

REVIEW ARTICLE

Artificial intelligence in health systems:
A comprehensive review of opportunities and
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Abstract

Artificial intelligence (AI) has emerged as a transformative tool across multiple sectors, with healthcare being one of the most promising domains. This review article explores the foundational concepts of AI and its rapidly expanding applications in the healthcare sector. The integration of AI in health systems encompasses various branches, including diagnostic imaging, drug discovery, virtual health assistants, robotic surgery, and personalized medicine. AI-powered tools have demonstrated significant advantages, such as enhancing diagnostic accuracy, optimizing treatment plans, reducing administrative burdens, and improving patient outcomes. However, the deployment of AI in healthcare also presents notable challenges and limitations. These include data privacy concerns, algorithmic bias, lack of transparency, and the need for substantial infrastructure and workforce training. Moreover, ethical and regulatory issues continue to influence the pace and scope of AI adoption. This review critically examines these aspects while highlighting recent innovations that underscore AI's potential. Finally, the article outlines future directions for AI in healthcare, emphasizing the need for interdisciplinary collaboration, robust ethical frameworks, and the development of explainable AI systems. As technology evolves, a balanced approach that maximizes benefits while mitigating risks is essential for the sustainable integration of AI into global health systems.

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1. Introduction

The introduction of artificial intelligence (AI) into the healthcare sector marks a pivotal development in enhancing public health systems globally. As health challenges become increasingly complex, the integration of AI offers transformative capabilities in disease prediction, surveillance, and management, thereby optimizing health outcomes across populations.¹ The application of AI technologies, such as machine learning (ML) algorithms, enables effective analysis and interpretation of vast amounts of health data, facilitating healthcare providers to make informed decisions quickly and efficiently.^{2,3}

Notably, AI tools are particularly advantageous for early detection of diseases and real-time monitoring of outbreaks, thus streamlining public health responses.⁴

Moreover, AI's potential for promoting health equity cannot be understated. By addressing social determinants of health through data analytics, AI can create a more equitable healthcare landscape.⁵ It can be programmed to identify health access and outcomes disparities, allowing public health organizations to target interventions more precisely and equitably.⁶ This precision in targeting enhances the effectiveness of health programs and ensures that vulnerable populations receive the resources and attention they need.⁷ The present study will focus on the basic concepts of AI modeling in health systems and their significant use in several sectors. Moreover, we will discuss the current challenges faced by healthcare systems while using AI and the ways to address them.

1.1. Research gap and contribution of this review

Most reviews remain primarily descriptive and focused on specific domains (e.g., imaging, drug discovery, or telemedicine), despite the increasing number of studies on AI in healthcare. Rarely do they incorporate cross-cutting issues into a single analytical framework, such as infrastructure, regulatory supervision, ethics, and equity. A comprehensive synthesis connecting technology, clinical practice, and governance is still lacking, even if past evaluations have emphasized technical opportunities or regulatory issues.

To fill these gaps, this review integrates the advantages and disadvantages of AI across healthcare domains, synthesizes data from real-world case studies (such as diagnostics, algorithmic bias, and explainability debates), and suggests a framework for AI adoption that emphasizes clinical integration, technological readiness, and ethical-legal governance. Mapping the current state of AI in health provides a strategic lens through which researchers, practitioners, and policymakers may assess sustainable integration.

2. Methodology

A literature search for this narrative review was conducted using both PubMed and Google Scholar databases. The search was limited to recent years (2013–2025) to capture key advancements in the field. The search terms included: (“Artificial Intelligence” OR “Machine Learning”) AND (“Healthcare” OR “Health Systems”) AND (“Applications” OR “Challenges” OR “Implementation”). For the context of this review, “AI” refers to intelligent systems used in healthcare, including diagnostics, monitoring, surgery, and decision-making.

The study selection process is illustrated in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram (Figure 1). A total of 573 records were identified. After screening and full-text assessment, 66 articles were selected as the most relevant and recent contributions and were included in this narrative review.

3. Operational process of AI

The application of AI in medicine dates to 1976, when a computer algorithm was first used to diagnose acute abdominal pain.⁸ Since then, there has been a major advancement in AI and ML approaches, which have produced advanced tools for clinical decision-making, risk assessment, and disease diagnosis. A typical AI-based disease prediction workflow comprises many linked phases. Initially, pertinent patient data are gathered and preprocessed to guarantee quality and consistency, including demographic data and results from medical testing. Following the identification of the most informative variables through feature extraction, classification techniques are used to assess predicted performance. When several classifiers are compared, the model with the best accuracy is chosen for deployment.⁹ Figure 2 illustrates the core steps involved in AI modeling in healthcare.

