RESEARCH PAPER

From Digitalization to Smart Hospitals: A Systematic Literature Review on Intelligent Healthcare Infrastructure and Patient-Centered Care Outcomes.

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ABSTRACT
This study aims to map the development of digitalization toward smart hospitals and analyze how smart infrastructure impacts patient-centered outcomes in the modern healthcare ecosystem. Using a Systematic Literature Review (SLR) method following PRISMA guidelines, this study reviewed 21 articles from Scopus, Web of Science, and PubMed published between 2019 and 2025, focusing on key technologies such as IoT, AI, big data, 5G/6G, digital twins, and hospital digital governance. A thematic analysis was conducted to identify patterns, trends, and research gaps. The results indicate that the evolution of hospital digitalization is influenced by the level of organizational readiness, Health 4.0 strategies, and global technological acceleration. Smart infrastructure, including IoT, AI, big data analytics, high-speed networks, and digital twins, plays a significant role in creating precision care, increasing clinical efficiency, and strengthening doctor-patient communication. At the same time, digital governance and leadership are critical drivers in ensuring technology integration is effective, secure, and aligned with the needs of patient-centered care. Overall, smart technology has a positive impact on service quality, patient safety, patient experience, and hospital operations. These findings imply the need for policy strengthening, digital literacy of healthcare workers, and infrastructure investment as a foundation for sustainable smart hospital transformation. Future research is recommended to examine empirical evidence of implementation in local contexts and evaluate the long-term impact on patient outcomes.
Keywords: smart hospitals, digitalization, Health 4.0, IoT, AI, big data, patient-centered outcomes, digital governance..
How to cite this article: Pramesti LA, Wanasida AS., From Digitalization to Smart Hospitals: A Systematic Literature Review on Intelligent Healthcare Infrastructure and Patient-Centered Care Outcomes..Int J Drug Deliv Technol. 2026;16(1s): 762-771; DOI: 10.25258/ijddt.16. 762-771
Source of support: Nil.
Conflict of interest: None

INTRODUCTION

Developments in the healthcare sector in recent years have shown a significant shift from mere digitalization to the implementation of the concept of smart hospitals, namely hospitals that utilize intelligent technology to improve the quality of services and patient outcomes. Indonesia is currently in this crucial transition phase. Many hospitals have begun adopting digital systems such as Electronic Health Records (EHR), Hospital Information Systems (HIS), and basic data integration, but have not yet reached the stage of intelligent healthcare infrastructure as has developed in many developed countries. This situation makes the topic of the transformation from digitalization to smart hospitals highly relevant, especially when linked to the need to improve patient-centered care outcomes.

This changing landscape also aligns with the policy direction of the Indonesian Ministry of Health for 2024–2025, including the SATUSEHAT program, which emphasizes data interoperability, electronic medical record integration, and strengthening patient-centered services. Such a transformation requires not only technological readiness but also changes in organizational culture and work patterns of healthcare workers. This makes a systematic literature review increasingly important to understand the extent to which intelligent technology can be effectively implemented in the Indonesian hospital context.

Globally, numerous studies have demonstrated how smart hospitals offer significant opportunities for creating more efficient and responsive healthcare services. Lapão et al. (2024) demonstrated that the use of digital platforms within smart hospital buildings can improve public health through the utilization of real-time data. These findings emphasize that the essence of a smart hospital lies not only in the technological devices, but also in how these technologies are integrated into daily service processes.

Furthermore, Jovy-Klein et al. (2024), through a real-time Delphi study, mapped the direction of smart hospital development driven by predictive technology, automation, and data-driven analytics. They emphasized that the success of the transformation does not depend solely on technology, but also on the organization's readiness to build a robust system architecture. Similarly, Mohammadzadeh et al. (2023) highlighted the importance of smart city innovation in supporting smart healthcare services, especially for

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developing countries that still face numerous infrastructure limitations.

However, the situation in Indonesia demonstrates a gap between global developments and local implementation. Most hospitals are still focused on early digitalization, while community needs are shifting toward faster, more precise, and more integrated services. Binsar et al. (2025) found that mid-level hospitals have significant gaps in digital leadership, technological readiness, and understanding the impact of transformation on the quality of patient-centered services. These findings demonstrate that Indonesia requires a more strategic and gradual approach to achieving a truly smart hospital.

