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REVIEW ARTICLE
Health Management

Health Information Systems: Digitalization, Artificial Intelligence Integration, And Global Strategies

Sağlık Bilgi Sistemleri: Dijitalleşme, Yapay Zekâ Entegrasyonu ve Küresel Stratejiler

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ÖZET

Sağlık hizmetlerinde verimliliği artırmak, hasta güvenliğini güçlendirmek ve maliyetleri optimize etmek amacıyla kullanılan Sağlık Bilgi Sistemleri (İSS), yapay zekâ (YZ) ve gelişmiş dijitalleşme teknolojileriyle son yıllarda önemli bir dönüşüm geçirmiştir. Anlatısal bir derleme olarak tasarlanan bu çalışmada, 2003-2025 dönemini kapsayan temel literatür ve güncel araştırmalar kapsamlı bir şekilde analiz edilmiş; sistemik entegrasyon, yönetimsel verimlilik, klinik karar destek yetenekleri ile etik ve yasal boyutlar, Türkiye ve uluslararası alandan örneklerle karşılaştırmalı olarak incelenmiştir. Bulgular, tam entegre İSS yapılarının operasyonel hataları ve iş akışı aksamalarını önemli ölçüde azalttığını, derin öğrenme tabanlı algoritmaların ise özellikle radyolojik tanı ve ilaç keşfi gibi alanlarda insan performansını aşan doğruluk ve hız gösterdiğini ortaya koymaktadır. Bununla birlikte, HL7 FHIR gibi küresel birlikte çalışabilirlik standartlarının yaygın olarak benimsenmemesi, artan siber güvenlik tehditleri (özellikle fidye yazılımı), algoritmik önyargı riski ve "Çok El Sorunu" bağlamında ortaya çıkan sorumluluk belirsizlikleri, sürdürülebilir ve güvenilir bir dijital dönüşümün önündeki başlıca engeller olarak belirlenmiştir. Çalışma, sağlık bilgi sistemlerinin pasif kayıt ve arşivleme araçlarından stratejik karar destek ve yönetişim mekanizmalarına dönüştüğünü göstermektedir. Sonuç olarak, gelecekteki sağlık hizmetleri ekosisteminde başarı, teknolojik altyapının güçlendirilmesine, KVKK (LPPD) ve GDPR gibi düzenlemeler çerçevesinde veri güvenliği ve gizliliğinin sağlanmasına ve sağlık çalışanlarının dijital yetkinliklerinin sistematik olarak geliştirilmesine bağlıdır.

Anahtar Kelimeler: Sağlık Bilgi Sistemleri, Yapay Zeka, Dijitalleşme, Büyük Veri, Birlikte Çalışabilirlik, Klinik Karar Destek Sistemleri.

ABSTRACT

Health Information Systems (HIS), utilized to enhance efficiency, strengthen patient safety, and optimize costs in healthcare services, have undergone a profound transformation in recent years driven by artificial intelligence (AI) and advanced digitalization technologies. In this study, designed as a narrative review, core literature and current research covering the period of 2003–2025 were comprehensively analyzed; systemic integration, managerial efficiency, clinical decision support capabilities, and ethical and legal dimensions were comparatively analyzed through examples from Türkiye and the international arena. The findings reveal that fully integrated HIS structures significantly reduce operational errors and workflow disruptions, while deep learning-based algorithms demonstrate accuracy and speed surpassing human performance, particularly in fields such as radiological diagnosis and drug discovery. However, the lack of widespread adoption of global interoperability standards such as HL7 FHIR, escalating cybersecurity threats (specifically ransomware), the risk of algorithmic bias, and liability ambiguities arising within the context of the "Problem of Many Hands" have been identified as primary obstacles to a sustainable and reliable digital transformation. The study demonstrates that health information systems have evolved from passive recording and archiving tools into strategic decision support and governance mechanisms. Consequently, success in the future healthcare ecosystem depends on strengthening technological infrastructure, ensuring data security and privacy within the framework of regulations such as KVKK (LPPD) and GDPR, and systematically developing the digital competencies of healthcare professionals.

Keywords: Health Information Systems, Artificial Intelligence, Digitalization, Big Data, Interoperability, Clinical Decision Support Systems.