3.1. Problem identification

Identifying suitable problems for AI intervention is an important initial step. In addition to comprehending the clinical problem, this entails setting quantifiable goals and evaluating the viability of AI-based solutions, considering data accessibility, complexity, and expected consequences.¹⁰ Effective problem framing guarantees that model development and data collection later on are in line with practical clinical requirements.

3.2. Data collection and preparation

Reliable ML outcomes depend heavily on high-quality input data, necessitating rigorous data preparation.¹¹ Data collection primarily involves three approaches: acquisition (sourcing or generating new datasets), labeling (annotating raw data with meaningful information), and enhancement (improving existing datasets and models). Due to the high cost of labeling, alternative strategies such as crowdsourcing, weak supervision, and semi-supervised learning are often employed.¹² Normalization, imputation, and error correction are appropriate data preprocessing techniques that guarantee downstream analysis appropriately captures patient features.

3.3. Algorithm development and training

With different uses and benefits, AI algorithms can be broadly divided into three categories: ML, deep learning

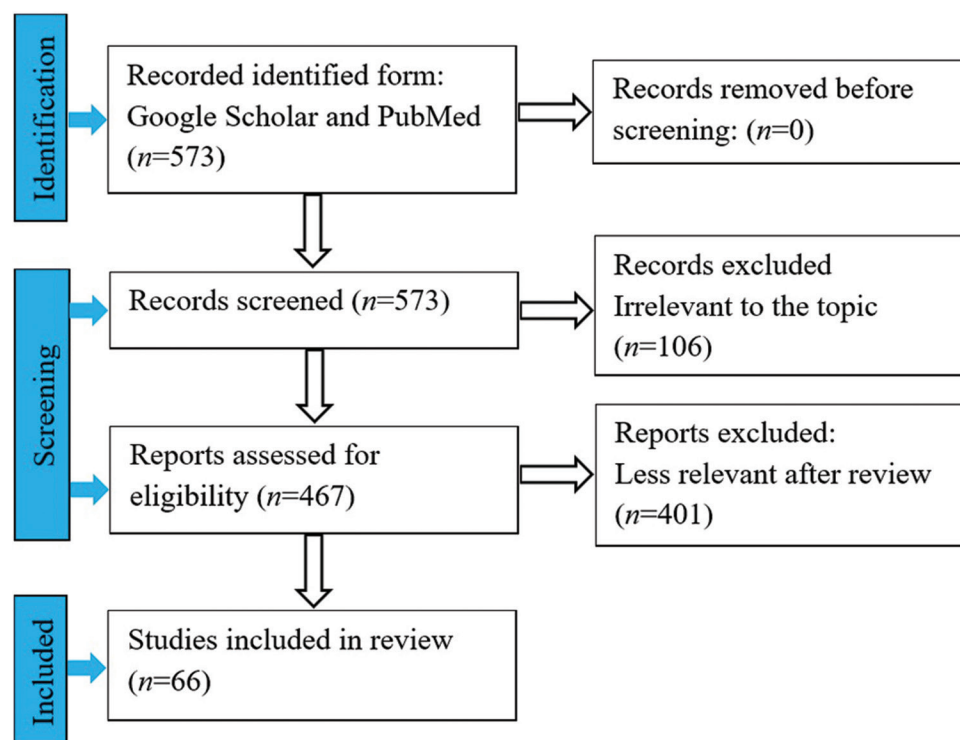


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram for literature selection

(DL), and natural language processing (NLP). While DL, a sophisticated subset of ML, uses multilayered neural networks to evaluate complicated data structures, ML models use data to develop predictions without explicit programming. For instance, convolutional neural networks (CNNs) are very good at deciphering medical images from X-rays and magnetic resonance imaging. NLP approaches make it easier to extract valuable information from clinical writings that are not structured, which helps in diagnosis and prognosis.¹³

3.4. Decision-making and prediction

ML enables prediction on unseen data by learning underlying statistical patterns.¹⁴ When combined with decentralized blockchain-based electronic health records, ML techniques can help doctors make predictions based on past patient outcomes and treatment efficiency.