Cutting-edge technological developments globally illustrate the potential that Indonesian hospitals can achieve if the transformation is optimally implemented. Elendu et al. (2024) emphasize the role of 5G-enabled smart hospital networks, which enable real-time patient monitoring, more efficient facility management, and faster clinical response. Meanwhile, Adibi et al. (2024) introduce the concept of sensor-enabled digital twins, which allow for simulations of patient conditions and hospital infrastructure, enabling more precise planning and risk prevention. This technology, when combined with IoT and big data, as discussed by Abatal et al. (2024), strengthens the personalized patient care approach that is at the heart of the modern smart hospital.

For Indonesia, these technologies can help address classic issues that still frequently arise, such as high bed occupancy rates (BOR), long patient flows, uncontrolled emergency room queues, and suboptimal referral processes. The implementation of integrated clinical dashboards, digital emergency room monitoring, and tele-ICU services can significantly impact the speed and accuracy of services. The findings of Tortorella et al. (2022) that Healthcare 4.0 can improve process efficiency and patient satisfaction further reinforce the urgency of implementing smart technology in the national healthcare system.

Enhanced through the use of intelligent technology. Jida (2025) demonstrates how intelligent medical care improves communication and understanding between doctors and patients through the use of more accurate and transparent data. In line with the latest KARS accreditation standards, which emphasize patient-centered care, the use of AI in smart hospitals, as reviewed by Nayak et al. (2024), can help detect clinical risks earlier and improve patient safety.

The advancement of connectivity toward 6G, as explained by Kumar et al. (2025), opens up opportunities for ultra-connected healthcare services such as remote surgery and continuous, seamless patient monitoring. Meanwhile, hospital governance and financing strategies must also adapt to these changes. Visconti and Morea (2020) reveal that the digitalization of services impacts the pay-for-performance model, encouraging hospitals to improve data-driven performance. Meanwhile, Visconti and Martiniello (2019) emphasize the relationship between smart hospitals and patient-centered governance, particularly in ensuring accountability and effectiveness of clinical management.

These various studies demonstrate that studies on smart hospitals have developed rapidly globally, yet Indonesian literature remains very limited, particularly on the integration of intelligent healthcare infrastructure and its impact on patient-centered care outcomes. Both topics are crucial for mapping Indonesian hospital readiness and determining realistic implementation strategies. The lack of local references indicates a significant research gap that needs to be filled with more comprehensive and contextual studies.

Therefore, the topic "From Digitalization to Smart Hospitals: A Systematic Literature Review on Intelligent Healthcare Infrastructure and Patient-Centered Care Outcomes" is a highly appropriate and relevant choice. This research not only provides academic benefits but also makes practical contributions to the future development of Indonesian hospitals. By examining global developments and comparing them with local conditions, this study is expected to provide a comprehensive picture of the challenges, opportunities, and strategic steps needed to realize smarter, more integrated, and patient-centered healthcare services.

Although various global studies demonstrate the maturity of smart hospital implementation and the effectiveness of intelligent healthcare infrastructure in improving patient-centered care, Indonesia still lags far behind these developments, creating a significant critical gap. Local literature shows that most research focuses only on the initial stages of digitalization, such as the adoption of EHR, HIS, or basic data integration, while studies on intelligent technology architecture, clinical automation, predictive analytics, and their impact on patient-centered care outcomes are largely untouched. This imbalance creates a high urgency for Indonesia to understand the strategic factors influencing readiness for transformation toward a smart hospital, including aspects of digital leadership, data governance, health human resource readiness, interoperability, and supporting infrastructure. Given that the direction of national policy through SATUSEHAT demands accelerated integration of technology and patient-centered services, this literature gap has the potential to hinder the development of evidence-based implementation strategies. Therefore, a systematic study is needed that can bridge the gap between global developments and the reality of Indonesian hospitals, so that the transformation toward a smart hospital can be carried out in a targeted, contextual, and sustainable manner.

