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Global Trends in Smart Healthcare and Smart Hospital Research: A Bibliometric and Systematic Literature Review Approach

Bahar Sangkur Gusasih [1*] Faradilla Savitri Prasetyawati [2] Rafi Yasnova [3] Vip Paramarta [4] Farida Yuliaty [5]

[1*, 2, 3, 4, 5] Universitas Sangga Buana YPKP, Bandung, Indonesia

Email: dr.sangkur@gmail.com, faradillasav@gmail.com, rafiyasnova@gmail.com, vip@usbypkp.ac.id, fari3da.07@gmail.com

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ABSTRACT

Purpose: This study analyzes global research trends, intellectual structures, collaboration networks, technological themes, and future directions in smart healthcare and smart hospital research.

Research Method: A bibliometric analysis combined with a Systematic Literature Review (SLR) based on the PRISMA protocol was employed. From 169 records identified in Scopus, ScienceDirect, Wiley Online Library, and Google Scholar, 26 international journal articles published between 2020 and 2025 met the inclusion criteria. VOSviewer was used to map keyword co-occurrence, thematic clusters, collaboration patterns, and temporal evolution of research.

Results and Discussion: The findings indicate a substantial increase in smart healthcare publications, particularly during 2024–2025. Four dominant research clusters emerged: (1) artificial intelligence and healthcare analytics, (2) Internet of Medical Things (IoMT) and connected healthcare systems, (3) smart hospitals and healthcare information systems, and (4) digital twins, cybersecurity, sustainability, and healthcare governance. The results also reveal growing international and interdisciplinary collaboration among scholars in healthcare, engineering, computer science, and information systems. The overlay visualization shows a thematic shift from healthcare digitalization to intelligent healthcare ecosystems driven by AI, predictive analytics, digital twins, and sustainable innovations.

Implications: This study provides a comprehensive overview of smart healthcare development and offers insights for policymakers, healthcare organizations, and technology developers in designing intelligent, secure, and sustainable healthcare systems.

Originality: This study integrates bibliometric analysis and SLR to provide a holistic understanding of the evolution, intellectual structure, and future trajectory of smart healthcare and smart hospital research.

Keywords: smart healthcare; smart hospital; bibliometric analysis; systematic literature review; healthcare digital transformation.

1. Introduction

The rapid advancement of digital technologies has fundamentally transformed healthcare systems worldwide, leading to the emergence of smart healthcare and smart hospital ecosystems. Smart healthcare integrates advanced technologies such as artificial intelligence (AI), the Internet of Medical

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Things (IoMT), big data analytics, cloud computing, blockchain, digital twins, and semantic web technologies to enhance healthcare delivery, operational efficiency, patient safety, and clinical decision-making (Mohammadzadeh *et al.,* 2023; Thacharodi *et al.,* 2024). Meanwhile, smart hospitals are technology-enabled healthcare environments in which interconnected digital infrastructures support intelligent management, personalized care, automation, and real-time monitoring of healthcare services (Rajaei *et al.,* 2024). The increasing complexity of healthcare demands, aging populations, rising healthcare expenditures, and the need for sustainable healthcare systems have accelerated the adoption of smart healthcare innovations across developed and developing countries.

The global healthcare sector is currently experiencing a digital transformation driven by the convergence of emerging technologies and data-centric healthcare models. Technologies such as electronic medical records (EMRs), IoMT devices, AI-assisted diagnostics, digital twins, and intelligent hospital information systems are reshaping healthcare operations and patient engagement (Izza & Lailiyah, 2024; Ira *et al.,* 2024). Consequently, smart healthcare has evolved into a multidisciplinary research domain involving healthcare management, medical informatics, computer science, engineering, and public health. As research output continues to grow rapidly, a comprehensive understanding of the intellectual structure, thematic evolution, and emerging trends within this field has become increasingly important for researchers, policymakers, and healthcare practitioners.

Recent studies have examined various technological dimensions of smart healthcare. AI has emerged as one of the most influential research themes, supporting predictive analytics, clinical decision support, medical imaging, and healthcare automation. Bhatia *et al.,* (2025) conducted a bibliometric evaluation of AI in sustainable and digital healthcare and reported a significant increase in scientific production after 2018. Similarly, Chen *et al.,* (2024) investigated AI and multimodal data fusion in smart healthcare using topic modeling and bibliometric techniques, identifying machine learning, medical imaging, and intelligent diagnostics as dominant research clusters. These studies demonstrate the growing importance of AI in healthcare innovation while highlighting the increasingly interdisciplinary nature of smart healthcare research.

Another prominent stream of research focuses on IoMT and connected healthcare ecosystems. Bovenizer and Chetthamrongchai (2023) provided a comprehensive bibliometric review of IoT-based healthcare systems, emphasizing the role of connected devices in remote monitoring and patient-centered care. Likewise, Ziwei *et al.,* (2024) and Xin *et al.,* (2026) identified substantial growth in IoMT-related publications and highlighted emerging themes such as wearable technologies, telemedicine, and intelligent healthcare services. Furthermore, Rehman *et al.,* (2025) examined technological innovations, security challenges, and future strategic directions in IoT-enabled healthcare, emphasizing the importance of data security and interoperability in smart healthcare environments.

Several systematic reviews have also explored emerging technologies supporting smart healthcare infrastructure. Pellegrino *et al.,* (2025) developed a conceptual framework for digital twins in healthcare, while Sheng *et al.,* (2023) analyzed latent topics and future trends in healthcare digital twin research. Studies by El Majdoubi *et al.,* (2022) and Haque *et al.,* (2022) investigated privacy-preserving solutions and semantic web applications, respectively, highlighting critical concerns related to data governance, security, and intelligent knowledge management. Additionally, Roy *et al.,* (2025) examined assistive technologies in hospital environments, and Cheng *et al.,* (2026) analyzed the evolution of visualization technologies in healthcare, demonstrating the expanding technological landscape of smart hospitals and healthcare systems.

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Despite the growing body of literature, existing studies predominantly focus on specific technologies or individual components of smart healthcare ecosystems, such as AI, IoMT, digital twins, blockchain, or healthcare information systems. Most bibliometric analyses remain fragmented and technology-centered, limiting a holistic understanding of how these innovations collectively shape the evolution of smart healthcare and smart hospitals. Furthermore, previous reviews often concentrate on a single technological domain, geographical context, or healthcare application area, resulting in a fragmented representation of the broader research landscape (Chen *et al.,* 2024; Xin *et al.,* 2026; Pellegrino *et al.,* 2025).

From a theoretical perspective, there remains limited evidence regarding the intellectual structure, thematic interconnections, research collaboration networks, and emerging research trajectories that characterize the global development of smart healthcare and smart hospital research. Existing reviews have not comprehensively integrated bibliometric mapping with systematic literature review approaches to examine the evolution of the field from a multidisciplinary perspective. Consequently, scholars and practitioners lack a consolidated overview of dominant research themes, influential contributors, knowledge clusters, and future research directions within the smart healthcare ecosystem.

Based on these gaps, this study addresses the following research questions: (1) How has global scientific production on smart healthcare and smart hospitals evolved over time? (2) What are the dominant research themes, intellectual structures, and collaboration patterns within this field? (3) What emerging trends and future research directions can be identified from the existing literature? Therefore, this study aims to systematically analyze the global development of smart healthcare and smart hospital research through a combined bibliometric and systematic literature review approach. The novelty of this research lies in its integrated examination of the smart healthcare ecosystem by synthesizing diverse technological domains including AI, IoMT, digital twins, healthcare information systems, data analytics, and intelligent hospital management within a single comprehensive analytical framework. This approach provides a broader and more holistic understanding of the evolution, current status, and future trajectory of smart healthcare and smart hospital research worldwide.

The remainder of this paper is organized as follows. Section 2 provides a literature review and hypothesis development. Section 3 presents the research method and design. Section 4 provides the results and discussion. Section 5 is Concluding Remarks and Recommendations.

2. Literature Review and Hypothesis Development

2.1 Smart Healthcare and Smart Hospital Research

The concept of smart healthcare has emerged as a transformative paradigm that integrates digital technologies, intelligent systems, and data-driven decision-making into healthcare delivery processes. Smart healthcare encompasses the application of artificial intelligence (AI), Internet of Medical Things (IoMT), big data analytics, cloud computing, blockchain, digital twins, and semantic web technologies to improve healthcare quality, accessibility, efficiency, and sustainability (Mohammadzadeh *et al.,* 2023; Thacharodi *et al.,* 2024). As healthcare systems worldwide face increasing demands driven by aging populations, chronic diseases, and resource constraints, smart healthcare solutions have become essential to improving healthcare performance and patient outcomes.

