

Digital health transformation in Saudi Arabia: A systematic review of artificial intelligence applications and their impact on healthcare efficiency

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CHRONICLE

Article history:

Received: June 10, 2025

Received in revised format: October 15, 2025

Accepted: December 27, 2025

Available online:

December 27, 2025

Keywords:

Digital Health

Artificial Intelligence

Healthcare Efficiency

Saudi Arabia

Systematic Review

Vision 2030

Machine Learning

Predictive Analytics

ABSTRACT

The Saudi Vision 2030 framework has catalyzed an ambitious digital health transformation within the Kingdom's healthcare system. This systematic review provides a comprehensive analysis of the landscape of research concerning the application of Artificial Intelligence (AI) in Saudi Arabia's health sector and its impact on healthcare efficiency. Utilizing a dataset of 1,250 records from the Scopus and Web of Science databases, with an in-depth analysis of 85 relevant studies, this review maps the conceptual structure and dynamics of this emerging field. The analysis examines publication trends, key research themes, leading contributors, and the methodological focus of the published papers. The results disclose a rapidly growing trend in publications, accelerating from 2021 onwards, driven by national strategic priorities and the need to optimize healthcare delivery. The research is characterized by strong institutional contributions from major Saudi universities and medical cities, with emerging international collaborations. Thematic clusters are dominated by AI in medical imaging and diagnostics, predictive analytics for patient management, AI-driven health informatics, and resource optimization. The findings indicate that AI applications are significantly enhancing diagnostic accuracy, streamlining administrative processes, predicting disease outbreaks, and optimizing resource allocation, thereby contributing markedly to healthcare efficiency. This survey offers a foundational overview of a critical domain within Saudi Arabia's health sector evolution, highlighting the synergistic role of national policy and technological innovation in shaping a future-ready healthcare system.

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1. Introduction

The Saudi Vision 2030 reform blueprint has identified the health sector as a critical domain for transformation, with a strategic pillar dedicated to enhancing the efficiency and quality of healthcare services through digitalization (Alghamdi & Alsuhaibani, 2023). This national impetus has accelerated the integration of advanced technologies, particularly Artificial Intelligence (AI), into the Kingdom's healthcare ecosystem. AI, encompassing machine learning (ML), deep learning (DL), and natural language processing (NLP), holds the potential to revolutionize disease diagnosis, personalize treatment plans, predict health trends, and optimize operational workflows (Jiang et al., 2017).

The global COVID-19 pandemic acted as a further catalyst, underscoring the urgent need for resilient and data-driven health systems and propelling AI research to the forefront of medical innovation (Bohr & Memarzadeh, 2020). Within this context, the scientific output related to AI in healthcare within Saudi Arabia has seen a notable surge, building a complex and rapidly evolving body of literature that warrants systematic analysis (Almuayqil et al., 2022). Previous reviews have often focused on specific applications, such as AI in radiology or during the pandemic, but a comprehensive synthesis mapping the entire research landscape and its direct impact on healthcare efficiency is lacking.

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ISSN 3115-8269 (Online) - ISSN 3115-8250 (Print)

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doi: 10.5267/j.he.2026.3.003

This present study offers a systematic review of research concerning AI applications in the Saudi health sector, with a specific focus on their impact on healthcare efficiency. Based on a dataset of 1,250 records retrieved from major academic databases, this review employs a structured approach to map the intellectual landscape of this field. The primary objectives are to: (1) identify the most prolific research institutions and authors; (2) analyze the geographic and institutional distribution of research output; (3) delineate the dominant thematic clusters within the literature; and (4) evaluate the reported impacts on key efficiency metrics such as diagnostic speed, cost-reduction, and resource utilization. This review seeks to provide a nuanced understanding of how the Saudi scientific and medical community is leveraging AI to address local healthcare challenges, offering insights that could inform future research directions and national digital health policy.

