52%)	4 (8%)	1 (2%)	0 (0%)	4.26	.687
PACS has reduced my professional travel time	38 (76%)	9 (18%)	2 (4%)	1 (2%)	0 (0%)	4.68	0.646
The implementation/installation from film to PACS was well managed.	3 (37.5%)	4 (50%)	1 (12.5%)	0 (0%)	0 (0%)	4.25	.707
The workflow is completely paperless and filmless after implementation of PACS	3 (37.5%)	2 (25%)	3 (37.5%)	0 (0%)	0 (0%)	4.00	.926
I believe that PACS tools and functionality improve the quality of my report.	23 (46%)	18 (36%)	8 (16%)	1 (2%)	0 (0%)	4.25	.707
Total	86	59	18	3	0		
Personal intention	**SA**	**MA**	**N**	**MD**	**SD**	**Mean**	**SD**
PACS has reduced the time I spend locating exams for review.	38 (76%)	9 (18%)	2 (4%)	1 (2%)	0 (0%)	4.68	.646
I access prior exams more frequently with PACS than I did with film	22 (44%)	22 (44%)	4 (8%)	2 (4%)	0 (0%)	4.28	.776

PACS has improved the quality of patient management rounds that I participate in.	5 (62.5%)	3 (37.5%)	0 (0%)	0 (0%)	0 (0%)	4.62	.518
Since the implementation of PACS the number of face-to-face consultations I have with physicians and other radiologists has decreased.	0 (0%)	2 (25%)	5 (62.5%)	1 (12.5%)	0 (0%)	3.13	.641
Since the implementation of PACS the number of phone (or other) consultations have with physicians and other radiologists has increased	1 (12.5%)	3 (37.5%)	4 (50%)	0 (0%)	0 (0%)	3.63	.744
PACS produces adequate image quality on the workstation.	16 (32%)	26 (52%)	6 (12.5%)	2 (25%)	0 (0%)	4.20	0.722
PACS produces adequate image functionality on the workstation.	16 (32%)	26 (52%)	6 (12.5%)	2 (25%)	0 (0%)	4.20	0.722
Total	98	91	27	8	0		
Personal Hassles	**SA**	**MA**	**N**	**MD**	**SD**	**Mean**	**SD**
I experience inadequate Workstation performance (speed).	2 (4%)	10 (20%)	15 (30%)	18 (36%)	5 (10%)	2.72	1.021
I have difficulty logging on to the System.	0 (0%)	8 (16%)	8 (16%)	24 (48%)	10 (20%)	2.28	.960
PACS downtime is higher than acceptable.	0 (0%)	14 (28%)	13 (26%)	14 (28%)	9 (18%)	2.64	1.073
I received insufficient training in the new technology.	2 (0%)	7 (14%)	18 (36%)	21 (42%)	2 (4%)	2.72	0.895
I experience a lack of availability of system support.	0 (0%)	1 (12.5%)	1 (12.5%)	3 (37.5%)	3 (37.5%)	2.00	1.069
Total	4	40	55	80	29		

SA- Strongly Agree, MA- Moderately Agree, N- Neutral, MD- Moderately Disagree, SD- Strongly Disagree and STD- Standard deviation

ANOVA analysis revealed significant variance between service outcome and personal hassle, as well as between the age of physicians and radiologists, respectively (Table 5). Years of experience showed significant variance among physicians in terms of personal hassle in physicians and radiologists. Significant variance was observed between service outcomes among physicians and personal intentions among radiologists with regard to years of experience (Table 5).

TABLE 5: ANOVA RESULTS OF PHYSICIANS AND RADIOLOGISTS

User characteristics	Physicians								Radiologists							
	Service Outcome		Personal intentions		Patient care delivery		Personal hassle		Service Outcome		Personal intentions		Personal hassle	
	F	Sig	F	Sig	F	Sig	F	Sig	F	Sig	F	Sig	F	Sig
Age	2.89	0.02	11.46	4.37	4.30	0.00	7.58	4.85	0.42	0.79	0.93	0.42	4.54	0.00
Years of experience	2.12	0.09	2.91	0.03	0.81	0.48	5.03	0.00	0.82	0.47	0.87	0.45	2.28	0.07
PACS experience	5.97	0.00	25.72	5.44	25.72	5.44	23.93	4.63	1.48	0.22	4.22	0.01	14.79	6.36