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Within this ecosystem, smart hospitals represent technology-enabled healthcare organizations that leverage interconnected digital infrastructures, intelligent devices, automation systems, and real-time data analytics to optimize clinical and administrative operations (Rajaei *et al.,* 2024). Recent studies indicate that smart hospitals are increasingly adopting electronic medical records, AI-assisted diagnostics, remote patient monitoring systems, and predictive analytics to improve operational efficiency and patient-centered care (Izza & Lailiyah, 2024; Ira *et al.,* 2024). The growing adoption of digital technologies has spurred substantial growth in academic research on smart healthcare and smart hospitals. However, the field remains highly interdisciplinary, involving contributions from healthcare management, information systems, engineering, computer science, public health, and sustainability studies. Consequently, understanding the intellectual structure and evolution of this research domain has become increasingly important for both scholars and practitioners.

2.2 Emerging Technologies Driving Smart Healthcare Research

One of the dominant themes in smart healthcare research is the integration of artificial intelligence into healthcare services. AI technologies have demonstrated significant potential in clinical decision support, disease prediction, medical imaging, personalized medicine, and healthcare automation (Bhatia *et al.,* 2025). Chen *et al.,* (2024) identified machine learning, multimodal data fusion, and intelligent diagnostic systems as rapidly expanding research clusters within the smart healthcare domain. Their findings suggest that AI is increasingly becoming a foundational technology supporting intelligent healthcare ecosystems. Another significant technological driver is the Internet of Medical Things (IoMT), which enables real-time communication between medical devices, healthcare providers, and patients. IoMT technologies facilitate remote monitoring, telemedicine, wearable health devices, and continuous patient management (Ziwei *et al.,* 2024; Xin *et al.,* 2026). Similarly, Bovenizer and Chetthamrongchai (2023) reported that IoT-based healthcare systems have experienced substantial growth in research due to their potential to enhance healthcare accessibility and efficiency.

Emerging technologies such as digital twins, blockchain, and advanced visualization systems are also reshaping healthcare innovation. Pellegrino *et al.,* (2025) proposed a conceptual framework demonstrating how digital twins can support predictive healthcare management and simulation-based decision-making. Likewise, Sheng *et al.,* (2023) highlighted the increasing relevance of digital twin applications in personalized medicine and healthcare system optimization. These developments illustrate the expanding technological diversity within smart healthcare research. Despite these advances, previous studies primarily focus on specific technologies rather than examining the broader integration of technologies within smart healthcare ecosystems. As a result, the interconnections among technological innovations, healthcare applications, and hospital digital transformation remain insufficiently explored.

2.3 Bibliometric Analysis as a Framework for Understanding Research Evolution

Bibliometric analysis has become an established method for evaluating scientific development, intellectual structures, collaboration networks, and emerging research trends. According to Jiang and Liu (2023), bibliometric approaches provide valuable insights into the evolution of knowledge by identifying influential publications, authors, institutions, and thematic clusters. Bibliometric methods are

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particularly useful for rapidly growing interdisciplinary fields where traditional literature reviews may struggle to capture the complexity of research development.

Recent healthcare studies have increasingly employed bibliometric techniques to investigate specific technological domains. For example, Bhatia *et al.,* (2025) analyzed AI in sustainable healthcare, while Xin *et al.,* (2026) examined the development of IoMT research. Similarly, Roy *et al.,* (2025) investigated assistive technologies in hospital environments, and Cheng *et al.,* (2026) explored visualization technologies in healthcare. Although these studies provide valuable insights into individual technological areas, they do not comprehensively examine the broader smart healthcare and smart hospital ecosystem. Moreover, many existing bibliometric studies focus on publication productivity and citation performance while providing limited discussion of thematic convergence, interdisciplinary collaboration, and emerging research trajectories. Consequently, there remains a need for a comprehensive bibliometric and systematic review that integrates diverse technological streams into a unified analytical framework.

2.4 Theoretical Framework

This study is grounded in Knowledge Evolution Theory and Innovation Diffusion Theory. Knowledge Evolution Theory explains how scientific knowledge develops through the interaction of researchers, institutions, technologies, and scholarly networks over time. Bibliometric indicators such as publication growth, citation networks, co-authorship patterns, and keyword co-occurrence provide measurable evidence of knowledge evolution within a research domain (Jiang & Liu, 2023). Furthermore, Innovation Diffusion Theory suggests that technological innovations spread through communication channels and social systems, influencing adoption patterns across organizations and industries. In the context of smart healthcare, innovations such as AI, IoMT, digital twins, and intelligent hospital systems are diffusing globally, generating new research clusters and interdisciplinary collaborations (Chen *et al.,* 2024; Xin *et al.,* 2026). Together, these theoretical perspectives provide a foundation for understanding the evolution and future trajectory of smart healthcare and smart hospital research. Conclude this section by summarizing how the literature review and hypotheses align with your research aims, emphasizing the study's potential contributions to theory, practice, or policy. Therefore, based on this relationship, the hypothesis proposed in this study is as follows:

H1: *Global smart healthcare and smart hospital research exhibits a significant increase in scientific publication output over time.*

H2: *The expansion of emerging healthcare technologies is positively associated with increased international and interdisciplinary research collaboration in smart healthcare and smart hospital studies.*

H3: *Emerging digital technologies significantly influence the evolution of thematic research clusters and future research directions in smart healthcare and smart hospital literature.*

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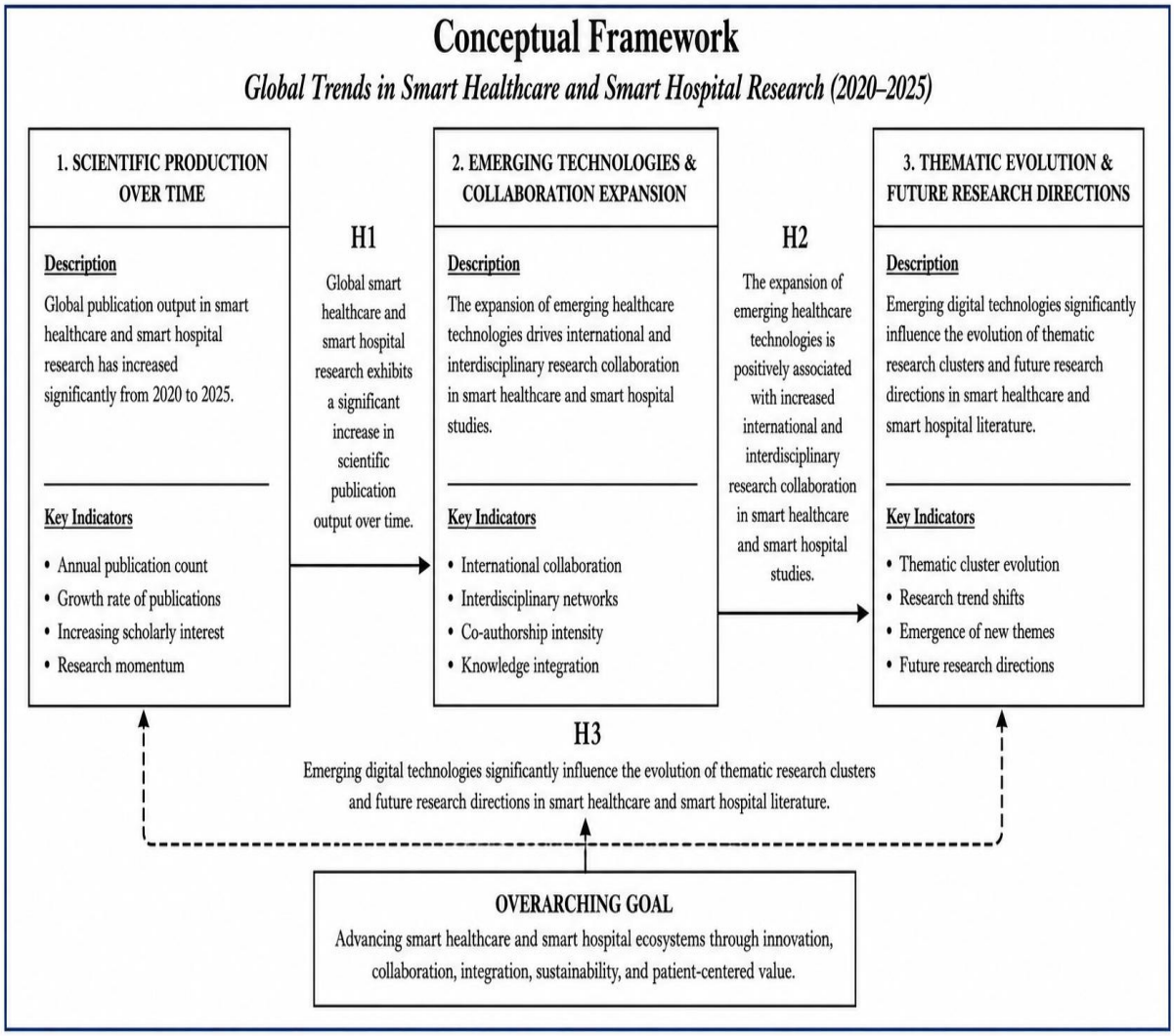

