

# TRENDS OF RESEARCH IN HOSPITAL FINANCING AND HEALTH INDUSTRY 4.0/5.0: A BIBLIOMETRIC ANALYSIS

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## ABSTRACT

### INTRODUCTION:

The convergence of Industry 4.0 (technologies) and 5.0 (human-centric) within the health sector heralds a transformative era, leveraging advanced technologies and human intelligence to redefine healthcare delivery. This evolution not only revolutionizes patient care and outcomes but also revolutionizes hospital financing, enabling cost reduction, improved efficiency, and enhanced revenue streams through the strategic integration of artificial intelligence (AI), Internet of Things (IoT), and blockchain technologies.

### AIM:

Through a bibliometric analysis, this paper seeks to unravel the evolving trends in research within hospital financial and Health Industry 4.0/5.0.

### MATERIALS & METHODS:

Bibliometric analysis was performed using the search results from Scopus database, Bibliometrix package in R Studio, and Vosviewer.

### RESULT & DISCUSSION:

178 studies were eligible for analysis from the search on Scopus database. Cooccurrence analysis revealed 5 clusters of keywords in the topic of hospital financing and Health Industry 4.0/5.0. The overlay cooccurrence map showed a shift of the main research topic from focusing on cost analysis and reduction to applying more advanced technologies and addressing privacy concerns.

### CONCLUSIONS:

The increasing impact of Industry 4.0 and 5.0 on hospital financing is indicated by an increasing scholarly focus towards applying more sophisticated technology in hospital financing.

### KEYWORDS

Industry 4.0, Industry 5.0, Healthcare 4.0, Healthcare 5.0, Hospital financing

## INTRODUCTION

The health industry is evolving along with the 4th and 5th industrial revolutions, otherwise known as Industry 4.0 and Industry 5.0. Industry 4.0 aims to increase automation and technology for efficiency improvement, while Industry 5.0 focuses on

creating a sustainable collaboration between humans and technologies. Both are transformative for the health industry.<sup>1,2</sup> Health Industry 4.0 and 5.0 refer to the integration of advanced technologies and human intelligence in the healthcare sector to revolutionize healthcare delivery, improve patient outcomes, and enhance the overall healthcare experience.<sup>2,3</sup>

Industry 4.0 focuses on technologies such as artificial intelligence (AI), the Internet of Things (IoT), big data analytics, and robotics to enable personalized medicine, sophisticated diagnostics, telemedicine, and more patient-centric care. However, it also faces challenges related to data security and privacy, ethical and legal issues, appropriate skills and training for healthcare professionals, and cost-effectiveness.<sup>3,4</sup> Moreover, Industry 5.0 builds upon Industry 4.0 by adding human, environmental, and social aspects back into the equation. It aims to create higher value jobs that afford greater personalization for customers and improved design freedom for workers, as well as to enhance resilience and sustainability in healthcare.<sup>2</sup> In this context, Health Industry 5.0 is a human-centric solution that leverages IoT and AI in healthcare, focusing on mass personalization and the interaction between people and machines to improve work efficiency and effectiveness. This revolution enables healthcare professionals to provide better, more efficient care and facilitates faster recovery for patients.

Health Industry 4.0/5.0 revolutionizes hospital financing through various means. It facilitates cost reduction by integrating advanced technologies such as AI, IoT, and cloud computing, optimizing resource utilization and efficiency across patient care, supply chain management, and administrative tasks.<sup>3,4</sup> Improved efficiency is achieved through telemedicine, remote monitoring, and AI-assisted diagnostics, which enhance diagnostic accuracy and reduce hospital visits, potentially cutting costs for patients and insurers. With a focus on mass personalization, Health Industry 5.0 offers tailored treatments, improving patient outcomes while curbing overall care expenses. Moreover, hospitals benefit from increased revenue by employing AI diagnostics to attract more patients and extending services via telemedicine to remote and underserved areas. Efficient resource allocation through blockchain and big data analytics further streamlines operations, resulting in cost savings and enhanced patient outcomes. Successful adoption hinges on meticulous planning, investment, and a strong prioritization of patient-centered care.<sup>2</sup>

This paper aims to investigate the trends of research in hospital financial and health industry 4.0/5.0 through a bibliometric analysis.