3.5. Development and implementation

Evaluating current tactics and obstacles in-depth is necessary for a successful AI deployment, as scoping and systematic reviews have shown. Further assisting in identifying gaps in practical knowledge, qualitative interviews and abductive reasoning guide the creation of implementation frameworks that combine stakeholder ideas with literary evidence.¹⁵

3.6. Continuous learning and improvement

Ongoing monitoring and maintenance are crucial to sustain the reliability and effectiveness of AI/ML clinical algorithms over time.¹⁶ AI promises to revolutionize healthcare across diagnosis, treatment, and beyond.¹⁷

4. Application of AI in the health sector

Over the past few decades, there has been a steady increase in scientific discoveries and media support for AI and robotics. Inference-driven healthcare access and medical prevention control are beginning to be dominated by the big data revolution, advances in hierarchical modeling, and increased computing capacity.¹⁸ Self-monitoring and therapeutic data-driven information, along with patient and claims data, have advanced to previously unheard-of levels of sophistication to influence results and suggest therapies. AI assists in guiding care, enhancing comprehension, analyzing trends, and identifying opportunities for additional research as scientific evidence obtained from big data grows.¹⁹ Customer-facing resources are guided through the planning and execution process by AI-powered engagement aids, which surface actions, evidence, and insights based on real-time, integrated data. Advancements in data creation, archiving, and analysis, combined with unprecedented statistical capabilities and computing capacity, have created the ideal environment for

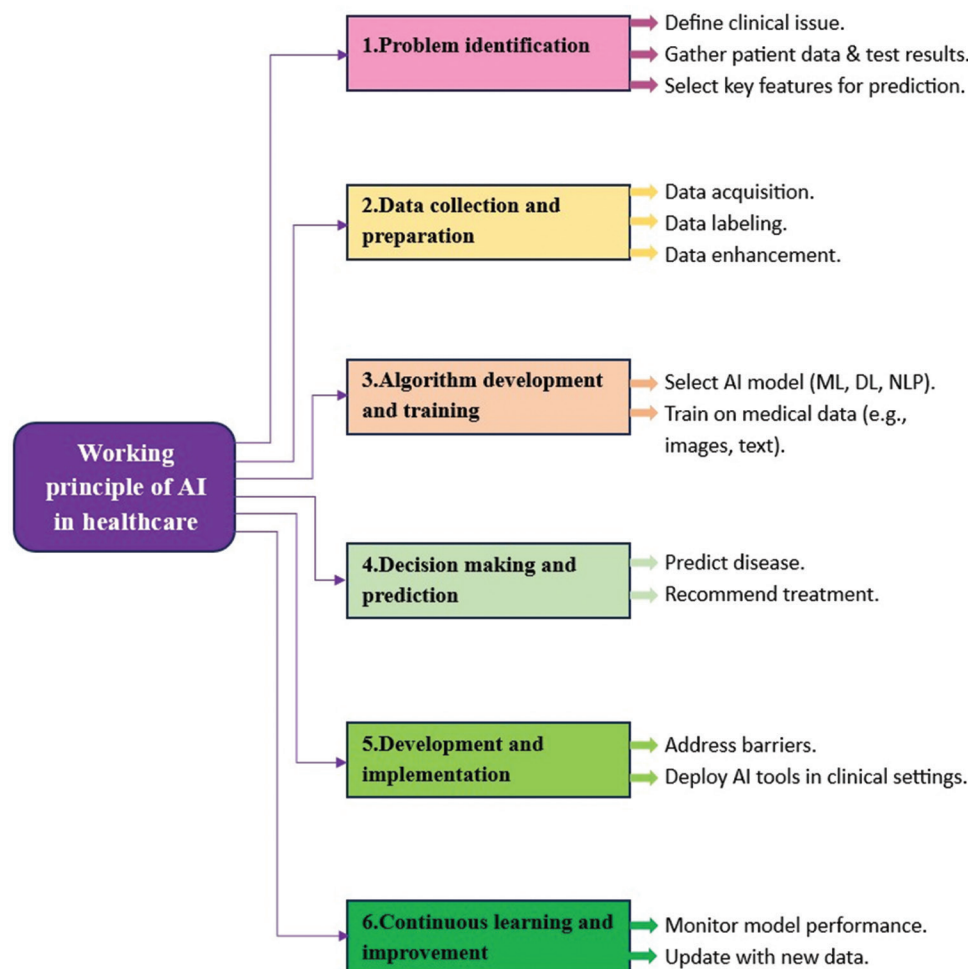


Figure 2. Flow diagram of an artificial intelligence (AI) model in healthcare
Abbreviations: DL: Deep learning; ML: Machine learning; NLP: Natural language processing.

large-scale data collection and processing advances. The abundance of electronic health records has demonstrated exceptional proficiency in digitalizing disease diagnosis, prevention, and outbreak management.²⁰ Figure 3 depicts some of the healthcare fields where AI can assist. The details of these applications are described in the following sections.

Diagnostic imaging and drug discovery dominate current AI adoption, whereas areas such as rehabilitation and *in vitro* fertilization (IVF) remain at an early stage, highlighting uneven maturity across domains.