Source: *Process Data, 2025*

Figure 1. Conceptual Framework

3. Research Method

This study employs a systematic literature review (SLR) combined with bibliometric analysis to examine the global development, intellectual structure, and emerging trends of smart healthcare and smart hospital research. The review protocol adopted in this study is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, which consists of four stages: identification, screening, eligibility, and inclusion. The bibliometric analysis procedure begins with defining the research objectives, formulating research questions, and developing a search strategy to collect the dataset. This study integrates systematic literature review and bibliometric analysis procedures because both approaches share similar methodological stages, including determining research objectives, establishing research questions, identifying relevant literature, collecting datasets, screening publications, and conducting quantitative and qualitative analyses. Therefore, the entire review process was conducted systematically to ensure transparency, reliability, and reproducibility throughout the research.

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The entire series of activities during this review followed a structured research design developed during the planning stage. The workflow specified in the research protocol was used as a guideline for implementing each stage of the study. Given the rapid evolution of digital healthcare technologies, a 10-year publication period was deemed sufficient to capture developments in smart healthcare and smart hospital research. Therefore, the dataset collection focused on publications from 2016 to 2025. The data collection process began chronologically by (1) accessing major scientific databases, including Scopus, ScienceDirect, Wiley Online Library, and Google Scholar; (2) entering predefined search keywords into the title, abstract, and keyword search fields; (3) selecting document types, including journal articles and review papers; (4) limiting the publication period to studies published between 2016 and 2025; and (5) exporting the bibliographic information for further screening and analysis.

The search strategy was developed based on the core concepts of smart healthcare and smart hospitals. The keywords used included: ("smart healthcare" OR "digital healthcare" OR "intelligent healthcare" OR "connected healthcare") AND ("smart hospital" OR "digital hospital" OR "intelligent hospital") AND ("artificial intelligence" OR "internet of medical things" OR "IoMT" OR "internet of things" OR "digital twin" OR "electronic medical records" OR "health information systems" OR "big data analytics" OR "healthcare technology"). The search query was designed to capture publications related to technological innovations, healthcare digitalization, intelligent healthcare systems, and smart hospital transformation. Duplicate records, non-English publications, conference abstracts, editorials, and publications lacking full bibliographic information were excluded during the screening process.

The systematic literature review was designed to answer three main research questions.

RQ1: What are the dominant intellectual structures, collaboration networks, technological themes, and research clusters identified through bibliometric analysis using VOSviewer?

RQ2: How has global scientific production related to smart healthcare and smart hospital research evolved during the period 2020–2025?

RQ3: What emerging trends, research gaps, and future research directions can be identified from the systematic literature review and bibliometric mapping of smart healthcare and smart hospital studies?

Meanwhile, the next step is document screening or extraction, applying the inclusion and exclusion criteria established in the previous identification stage. At this stage, all articles and reviews are extracted (screened) to determine the data suitable for SLR analysis.

Table 1. Inclusion and Exclusion Criteria

No.	Inclusion Criteria	Exclusion Criteria
1	169 articles related to smart healthcare and smart hospital research published between 2020–2025	58 articles were excluded because they did not meet publication year, document type, or language criteria
2	111 articles remaining after the initial screening process	78 articles were excluded because they were not relevant to the research objectives
3	33 articles eligible for full-text review	7 duplicate articles removed
4	26 articles included in the final bibliometric and systematic literature review analysis	-

Data extraction using the exclusion criteria described above yielded 58 articles. The articles were then assessed for eligibility. The collected data will be evaluated using the following quality assessment criteria:

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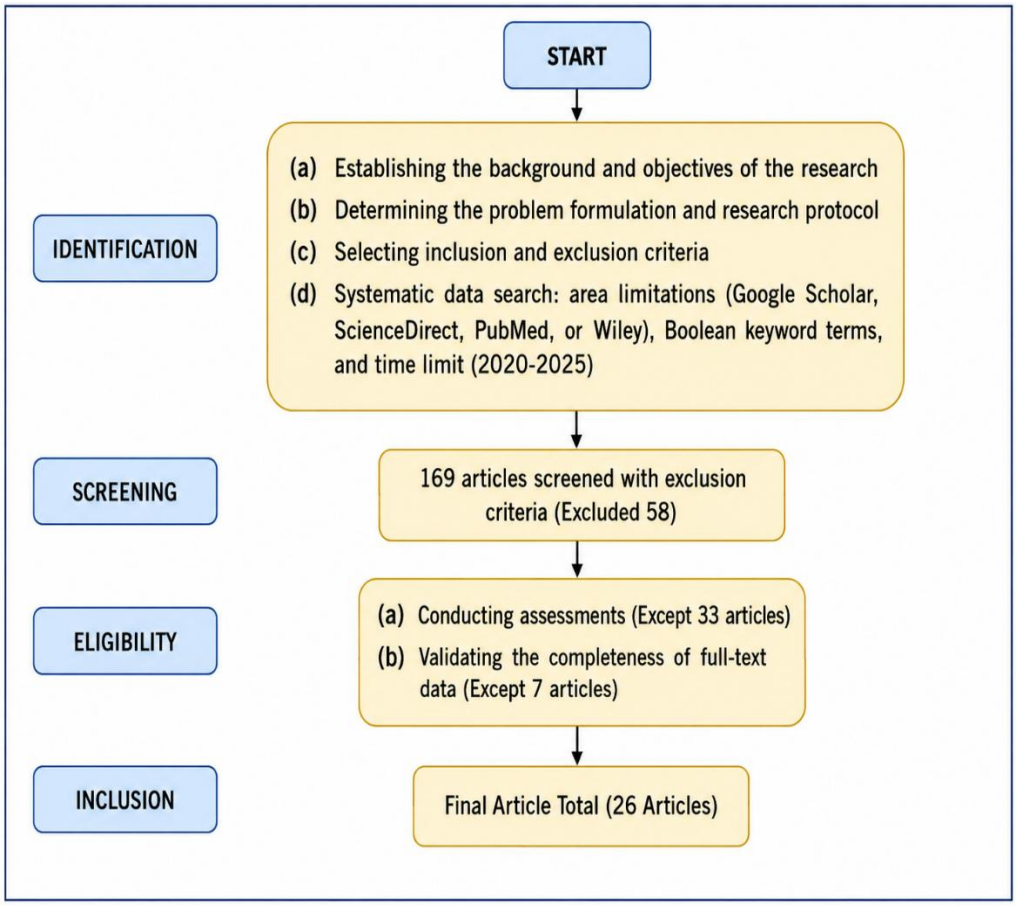
- Was the article published in a journal listed in Google Scholar, ScienceDirect, PubMed, or Wiley Online Library between 2020 and 2025?
- Does the article discuss smart healthcare, smart hospitals, or related digital healthcare technologies and contribute to understanding global research trends in this field?

If the questions are answered correctly, the article passes the quality assessment for eligibility.



Source: *Process Data, 2025*

Figure 2. The flowchart

The flowchart in Figure 1 summarizes the details of the SLR and bibliometric analysis in the following steps: (1) Identification of articles based on keywords. Systematic data search in Google Scholar and journal articles from 2020 to 2025 (2) in screening; 169 articles were extracted using exclusion criteria. A total of 58 articles were excluded, and 33 articles proceeded to the next level; (3) in terms of eligibility, the articles had to be validated and completed, and (4) finally, 26 articles in full text that were eligible for Systematic Literature analysis were included, and their content was reviewed manually. Data synthesis continued with the extraction of article data corresponding to the Research Questions (RQs), presented in thematic form.