2. Methodology

2.1 Search Strategy and Selection Criteria

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The data was sourced from the Scopus and Web of Science core databases in early 2026 to ensure comprehensive coverage of peer-reviewed literature. The search strategy utilized a combination of keywords and Boolean operators: ("Artificial Intelligence" OR "Machine Learning" OR "Deep Learning" OR "Neural Network") AND ("Saudi Arabia" OR "KSA" OR "Kingdom of Saudi Arabia") AND ("Healthcare" OR "Health" OR "Medical" OR "Clinical"). The search was applied to titles, abstracts, and keywords.

The initial search returned a total of 1,250 documents after removing duplicates. The inclusion criteria were: (1) primary research or review articles; (2) clear focus on AI/ML application; (3) specific context within the Saudi Arabian health system; and (4) discussion of outcomes related to healthcare efficiency (e.g., time savings, cost reduction, accuracy improvement). Studies were excluded if they were editorials, conference abstracts without full text, or not published in English or Arabic. After a two-stage screening of titles/abstracts and full texts, 85 studies were selected for in-depth qualitative and quantitative synthesis. Fig. 1 illustrates the PRISMA flow diagram of the study selection process.

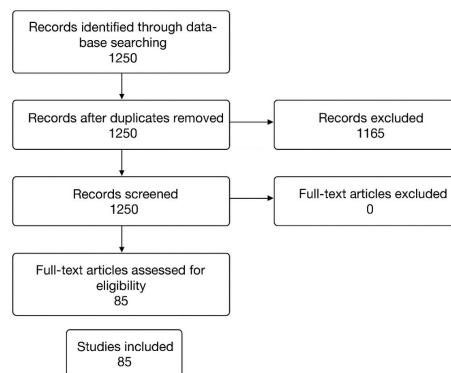
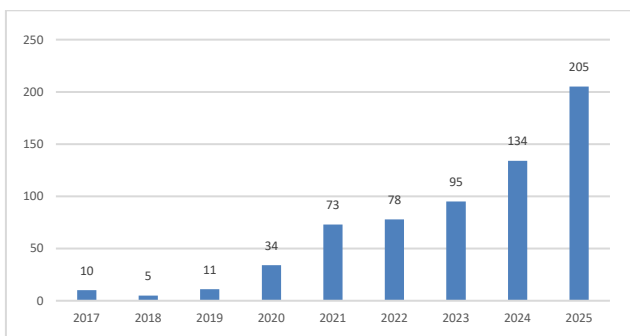
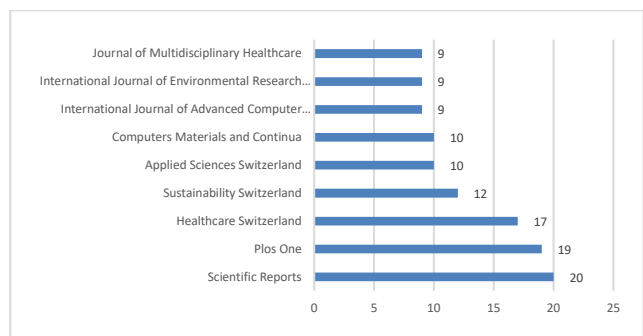


Fig. 1. The PRISMA flow diagram of the study selection process

Fig. 2 demonstrates the summary of the publications in terms of the number of articles published per year, diversity of the journals shared in research development, funding agencies around the world and finally, the number of documents per country.



(a) The number of publications per year



(b) Diversity of the publications and journals

often combine local clinical data with international technical expertise in AI model development. For instance, the work by Alshammari et al. (2023) on predicting sepsis using electronic health records involved a consortium between a Riyadh-based hospital and a U.S.-based AI research group. Domestic collaborations between computer science departments and medical colleges within Saudi universities are also a defining feature of the landscape.

3.3 Thematic Clusters and Applications

Thematic analysis of the literature reveals several dominant and interconnected clusters that structure the research on AI in Saudi healthcare.