4.1. Early disease detection

Predictive analytics powered by AI has emerged as a transformative tool in the early diagnosis of diseases across various medical specialties, significantly improving patient outcomes. By leveraging large-scale datasets—including genomic sequences, medical imaging, electronic

health records, and data from wearable health-monitoring devices—AI-driven models can detect disease onset with greater accuracy and speed than conventional diagnostic approaches. ML algorithms, in particular, are capable of identifying genetic markers associated with increased susceptibility to conditions such as breast, lung, and prostate cancer. Furthermore, AI enhances diagnostic imaging by detecting subtle abnormalities that human radiologists may overlook. The Mayo Clinic employed AI to test for cervical cancer and identify precancerous alterations. The AI-based method used more than 60,000 cervical cancer photos from the National Cancer Institute to detect precancerous indications. The algorithm's accuracy rate was 91%, whereas a trained human expert's accuracy rate was 69%.²¹

4.2. Personalized medicine

Personalized medicine refers to a healthcare approach that tailors medical interventions to an individual's unique



Figure 3. Representation of various applications of artificial intelligence (AI) in healthcare

genetic, biochemical, physiological, environmental, and behavioral characteristics.²² At the core of personalized medicine lies the analysis and interpretation of complex biological data—a process in which AI plays a pivotal role. By leveraging advanced algorithms, AI can efficiently process vast datasets, including genomic sequences, electronic health records, and biomedical imaging, to uncover patterns and associations that are often undetectable through conventional analytical methods. A subset of AI, ML, demonstrates particular proficiency in decoding the intricate language of genetics. These models can analyze an individual's genomic profile to predict disease susceptibility, understand genetic predispositions, and forecast disease progression. This advanced level of data interpretation enables healthcare providers to design highly personalized treatment plans for each patient's unique genetic makeup.²³

4.3. Drug discovery and development

The process of finding and creating new drugs, or drug discovery, is a difficult and drawn-out undertaking that has historically relied on time-consuming methods such as high-throughput screening and trial-and-error testing. AI techniques such as ML and NLP have the potential to speed up and enhance this process by making it possible to analyze vast volumes of data more accurately and efficiently.²⁴

More than 1,060 molecules comprise the enormous chemical space, encouraging the creation of numerous pharmacological compounds. AI can identify hit and lead compounds, validate drug targets more quickly, and optimize drug structure design.²⁵ By supplementing other research levels and current modeling techniques within *in silico* experimental alternatives, AI promotes research

and discoveries.¹⁹ AI models assist in determining how the structure of chemical compounds influences behavior in live organisms. They are crucial for discovering novel medications and assisting researchers in forecasting how a possible medication will function in the body.²⁶

4.4. Disease surveillance

Surveillance plays a critical role in both public health and global health practices. The World Health Organization defines surveillance as the “continuing scrutiny of all aspects of the occurrence and spread of disease that are pertinent to effective control.”²⁷

AI can assist in the control of illness outbreaks in local hospitals. Hospitals identify local infection outbreaks using infection control protocols and national and local recommendations. Manually reviewing patient records and tracking contacts may be necessary for localized hospital-based outbreak identification, which can be time-consuming and may prevent early discovery and management.²⁸ An important development in public health practices is the use of AI in disease monitoring systems, especially in underdeveloped nations, where conventional surveillance techniques frequently encounter major obstacles.²⁹

4.5. Patient monitoring

The rapidly expanding discipline of remote patient monitoring (RPM) in healthcare uses flexible materials for wearable sensors and is intended to provide doctors with additional support across a range of general medical and surgical wards.³⁰ Modern AI-based RPM includes various methods and algorithms to mimic and enhance human-like cognitive capacities. By utilizing AI in RPM, healthcare professionals can proactively monitor patients in real time, anticipate health problems, and act before symptoms worsen. AI-powered systems enable wearable technology or sensors to automatically monitor vital signs, including blood pressure, heart rate, and respiration rate. These elements include wearable technology and sensors, data transmission and capture, data management and storage, AI algorithms and analytics, and user interface.³¹

4.6. Healthcare operation and management

Surgical pathways are characterized by clearly defined, evidence-based protocols and standardized metrics that assess performance, efficiency, and patient-centered outcomes. These pathways often incorporate baseline technological integration, contributing to the advancement and regulatory approval of mature AI models and software as medical devices across critical stages of surgical care. Examples include AI-assisted robotic surgical systems, tools for optimizing procedural workflows, decision

support systems for post-operative and follow-up management, radiomics-based diagnostic and screening technologies, and predictive models utilizing large-scale clinical datasets to estimate operative risk. As a result, implementing AI-driven workflows across various surgical specialties is becoming increasingly viable, supported by growing evidence of enhanced clinical outcomes and healthcare cost reductions.³²