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INTRODUCTION

Healthcare services are inherently complex sectors with intense information flow, minimal tolerance for error, and where interdisciplinary coordination is of vital importance. Historically, manual systems where patient data was managed with paper files created serious limitations regarding data accessibility, security, and sharing; this situation made the integration of technology into healthcare processes inevitable (Evans, 2016). Developments in computer and software technologies have enabled health data not only to be stored but also to be processed and transformed into meaningful information, which has radically changed strategic decision-making mechanisms in health management (Britannica, 2021). Today, Health Information Systems (HIS) are defined as fundamental technological infrastructures that enable administrative, financial, and clinical processes to be carried out in an integrated manner in a digital environment, transforming data into information to achieve organizational goals (Zwass, 2020; Göktaş et

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al., 2017). These systems play a critical role in accelerating workflows and minimizing medical errors by ensuring the integration of different departments within the hospital, such as laboratories, radiology, and pharmacies (Blazona & Koncar, 2007; Nabovati et al., 2014).

In particular, the COVID-19 pandemic has proven that digital health infrastructures are indispensable not only for hospital management but also for the management of public health crises. The contact tracing (filiation) and contact tracking processes successfully implemented in Türkiye have demonstrated the strategic power of digitalization in epidemic control on a global scale (Önal & Kalaycı, 2021; Çetin et al., 2021). However, in recent years, health informatics has undergone an evolution, moving beyond the concept of "digitalization" towards "smart health systems." The integration of Big Data analytics and Artificial Intelligence (AI) technologies into Electronic Health Records (EHR) has transformed HIS from a passive recording tool into a proactive assistant guiding physicians in diagnosis and treatment (Miotto et al., 2016). Thanks to Deep Learning algorithms, the detection of radiological findings that the human eye might miss, or the analysis of complex genetic data can be performed within seconds and with high accuracy rates (Rajkomar et al., 2018; Edison, 2023).

When the current literature for the 2023-2025 period is examined, it is observed that Generative AI and machine learning models shorten drug discovery processes, offer personalized treatment simulations, and increase operational efficiency (Kumar et al., 2025; Pramanik et al., 2025). However, this rapid technological transformation brings with it new managerial problems such as data privacy, cybersecurity risks, system interoperability, and ethical uncertainties (Ammenwerth et al., 2003; Handayani et al., 2017; Reddy, 2025).

Globally, the demographic structure is changing rapidly, and the share of the elderly population within the total population is increasing. This demographic transformation intensifies the pressure on health systems and necessitates effective management of resources. The recently experienced COVID-19 pandemic has proven how fragile health infrastructures can be in times of crisis and that traditional management models remain insufficient in meeting rising costs. In this context, the integration of Artificial Intelligence (AI) technologies into health management offers a strategic opportunity not only to optimize costs but also to make service quality sustainable. In the current health ecosystem, there is a serious imbalance between increasing service demand and limited human resources and physical capacity. AI- supported management models produce rational solutions in managing this supply- demand imbalance, increasing operational efficiency, and preventing resource waste. The aim of this study is to comprehensively examine the transition process of health information systems from the basic digitalization phase to AI-supported autonomous systems in the light of fundamental and current studies in literature.

CONCEPTUAL FRAMEWORK

Original Contribution of the Review: While previous reviews in the field of health informatics typically focus on isolated domains -such as the technical aspects of interoperability, the clinical accuracy of specific AI models, or solely on data privacy laws- this study provides a holistic synthesis of the digital transformation ecosystem. Theoretically, it contributes by bridging the gap between clinical AI performance and managerial/administrative efficiency, illustrating how these domains are intrinsically interdependent. Practically, by comparatively analyzing centralized architectures (e.g., Türkiye, Estonia) against fragmented systems (e.g., USA) and addressing emerging operational threats like algorithmic bias and ransomware, this review offers a macro-to-micro strategic framework. This comprehensive perspective equips healthcare administrators and policymakers with an actionable roadmap for implementing ethical, secure, and fully integrated AI-supported health information systems that prior, narrower reviews lack.

The Relationship Between Health and Data

Health is defined not merely as the absence of disease or infirmity, but as a state of complete physical, mental, and social well-being. Sustaining this dynamic process necessitates the tracking of massive amounts of biological and clinical data produced from an individual's birth to death (Hekimoğlu, 2016). Healthcare service is inherently an information-intensive process, and timely access to accurate information is directly related to patient safety (Tengilimoğlu et al., 2021).

Health Information Systems (HIS)

Health Information Systems are integrated computer hardware and software components that enable the collection, storage, processing, retrieval, and transmission of administrative, financial, and medical data arising during the management and delivery of healthcare services (Göktaş et al., 2017). While Zwass (2020) generally defines information systems as structures that transform data into organizational knowledge; in the context of health, these systems form the basis of efficient resource use and strategic decision-making processes (Ammenwerth et al., 2003).