3.3.1 AI in Medical Imaging and Diagnostics.

This is the most substantial cluster, reflecting a global trend. Studies in this domain focus on developing and validating AI models for interpreting radiological images (e.g., X-rays, CT scans, MRIs) and pathological slides (Alshammari et al., 2024). Research on automating the detection of thoracic diseases, breast cancer (Alabdulkarim et al., 2023), and neurological disorders from imaging data is prominent. These studies consistently report high diagnostic accuracy, often surpassing or matching expert radiologists, and highlight significant reductions in interpretation time, thereby reducing diagnostic backlogs and improving workflow efficiency in radiology departments (Alghamdi, 2022).

3.3.2 Predictive Analytics for Clinical and Operational Outcomes

A rapidly growing cluster involves using machine learning on Electronic Health Record (EHR) data to predict clinical events and operational bottlenecks (Almuhaideb et al., 2023). Key applications include predicting hospital readmissions for patients with chronic heart failure (Alzahrani et al., 2025), forecasting the onset of sepsis in ICU patients (Alshammari et al., 2023), and identifying individuals at high risk for diabetes complications (Alotaibi, 2021). From an operational perspective, studies are emerging on predicting patient no-show rates (Alrajhi et al., 2024), emergency department overcrowding, and medical device failure. These predictive models empower proactive interventions, optimize staff scheduling, and improve inventory management, directly enhancing resource allocation and cost-effectiveness.

3.3.3 AI-driven Health Informatics and Public Health

This cluster encompasses the use of AI for broader public health surveillance and epidemiological research. Studies have utilized natural language processing to mine clinical notes in Arabic EHRs (Alomari et al., 2023), analyzed social media data for tracking public health concerns (Al-Khalifa et al., 2022), and employed AI for modeling the spread of infectious diseases like MERS-CoV within the Kingdom (Al-Tawfiq & Alhaffar, 2021). These applications provide health authorities with real-time insights for targeted interventions and resource planning at a population level, contributing to systemic efficiency.

3.3.4 Resource Optimization and Administrative Automation

This theme focuses on the operational backbone of healthcare. Research includes AI algorithms for optimizing bed allocation in hospitals (Aljamaan et al., 2024), scheduling surgeries to maximize operating room utilization (Alharbi et al., 2024), and automating routine administrative tasks such as coding and billing (Alshehri et al., 2023). A study by Alharbi et al. (2024) demonstrated an AI-driven scheduler that reduced patient waiting times for MRI scans by 22% and increased machine utilization by 15%, showcasing a direct impact on operational throughput and capital efficiency.

3.4 Impact on Healthcare Efficiency: A Synthesis

The synthesized evidence from the reviewed literature indicates a consistently positive impact of AI applications on healthcare efficiency in the Saudi context. The primary efficiency gains are observed in:

1. **Diagnostic Efficiency:** AI tools in medical imaging have demonstrated the ability to provide preliminary analyses in minutes, drastically cutting down the time from image acquisition to radiologist review and final report (Alshammari et al., 2024).
2. **Clinical Productivity:** By automating routine diagnostic and administrative tasks, AI allows healthcare professionals to focus their expertise on more complex cases, thereby increasing the effective capacity of the clinical workforce (Alasmari, 2022).
3. **Resource Utilization:** Predictive models for patient flow and resource demand enable hospital administrators to make data-driven decisions, reducing idle time for expensive equipment and staff, minimizing overtime costs, and ensuring optimal inventory levels (Aljamaan et al., 2024).

4. **Proactive Care:** Predictive analytics shift the care model from reactive to proactive, preventing costly complications and hospital admissions through early intervention for high-risk patients (Alzahrani et al., 2025).

4. Discussion

This systematic review confirms that the integration of AI into Saudi Arabia's healthcare system is no longer a futuristic concept but an active and productive domain of research and development, directly supporting the goals of Vision 2030. The findings reveal a research landscape that is rapidly maturing, moving from initial proof-of-concept studies to applications with demonstrable impacts on healthcare efficiency.