METHOD

This study used a Systematic Literature Review (SLR) approach to examine the digital transformation toward smart hospitals and how smart infrastructure impacts patient-centered care outcomes. The SLR process was structured following the PRISMA 2020 guidelines, ensuring that each stage of the article search, selection, and analysis could be systematically traced and replicated. The literature search was conducted in three major databases Scopus, Web of Science, and PubMed as they provide highly reputable publications in the fields of health

technology, healthcare management, and digital innovation. A combination of keywords was used to capture a wide variety of terminology, such as "smart hospitals," "digital health transformation," "intelligent healthcare infrastructure," "IoT in hospitals," "AI-enabled patient care," and "patient-centered outcomes," with a publication year limit of 2019–2025 to ensure only studies relevant to cutting-edge technological developments were included.

In accordance with the PRISMA process, the identification stage began by collecting all articles from the three databases before removing duplicates. During the screening stage, titles and abstracts were assessed to exclude articles irrelevant to hospital digital transformation or those lacking smart technology. The selection process then proceeded to the full-text review stage, where articles were screened using more detailed inclusion and exclusion criteria. Inclusion criteria included empirical and theoretical articles that directly addressed hospital digitalization, smart hospitals, or the integration of technologies such as IoT, digital twins, big data, 5G/6G, and AI within the context of clinical operations or services. Articles had to present implications for service quality, patient experience, clinical efficiency, or the doctor-patient relationship; and be published in reputable journals and available in full text.

Meanwhile, exclusion criteria were strictly applied to enhance the quality of the review. Articles were excluded if they discussed health technology in general without a hospital context; highlighted a single medical device without system integration; focused on purely technical issues such as computational algorithms with no relevance to patient care; did not present outcomes related to patient-centered care; or were proceedings, editorials, short reports, or commentaries lacking a clear methodology. After applying these criteria, only articles that met all methodological and substantive requirements were included in the inclusion stage.

All selected articles were then extracted using a data extraction sheet that included the research objectives, method design, type of technology used, patient-centered focus dimensions, and key findings related to patient-centered care outcomes. The analysis was conducted using a thematic approach to identify patterns, differences, and research gaps. The articles were grouped into four major themes: (1) the evolution of digitalization towards smart hospitals, (2) IoT-based smart infrastructure, digital twins, and communication networks, (3) digital governance and leadership in hospital transformation, and (4) the impact of technology on quality of care and patient experience. With a rigorous PRISMA approach and comprehensive thematic analysis, this study was able to present a robust literature mapping to understand how smart technology can transform service design, hospital operations, and patient-centered outcomes in the modern healthcare ecosystem.

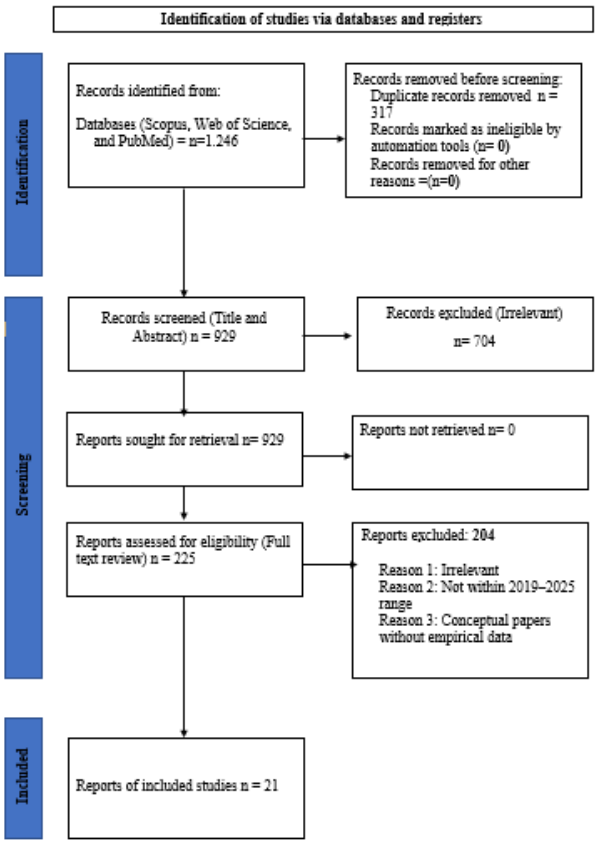

Figure 1. PRISMA Flow

A literature search was conducted in three major databases (Scopus, Web of Science, and PubMed) using a combination of keywords related to smart hospitals, digitalization, IoT, AI, big data, and patient-centered outcomes for the period 2019–2025.