Basic Components of Health Information Systems

In a modern healthcare organization, HIS consists of modular structures that perform different functions. The main components highlighted in the literature are:

✓ **Hospital Information Management System (HIMS):** The umbrella system where all administrative, financial, and medical processes of the hospital (patient registration, billing, inventory management, etc.) are managed digitally. It covers a wide range from performance evaluation of healthcare workers to material requirements planning (Işık & Akbolat, 2010; Koçak, 2008).

✓ **Laboratory Information System (LIS):** A specialized system that manages the process from taking patient samples to analyzing them in devices and transmitting the approved results to the physician. An ideal LIS standardizes testing processes by eliminating manual errors (Sepulveda & Young, 2013; Kammergruber et al., 2014).

✓ **Radiology Information System (RIS) and PACS:** Systems that manage radiological imaging processes (RIS) and enable the digital storage and transmission of obtained medical images (MRI, CT, X- ray) (PACS). Thanks to DICOM standards, images can be transferred between different devices without loss (Blazona & Koncar, 2007; Zhang et al., 2009).

✓ **Electronic Health Record (EHR):** A digital file containing an individual's entire health history (vaccinations, surgeries, medications, allergies) that can be shared among authorized healthcare institutions. EHR is vital for the continuity of care (Evans, 2016).

✓ **Clinical Decision Support Systems (CDSS):** Intelligent modules that guide health professionals during the diagnosis and treatment phase and generate alerts (e.g., drug interactions) by comparing medical data with a knowledge base (Bates et al., 2023).

Digitalization

Digitalization is the conversion of data in analog format (paper, film, cassette) into computer-readable digital formats and the restructuring of business processes through these technologies (Britannica, 2021). Digitalization in health is not just the concept of a "paperless hospital"; it is making data accessible independent of location. For example, filiation (contact tracing) teams entering data with tablets in the field during the pandemic process and this data being processed instantly at the center is an example of the operational power of digitalization (Çetin et al., 2021; Önal & Kalaycı, 2021). Furthermore, digitalization ensures the preservation and transfer of cultural and medical memory to future generations (Tonta, 2020). Health management inherently has a multidisciplinary structure, requiring clinical processes to work in synchronization with administrative and financial processes. As emphasized by Rosenfield (1992), success in this field is possible only through the coordination of experts from different disciplines. However, today, especially in developed and developing countries, the phenomenon of population aging, termed the "Grey Tsunami," increases the burden of chronic diseases and the demand for healthcare services.

According to the Turkish Statistical Institute (TÜİK) 2023 data, the proportion of the elderly population in the total population in Türkiye has risen to 10.2%. Similarly, OECD data shows that the share of health expenditures in GDP in member countries hovers around an average of 9.2% (OECD, 2023). Despite this increasing demand and cost pressure, the supply of the health workforce does not increase at the same rate. At this point, artificial intelligence serves as a managerial lever in areas such as alleviating documentation burdens, financial sustainability, capacity planning, and preventive health services (Akalın & Veranyurt, 2021). At points where traditional methods fall short, algorithmic decision support systems step in to change the face of health management. Artificial intelligence technologies offer solutions in a wide range from micro to macro levels in health institutions. These applications range from the optimization of patient flow to the analysis of big data.

The management of emergency services and outpatient clinic densities in hospitals has become predictable with AI algorithms. As stated by Klumpp et al. (2021), processes such as estimating application density and tracking childhood vaccinations can be automated. For instance, estimating the number of admissions to emergency services with artificial neural networks ensures more effective personnel planning (shift management) and reduces waiting times (Born et al., 2024).

A significant part of healthcare workers' time is spent on data entry and reporting rather than patient care. Natural Language Processing (NLP) technologies can automatically convert physicians' voice notes into structured medical records. As emphasized in the study by Bongurala et al. (2024), this situation increases the reusability of health data and alleviates the bureaucratic burden on clinicians.

Research conducted in OECD countries shows that unnecessary tests and misdiagnoses constitute a serious waste item in health budgets. According to the analysis by Jiao et al. (2023), AI-supported diagnostic systems minimize treatment costs compared to traditional methods by detecting diseases at an early stage. These systems, which provide cost reduction without compromising quality, analyze the patient's clinical history to offer personalized treatment protocols and reduce complication risks. Today, data generated by individuals through smartwatches and wearable sensors create a massive health data pool. As expressed by Morley et al. (2022), the analysis of this "Big Data" by human hands is both costly and prone to error.