## METHODS

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### BIBLIOMETRIC ANALYSIS

Bibliometric analysis is a research approach that employs statistical methods to examine data from published scientific literature, offering valuable insights into the progression of scientific research domains such as hospital financing and Health Industries 4.0 and 5.0. This method involves selecting a database and using keywords to retrieve relevant publications. In this paper, published articles listed on Scopus are used for the analysis.

Data from Scopus were analysed using VosViewer<sup>5</sup>, a software for bibliometric analysis, and Bibliometrix package<sup>6</sup> on R Studio using R version 4.3.1. Basic information, such as the number of documents, trends, countries of origin, and relevant authors, was gathered from Scopus during the search. The results from the search were then exported into a CSV file for further analysis using VOSviewer and Bibliometrix. Network analysis was conducted using VOSviewer, including keywords occurring five or more times in the search. Bibliometrix was used to create visuals for country production on these topics and the most cited documents.

### SEARCH STRATEGY

Search was done in Scopus using several keywords and Boolean operators. The search was limited to publication years after 1999, published as articles, and in English. The keywords used are ( TITLE-ABS-KEY ( "smart hospital" OR "digital health\*" OR "Digital\*" OR "4.0" OR "5.0" OR "Health\* Industr\*" ) AND TITLE-ABS-KEY ( "Hospital financ\*" OR "Hospital Profit\*" OR

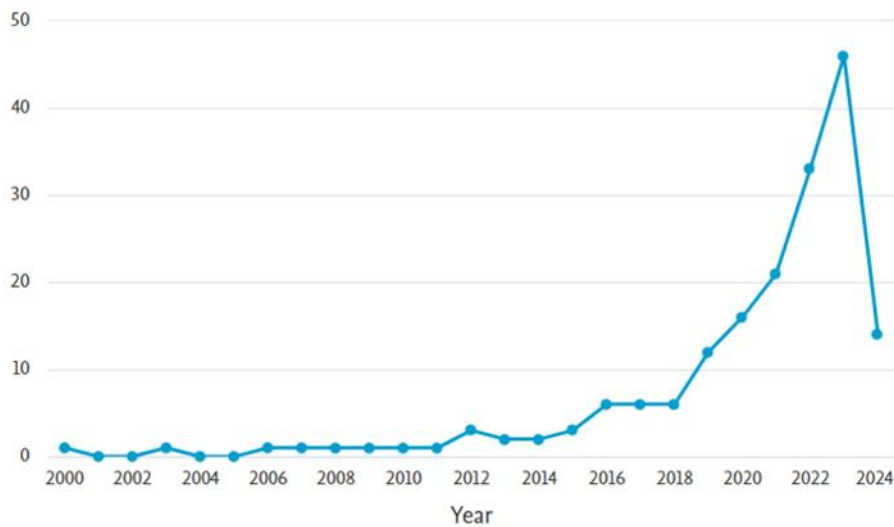
"Hospital Cash\*" OR "Hospital Income" OR "Health\* financ\*" OR "Health\* Profit\*" OR "Health\* Cash\*" OR "Health\* Income" ) AND PUBYEAR > 1999 AND PUBYEAR < 2025 AND ( LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) ).

## RESULTS

Based on the search, 178 studies were included in the analysis. The studies were reported between the years 2000 and 2024. The number of studies published on these keywords experienced a significant increase, from only 6 in 2018 to 12 published studies in 2019 (Figure 1). The number of published studies increased in the following years, reaching 46 studies in 2023.

Data for the 10 most contributing countries are shown in Figure 2 and visualized in Figure 3. The United States contributed the most to these topics, with over 45 publications. India followed as the second most prolific country, with over 35 publications. The United Kingdom and Germany ranked fourth and fifth in terms of contributions, followed by China, Australia, Canada, France, Switzerland, and The Netherlands. The distribution of the 73 contributing countries is shown in Figure 3. Europe, Asia, North and South America, and Australia all made significant contributions to these topics, with sparse contributions from Africa.