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4. Results and Discussion

4.1 Analysis Results

RQ1: *The Dominant Intellectual Structures, Collaboration Networks, Technological Themes, And Research Clusters Identified Through Bibliometric Analysis Using Vosviewer*

Network Visualization in VOSviewer was employed to identify the intellectual structure, collaboration patterns, and thematic evolution of global smart healthcare and smart hospital research. The visualization maps conceptual relationships among keywords based on their co-occurrence frequency within the selected publications. Each color represents a thematic cluster formed through semantic connections among research topics, while the node size indicates the frequency and significance of a keyword within the scientific network. This analysis serves as a key instrument for answering RQ1 by identifying the dominant technological themes, intellectual structures, and emerging research directions in smart healthcare and smart hospital studies between 2020 and 2025. The bibliometric mapping revealed four major clusters representing the principal scientific domains that have shaped the development of smart healthcare research during the study period.

Cluster 1 (Red): Artificial Intelligence, Big Data Analytics, and Intelligent Healthcare Systems

The first cluster consists of keywords such as artificial intelligence, machine learning, deep learning, predictive analytics, healthcare data, decision support systems, and personalized medicine. This cluster represents the dominant intellectual structure within contemporary smart healthcare research, emphasizing the role of intelligent algorithms and data-driven decision-making in healthcare delivery. Studies by Bhatia *et al.,* (2025) demonstrate the rapid growth of AI-related healthcare research, particularly in clinical diagnostics, predictive healthcare management, and sustainable healthcare systems. Similarly, Chen *et al.,* (2024) identify multimodal data fusion, machine learning, and intelligent healthcare analytics as emerging hotspots that increasingly influence healthcare innovation. The strong interconnection among AI, big data, and healthcare intelligence suggests that future healthcare systems will rely heavily on predictive and adaptive technologies to support clinical and managerial decision-making. The prominence of this cluster also reflects the transition from conventional healthcare information systems toward intelligent healthcare ecosystems driven by advanced analytics and automation technologies.

Cluster 2 (Green): Internet of Medical Things (IoMT), Connected Healthcare, and Smart Monitoring Systems

The second cluster includes Internet of Medical Things (IoMT), Internet of Things (IoT), wearable devices, telemedicine, remote monitoring, connected healthcare, sensors, and digital health platforms. This cluster highlights the growing importance of an interconnected healthcare infrastructure that enables real-time communication among patients, healthcare professionals, and medical devices. Research conducted by Xin *et al.,* (2026), Ziwei *et al.,* (2024), and Bovenizer and Chetthamrongchai (2023) demonstrates that IoMT technologies have become fundamental components of smart healthcare systems due to their ability to facilitate continuous patient monitoring, chronic disease management, and healthcare accessibility. The strong association between telemedicine and remote monitoring became particularly evident following the COVID-19 pandemic, which accelerated the global adoption

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of digital healthcare services. The collaborative nature of this cluster further illustrates the multidisciplinary integration of healthcare, engineering, computer science, and communication technologies in developing connected healthcare ecosystems.

Cluster 3 (Blue): Smart Hospitals, Digital Transformation, and Healthcare Information Systems

The third cluster comprises smart hospital, digital transformation, electronic medical records, healthcare information systems, interoperability, healthcare management, and operational efficiency. This cluster focuses on organizational transformation within healthcare institutions and on the adoption of digital infrastructure to support smart hospital development. Rajaei *et al.,* (2024) define smart hospitals as technology-enabled healthcare organizations integrating intelligent systems, automation, and data-driven management practices. Research on electronic medical records and healthcare information systems, including studies by Izza and Lailiyah (2024) and Ira *et al.,* (2024), highlights the importance of digital infrastructure in improving service quality, information accessibility, and healthcare efficiency. The relationships observed within this cluster indicate that healthcare digitalization remains a foundational element for the successful implementation of smart healthcare ecosystems. Moreover, collaboration networks associated with this cluster show increasing participation by healthcare administrators, policymakers, information systems specialists, and hospital managers.

Cluster 4 (Yellow): Digital Twins, Blockchain, Sustainability, Security, and Future Healthcare Innovation

The fourth cluster consists of digital twins, blockchain, cybersecurity, privacy preservation, sustainability, healthcare governance, and healthcare innovation. This cluster represents the most recent and rapidly emerging research frontier within smart healthcare studies. Pellegrino *et al.,* (2025) and Sheng *et al.,* (2023) identify digital twins as transformative technologies that support predictive healthcare modeling, personalized medicine, and virtual healthcare simulations. Meanwhile, studies by El Majdoubi *et al.,* (2022) emphasize the growing importance of privacy-preserving architectures and secure healthcare information exchange. Sustainability-related research has also gained significant attention, with Mohammadzadeh *et al.,* (2023), Rahat *et al.,* (2024), and Salvatore *et al.,* (2026) highlighting the role of sustainable healthcare innovation, governance, and climate-responsive healthcare systems. The emergence of these themes indicates that smart healthcare research is gradually expanding beyond technological implementation to encompass broader organizational, environmental, ethical, and governance considerations.

The collaboration network analysis further demonstrates the increasing internationalization of smart healthcare research. Countries such as the United States, China, the United Kingdom, Germany, and several European nations occupy central positions within the co-authorship network, reflecting their significant contribution to scientific production and technological innovation. The literature also reveals increasing interdisciplinary collaboration among researchers from healthcare management, medical informatics, engineering, computer science, public health, and data science. This interdisciplinary integration is particularly visible within AI, IoMT, and digital twin research, where technological innovation requires expertise from multiple scientific domains. Such collaboration patterns support the diffusion of knowledge and accelerate the development of integrated healthcare solutions at a global scale.

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The temporal evolution of research themes indicates a gradual shift in scientific focus throughout the study period. Publications from 2020–2021 primarily focused on healthcare information systems, digital health infrastructure, telemedicine, and electronic medical records. During 2022–2023, research increasingly explored IoMT, healthcare analytics, semantic web applications, cybersecurity, and digital healthcare integration. More recent publications from 2024–2025 place greater emphasis on artificial intelligence, digital twins, predictive healthcare, sustainability, and intelligent healthcare ecosystems. This evolution demonstrates the maturity of the research field as it progresses from healthcare digitalization toward comprehensive smart healthcare environments characterized by intelligence, connectivity, automation, and sustainability.

The VOSviewer network visualization reveals that smart healthcare and smart hospital research is structured around four interconnected domains: intelligent healthcare technologies, connected healthcare systems, smart hospital transformation, and emerging innovations related to sustainability and governance. The increasing density of collaboration networks, the diversification of technological themes, and the emergence of interdisciplinary research clusters collectively indicate that smart healthcare has evolved into a highly dynamic and globally connected scientific field. These findings provide a comprehensive understanding of the intellectual structure and thematic evolution of smart healthcare research and establish a foundation for identifying future research opportunities and innovation pathways.

Based on the overlay visualization analysis, the temporal evolution of smart healthcare and smart hospital research demonstrates a significant transformation in research priorities between 2020 and 2025. Keywords associated with healthcare information systems, electronic medical records (EMRs), digital health, telemedicine, and healthcare management emerge as dominant themes in the early phase of the observation period, particularly between 2020 and 2022. During this stage, scientific discussions primarily focused on healthcare digitalization, interoperability, hospital information infrastructure, and the implementation of digital technologies to improve operational efficiency and the quality of healthcare services. Studies by Izza and Lailiyah (2024) and Ira *et al.,* (2024) indicate that healthcare organizations are focusing on strengthening digital infrastructure and optimizing information systems as fundamental components of hospital transformation. This pattern suggests that the initial phase of smart healthcare research was largely driven by the need to establish digital foundations to support healthcare modernization and service integration.

The thematic transition becomes increasingly visible during the 2022–2023 period, when research attention expanded toward Internet of Medical Things (IoMT), connected healthcare, wearable technologies, remote monitoring systems, semantic web applications, and healthcare data integration. Keywords associated with IoMT, connected devices, healthcare sensors, interoperability, and intelligent monitoring systems gained greater prominence within the scientific network. Research conducted by Xin *et al.,* (2026), Ziwei *et al.,* (2024), Bovenizer and Chetthamrongchai (2023), and Haque *et al.,* (2022) demonstrates that healthcare researchers have increasingly explored technologies that enable real-time communication among patients, healthcare providers, and medical devices. This shift reflects the growing recognition that healthcare innovation extends beyond digitizing records and processes to creating interconnected healthcare ecosystems that support continuous patient monitoring and proactive healthcare management. Consequently, the intellectual focus evolved from information management toward connectivity, integration, and intelligent healthcare infrastructure.