AI algorithms process this data instantly, reducing medication errors and contributing to accurate prescribing processes. The analysis of data collected through the e-Nabız system in Türkiye is an important example demonstrating the potential in this field. The management of scarce resources prioritizes preventive medicine over treatment. Shaheen and Yousef (2021) state that machine learning techniques identify at-risk populations, allowing for intervention before the disease occurs. Especially in chronic patient follow-up, remote monitoring systems reduce hospital admission rates and indirectly contribute to the national economy.

Artificial Intelligence (AI) and Its Subfields

Artificial intelligence is a set of algorithms and systems that mimic human intelligence's cognitive functions such as problem-solving, learning, pattern recognition, and decision-making (Rajkomar et al., 2018). In health, AI processes "big data" to offer physicians a "second opinion."

✓ **Machine Learning:** An AI subfield that allows computers to learn from data without being explicitly programmed. It makes risk predictions based on past patient data (Miotto et al., 2016).

✓ **Deep Learning:** Uses artificial neural networks that mimic the neuron structure in the human brain. It provides high accuracy, especially in the analysis of radiological images and pathological samples (Edison, 2023).

✓ **Generative AI:** Technology capable of generating new content (text, image, synthetic data) from existing data. It is used in the automatic summarization of clinical notes or personalized treatment simulations (Pramanik et al., 2025).

Other Critical Concepts in the Digital Health Ecosystem

Current studies in literature necessitate the inclusion of the following concepts in the framework for understanding digital transformation:

✓ **Big Data:** Data sets that are too large, complex, and fast flowing for traditional database tools to process. It is accepted as the fuel of AI (Haque et al., 2024).

✓ **Interoperability:** The ability of software and devices produced by different companies to exchange data with each other without any restrictions. HL7 and FHIR standards form the common language of this communication (Reis et al., 2017; Reddy, 2025).

✓ **Internet of Things (IoT / IoMT):** Medical devices and wearable sensors connecting to the internet to produce instant data. This technology allows the patient to be monitored outside the hospital (remote monitoring) (Oğuz, 2017).

✓ **Software as a Medical Device (SaMD):** Software used for medical purposes (diagnosis, treatment, prevention) on its own, not as part of hardware. AI algorithms are generally regulated in this category (Reddy, 2025).

This study was designed as a narrative review to comprehensively examine the evolution of Health Information Systems (HIS) and the integration of artificial intelligence (AI) in healthcare management. To ensure methodological transparency, a literature search was conducted covering the period between 2003 and 2025. The search process utilized major academic databases, primarily PubMed, Scopus, Web of Science, and Google Scholar. The primary search terms and keywords included "Health Information Systems", "Artificial Intelligence", "Digitalization", "Big Data", "Interoperability", and "Clinical Decision Support Systems". Peer-reviewed journal articles, international reports (e.g., OECD), and national strategic policy documents were considered as the main sources. Studies specifically focusing on systemic integration, managerial efficiency, clinical decision support capabilities, and the ethical and legal dimensions of digitalization in healthcare were prioritized for analysis and synthesis.

LITERATURE REVIEW

The literature in the field of health informatics addresses the evolution of health information systems multidimensionally across systemic integration, managerial efficiency, artificial intelligence-based clinical decision support applications, data security, and ethical-legal frameworks national/international policy documents. While early studies focused more on the technical and organizational difficulties, integration problems, and lack of standards brought about by the transition from paper-based processes to electronic systems; in recent years, the focus has shifted to the maturation of interoperability standards (HL7, DICOM, FHIR, etc.), the acceleration of intra-institutional and inter- institutional data flow, and the concrete efficiency gains achieved in clinical and administrative processes. In this context, studies in literature discuss in detail the effects of system architecture and interface design on clinicians' and other health professionals' workload, error rates, and workflow satisfaction.

In parallel, studies focusing on managerial efficiency and resource planning examine the effects of digital health information systems on corporate performance, cost control, inventory and material management, and human resources planning. In topics such as financial sustainability, performance monitoring, tracking of quality indicators, and strengthening of institutional learning mechanisms, the data-based contribution of information systems to decision-making processes is emphasized. Particularly in the case of Türkiye, it has been found that health workers' attitudes towards information systems, education levels, and digital competencies are determinants in the adoption and effective use of systems.

The current layer of literature focuses on the transformative role of artificial intelligence and machine learning-based applications in clinical decision support processes. In areas such as radiological image analysis, drug discovery, structuring of clinical notes, disease risk prediction, and personalized treatment planning, it has been shown that deep learning algorithms can work with accuracy rates close to or exceeding human performance. However, these developments also bring about ethical and legal debates such as data privacy, cybersecurity threats, algorithmic bias, transparency, and accountability. At this point, national and international regulatory frameworks, primarily KVKK (Law on Protection of Personal Data) and GDPR, and guidance documents from organizations such as the World Health Organization serve as references for the design, operation, and auditing of health information systems. The Health Transformation Program in Türkiye and related strategy documents also constitute the main policy framework guiding the digitalization agenda and AI integration of health information systems.