**FIGURE 1. NUMBER OF DOCUMENTS ON HOSPITAL FINANCING AND HOSPITAL INDUSTRY 4.0/5.0 PUBLISHED OVER THE YEARS.**



**FIGURE 2. 10 COUNTRIES WITH MOST PUBLICATIONS ON HOSPITAL FINANCING AND HOSPITAL INDUSTRY 4.0/5.0.**

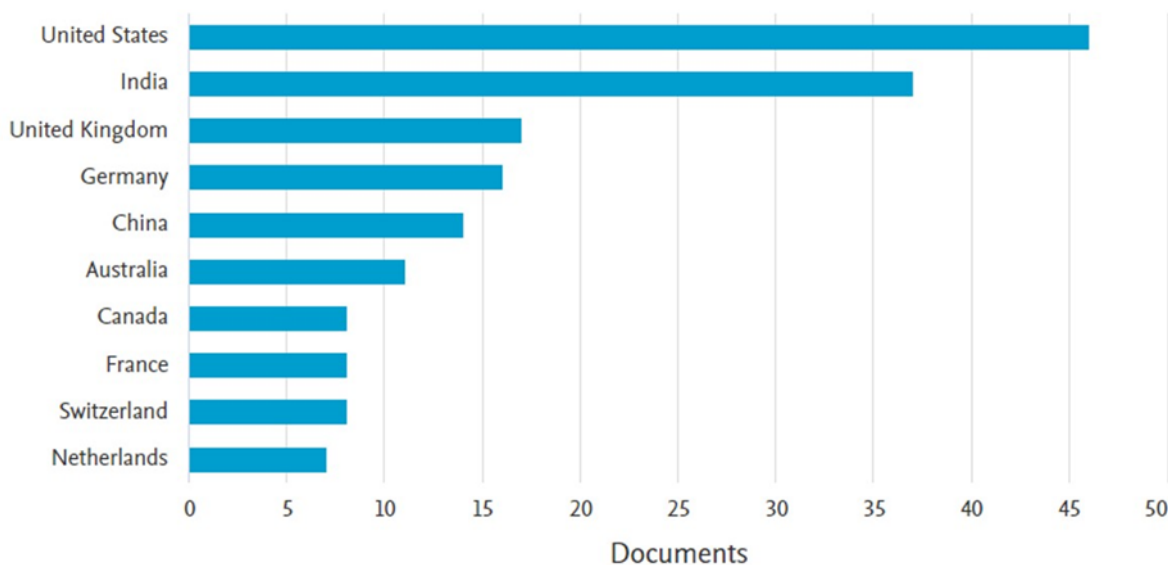


FIGURE 3. COUNTRIES WITH PUBLICATIONS ON HOSPITAL FINANCING AND HOSPITAL INDUSTRY 4.0/5.0.