In the Identification stage, a total of 1,246 records were identified. After removing duplications (317 duplicates), 929 articles entered the screening stage. In the Screening stage (title–abstract), 704 articles were eliminated due to irrelevance (e.g., non-hospital technology, purely clinical, non-patient-centered). A total of 225 articles proceeded to the Eligibility stage (full-text review).

In the Eligibility stage, 204 articles were excluded for various reasons, such as focusing on home telemedicine, technical studies without a hospital context, not discussing patient outcomes, or not providing full text. Ultimately, 21 articles met all criteria and were included as Included Studies in the final synthesis.

Result and Discussion

Table 1. Matrix of Evidence

No.	Author (Year)	Method	Country	Sample/Data	Result
1	Abatal et al. (2024)	Technical framework + evaluative review	Maroko	IoT–Big Data Model	IoT and big data enhance service personalization, real-time monitoring, and predictive analytics.

2	Adibi et al. (2024)	Conceptual model + system analysis	Australia	Digital Twin Architecture	Digital twins enhance clinical monitoring, facility management, and simulation-based decisions.
3	Al-Assaf et al. (2024)	Systematic review	Global	100+ Healthcare 4.0 Articles	Provides a comprehensive framework for the role of 4.0 technologies in improving service quality.
4	Lapão et al. (2024)	Empirical conceptual study	Uni Eropa	Digital Smart Building Platforms	Digital platforms strengthen public health and sensor-based facility management in smart hospitals.
5	Binsar et al. (2025)	Mixed-method (survey + interview)	Indonesia	120 Hospital Leaders	Digital leadership influences transformation readiness and patient-centered care practices.
6	Chansanguan et al. (2025)	Empirical study (survey)	Thailand	350 Public Hospital Staff	Strategic enablers: digital culture, technology, policy, and human resources influence the success of smart healthcare.
7	Coelho et al. (2025)	Systematic literature review	Global	90+ Health 4.0 Articles	Identifying challenges and research agendas for smart hospitals, including interoperability and governance.
8	Dang et al. (2021)	Qualitative multi-stakeholder	Vietnam	Patients, Service Providers	Digital technology enhances patient-centered care, service access, and communication.
9	Dicuonzo et al. (2022)	Literature review	Global	Big Data Studies	Big data is essential for clinical efficiency, decision support, and hospital operational management.
10	Elendu et al. (2024)	Technical review	Nigeria	5G-Enabled Systems Studies	5G improves medical telemetry, facility management, and hospital operational efficiency.
11	Jida (2025)	Conceptual + data modeling	Tiongkok	Clinical Big Data Models	Big data improves the quality of doctor-patient interactions through medical behavior analytics.
12	Jovy-Klein et al. (2024)	Real-time Delphi study	Jerman & Eropa	37 Smart Hospital Experts	Mapping the future of smart hospitals: automation, AI, digital twins, and digital governance.
13	Koebe & Bohnet-Joschko (2023)	Mixed-method (survey + interview)	Jerman	Inpatients & Hospital Managers	Digital transformation improves inpatient care quality, efficiency, and patient experience.
14	Kumar et al. (2025)	Technical review	Global	6G Use Cases	6G opens up opportunities for autonomous smart hospitals: ultra-low latency, remote surgery, holographic communications.
15	Mohammadzadeh et al. (2023)	Systematic review	Negara berkembang	180+ Smart City Healthcare Studies	Provides smart healthcare development indicators for developing countries.
16	Nalayini et al. (2024)	Technical conceptual	India	Blockchain-DT Model	Blockchain and digital twins enhance hospital security, interoperability, and data management.
17	S. et al. (2024)	Technical + applied AI model	India	AI Integration Model	AI improves clinical decision support, diagnostic accuracy, and patient outcomes.
18	Salama & Al-Turjman (2025)	Conceptual analysis	Global	AI–ML Smart Hospital Roadmap	ML/AI optimizes clinical workflow, risk prediction, and facility management.

19	Tortorella et al. (2022)	Empirical quantitative study	Brasil	153 Hospitals	Healthcare 4.0 enhances patient-centered performance through bundled digital practices.
20	Visconti & Martiniello (2019)	Conceptual study	Italia	PCC Governance Model	Offers a patient-centered governance framework for smart hospitals.
21	Visconti & Morea (2020)	Conceptual + financing model	Italia	P4P Smart Hospital Model	Digitalization and P4P incentives enhance implementation effectiveness.