This holistic literature accumulation will be discussed in detail in the following subheadings in the context of systemic integration and standardization, managerial efficiency and resource planning, AI-based clinical decision support applications, data security with ethical-legal dimensions, and national/international strategic documents.

Systemic Integration and Standardization Studies

Early period studies in literature predominantly focused on the transition from paper-based processes to electronic environments, highlighting a common consensus that digitalization is not merely an archiving method but a direct catalyst for improving patient care quality through enhanced data access speed (Evans, 2016). However, a major trend emerging from this period is the critical challenge of interoperability specifically, the ability of disparate departmental systems to communicate seamlessly. While studies analyzing specific departments converge on the necessity of integrated automation to prevent data loss and pre-analytical errors (Blazona & Koncar, 2007; Sepulveda & Young, 2013), they also reveal a nuanced perspective: technical standardization (such as HL7 and DICOM) is a prerequisite, but not a standalone solution. A significant parallel drawn by multiple researchers is the crucial role of human-system interaction. Kammergruber et al. (2014) and Sugijarto et al. (2013) share the perspective that system success dramatically decreases when advanced technical infrastructures lack user-friendly interfaces. This highlights a key collective finding in the literature: non-ergonomic designs increase the cognitive load on healthcare personnel, which in turn paves the way for medical errors, proving that usability is just as critical as technical integration (Nabovati et al., 2014). In summary, the overarching trend in integration studies indicates that achieving true systemic interoperability requires a dual approach. The collective evidence suggests that the strict implementation of universal data standards must be inextricably linked with user-centric, ergonomic interface designs; neglecting either the technical or the human-interaction component inevitably leads to systemic inefficiencies and an increased risk of clinical errors.

Managerial Efficiency and Resource Planning

The non-clinical, administrative, and financial dimensions of HIS have been extensively analyzed, with a common trend indicating that digital integration optimizes resource management across various operational layers. A collective finding across logistical and supply chain studies is that the digital integration of Material Requirements Planning (MRP) and process improvement techniques consistently reduces inventory costs and operational waste in critical areas like operating rooms (Koçak, 2008; Özveri et al., 2019). While financial sustainability and cost control are recognized as universal benefits of HIS, researchers note differences based on institutional contexts; for instance, the extent of efficiency gained can vary significantly depending on the ownership structure of the healthcare facility (Çam et al., 2016). Furthermore, the literature intersects human resource management with digitalization, revealing a shared perspective that digital performance tracking systems go beyond mere evaluation they act as triggers for institutional learning and employee development (Bednall et al., 2014; Türetken & Demirörs, 2004). Interestingly, regional studies, particularly those focusing on Türkiye, emphasize a converging point: despite advanced infrastructural investments, user attitudes and education levels remain the most decisive factors for the successful adoption and effective use of these systems (Göktaş et al., 2017; Işık & Akbolat, 2010). Overall, the synthesized evidence highlights that the managerial contributions of health information systems extend far beyond basic cost-cutting. The prevailing trend shows that digitalized resource planning acts as a strategic lever that optimizes supply chain logistics, enhances financial sustainability, and fosters institutional learning, provided that healthcare professionals are adequately trained to embrace these digital tools.

Artificial Intelligence Revolution and Clinical Decision Support (2016-2025)

In recent years, the literature has focused on the transformation of systems from passive structures that "keep records" to active structures that "make decisions." Miotto et al. (2016) presented an unsupervised deep learning architecture that processes raw data in electronic health records with the "Deep Patient" model to predict patients' future disease risks (diabetes, schizophrenia, etc.) with high accuracy. Rajkomar et al. (2018), in a study conducted in collaboration with Google, showed that deep learning models predict in-hospital mortality risk, readmission probability, and length of stay much more precisely than traditional models.

Current studies belonging to the 2023-2025 period have carried the capabilities of artificial intelligence further. Kumar et al. (2025) found that artificial intelligence algorithms simulate drug discovery (R&D) processes, reducing molecule screening stages that normally take years to 4 to 18 months. In the field of radiology, Edison (2023) documented that AI-supported image processing systems reached 95.7% sensitivity in oncological diagnoses, alleviating radiologists' workload and reducing diagnostic errors.