The most recent period, spanning 2024–2025, is characterized by the emergence of advanced technological themes including artificial intelligence, machine learning, digital twins, predictive

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healthcare, healthcare analytics, sustainability, and intelligent decision-support systems. The prominence of these topics indicates that smart healthcare research has entered a more mature stage in which intelligent technologies are increasingly employed to generate predictive insights, automate clinical processes, and personalize healthcare services. Studies by Bhatia *et al.,* (2025) and Chen *et al.,* (2024) identify artificial intelligence and multimodal data fusion as dominant research hotspots, while Pellegrino *et al.,* (2025) and Sheng *et al.,* (2023) highlight the growing influence of digital twins in predictive healthcare modeling and virtual healthcare simulation. The increasing visibility of these themes suggests a transition from technology adoption toward intelligent healthcare ecosystems capable of learning, adapting, and optimizing healthcare delivery in real time.

The overlay analysis further reveals the emergence of sustainability, governance, cybersecurity, and privacy-preserving technologies as rapidly developing research domains. Earlier smart healthcare studies focused predominantly on technological implementation and operational performance; however, recent publications increasingly recognize the importance of ethical governance, secure data management, healthcare resilience, and environmental sustainability. Research by El Majdoubi *et al.,* (2022) emphasizes the growing importance of privacy-preserving architectures within smart healthcare environments, while Mohammadzadeh *et al.,* (2023), Rahat *et al.,* (2024), and Salvatore *et al.,* (2026) demonstrate increasing scholarly attention toward sustainable healthcare systems and healthcare governance. This thematic evolution indicates that researchers now view smart healthcare not only as a technological innovation agenda but also as a strategic framework encompassing social, organizational, environmental, and policy dimensions.

The interconnected relationships among keywords reveal that healthcare digitalization remains the central node connecting multiple technological developments across the research landscape. However, the role of digital health infrastructure has gradually expanded through its integration with artificial intelligence, IoMT, digital twins, healthcare analytics, and sustainable healthcare management. This finding suggests that contemporary smart healthcare systems are no longer conceptualized as isolated technological applications but as integrated ecosystems in which multiple technologies interact to improve healthcare quality, accessibility, efficiency, and sustainability. The strengthening of connections among technological innovation, healthcare governance, and sustainability further indicates the increasing complexity and maturity of the field.

From an epistemological perspective, the overlay visualization illustrates a progressive transition from infrastructure-oriented healthcare digitalization to intelligence-oriented, ecosystem-based healthcare innovation. Early research concentrated on establishing digital platforms and information systems, while subsequent studies explored connected healthcare networks and data integration. More recent investigations emphasize predictive intelligence, personalized medicine, digital twins, sustainability, and healthcare governance. This evolution reflects the broader transformation of healthcare systems worldwide, in which technological innovation increasingly serves as a catalyst for organizational change, patient-centered care, and sustainable healthcare development.

The overlay visualization confirms that smart healthcare and smart hospital research has evolved from a focus on digital transformation and information management toward a comprehensive framework characterized by intelligent technologies, connected healthcare ecosystems, sustainability, cybersecurity, and governance. The emergence of artificial intelligence, IoMT, digital twins, healthcare analytics, and sustainable healthcare management as dominant themes demonstrates the field's growing sophistication and highlights key directions likely to shape future research and healthcare innovation in the coming years.

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Table 2. Frequency of Articles Based on Year of Publication

Year of Publication	Frequency (f)	Percentage (%)
2020	2	7.69
2021	3	11.54
2022	4	15.38
2023	4	15.38
2024	6	23.08
2025	7	26.92
Total	**26**	**100.00**

The publication trend shows a steady increase in scientific output on smart healthcare and smart hospital research during 2020–2025. The number of publications remained relatively low in 2020 (7.69%) and 2021 (11.54%), reflecting the early stage of research development in intelligent healthcare systems. Research productivity began to increase in 2022 and 2023, accounting for 15.38% of publications each year. The most significant growth occurred in 2024 (23.08%) and 2025 (26.92%), indicating growing academic interest in emerging technologies such as artificial intelligence, Internet of Medical Things (IoMT), digital twins, healthcare analytics, and smart hospital transformation. These findings suggest that smart healthcare has become an increasingly important and rapidly expanding research domain, particularly during the post-pandemic digital transformation era.

RQ2: *Global Scientific Production Related to Smart Healthcare and Smart Hospital Research Evolved During the Period 2020–2025*

Global scientific output on smart healthcare and smart hospital research experienced substantial growth during 2020–2025, reflecting the increasing digital transformation of healthcare systems worldwide. The COVID-19 pandemic accelerated the adoption of digital health technologies, creating unprecedented demand for intelligent healthcare solutions such as artificial intelligence (AI), Internet of Medical Things (IoMT), telemedicine, electronic medical records (EMRs), digital twins, and healthcare data analytics. The literature indicates that research output expanded significantly after 2020, with publications increasingly focusing on technology-enabled healthcare delivery, real-time patient monitoring, intelligent clinical decision support systems, and hospital digitalization. Studies by Bhatia *et al.,* (2025) and Chen *et al.,* (2024) demonstrate that AI-related healthcare research has become one of the fastest-growing scientific domains, with substantial increases in publication volume, citation impact, and international collaboration. Similarly, bibliometric evidence reported by Xin *et al.,* (2026) and Ziwei *et al.,* (2024) shows rapid growth in IoMT and connected healthcare research, indicating that healthcare digitalization has become a central theme within contemporary healthcare innovation studies.

The thematic evolution of smart healthcare research reveals a gradual transition from healthcare information systems and electronic medical records toward more advanced intelligent technologies. Early studies published between 2020 and 2021 primarily focused on digital health infrastructure, hospital information systems, interoperability, and electronic medical record implementation. This trend is particularly visible in healthcare organizations seeking to improve service efficiency, information accessibility, and patient-centered care through digital platforms. Research on EMR implementation, health information systems, and digital hospital management has become increasingly prominent as healthcare institutions adopt technology-driven operational models. Studies examining EMR

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implementation and hospital information systems further highlighted the importance of digital infrastructure as a foundation for smart hospital development. Consequently, research themes evolved beyond basic digitalization toward integrated intelligent healthcare ecosystems.

Between 2022 and 2023, scientific production increasingly emphasized emerging technologies such as IoMT, AI-assisted healthcare systems, semantic web applications, privacy-preserving technologies, and digital twin frameworks. Research conducted by Haque *et al.,* (2022) identified growing interest in semantic web applications for healthcare knowledge management, while El Majdoubi *et al.,* (2022) highlighted increasing concerns regarding privacy-preserving mechanisms in smart healthcare environments. During the same period, Sheng *et al.,* (2023) reported a rapid increase in digital twin studies, particularly in predictive healthcare management, virtual patient modeling, and healthcare simulation. The literature suggests that researchers have increasingly shifted their focus from healthcare digitalization to intelligent healthcare ecosystems that support predictive, personalized, and data-driven healthcare services.

The period between 2024 and 2025 witnessed further diversification and maturation of research topics. Artificial intelligence emerged as the dominant research cluster, encompassing machine learning, deep learning, predictive analytics, clinical decision support, and medical imaging applications. Chen *et al.,* (2024) identified multimodal data fusion and AI-enabled healthcare intelligence as emerging hotspots, while Bhatia *et al.,* (2025) reported a strong upward trajectory in AI-driven sustainable healthcare research. Simultaneously, studies by Roy *et al.,* (2025) emphasized the growing role of assistive technologies in hospital settings, highlighting the increasing integration of smart technologies into clinical workflows. Research also expanded toward sustainability, governance, and healthcare resilience, indicating a broader understanding of smart healthcare beyond technological innovation alone.

Collaboration patterns similarly evolved during the study period. The literature demonstrates increasing interdisciplinary cooperation among researchers from healthcare management, medical informatics, engineering, computer science, public health, and data science. International collaboration networks expanded considerably as healthcare digitalization became a global priority. Studies conducted by Xin *et al.,* (2026) and Bhatia *et al.,* (2025) revealed that countries with strong technological capabilities, including the United States, China, the United Kingdom, and several European nations, played dominant roles in knowledge production and research collaboration. The expansion of international research networks facilitated knowledge exchange and accelerated the diffusion of innovation across healthcare systems. Consequently, smart healthcare research evolved into a highly interconnected and multidisciplinary scientific field.