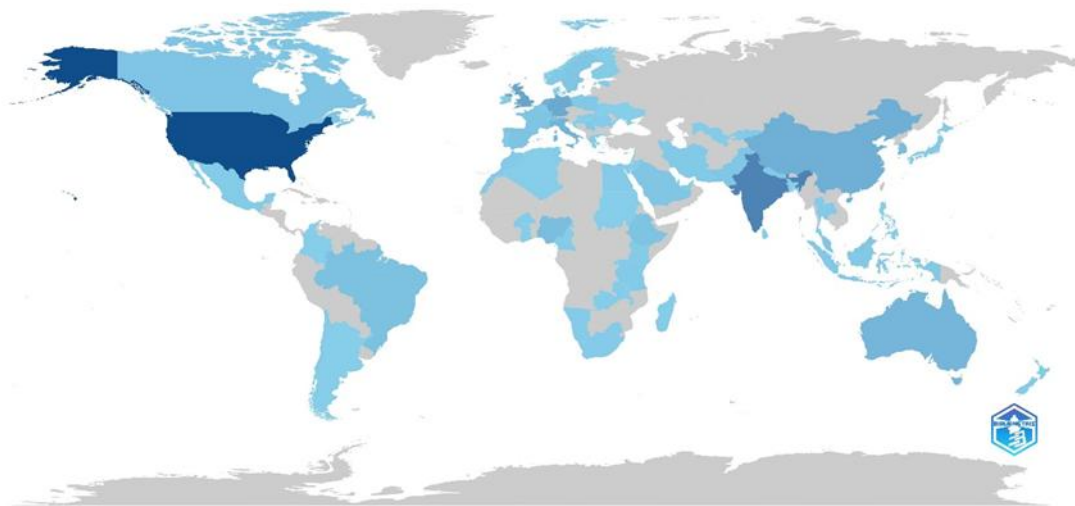


FIGURE 4. 10 MOST CONTRIBUTING AUTHORS ON HOSPITAL FINANCING AND INDUSTRY 4.0/5.0.

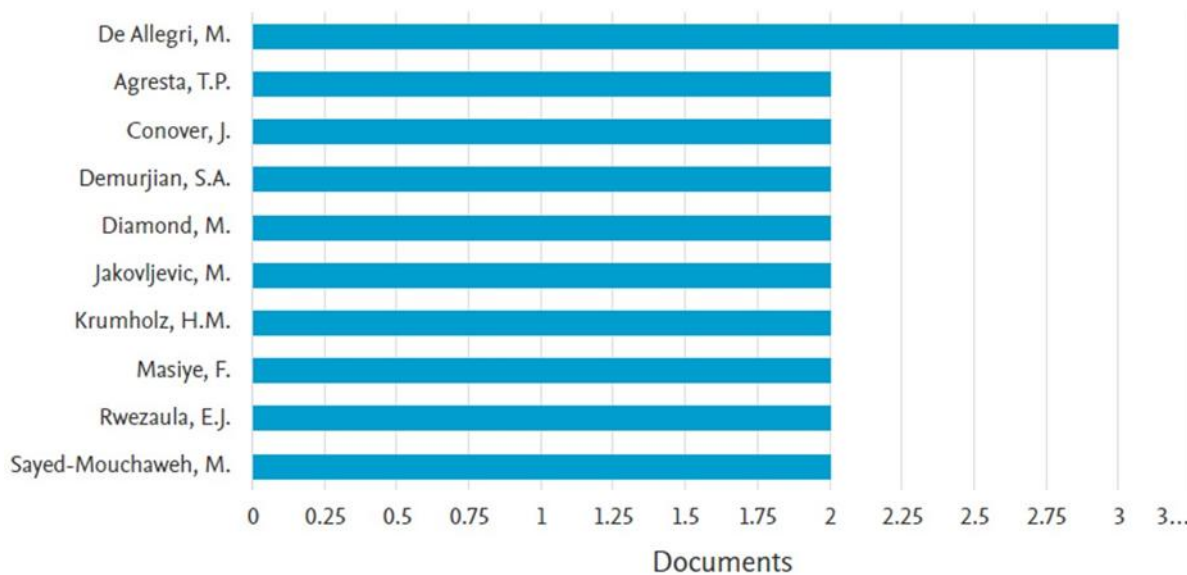


Figure 4 shows the 10 most contributing authors on these topics. The author with the highest number of published papers on this topic is De Allegri, M., with 3 published papers recorded. Agresta, T.P., Conover, J., Demurjian, S.A., Diamond, M., Jakovljevic, M., Krumholz, H.M., Masiye, F., Rwezaula, E.J., and Sayed-Mouchaweh, M., respectively published two papers on these topics.

VosViewer was used to visualize links and occurrences of keywords in the included studies and classify those keywords into clusters. The 113 identified keywords were classified into 5 clusters, each containing different keywords (Figure 5). Each of the clusters has a different number of items, with Cluster 1 containing the most item (35 items), followed by Cluster 2 (30 items), Cluster 3 (21 items), Cluster 4 (15 items), and Cluster 5 (12 items).