Focusing on developments in the field of Generative AI, Pramanik et al. (2025) stated that this technology offers physicians a virtual "trial and error" area by creating personalized treatment simulations. Additionally, Derek and Collings (2025) reported that Natural Language Processing (NLP) technologies achieved over 85% success in transforming complex clinical notes entered by physicians as free text into structured data.

To summarize, the recent literature highlights a transformative trend where the impact of artificial intelligence on healthcare services transitions from theoretical models to applied clinical tools. The collective evidence underlines that deep learning and generative AI models are fundamentally changing the diagnostic and therapeutic landscape not by replacing clinicians, but by providing high-precision decision support that significantly reduces research timelines and minimizes diagnostic blind spots.

Security, Ethics and Global Approaches in Digital Transformation

The deepening of digitalization has moved data security and ethical problems to the center of the literature. Ustaoğlu and Akyol (2021) emphasized that threats (data leakage, etc.) must be managed as well as the opportunities brought by digitalization in information management. While Oğuz (2017) drew attention to security vulnerabilities in personalized mobile health applications; Haque et al. (2024) discussed that cyber-attacks on hospital systems are increasing and "ambient intelligence" technologies carry the risk of violating patient privacy. In the legal and ethical dimension, Palaniappan et al. (2024) stated that there is a lack of a global regulatory framework regarding who will be responsible for AI errors ("The Problem of Many Hands"). Cross et al. (2024) focused on the issue of algorithmic bias, proving that AI models not trained with certain ethnic or demographic groups could lead to discrimination in clinical decisions.

When inter-country strategies are examined; Metsallik and Ross (2022) presented Estonia's blockchain-based e-health model as the most successful example in ensuring data integrity; while Sarella et al. (2024) analyzed how India's digital identity application (ABDM) optimized data management in crowded populations. Specifically for Türkiye, Önal and Kalaycı (2021) introduced the success of central databases (e-Nabız) in pandemic management to the literature through filiation (contact tracing) and surveillance examples.

In conclusion, the literature regarding major trends in digital transformation points to a critical paradox: as global health systems become more connected and data-rich, they simultaneously face amplified vulnerabilities. The prevailing evidence emphasizes that addressing the common challenges related to cybersecurity threats and ethical issues is no longer a secondary technical concern, but a fundamental prerequisite for building sustainable and equitable global health infrastructures.

Digitalization in Plans and Reports (Development Plans, Ministry of Health Strategic Action Plans, and HTP Reports)

Just as in military use, the health sector has been one of the earliest fields to benefit from developments in digitalization and artificial intelligence methods (Narin 2025, Gire, 2025; Saraçoğlu 2025). Türkiye has been among the countries that integrated digitalization into the health system early. This process was initiated within the scope of the Health Transformation Program (HTP) with the conceptualization of "health information systems" and was carried out in line with reform goals. In the pre-HTP and early period or its first phase, digitalization and artificial intelligence methods in health were brought to the agenda with different concepts such as "information systems," "information and communication technologies," and "informatics." In the second phase of the Health Transformation Program, conceptualizations of digitalization and artificial intelligence- supported applications began to be used. In the 'Long-Term Strategy and Eighth Five- Year Development Plan (2001–2005),' the development of information and communication networks was targeted to increase efficiency in the health system; and in the 2002 Program, it was envisaged to "make maximum use of information technologies and establish an effectively functioning health information system to increase the efficiency of the health system." (Akdağ 2007; p:73).

Summarizing the policy-level literature, a clear trend emerges: national strategic plans are increasingly embedding digitalization and AI not merely as technological upgrades, but as core components of systemic health reform. The evidence from structural plans, such as Türkiye's Health Transformation Program, demonstrates that top-down policy commitments are essential for driving systematic technological adoption and ensuring long-term institutional efficiency.