Keyword evolution further illustrates the dynamic growth of the research landscape. Frequently occurring keywords during the early years included "electronic medical records," "health information systems," and "digital health." However, more recent publications increasingly incorporated terms such as "artificial intelligence," "Internet of Medical Things," "digital twin," "big data analytics," "predictive healthcare," "smart hospital," and "healthcare sustainability." The emergence of these keywords indicates a transition toward intelligent, interconnected, and patient-centered healthcare ecosystems. Research clusters became increasingly integrated, reflecting the convergence of multiple technologies in supporting healthcare innovation and hospital transformation.

The analysis also reveals a growing emphasis on healthcare sustainability, governance, security, and policy dimensions. Recent studies have expanded beyond technological implementation to examine organizational readiness, healthcare governance, cybersecurity, environmental sustainability,

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and digital transformation strategies. Research by Mohammadzadeh *et al.,* (2023) emphasized smart-city healthcare innovations in developing countries, while Rahat *et al.,* (2024) explored sustainability practices in healthcare systems. Similarly, Salvatore *et al.,* (2026) highlighted the increasing importance of climate change and sustainability governance within healthcare organizations. These findings suggest that smart healthcare research is evolving from a technology-centric perspective toward a more holistic framework encompassing organizational, social, environmental, and policy considerations.

Overall, the findings demonstrate that global scientific production related to smart healthcare and smart hospital research increased substantially between 2020 and 2025. The field evolved from a focus primarily on healthcare digitalization and information systems to a broader ecosystem encompassing artificial intelligence, IoMT, digital twins, intelligent healthcare services, sustainability, governance, and interdisciplinary collaboration. The rapid expansion of publication output, diversification of research themes, and strengthening of international collaboration networks indicate that smart healthcare has become one of the most dynamic and influential research domains within contemporary healthcare and digital innovation studies.

RQ3: *Emerging Trends, Research Gaps, and Future Research Directions Can Be Identified from the Systematic Literature Review and Bibliometric Mapping of Smart Healthcare and Smart Hospital Studies*

The evolution of smart healthcare research demonstrates a clear transition from healthcare digitalization toward intelligent, interconnected, and data-driven healthcare ecosystems. Bibliometric mapping reveals that artificial intelligence (AI), Internet of Medical Things (IoMT), digital twins, healthcare analytics, and smart hospital management systems have emerged as the most influential research clusters during the period 2020–2025. Studies by Bhatia *et al.,* (2025) and Chen *et al.,* (2024) indicate that AI-related applications have become central to healthcare innovation, particularly in predictive analytics, medical imaging, decision support systems, and personalized medicine. Similarly, research conducted by Xin *et al.,* (2026), Ziwei *et al.,* (2024), and Rehman *et al.,* (2025) demonstrates the rapid expansion of IoMT technologies, remote monitoring systems, and connected healthcare infrastructures. These findings suggest that future smart healthcare ecosystems will increasingly rely on intelligent technologies that support real-time decision-making, proactive healthcare management, and patient-centered service delivery.

The convergence of multiple digital technologies represents another significant emerging trend. Earlier studies primarily examined individual technologies such as electronic medical records, healthcare information systems, or telemedicine. However, recent publications increasingly emphasize integrated healthcare platforms combining AI, IoMT, cloud computing, big data analytics, blockchain, and digital twins within a unified healthcare ecosystem. Pellegrino *et al.,* (2025) and Sheng *et al.,* (2023) demonstrate the growing relevance of digital twins in predictive healthcare management and virtual patient modeling, while studies on semantic web technologies and privacy-preserving systems emphasize the importance of intelligent data integration and secure information exchange. The convergence of these technologies suggests that future smart hospitals will operate as interconnected digital environments rather than collections of isolated technological solutions.

Data governance, cybersecurity, and privacy protection emerge as critical research priorities within the smart healthcare literature. The increasing use of interconnected devices, patient monitoring systems, and cloud-based healthcare platforms poses significant challenges for data security and patient confidentiality. El Majdoubi *et al.,* (2022) highlight the growing demand for privacy-preserving

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solutions in smart healthcare environments, while Haque *et al.,* (2022) emphasize the importance of semantic interoperability and secure knowledge management frameworks. Despite significant technological advancements, bibliometric evidence indicates that security-related research remains fragmented and frequently lags behind technological innovation. Consequently, future studies should prioritize developing comprehensive cybersecurity frameworks, ethical AI governance models, and privacy-preserving architectures to support large-scale smart healthcare implementation.

Another important trend concerns the growing integration of sustainability and healthcare governance into smart healthcare research. Traditionally, smart healthcare studies focused predominantly on technological innovation and operational efficiency. More recent investigations increasingly explore environmental sustainability, healthcare resilience, digital governance, and organizational transformation. Mohammadzadeh *et al.,* (2023) emphasize the role of smart healthcare innovations in supporting sustainable healthcare delivery in developing countries, while Rahat *et al.,* (2024) highlight the importance of sustainability-oriented healthcare practices. Similarly, Salvatore *et al.,* (2026) demonstrate growing scholarly interest in climate-responsive healthcare governance and sustainable healthcare organizations. These findings indicate that future smart healthcare systems will need to balance technological innovation with environmental responsibility, organizational sustainability, and equitable healthcare access.

The bibliometric analysis also reveals several important research gaps that remain insufficiently addressed within the current literature. First, existing studies tend to focus on individual technological innovations rather than on the interactions among multiple technologies within smart healthcare ecosystems. Most research investigates AI, IoMT, digital twins, blockchain, or healthcare information systems independently, creating fragmented knowledge structures. Consequently, limited evidence exists regarding how these technologies collectively contribute to healthcare transformation and smart hospital performance. Future research should develop integrative frameworks that explain technological convergence and ecosystem-level healthcare innovation.

Second, the majority of existing studies are technology-centered and place relatively less emphasis on organizational, managerial, and human dimensions. While technological capabilities are extensively discussed, issues such as organizational readiness, leadership, workforce competencies, digital culture, healthcare professionals' acceptance, and patient engagement remain underexplored. Smart healthcare implementation ultimately depends on the successful interaction between technology, healthcare workers, administrators, and patients. Therefore, future studies should adopt a socio-technical perspective to examine how technological innovations interact with organizational structures and human behavior in healthcare settings.

A further research gap concerns geographical and contextual diversity. Bibliometric mapping indicates that smart healthcare research is dominated by technologically advanced countries, particularly the United States, China, the United Kingdom, and several European nations. Fewer studies investigate smart healthcare implementation in developing countries, rural healthcare systems, and resource-constrained environments. Mohammadzadeh *et al.,* (2023) highlight the importance of contextual adaptation for developing nations, yet empirical evidence remains limited. Future research should therefore examine the challenges, opportunities, and implementation strategies associated with the adoption of smart healthcare in emerging economies, particularly in Southeast Asia, Africa, and Latin America.

Methodological limitations also create opportunities for future investigation. Most existing studies employ cross-sectional designs, bibliometric approaches, conceptual frameworks, or technology

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assessments. Longitudinal research examining the long-term impact of smart healthcare technologies on patient outcomes, operational efficiency, healthcare quality, and organizational sustainability remains relatively scarce. Similarly, comparative studies investigating differences between healthcare systems, hospital types, and regulatory environments are limited. Future research should incorporate longitudinal datasets, mixed-method approaches, and multi-country comparative analyses to provide more robust evidence regarding the effectiveness and sustainability of smart healthcare innovations.

The future trajectory of smart healthcare research appears increasingly oriented toward intelligent, predictive, and personalized healthcare systems. Emerging technologies such as generative AI, explainable artificial intelligence, digital twins, advanced healthcare visualization, predictive analytics, and autonomous clinical support systems are expected to become dominant research themes. Studies by Cheng *et al.,* (2026) and Roy *et al.,* (2025) indicate a growing interest in advanced visualization technologies and assistive systems that enhance clinical decision-making and healthcare delivery. At the same time, the increasing availability of healthcare big data creates opportunities for developing precision medicine, predictive population health management, and real-time healthcare intelligence platforms. These developments suggest that future research will move beyond healthcare automation toward comprehensive intelligent healthcare ecosystems that continuously learn, adapt, and optimize healthcare services.