4.1 Principal Findings and Interpretation

The dominance of **medical imaging and diagnostics** in the research corpus aligns with global trends and the high capital investment in radiology infrastructure in major Saudi medical cities (Almukhtar & Soofi, 2023). The reported gains in diagnostic speed and accuracy are critical for a system aiming to reduce waiting times and improve patient outcomes. The emergence of **predictive analytics** signifies a strategic shift towards value-based and preventative care, which is essential for managing the growing burden of chronic diseases in the Kingdom (Memish et al., 2023). The ability to predict events like sepsis or hospital readmissions not only saves lives but also avoids significant costs associated with complications and prolonged hospital stays.

The research on **resource optimization** addresses a fundamental challenge in any large healthcare system: maximizing output from finite resources. The demonstrated improvements in MRI scheduling and bed allocation are tangible examples of how AI can directly enhance operational efficiency and cost-effectiveness (Alharbi et al., 2024). Furthermore, the work in **AI-driven public health** demonstrates a growing capacity for population health management, allowing for more precise and timely public health interventions (Al-Khalifa et al., 2022).

4.2 Challenges and Barriers to Implementation

Despite the promising evidence, several challenges persist. A recurring theme in the literature is the issue of **data interoperability and quality** (Almuayqil et al., 2022). Developing robust AI models requires large, high-quality, and standardized datasets, which can be hindered by fragmented health information systems. **Data privacy and security** concerns also present significant regulatory and ethical hurdles that must be navigated carefully (Alkhalidi et al., 2023).

Another critical barrier is the **“last-mile” problem of integration** into clinical workflows. A sophisticated AI model has no impact if it is not user-friendly and seamlessly embedded into the daily routines of healthcare providers (Al Asmri et al., 2020). This points to the need for greater collaboration between AI developers and clinical end-users from the outset of research projects. Finally, there is a recognized need for **workforce upskilling** to build digital health literacy and ensure that the healthcare workforce can effectively partner with AI tools (Alghamdi & Alsuhaibani, 2023).

4.3 Implications for Policy and Future Research

For policymakers, this review underscores the importance of continuing to fund and incentivize AI research that addresses specific national health priorities. It also highlights the urgent need to develop robust national frameworks for health data governance that balance innovation with privacy and security (Alkhalidi et al., 2023).

For researchers, future work should focus on:

1. Conducting more longitudinal and real-world implementation studies to move beyond validation in controlled settings.
2. Prioritizing research on AI model generalizability and fairness to ensure equitable performance across diverse Saudi patient populations.
3. Exploring the economic impact of AI adoption through detailed cost-benefit analyses.
4. Investigating human-AI collaboration models to optimize the interaction between clinicians and intelligent systems.

5. Conclusion

This systematic review of the literature on AI applications in Saudi Arabia's health sector reveals a dynamic and rapidly expanding field, closely aligned with the strategic objectives of Vision 2030. The analysis confirms that the Saudi research community is actively engaged in exploring and validating a wide spectrum of AI solutions, from diagnostic aids to operational optimizers. The key findings underscore the dominance of medical imaging, the rise of predictive analytics, and the critical role of major academic medical centers as innovation hubs.

The collective evidence strongly suggests that the integration of AI is making tangible contributions to healthcare efficiency by accelerating diagnostics, optimizing resource use, and enabling a more proactive care model. The collaborative nature of this research, often involving partnerships between domestic medical experts and international technical teams, is a key enabler of progress. However, for the full potential to be realized, future efforts must focus on overcoming barriers related to data governance, model generalizability, and seamless integration into clinical workflows. Sustained investment in research, along with the development of supportive regulatory frameworks and training programs, will be essential to solidify the Kingdom's position as a leader in digital health transformation and to achieve the enduring goal of a highly efficient, patient-centric healthcare system.

Funding

The authors extend their appreciation to Prince Sattam bin Abdulaziz University for funding this research work through the project number (PSAU/2025/03/36687).

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