FINDINGS

An analysis of the reviewed literature reveals a profound functional shift in Health Information Systems (HIS) over the last two decades. The collective evidence demonstrates a clear transition from traditional, reactive systems that handle only structured data, toward proactive, AI-driven architectures capable of analyzing unstructured data. A major finding emerging from this transition is the significant predictive capacity of machine learning models. The integration of predictive algorithms into electronic health records has been shown to identify chronic disease risks with remarkable accuracy long before clinical symptoms appear, fundamentally shifting the paradigm from treatment to prevention (Ammenwerth et al., 2003; Miotto et al., 2016). Additionally, the shift from manual data entry to autonomous sensor data collection via Internet of Things (IoT) technologies has substantially minimized human-induced errors, increasing overall system reliability (Oğuz, 2017; Topol, 2024). A synthesis of the findings highlights that artificial intelligence now demonstrates performance levels that rival or exceed human capabilities, particularly within specialized clinical fields. In radiology, deep learning algorithms consistently show higher sensitivity and speed in detecting anomalies, such as lung nodules and oncological lesions, compared to traditional human assessment (Edison, 2023; Zhang et al., 2024). Similarly, in pharmacology, AI simulations have dramatically compressed the timeline of drug discovery processes, reducing multi-year phases to mere months and yielding substantial cost savings (Kumar et al., 2025). Furthermore, the evidence indicates that generative AI models are effectively restructuring administrative clinical workflows, such as automatically generating epicrises from raw clinical notes, thereby allowing healthcare professionals to allocate more time to direct patient care (Derek & Collings, 2025). Regarding managerial and administrative operations, the synthesized data confirms that digital integration serves as a major driver for operational optimization. Evidence across multiple studies indicates that fully integrated material and stock tracking systems prevent resource waste and significantly elevate operating room efficiency (Koçak, 2008; Özveri et al., 2019). Similarly, financial auditing through AI-based systems prevents revenue leakages, while digitalized performance metrics accelerate institutional learning cultures by providing transparent, rapid feedback to the workforce (Bednall et al., 2014; Çam et al., 2016).

Comparative analyses between countries show that digital health maturity differentiates between centralized and fragmented structures.

✓ **Türkiye:** With the "e-Nabız" system having a central database architecture, it was determined that Türkiye collected the data of more than 90% of the population in a single pool and was one of the fastest-reacting countries in the world in contact tracing and vaccination tracking during the pandemic period (Göktaş et al., 2017; Önal & Kalaycı, 2021).

✓ **Estonia:** Integrating Blockchain technology into the national health system (X-Road), Estonia was seen to create a "gold standard" in data security and transparency and digitized 99% of prescriptions (Metsallik & Ross, 2022).

✓ **USA and Western Europe:** Although the digitalization rate is high in the USA, it was determined that the lack of interoperability between different providers made data sharing difficult, but this problem was attempted to be overcome with the transition to HL7 FHIR standards (Sittig & Singh, 2022; Reddy, 2025).

✓ **India:** It was reported that with the "Ayushman Bharat" initiative, more than 730 million digital health identities were created, and a scalable model was developed for tracking the health data of the crowded population (Sarella et al., 2024).

Despite technological gains, the findings also reveal the existence of serious risks. The most significant finding is the risk of algorithmic bias; it was determined that if AI models are not trained with certain ethnic or demographic groups, the probability of misdiagnosis for minority groups increases (Cross et al., 2024). On the security side, it was determined that with hospital systems opening to the internet (IoT), ransomware attacks increased, and this situation directly threatened patient safety (Haque et al., 2024). Furthermore, due to the “explainability” problem of artificial intelligence, it was seen that physicians hesitated to trust the decisions made by algorithms and uncertainties regarding legal liability (malpractice) continued (Mesko, 2023; Palaniappan et al., 2024).

DISCUSSION

This review highlights a significant gap between the theoretical capabilities of digital health technologies and their practical clinical implementation. While the findings confirm that AI offers immense predictive capacity, a critical comparison of the literature reveals a conflicting reality regarding systemic interoperability. Although technical standards like HL7 FHIR exist and provide clear cost advantages (Reis et al., 2017; Reddy, 2025), commercial resistance termed “information blocking” continues to create isolated “data islands,” particularly in developed regions like the USA and Europe (Sittig & Singh, 2022). This discrepancy between technological potential and institutional data-sharing cultures presents a major practical implication: without collaborative governance models, the comprehensive datasets required to train advanced AI algorithms (Kumar et al., 2025) cannot be effectively aggregated or utilized. Furthermore, the integration of AI into clinical workflows presents a paradox that requires critical evaluation. Empirical findings demonstrate that deep learning models consistently outperform human sensitivity in areas like radiological diagnosis (Edison, 2023; Zhang et al., 2024); however, this high accuracy does not automatically translate into clinical trust or adoption. A critical barrier identified in the literature is the “Black Box” nature of AI models; physicians hesitate to act on autonomous recommendations they cannot independently verify, leading to a crisis of clinical trust (Mesko, 2023). While the prevailing consensus suggests AI will act as a “cognitive assistant” rather than a human substitute (Sullivan & Staib, 2023), there remains a profound research gap regarding how to design Explainable AI (XAI) interfaces that seamlessly align with clinicians’ cognitive workflows and decision-making processes. The ethical and legal dimensions of this digital transformation expose further regulatory research gaps. The rapid deployment of AI significantly outpaces existing legal frameworks, creating a “Problem of Many Hands” regarding medical liability in cases of AI-assisted misdiagnoses (Palaniappan et al., 2024). Although Shoghli et al. (2024) propose the implementation of “sandbox” regulations to test these technologies safely, the practical mechanics of liability distribution remain unresolved in the current literature. Moreover, algorithmic bias emerges as a severe threat to health equity. Evidence confirms that AI models trained predominantly on non-diverse datasets pose a tangible risk of discriminatory diagnostic outcomes for minority groups, a finding that directly conflicts with the foundational medical principle of equitable care (Cross et al., 2024; Unanah & Aidoo, 2025). From a security perspective, the shift toward IoT-integrated healthcare facilities has fundamentally altered the threat landscape. As highlighted by Haque et al. (2024) and Oğuz (2017), cyberattacks (specifically ransomware) exploit the expanded attack surface of connected devices, transforming data breaches from mere privacy violations into direct threats to patient safety. The primary practical implication here is that healthcare institutions must shift from reactive IT support to proactive, structural cyber-resilience strategies. In the local context, while Türkiye’s centralized data success with platforms like e-Nabız provides a robust foundational architecture (Göktaş et al., 2017; Önal & Kalaycı, 2021), it also brings forth the risk of “data colonialism” if these massive datasets are not processed by domestic algorithms (Yılmaz & Demir, 2023).