Policy implications emerging from the literature emphasize the importance of integrated digital health strategies, regulatory frameworks, and investment in healthcare infrastructure. Governments and healthcare organizations must ensure that technological innovation is accompanied by workforce development, cybersecurity preparedness, ethical governance, interoperability standards, and sustainable financing mechanisms. The successful implementation of smart healthcare depends not only on technological sophistication but also on institutional readiness, stakeholder collaboration, and long-term strategic planning. The findings further suggest that policymakers should encourage interdisciplinary collaboration among healthcare professionals, engineers, data scientists, policymakers, and technology developers to accelerate innovation and ensure the equitable distribution of smart healthcare benefits.

Overall, the systematic literature review and bibliometric mapping reveal that research on smart healthcare and smart hospitals is rapidly evolving toward integrated, intelligent, sustainable, and patient-centered healthcare ecosystems. Artificial intelligence, IoMT, digital twins, healthcare analytics, cybersecurity, sustainability, and governance constitute the primary emerging themes shaping future scientific development. At the same time, significant research gaps remain regarding technological integration, socio-technical implementation, contextual adaptation, and long-term effectiveness. Addressing these gaps will contribute to the development of more comprehensive theoretical frameworks and practical strategies to support the next generation of smart healthcare and smart hospital systems.

This section is the central part of the article. It is where the author/s should explain in words what they discovered in the research. It should be laid out in a logical sequence. The results presented in this section are the outcome of a rigorous data analysis process, including statistical calculations and testing, as well as other methods used to achieve the research objectives. We would appreciate it if you could summarize the study's findings.

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4.2 Discussion

The findings of this study provide strong evidence that research on smart healthcare and smart hospitals has undergone substantial growth and transformation during the 2020–2025 period. The bibliometric mapping and systematic literature review reveal not only an increase in scientific productivity but also a significant shift in the field's intellectual structure. The results support H1, which proposed that global smart healthcare and smart hospital research exhibits a significant increase in scientific publication output over time. The publication trend analysis shows a continuous rise in scholarly output, particularly during 2024–2025, indicating growing academic and practical interest in healthcare digitalization and intelligent healthcare systems. This finding is reasonable, given the rapid advancement of healthcare technologies, the accelerated digital transformation following the COVID-19 pandemic, and the increasing investments in healthcare innovation worldwide. Previous studies by Bhatia *et al.,* (2025), Chen *et al.,* (2024), and Xin *et al.,* (2026) similarly reported exponential growth in publications on artificial intelligence, the Internet of Medical Things (IoMT), and digital healthcare ecosystems. Therefore, the results confirm earlier observations that smart healthcare has evolved into one of the fastest-growing interdisciplinary research domains in healthcare management, information systems, and engineering.

The bibliometric results further demonstrate that the growth of scientific production is not merely quantitative but also reflects the increasing complexity of healthcare innovation. Early research concentrated primarily on electronic medical records, healthcare information systems, and telemedicine infrastructure, whereas recent studies increasingly investigate artificial intelligence, predictive analytics, digital twins, and intelligent decision-support systems. This progression supports the theoretical argument that technological innovation follows a cumulative development pathway in which foundational digital infrastructures create the conditions necessary for advanced intelligent healthcare applications. The observed transition corresponds closely with the digital transformation framework proposed by Rajaei *et al.,* (2024), which conceptualizes smart hospitals as evolving ecosystems that progressively integrate data, connectivity, intelligence, and automation. Consequently, the increase in publication output reflects not only greater scholarly attention but also the maturation of the field itself.

The results associated with RQ1 also support H2, which posits that the expansion of emerging healthcare technologies is positively associated with increased international and interdisciplinary research collaboration. The collaboration network analysis indicates that extensive partnerships among researchers from medicine, computer science, engineering, public health, healthcare management, and information systems characterize smart healthcare research. This finding is consistent with the interdisciplinary nature of healthcare digitalization, where successful technological implementation requires expertise from multiple domains. Studies examining IoMT, digital twins, artificial intelligence, blockchain, and healthcare analytics frequently involve collaboration among researchers from different countries and scientific disciplines. Similar patterns have been reported by Chen *et al.,* (2024), Ziwei *et al.,* (2024), and Roy *et al.,* (2025), who identified interdisciplinary integration as a key driver of innovation in smart healthcare environments.

The increasing internationalization of research can also be explained through the global nature of healthcare challenges. Issues such as healthcare accessibility, aging populations, chronic disease management, healthcare sustainability, and digital transformation transcend national boundaries and require collaborative solutions. Consequently, technological innovations developed in one healthcare system can often be adapted and implemented in others. The strong presence of multinational research teams within AI, IoMT, and digital twin studies suggests that smart healthcare innovation increasingly

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depends on global knowledge-sharing networks. These findings support existing theories regarding innovation diffusion and knowledge exchange, which argue that collaboration accelerates scientific development by combining diverse expertise and perspectives. Rather than contradicting previous theories, the results strengthen the argument that technological advancement and collaborative research development are mutually reinforcing processes.

The thematic evolution identified through the overlay visualization provides strong empirical support for H3, which proposed that emerging digital technologies significantly influence the evolution of thematic research clusters and future research directions in smart healthcare and smart hospital literature. The results reveal a clear chronological transition from healthcare information systems and digital infrastructure toward artificial intelligence, digital twins, predictive healthcare, healthcare analytics, cybersecurity, sustainability, and healthcare governance. This thematic shift appears reasonable because healthcare organizations have largely completed the initial stages of digitalization and are now focusing on extracting value from their digital infrastructure through advanced analytics and intelligent technologies. Similar trends have been identified by Pellegrino *et al.,* (2025), Sheng *et al.,* (2023), and Cheng *et al.,* (2026), who reported increasing research attention toward predictive technologies, virtual healthcare environments, and intelligent decision-support systems.

The emergence of digital twins, multimodal artificial intelligence, and predictive analytics reflects a broader transformation in healthcare paradigms. Traditional healthcare systems primarily focused on reactive treatment, whereas smart healthcare technologies increasingly enable proactive, preventive, and personalized healthcare delivery. This transition aligns with theories of Healthcare 4.0, which emphasize interconnected, intelligent, and patient-centered healthcare ecosystems. The results, therefore, extend existing theoretical frameworks by demonstrating how technological convergence among AI, IoMT, big data analytics, and digital twins creates entirely new research domains that were largely absent from the literature only a few years ago. The increasing prominence of these technologies confirms that healthcare innovation is becoming progressively data-driven, adaptive, and predictive.

Another important finding emerging from RQ3 concerns the growing integration of sustainability, governance, cybersecurity, and ethical considerations within smart healthcare research. Earlier studies often focused primarily on technological performance and operational efficiency. However, the recent literature increasingly recognizes that successful healthcare innovation requires attention to privacy protection, cybersecurity resilience, healthcare governance, and environmental sustainability. Research by El Majdoubi *et al.,* (2022), Mohammadzadeh *et al.,* (2023), Rahat *et al.,* (2024), and Salvatore *et al.,* (2026) highlights the importance of balancing technological advancement with ethical and organizational considerations. This finding supports contemporary socio-technical systems theory, which argues that technological systems cannot be understood independently from the social, organizational, and regulatory environments in which they operate. Consequently, the future of smart healthcare will likely depend not only on technological innovation but also on effective governance frameworks that ensure trust, security, and sustainability.

The discussion also reveals several research gaps that remain underexplored in the existing literature. Although artificial intelligence and IoMT dominate current research, relatively little attention has been paid to integrating these technologies into resource-constrained healthcare systems, particularly in developing countries. Furthermore, while many studies evaluate technological effectiveness, fewer investigations examine long-term organizational impacts, implementation barriers, workforce adaptation, and patient acceptance. Research on healthcare governance, sustainability, ethical AI, and digital equity remains fragmented compared with studies focusing on technological

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development. These gaps suggest that future research should move beyond technology-centered perspectives and adopt more holistic approaches that consider organizational, social, economic, and policy dimensions of healthcare innovation.

Overall, the findings support all three proposed hypotheses and demonstrate that smart healthcare research has evolved into a highly dynamic, interdisciplinary, and globally connected scientific field. The results closely align with previous empirical findings while simultaneously extending the existing theoretical understanding of healthcare digital transformation. The evidence suggests that future smart healthcare ecosystems will be increasingly characterized by artificial intelligence, connected medical technologies, digital twins, predictive analytics, sustainability-oriented innovation, and integrated governance frameworks. Consequently, this study contributes to both theory and practice by providing a comprehensive overview of the intellectual structure, technological evolution, collaboration patterns, and future directions of global smart healthcare and smart hospital research.