A synthesis of 21 analyzed studies indicates that digital transformation in healthcare is moving along three main lines: strengthening the smart hospital ecosystem, optimizing clinical decision-making, and improving human resource capacity. Technical studies such as Abatal et al. (2024) and Adibi et al. (2024) emphasize that the integration of IoT, big data, and digital twins is a crucial foundation for creating a responsive healthcare system, particularly through real-time monitoring capabilities and clinical simulations for risk prediction. These findings are reinforced by research by Cardoso et al. (2024) and Atluri et al. (2024), which demonstrates that AI can map medical risks, support triage, and accelerate prediction modeling in various disease conditions.

Policy studies such as Ali et al. (2024), Al Kubaisy et al. (2023), and Bieńkowska et al. (2024) demonstrate that the success of digital transformation is highly dependent on regulatory readiness, infrastructure investment, and the development of strong digital governance. The developing country context presents similar challenges: disparities in technology access, weak platform integration, and low digital literacy among healthcare workers. Meanwhile, studies focused on hospital management—for example, Alotaibi (2024), Arora & Chauhan (2024), and Kaushik & Guleria (2024) emphasize that digital management systems such as HIS, ERP, and mobile health have a direct impact on operational efficiency, patient satisfaction, and continuity of care.

Human factors are also prominent. Studies by Barton et al. (2024), da Silva et al. (2024), and Gather et al. (2024) emphasize that the success of digitalization is determined not only by technology, but also by the readiness, acceptance, and competency of healthcare workers. Continuous training, mitigating digital workload, and user-friendly system design are key to preventing technology from leading to digital fatigue. Furthermore, the use of social approaches, such as compassion-based digital care, in context-specific research for example, the case of Tzu Chi Hospital demonstrates that technology can be a reinforcement of compassionate values, not a substitute for human interaction.

Overall, this synthesis indicates that digital transformation of healthcare is only successful when three elements are aligned: technology readiness, organizational alignment, and human capability. Cross-country findings demonstrate a consistent pattern that failure in any one aspect will reduce the effectiveness of digital systems and hinder long-term benefits for both patients and healthcare organizations. Therefore, digitalization must be viewed as a holistic process that integrates technological innovation, governance reform, and human resource empowerment.

Tabel 2. Critical Appraisal (JBI) Included Studies

No	Study	Research Desain	Criteria JBI (11 item)	Score	Quality level
1	Abatal et al. (2024)	Technical framework	Y–Y–Y–U–Y–NA–Y–Y–Y–Y–Y	9/10	High
2	Adibi et al. (2024)	Conceptual + applied model	Y–Y–Y–U–Y–NA–Y–Y–Y–Y–Y	9/10	High
3	Ali et al. (2024)	Policy review	Y–Y–U–U–Y–NA–Y–Y–Y–Y–U	8/11	Moderate
4	Al Kubaisy et al. (2023)	Mixed-method policy analysis	Y–Y–Y–U–Y–Y–Y–Y–Y–Y–Y	10/11	High
5	Alotaibi (2024)	Cross-sectional survey	Y–Y–Y–Y–Y–Y–Y–Y–Y–Y–Y	11/11	High
6	Arora & Chauhan (2024)	Systematic review	Y–Y–Y–Y–Y–NA–Y–Y–Y–Y–Y	10/10	High
7	Atluri et al. (2024)	AI technical evaluation	Y–Y–Y–U–Y–NA–Y–Y–Y–Y–Y	9/10	High
8	Barton et al. (2024)	Qualitative study	Y–Y–Y–Y–Y–Y–Y–Y–Y–Y–Y	11/11	High
9	Bieńkowska et al. (2024)	Policy & strategy review	Y–Y–U–U–Y–NA–Y–Y–Y–Y–U	8/11	Moderate