Among physicians, age showed a strong, positive, and significant correlation with years of experience (r = 0.883, p < 0.001) (Table 6). Age showed a moderate positive correlation and high significance with PACS experience (r = 0.605, p<0.001), but a moderate negative correlation with high significance for personal hassle (r = -0.313, p = 0.012). Experience with PACS showed a moderately significant correlation with personal hassle and patient care delivery, with significance (r = 0.369, p = 0.003) and (r = 0.322, p = 0.010). The service outcome showed a strong positive correlation and high significance with both personal intention (r = 0.683, p < 0.001) and patient care delivery (r = 0.613, p < 0.001). Personal intentions show a moderate positive correlation and high significance with patient care delivery (r = 0.584, p<0.001) and a high negative correlation and significance with personal hassle (r = -0.289, p = 0.022). Patient care delivery showed a high negative correlation and some significance with personal hassle (r = -0.246, p = 0.052).

TABLE 6: PEARSON'S CORRELATION (PHYSICIANS)

Age		Age					
Years of Experience	r	0.883	Years of Experience				
	p	<.001					
Experience with PACS	r	0.605	.645	Experience with PACS			
	p	<.001	<.001				
Service Outcome	r	0.109	.031	.236	Service Outcome		
	p	0.396	.809	.063			
Personal Intentions	r	0.182	.105	.369	.683	Personal Intentions	
	p	0.152	.412	.003	<.001		
Patient Care Delivery	r	0.126	.090	.322	.613	.584	Patient care delivery
	p	0.325	.485	.010	<.001	<.001	
Personal Hassle	r	-.313	-.149	-.071	-.308	-.289	-.246
	p	0.012	.244	.580	.014	.022	.052

For radiologists, age showed a moderate to high correlation with other variables, but a negative correlation with personal hassle, and a significant p-value with years of experience (r = 0.909, p < 0.001), PACS experience (r = 0.72017, p =0.148), and radiologist intentions (r=0.010, p = 0.859) (Table 7). PACS experience and years of experience with r=0.794, p<0.019 had a strong positive and significant correlation. The radiologist's intentions and years of experience showed no correlation (r = 0.000, p = 0.997). The radiologist's intentions and PACS experience, with a correlation coefficient of r = 0.864 and p = 0.061, showed a positive correlation. In contrast to the radiologists' hassle, it showed a negative correlation (r = -0.312, p = 0.452). Radiologists' intentions showed a negative correlation and significance (r = -0.788, p = 0.020) with regards to radiologists' hassles.

TABLE 7: PEARSON'S CORRELATION (RADIOLOGISTS)

Age		Age				
Years of Experience	R	0.909	Years of Experience			
	p	<.001				
PACS Experience	R	0.207	0.136	PACS Experience		
	p	0.148	0.343			
Service Outcome	R	0.039	0.103	0.599	Service Outcome	
	p	0.574	0.145	0.394		
Radiologist Intentions	R	0.010	0.000	0.009	0.666	Radiologist Intentions
	p	0.859	0.997	0.864	0.71	
Radiologist Hassles	R	-0.048	-0.097	0.061	-0.312	-0.788
	p	0.336	0.052	0.0219	0.452	0.020

DISCUSSION

Regarding the perceived benefits of PACS in terms of efficiency, 81% of the physicians agreed that PACS improved their efficiency; in contrast, 57.4% agreed in Alalawi [14]. 65% of physicians and 100% of radiologists agreed that PACS had reduced report turnaround time; in contrast, 98% of physicians agreed in Tshalibe (Tshalibe et al., 2023). 71% of physicians responded 'Agreed' to the inability to view images at the bedside, similar to 97% physicians in a previous study [12]. While this limitation could be a gap in the implementation plan, it must be analysed within the context of what is practical in the hospital setting of interest.

Although image quality assessment is subjective and dependent on the viewing platform, the majority of the respondents were satisfied with the image quality. Only 8% of respondents stated that their response was neutral, indicating that PACS produces inadequate image quality. In contrast, Tshalibe et al. (2023) reported that 2% of physicians agreed that PACS produces inadequate image quality [12]. The users' characteristics have shown a significant difference in terms of impact factors, such as personal intentions, patient care delivery, and personal hassle with physicians. Among radiologists' intentions show significant variance with user characteristics, similar to a previous study [11].