5. Concluding Remarks and Recommendation

This study examined the global development of smart healthcare and smart hospital research through a combination of bibliometric analysis and systematic literature review covering publications from 2020 to 2025. The findings indicate a substantial increase in scientific production over the study period, reflecting the growing importance of digital transformation within healthcare systems. Bibliometric mapping identified four dominant research clusters: artificial intelligence and healthcare analytics; Internet of Medical Things (IoMT) and connected healthcare; smart hospitals and healthcare information systems; and digital twins, sustainability, cybersecurity, and healthcare governance. The results further revealed an increase in international and interdisciplinary collaboration among researchers across healthcare, engineering, information systems, and data science. Moreover, thematic evolution analysis revealed a shift from studies focusing on healthcare digitalization and information infrastructure to more advanced topics, including predictive healthcare, intelligent decision-support systems, digital twins, and sustainable healthcare ecosystems. These findings address the research questions by illustrating the intellectual structure, collaboration patterns, technological themes, and emerging research directions that shape the smart healthcare research landscape.

The study contributes to the growing body of knowledge on healthcare digital transformation by providing a comprehensive overview of the evolution, maturity, and future trajectory of smart healthcare and smart hospital research. Scientifically, the integration of bibliometric analysis and systematic literature review offers a holistic perspective that captures both quantitative publication trends and qualitative thematic developments. The study also highlights the convergence of emerging technologies, including artificial intelligence, IoMT, big data analytics, blockchain, and digital twins, as key drivers of healthcare innovation. From a policy and managerial perspective, the findings may assist healthcare organizations, policymakers, and technology developers in identifying priority areas for investment, fostering interdisciplinary collaboration, and formulating strategies that support intelligent, secure, and sustainable healthcare systems. The originality of this study lies in its integrated examination of global smart healthcare and smart hospital research trends, providing a consolidated framework that connects technological innovation, healthcare management, sustainability, and governance perspectives.

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Several limitations should be acknowledged. First, the analysis was limited to articles retrieved through predefined search strategies and selected databases, which may not capture all relevant publications in the field. Second, the study focused on publications from 2020 to 2025, thereby excluding earlier contributions that may have influenced the development of smart healthcare concepts. Third, bibliometric indicators primarily reflect publication characteristics and cannot fully explain the practical effectiveness or implementation outcomes of healthcare technologies. Future research may expand the scope by incorporating additional databases, extending the observation period, and conducting comparative analyses across countries, healthcare systems, or technological domains. Further studies are also encouraged to investigate the organizational, ethical, regulatory, and socio-economic implications of emerging technologies such as artificial intelligence, digital twins, and autonomous healthcare systems to support the development of more inclusive, resilient, and sustainable smart healthcare ecosystems.

Statement of Use of Generative AI

During the preparation of this work, the author used generative artificial intelligence tools to support the scientific writing process. Grammarly was used to check grammar, refine writing style, and improve clarity in scientific writing. All interpretations, analyses, and conclusions presented in this study are the sole responsibility of the author.

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Corresponding author
Bahar Sangkur Gusasih can be contacted at: dr.sangkur@gmail.com

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Appendix

Table A1. Summary of 26 International Articles Related to Smart Healthcare and Smart Hospital Research

No	Author (Year)	Research Objectives	Research Methods and Objects	Results and Conclusions
1	Peralta-Ochoa *et al.,* (2023)	To review smart healthcare applications supported by 5G networks.	Systematic Review. Smart healthcare and 5G technologies.	5G significantly enhances telemedicine, remote monitoring, and smart healthcare services.
2	Mengiste *et al.,* (2023)	To develop an eHealth policy framework for developing countries.	PRISMA Systematic Review. eHealth policy studies.	Effective eHealth governance is essential for healthcare digital transformation.
3	Bitkina *et al.,* (2023)	To identify trends in AI applications in medical technologies.	Systematic Review. AI healthcare studies.	AI increasingly supports diagnostics, treatment planning, and healthcare automation.
4	Minartz *et al.,* (2024)	To explore perceptions of safety in healthcare digitalization.	Scoping Review. Digital healthcare environments.	Digital transformation requires patient trust and perceived safety.
5	Snowdon *et al.,* (2024)	To assess the impact of digital hospitals on patients and clinicians.	Systematic Review and Qualitative Evidence Synthesis. Digital hospitals.	Digital hospitals improve healthcare experiences but require organizational adaptation.
6	Sun *et al.,* (2023)	To review Internet of Medical Things (IoMT) technologies.	Systematic Review. IoMT systems.	IoMT supports real-time monitoring, diagnosis, and smart hospital operations.
7	Allen (2024)	To evaluate explainable AI in precision medicine.	Systematic Review. Digital health and AI.	Explainable AI improves transparency and trust in clinical decision-making.
8	Shen *et al.,* (2024)	To assess the effectiveness of digital twins in healthcare.	Systematic Review. Digital twin applications.	Digital twins enhance predictive and personalized healthcare services.
9	Navakauskas & Kazlauskas (2023)	To investigate fog computing applications in healthcare.	Systematic Review. Fog computing and healthcare systems.	Fog computing improves latency, security, and healthcare data processing.
10	Tortorella *et al.,* (2023)	To evaluate Healthcare 4.0 technologies and healthcare quality.	PRISMA-Based Systematic Literature Review and Meta-Analysis.	Healthcare 4.0 technologies positively influence service quality and efficiency.
11	Dhamanti *et al.,* (2023)	To review smart home healthcare for chronic disease management.	Scoping Review. Smart home healthcare systems.	Smart home technologies support patient monitoring and chronic care management.
12	Jung *et al.,* (2023)	To identify essential properties of explainable AI in healthcare.	Systematic Review. Explainable AI healthcare research.	Explainable AI improves usability, transparency, and clinical acceptance.
13	Kamel Boulos & Zhang (2024)	To analyze digital twin implementation in healthcare.	Systematic Review. Healthcare digital twin studies.	Digital twins provide opportunities for predictive healthcare ecosystems.
14	Ahmad *et al.,* (2024)	To examine cybersecurity challenges in smart healthcare.	Systematic Review. Smart healthcare security studies.	Cybersecurity remains a critical barrier to smart healthcare implementation.

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No	Author (Year)	Research Objectives	Research Methods and Objects	Results and Conclusions
15	Aceto *et al.*, (2023)	To review big data analytics in healthcare.	Systematic Literature Review. Healthcare analytics research.	Big data enhances healthcare intelligence and operational decision-making.
16	Javaid *et al.*, (2023)	To explore AI applications in healthcare systems.	Systematic Review. AI-enabled healthcare services.	AI improves diagnosis, prediction, and healthcare management performance.
17	Haleem *et al.*, (2022)	To investigate artificial intelligence in healthcare.	Systematic Literature Review. Healthcare AI studies.	AI significantly improves healthcare quality and efficiency.
18	Sharma *et al.*, (2024)	To evaluate blockchain integration in smart healthcare.	Systematic Review. Blockchain healthcare applications.	Blockchain enhances security, transparency, and healthcare interoperability.
19	Alowais *et al.*, (2023)	To analyze generative AI in healthcare systems.	Systematic Review. Generative AI healthcare research.	Generative AI has strong potential for healthcare innovation and decision support.
20	Vimal *et al.*, (2024)	To review smart healthcare ecosystems and digital transformation.	PRISMA-Based Review. Smart healthcare infrastructure.	Integrated digital ecosystems improve healthcare effectiveness.
21	Nascimento *et al.*, (2023)	To investigate wearable healthcare technologies.	Systematic Review. Wearable healthcare devices.	Wearables enhance preventive care and continuous patient monitoring.
22	Singh *et al.*, (2024)	To assess machine learning applications in healthcare.	Systematic Literature Review. Machine learning healthcare studies.	Machine learning supports predictive analytics and precision medicine.
23	Gupta *et al.*, (2024)	To examine quantum machine learning in digital health.	Systematic Review. Digital health and quantum computing.	Quantum machine learning represents an emerging frontier in healthcare analytics.
24	Rahman *et al.*, (2023)	To review IoT progression and challenges in healthcare.	Systematic Review. IoT healthcare technologies.	IoT improves healthcare connectivity but raises security concerns.
25	Wijaya *et al.*, (2026)	To map intelligent and secure smart hospital ecosystems.	Scoping Review Based on Bibliometric Analysis (ScoRBA).	Smart hospitals are evolving toward integrated AI-driven ecosystems.
26	Mohammadrezaei *et al.*, (2024)	To review smart built environments and healthcare-related XR technologies.	PRISMA Systematic Review. Smart environments and healthcare technology integration.	Extended reality technologies support future healthcare simulation and smart environments.

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