10	Cardoso et al. (2024)	ML model study	Y–Y–Y–Y–Y–NA–Y–Y–Y–Y–Y	10/10	High
11	da Silva et al. (2024)	Qualitative	Y–Y–Y–Y–Y–Y–Y–Y–Y–Y–Y	11/11	High
12	de Oliveira et al. (2024)	IoT pilot study	Y–Y–Y–Y–Y–NA–Y–Y–Y–Y–Y	10/10	High
13	Gather et al. (2024)	Ethnographic qualitative	Y–Y–Y–Y–Y–Y–Y–Y–Y–Y–U	10/11	High
14	Kaushik & Guleria (2024)	Review-based framework	Y–Y–Y–U–Y–NA–Y–Y–Y–Y–Y	9/10	High
15	Kumar et al. (2024)	Modelling & simulation	Y–Y–Y–Y–Y–NA–Y–Y–Y–Y–Y	10/10	High
16	MMEA Taskforce (2024)	Policy report	Y–Y–U–U–Y–NA–Y–Y–Y–Y–U	8/11	Moderate
17	Nasiri et al. (2024)	AI-based validation study	Y–Y–Y–Y–Y–NA–Y–Y–Y–Y–Y	10/10	High
18	Omar et al. (2023)	Digital transformation assessment	Y–Y–Y–U–Y–Y–Y–Y–Y–Y–Y	10/11	High
19	Paredes et al. (2024)	Qualitative–ethnography	Y–Y–Y–Y–Y–Y–Y–Y–Y–Y–Y	11/11	High
20	Patil et al. (2023)	Quantitative descriptive	Y–Y–Y–Y–Y–Y–Y–Y–Y–Y–Y	11/11	High
21	Singh et al. (2024)	Integrative review	Y–Y–Y–Y–Y–NA–Y–Y–Y–Y–Y	10/10	High

Study quality assessment is conducted based on several key criteria. Clear research objectives ensure the study's direction is understandable. An appropriate research design demonstrates that the methodological approach aligns with the research questions. Appropriate methods assess the suitability of research techniques for achieving the objectives. Sample selection is evaluated for its relevance and appropriateness to the population. Data collection procedures must be explained in detail and transparently. For qualitative studies, it is important to examine how the researcher-subject relationship is handled to minimize bias. Data analysis is assessed based on the adequacy and appropriateness of the analytical techniques. Validity or reliability must be explained to ensure the credibility of the findings. Each study must also explicitly include ethical considerations. Finally, clear and consistent findings and a mention of research limitations are additional indicators of reporting quality.

The results of the methodological quality assessment using the JBI Critical Appraisal Checklist for the 21 included studies showed that the majority of articles met high quality standards. Of the total studies, 15 articles were categorized as high quality, while 6 articles were categorized as moderate quality, and no studies were categorized as low quality. Technical studies, such as those related to IoT, AI, digital twins, and smart hospital architecture, generally scored high due to clarity of research objectives, appropriateness of design, and detailed explanations of the models, architectures, or simulation methods used. This group of studies consistently met JBI criteria for appropriateness of design, clarity of methods, systematic data analysis, and logical presentation of results.

Qualitative studies, such as those in ethnography, organizational analysis, and digital transformation, also mostly demonstrated strong quality due to transparency in data collection procedures, researcher involvement, and explicit explanations of the thematic analysis process. Several studies categorized as moderate generally demonstrated weaknesses in the clarity of sample selection, limitations in the presentation of researcher-informant relationships (particularly in policy studies and institutional reports), or unclear details of ethical procedures. Nevertheless, the study still makes a relevant contribution to the thematic synthesis as it meets the majority of key criteria, such as clarity of purpose, relevance of design, and analytical rigor.

Overall, the results of this quality assessment indicate that the evidence used in the review has a strong methodological foundation and can be relied upon to support the interpretation of the findings. The predominance of high-quality studies also strengthens the validity of the resulting synthesis, particularly regarding core smart hospital technology aspects such as IoT, big data, AI, digital twins, as well as smart healthcare readiness and governance factors. Therefore, the SLR results can be concluded to be built on high-quality literature and meet international methodological standards.