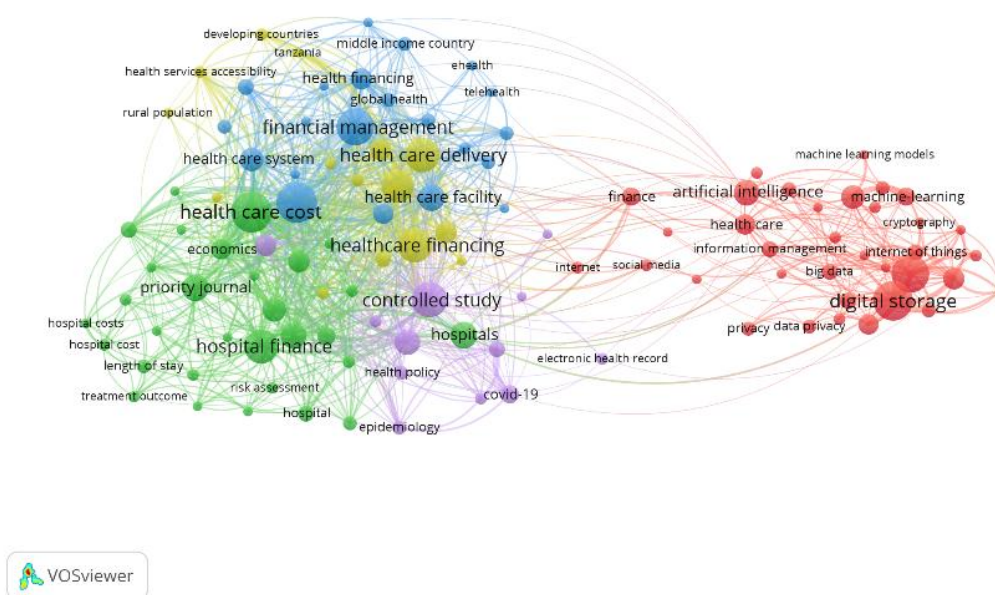
Cluster 1 (red): digital storage, blockchain, artificial intelligence, machine learning, block-chain, health care, security, finance, machine-learning; Cluster 2 (green): health care cost, hospital financing, health care quality, health expenditures, economics; Cluster 3 (blue): health insurance, financial management, health financing, health service, health care access, digital technology, global health, e-health, middle income country; Cluster 4 (yellow): health care delivery, healthcare financing, health care financing, delivery of health care, patient care, developing countries, health

services accessibility; Cluster 5 (purple): public health, health care policy, covid-19, pandemic, epidemiology, health policy, electronic health record, pandemics.

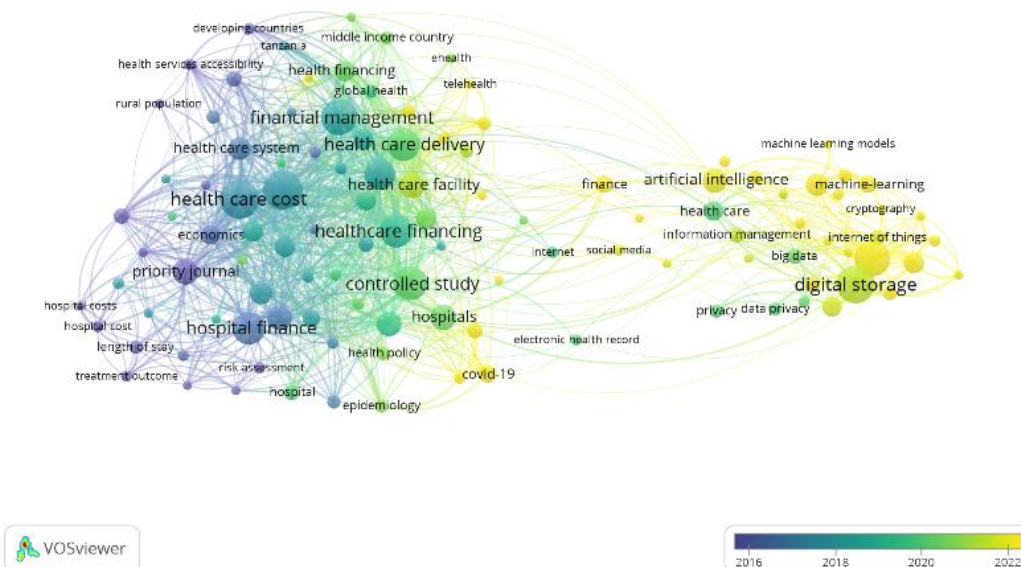
Figure 6 shows the overlay visualization of the co-occurrence network map. The map utilizes a colour gradient to represent the average publication year of documents, ranging from blue for older publications, through green for those evenly distributed across time, to yellow indicating more recent publications. The map highlighted the shift of main topics from the economic perspective and treatment outcomes to the impact of IoT, machine learning, artificial intelligence, and blockchain towards hospital financing.