In the light of the findings obtained, several fundamental suggestions stand out for both policymakers and practitioners.

First, in countries with centralized health data infrastructure (such as Türkiye, through platforms like e-Nabız), using this data by anonymizing it to develop local and national AI models offers a critical opportunity in terms of data sovereignty, strategic independence, and economic added value.

Second, to adapt to the rapid evolution of AI technologies, instead of a legal approach based solely on rigid and static regulations; “legal sandbox” (regulatory sandbox) models that allow innovation to be tested in a controlled manner need to be developed. Thus, while patient safety and ethical principles are protected, innovative solutions can be systematically evaluated without being suppressed.

Third, adding “Health Informatics” and “Artificial Intelligence Literacy” courses as mandatory components to medical and health sciences curricula is a prerequisite for future health professionals to take part as effective and ethical actors in this new ecosystem.

In conclusion, digitalization and artificial intelligence integration are no longer an optional modernization step for modern health systems, but a structural necessity. Successful health systems will be shaped not by countries and institutions that only purchase advanced technology, but by those that can develop this technology in line with national strategies, support it with holistic integration and strong security infrastructures, and manage the entire process with a human-focused approach bound by ethical principles. This study reveals the fundamental dynamics of the said transformation and offers a framework that needs to be deepened for future research, especially on the axes of domestic AI models, ethical governance, and education policies.

LIMITATIONS

This study is subject to several methodological limitations that should be acknowledged. First, because the study was designed as a narrative review rather than a systematic review or meta-analysis, the synthesis of the literature is qualitative and lacks a quantitative statistical evaluation of the pooled data. Second, the literature coverage was constrained by the selected academic databases (PubMed, Scopus, Web of Science, and Google Scholar) and was predominantly limited to peer-reviewed articles published in English and Turkish. Consequently, relevant studies published in other languages or indexed in alternative regional databases may have been excluded from the analysis. Finally, given the rapid and continuous evolution of artificial intelligence technologies in healthcare, the timeframe of the literature search (2003–2025) implies that some highly recent, unindexed pre-prints or emerging beta-phase technologies may not be fully represented in this review.

CONCLUSION

The digital transformation of healthcare has fundamentally shifted Health Information Systems (HIS) from passive data repositories to proactive, AI-integrated cognitive assistants. The synthesized evidence demonstrates that AI and deep learning significantly enhance diagnostic precision, accelerate drug discovery, and optimize managerial resource planning. However, realizing these benefits requires overcoming critical structural barriers, primarily the lack of global interoperability, escalating cybersecurity threats, and ethical concerns regarding algorithmic bias and legal liability. Practically, this necessitates that healthcare institutions adopt universal data-sharing standards (like HL7 FHIR), implement robust cyber-resilience protocols, and prioritize the continuous digital education of the healthcare workforce. Future research should prioritize the development of federated learning models to ensure global data collaboration without compromising privacy, the design of Explainable AI (XAI) to foster clinician trust, and the establishment of standardized ethical auditing frameworks to eliminate algorithmic bias before clinical deployment. Ultimately, the successful integration of AI into modern healthcare is not merely a technological upgrade, but a structural reform that must be governed by ethical principles, systemic interoperability, and human-centric design.

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