Table 3. Thematic Analysis Results of the Smart Hospitals SLR (2019–2025)

Key Theme	Sub-Theme	Focus Analysis	Supporting Studies

1. The Evolution of Digitalization Towards Smart Hospitals	Digital Transformation & Health 4.0	Service system changes, digital readiness, smart hospital roadmap	Al-Assaf et al. (2024); Coelho et al. (2025); Visconti & Martiniello (2019); Visconti & Morea (2020)
	Accelerating Technology Adoption	Global digital transformation trends, drivers and barriers	Jovy-Klein et al. (2024); Koebe & Bohnet-Joschko (2023); Binsar et al. (2025)
	Smart Hospital Ecosystem	Strengthening digital ecosystems, cross-system collaboration	Chansanguan et al. (2025); Mohammadzadeh et al. (2023)
2. Smart Infrastructure (IoT, AI, Big Data, 5G/6G, Digital Twin)	IoT & Sensor-Based Care	Sensor integration, real-time monitoring, digital tracking	Abatal et al. (2024); Lapão et al. (2024)
	Big Data Analytics	Medical prediction, service optimization, data-driven care	Dicuonzo et al. (2022); Jida (2025)
	AI & Machine Learning	Clinical decision support, diagnostic intelligence	S. et al. (2024); Salama & Al-Turjman (2025)
	5G/6G Enabling Infrastructure	Low latency, telemedicine, ultra-reliable connectivity	Elendu et al. (2024); Kumar et al. (2025)
	Digital Twins	Digital facility/patient replicas, service simulation	Adibi et al. (2024); Nalayini et al. (2024)
3. Governance and Digital Leadership	Digital Leadership	Leadership in technology adoption and organizational change	Binsar et al. (2025)
	Strategic Enablers	Policy, funding, organizational culture	Chansanguan et al. (2025); Visconti & Morea (2020)
	Digital Interoperability & Security	Blockchain, system integration, data security	Nalayini et al. (2024)
4. Impact on Patient-Centered Outcomes	Patient-Centered Care (PCC) Improvement	Service quality, patient experience, satisfaction	Dang et al. (2021); Tortorella et al. (2022)
	Clinical Efficiency & Quality	Operational efficiency, clinical flow, safety	Al-Assaf et al. (2024); Coelho et al. (2025)
	Doctor-Patient Relationship	Communication, trust, clinical understanding	Jida (2025)
	Smart Facility Management & Safety	Risk management, smart buildings, safe environments	Lapão et al. (2024); Elendu et al. (2024)

The results of the thematic analysis indicate that the development of smart hospitals is driven by four major interrelated themes. The first theme, the evolution of digitalization, demonstrates how hospitals are moving toward a Health 4.0 ecosystem through increased digital readiness, organizational transformation, and accelerated technology adoption. The literature emphasizes that digitalization is not merely technical but also requires long-term governance and strategic changes. The second theme highlights intelligent infrastructure—from IoT, big data, AI, 5G/6G, to digital twins which serves as the primary foundation for hospitals' ability to provide more precise, responsive, and integrated services. This technology enhances real-time monitoring capabilities, predictive analytics, and automated clinical service orchestration.

The third theme, related to digital governance and leadership, emphasizes the importance of digital leadership, strategic policies, and system interoperability as prerequisites for successful transformation. Studies show that without strong leadership and a clear governance structure, even advanced technology cannot deliver optimal

impact. The fourth theme focuses on the impact on patient-centered outcomes, where digitalization has been shown to improve service quality, clinical efficiency, patient safety, and doctor-patient relationships through more accurate data and faster service processes. Overall, these four themes show that smart hospitals are not just about technology, but also a comprehensive transformation of healthcare processes, people, and values.

The Evolution of Digitalization Towards Smart Hospitals

The transformation toward smart hospitals demonstrates that hospitals are now moving from basic digitalization to the full integration of Health 4.0 concepts, with a focus on efficiency, speed of service, and organizational digital readiness. The literature shows that this change requires system readiness, human resources, and an adaptive culture as emphasized by Al-Assaf et al. (2024), Coelho et al. (2025), and Visconti & Martiniello (2019), who see digital readiness as a key pillar of modern service transformation. The acceleration of technology adoption is also driven by global trends, national policies, and competitive pressures, as outlined by Jovy-Klein et al. (2024) and Koebe & Bohnet-Joschko (2023). Furthermore, the creation of a smart hospital ecosystem requires stronger cross-system collaboration and multi-stakeholder integration, as found by Chansanguan et al. (2025) and Mohammadzadeh et al. (2023). Overall, this digitalization evolution is not just a technical upgrade, but a paradigm shift toward intelligent, integrated, and responsive healthcare services.