Figure 7 shows the density map visualization. The map showed the dominance of research in health care cost, hospital financing, healthcare delivery, healthcare financing, and digital storage among other topics. The utilization of social media, information management, and data privacy still remain understudied.

**FIGURE 5. CO-OCCURRENCE NETWORK MAP.**



**FIGURE 6. OVERLAY CO-OCCURRENCE NETWORK MAP.**





Authors	Title	Source title	Cited by
Okuzu O., et al. (2022) <sup>12</sup>	Role of digital health insurance management systems in scaling health insurance coverage in low- and Middle-Income Countries: A case study from Nigeria	Frontiers in Digital Health	2
Suess T.M., et al. (2019) <sup>13</sup>	Smart Pump–Electronic Health Record (EHR) Interoperability with Auto-Documentation is Associated with Increased Submission of Infusion-Therapy Billing Claims at a Community Hospital	Pharmacoeconomics - Open	2
Schuetze L., et al. (2023) <sup>14</sup>	Factors Affecting the Successful Implementation of a Digital Intervention for Health Financing in a Low-Resource Setting at Scale: Semistructured Interview Study with Health Care Workers and Management Staff	Journal of Medical Internet Research	1
Malhan A., et al. (2022) <sup>15</sup>	Role of Electronic Healthcare Record Adoption in Enhancing the Relationship between Quality Measures and Hospital Financial Performance	American Business Review	1
Vogel J., et al. (2024) <sup>16</sup>	The association of hospital profitability and digital maturity – An explorative study using data from the German DigitalRadar project	Health Policy	0

**TABLE 2. MOST OCCURRING KEYWORDS IN HOSPITAL FINANCING AND HEALTH INDUSTRY 4.0/5.0**

Keyword	Total link strength	Occurrences	Keyword	Total link strength	Occurrences
Health care cost	223	21	Health care facility	114	13
Health insurance	207	21	Hospitals	70	13
Digital storage	82	20	Artificial intelligence	33	12
Blockchain	79	19	Health care quality	121	12
Financial management	194	19	Public health	113	12
Health care delivery	183	17	Health care system	117	11
Healthcare financing	173	17	Machine learning	50	11
Hospital financing	136	17	Block-chain	58	10
Health care financing	177	16			

## DISCUSSION

The concept of Industry 4.0 emerged in 2011, describing a phenomenon facilitating the integration of internet technologies for enhanced interaction among factories and businesses spanning various industries.<sup>1,3</sup> Entering a new era characterized by Industry 5.0, we observe a fusion of human capabilities with technological innovations.<sup>17</sup> Industry 5.0 combines the progress of Industry 4.0 with human expertise to amplify communication, collaboration, and workforce capabilities, rather than substituting them. While this paradigm revolutionizes numerous industries, the pace of change within the healthcare sector is comparatively slower when contrasted with other sectors.<sup>18</sup> Therefore, this bibliometric analysis aims to investigate the trends of research in these topics, especially about how Industry 4.0 and 5.0 affect the financial aspect of hospitals.