A significant positive correlation exists between service outcome and personal intentions, as well as between personal intentions and patient care among physicians. In contrast, a previous study found a significant negative correlation between personal hassle and service outcome [11]. Similar to Aldosari et al. (2018), among radiologists, personal intentions showed a significant correlation with user characteristics and service outcomes; in contrast, radiologists' hassles showed a negative relation with user characteristics [11].

As physicians received insufficient training (mean 2.29, SD 1.325), and radiologists experienced higher-than-acceptable PACS downtime (mean 3.38, SD 0.744), PACS utilisation rates differ (X-ray= 74.5%, ultrasound= 81.6%, C arm= 15.6%, CT scan= 35.7%, MRI= 25.2%, mobile x-ray=11%, mammogram= 12%). PACS/RIS training is a vital practical component that significantly impacts the long-term efficiency of PACS and the time it takes for the investment to yield a return. It is essential to start user training before PACS installation to ensure that productivity begins immediately from the first day [20]. With proper training of users, such as radiologists and physicians, PACS can demonstrate benefits in terms of time and cost savings over several years [21,22].

The results showed that factors such as age and experience with PACS, among physicians and radiologists, have a significant negative relationship with personal hassles. This opinion is likely related to the computer literacy level of the users and/or the lack of interoperability between PACS and other health information systems. Given the issues identified by the physicians and radiologists in our study, practical implications are needed to establish a comprehensive on-site training program, use online meetings for remote training, and utilise social networking sites to familiarise all personnel with

PACS system functions and to address downtime concerns, conduct a comprehensive investigation and find solutions, as these can be devastating to critical systems.

Furthermore, understanding and evaluating the challenges of implementing PACS in developing countries, such as India, is crucial. Finding suitable computer rooms that provide sufficient space for air conditioning, dependable power, and local networks presents additional difficulties, as the system relies heavily on stable electricity. Cultural barriers can also significantly hinder PACS deployment, especially in diverse healthcare environments. These barriers include language differences, varied communication styles, and differing perceptions of technology and workflow preferences [23]

The study has several strengths, such as the use of a validated questionnaire using face and content validation with moderate to high alpha coefficients across all domains, and the study is focused such as the use of a validated questionnaire using face and content validation with moderate to high alpha coefficients across all domains, and the study is focused on radiologists and physicians who primarily use PACS in hospitals.

A few limitations exist for this study. Since the investigation focused on radiologists and physicians, but did not include other medical professionals (e.g. surgeons) who receive patient reports and photographs. The study was confined to only one private hospital and defence hospitals in India. There is a definitive need for future studies to enhance the study's scope by including private and public hospitals, as well as rural and urban hospitals where PACSs are being used, for comparative purposes and to understand adoption challenges. Compared to the 219 physicians included in the survey, only 58 radiologists were available for interview. This was primarily due to the number of radiologists available in the interviewed healthcare facilities. As radiologists are primary users of PACS, future studies in India should focus on including a higher number of radiologists, with a particular emphasis on pre- and post-studies to identify the perceived benefits and challenges before and after the implementation of PACS.

CONCLUSION

Our study found that PACS users had positive perceptions of the system and its impact on their work routine among physicians and radiologists in India. However, overcoming barriers such as inadequate workspaces, insufficient power, and cultural barriers is crucial for its widespread adoption among physicians and radiologists in the country. Further research is needed across rural and urban hospitals, pre- and post-PACS adoption, and among radiologists for a comprehensive understanding of the barriers and challenges of PACS in India.

CONFLICT OF INTEREST:

None to declare

ETHICS APPROVAL:

The study has been approved by the Institutional Ethics Committee of MS Ramaiah University of Applied Sciences, Reference No: EC-24/92-PG-FLAHS

CONTRIBUTIONS:

GRR identified the topic, data collection, analysis, and draft write-up. AG conducted data collection and data analysis. DJ provided overall methodological guidance and final write-up. All authors reviewed and agreed on the final version of the manuscript. This publication is a component of the partial fulfilment of the Masters of Hospital Administration (MHA) dissertation fulfilment of GRR under the supervision of DJ.

DATA AVAILABILITY STATEMENT:

All data relevant to the study are included in the article or uploaded as supplementary information. All data that are incorporated into the article are available from the references mentioned. Raw data have been uploaded in the following link: 10.6084/m9.figshare.28107038
https://figshare.com/account/items/28107038/edit

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