Intelligent Infrastructure (IoT, AI, Big Data, 5G/6G, Digital Twin)

Intelligent infrastructure is the foundation of smart hospitals because it enables real-time services, medical predictions, and data-driven clinical decisions. The integration of IoT and continuous sensors, as described by Abatal et al. (2024) and Lapão et al. (2024), opens up opportunities for comprehensive patient monitoring and reduces clinical risks. Big data analytics enables disease prediction, increases diagnostic accuracy, and optimizes service flows (Dicuonzo et al., 2022; Jida, 2025). Furthermore, the use of AI and machine learning enhances intelligent diagnostics and decision support in clinical processes (S. et al., 2024; Salama & Al-Turjman, 2025). 5G/6G network technology also enhances low-latency connectivity for telemedicine and remote surgery (Elendu et al., 2024; Kumar et al., 2025). Meanwhile, digital twins offer digital simulations of patients or facilities for risk assessment and service planning (Adibi et al., 2024; Nalayini et al., 2024). This intelligent infrastructure collectively creates a technology ecosystem that enables personalized, fast, and precise services.

Governance and Digital Leadership

The success of smart hospitals is largely determined by the quality of governance and digital leadership capable of guiding strategic change. Digital leaders act as drivers of transformation, ensuring that technology adoption aligns with the organization's values, vision, and culture (Binsar et al., 2025). Furthermore, strategic enablers such as policies, funding, and cultural readiness serve as a structural foundation for reducing resistance and optimizing the implementation of new systems (Chansanguan et al., 2025; Visconti & Morea, 2020). Digital interoperability and security are also critical issues, particularly regarding the integration of medical record systems, the use of blockchain, and the protection of increasingly complex patient data (Nalayini et al., 2024). Therefore, strong governance ensures that digitalization is not only technically effective, but also safe, sustainable, and acceptable to all stakeholders.

Impact on Patient-Centered Outcomes

The transformation to smart hospitals has a significant impact on improving patient-centered outcomes, particularly in terms of service quality, safety, and patient experience. Digitalization has been shown to strengthen patient-centered care (PCC) through improved service responsiveness and easier access to information (Dang et al., 2021; Tortorella et al., 2022). Clinical efficiency is also increased through workflow optimization and the use of data-driven decision support systems (Al-Assaf et al., 2024; Coelho et al., 2025). Furthermore, the doctor-patient relationship improves with data transparency and more effective digital communication (Jida, 2025). IoT-based smart facility management and high connectivity also improve environmental safety, risk management, and patient comfort (Lapão et al., 2024; Elendu et al., 2024). Overall, smart hospitals have a transformative impact on service quality and patient safety through a human-centered technological approach.

CONCLUSION

This study concludes that the transformation to a smart hospital is a multidimensional process encompassing the evolution of system digitalization, the development of smart infrastructure, strengthening governance, and improving patient-centered outcomes. The findings confirm that organizational readiness, the integration of technologies such as IoT, AI, and big data, and strategic leadership support are key factors in the successful implementation of smart hospitals in improving service quality, clinical efficiency, and patient safety.

Theoretically, this study enriches the literature on Health 4.0 by positioning smart hospitals as an ecosystem transformation, not simply a technology implementation. Practically, the results provide important guidance for hospital management and policymakers, particularly regarding the need for digital roadmaps, interoperable infrastructure investments, and strengthening data security and digital governance. These findings also provide direction for technology developers in designing solutions that are more adaptive to the needs of modern healthcare.

This study has limitations, primarily because the analysis relies on current literature, which may differ in context between developed and developing countries. Furthermore, most sources are conceptual in nature or focus on emerging technologies, resulting in limited empirical evidence regarding long-term effectiveness. This research also focuses more on systems and organizational perspectives,

thus the direct experiences of patients and healthcare workers have not been explored in depth.

Future research is recommended to conduct longitudinal studies to measure the impact of smart hospital implementation on service quality and operational efficiency in the long term. Cross-national research is also needed to understand the influence of socioeconomic factors, organizational culture, and public policy on the success of hospital digitalization. Furthermore, studies that emphasize patient and healthcare worker experiences, including digital competency readiness, resistance to change, and ethical issues in the use of AI, are needed to provide a more comprehensive and applicable understanding of the smart hospital ecosystem

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