This paper uses analysis directly from Scopus, VOSviewer, and the Bibliometrix package in R Studio. Scopus was used to identify relevant research, as it is one of the most comprehensive research databases. Our findings showed that the United States and India are two of the most contributing countries to these topics. This finding is similar to the market share both regions hold in the healthcare digitalization sector. North America, with the US accounting for 88.2% of the revenue share, and India are among the countries with the highest compound annual growth rate (CAGR) in the digital health sector.<sup>4</sup> This paper identified five main growing clusters in our findings, showing growing evidence of the impact of Industry 4.0 and 5.0 on hospital financing. The overlay co-occurrence network in our study indicated a shift in the main research topics, from focusing on improving treatment outcomes and reducing costs, to further elaborating on advanced technologies to improve hospital financing. A systematic review published in 2022 notably showed that digital interventions have a higher cost-effectiveness compared to conventional ones.<sup>19</sup> The quality of care was also shown not to be compromised in the digital intervention group compared to the control groups. Another study analyzed the association between hospital profitability, digital maturity, and the adoption of electronic health records (EHR), showing that a one-percentage-point increase in earnings before interest, taxes, depreciation, and amortization (EBITDA) is associated with a 0.359-point increase in digitalization. Another study also found that the full implementation of EHR enhances the relationship between benchmark quality and a hospital's operating margins, where benchmark quality is positively correlated with hospital operating margins.<sup>15</sup> These findings support the development of research to further integrate Industry 4.0 and 5.0 in healthcare.

The largest and most recently growing cluster of keywords consists of digital storage, blockchain, artificial intelligence, machine learning, block-chain, health care, security, finance, and machine-learning. This signifies the direction of development towards collaboration with digital technology in healthcare while addressing the privacy and security concerns of users.<sup>20</sup> Digital storage, in the form of EHR, is the fastest-growing application of digital technology in healthcare. However, the risks related to privacy and security in this context are considered to be higher compared to conventional methods.<sup>21,22</sup> This is where blockchain, a decentralized network of nodes, serves as an effective technology for safeguarding confidential data within the system. Employing blockchain technology involves utilizing technically derived and impressive features such as protecting healthcare data, managing genomic information, electronic data management, medical record keeping, promoting interoperability, digitally tracking issues, and managing outbreaks.<sup>23</sup> Despite the large number of growing studies on the application of more advanced technologies in healthcare, the impact of these advanced technologies on hospital financing is rarely studied. However, at the current growth rate, it is feasible to expect further advancements in the near future and identify where they can contribute to hospital financing.

Qualitatively, this study reveals significant insights into the transformative trends of hospital financing within the paradigm of Industry 4.0 and 5.0, highlighting both challenges and opportunities. The bibliometric study elucidates a shift in focus from traditional cost reduction measures to advanced technological applications, such as artificial intelligence, blockchain, and IoT, which are central to enhancing financial processes like billing, insurance claims management, and budget monitoring. These advancements necessitate substantial initial investments, yet they offer efficiencies through automation and centralized data processing. Moreover, the integration of telemedicine and predictive health services – healthcare services that focus on predicting future outcomes or diseases rather than diagnosing when the diseases have

occurred – underscores a redefinition of hospital business models, enabling competitive and sustainable strategies. However, the digital transformation is not without concerns. Ethical issues, particularly data privacy and security in blockchain systems, are paramount to maintaining patient trust. Additionally, societal impacts, including disparities in technology adoption and potential discomfort for less tech-savvy populations, require targeted communication and education strategies.

## CONCLUSIONS

Industry 4.0 and 5.0 have revolutionized many aspects of people's lives, including healthcare finances. Although growing at a relatively slower pace than other sectors, this paper shows an increased research interest in this topic. The growing number of papers and the shift towards more advanced technological keywords are the main characteristics of research in healthcare financing 4.0 and 5.0.

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