4.7. Virtual health assistants

To create virtual assistants that are responsive and intuitive, NLP—a branch of AI that focuses on computer-human interaction through natural language—is necessary. More meaningful interactions with patients are made possible by NLP, which enables machines to understand and produce human language.³³ Based on the patient's medical history, AI-powered healthcare app development provides a customized online consultation experience.³⁴

4.8. Electronic health records for clinical documents

AI effectively utilizes multi-level datasets and facilitates the interpretation of their interrelationships by integrating multiple heterogeneous data domains, including medical and dental history, socio-demographic and clinical information, imaging data, biomolecular data, and even social network data.¹⁹ In the healthcare industry, medical errors continue to be a significant challenge, as they can lead to adverse patient outcomes, higher expenses, and longer hospital stays. These blunders include incorrect diagnosis, inappropriate treatment approaches, inaccurate surgical procedures, and poor communication. AI technologies, such as ML algorithms and decision support systems, have shown great promise in boosting surgical results, reducing pharmaceutical errors, and improving diagnostic accuracy.³⁵

4.9. Rehabilitation

Similar to treatment and palliative care, illness prevention, and health promotion, rehabilitation is a vital component of healthcare services both locally and internationally. The rehabilitation process enables older individuals, young adults, and even children to engage in work, education, leisure, and other meaningful activities while fostering the greatest possible autonomy in daily life.³⁶

AI applications are thought to be crucial to the development and upkeep of a decentralized rehabilitation paradigm, wherein intelligently connected technologies can support clinical decision-making and health outcomes monitoring.³⁷

4.10. Surgical navigation and medical robotics

Surgical techniques are increasingly being customized to meet the demands of each patient to improve patient

outcomes and satisfy public demand. These AI techniques have thus far mostly addressed the surgical planning element, offering an automatic segmentation of tumors and organs at risk based on patient imaging and metadata. Most of these segmentation algorithms now use DL techniques, frequently based on CNNs. CNNs have demonstrated superiority over humans in image processing techniques for determination and classification.³⁸ To address poor surgeon-robot cooperation in endoscopic surgery, an intelligent tracking system was created. The solution automatically follows instruments while respecting surgeon preferences, as validated through rigorous testing.³⁹

Robotic surgery enables cameras and devices to operate through tiny incisions in deep anatomical regions, such as the pelvic and abdominal cavities and synovial joints. With real-time AI image improvement (autonomy level 1), anatomical features and instruments can be more accurately identified.⁴⁰ AI-driven surgical robotics is transforming modern medicine by enhancing precision, reducing human error, and enabling minimally invasive procedures with superior patient outcomes.⁴¹

Ultrasound has facilitated regional block performance, which has also been utilized to lower the rate of complications and raise the proportion of completed procedures. AI-assisted ultrasound-guided regional anesthesia has been shown to support non-experts in identifying the correct ultrasound anatomy for interventions and to facilitate the recognition of anatomical structures.⁴² With computer vision and AI, capsule endoscopy, which uses pictures to diagnose gastrointestinal disorders, has made significant strides in recent years. Over the past 20 years, and particularly in the past 10 years, researchers and medical professionals worldwide have worked to develop methods for AI-assisted capsule endoscopy diagnosis using AI technology to train algorithms on images or videos from capsule endoscopies.⁴³ The combination of AI, robotics, and other cutting-edge technologies, such as augmented reality, telemedicine, and nanorobotics, holds the key to the future of surgical robotics.⁴⁴

4.11. IVF

AI can be used in the fertility sector in several ways to enhance the results of reproductive treatments. Among these are sperm analysis, IVF optimization, and picture analysis.⁴⁵ In the IVF procedure, gamete selection is a crucial phase that greatly impacts the development of subsequent embryos and fertilization success rates. Through very accurate analysis of motility, morphology, and other relevant elements, AI and DL technologies can greatly improve sperm selection.⁴⁶ The most popular method for choosing embryos for transfer is morphological evaluation.

Time-lapse photography or direct visualization with a light microscope is used to accomplish this. Both methods assess embryos based on their capacity to promptly attain specific developmental stages. Given that these evaluations are subjective, there is a great deal of difference among operators and clinics, much like with gamete selection. Standardization is, therefore, difficult within a clinic and practically impossible between institutions. Therefore, morphological grading's capacity to forecast live birth outcomes is still restricted.⁴⁷ DL and AI technologies have the potential to completely transform embryo selection by offering more thorough, accurate, and impartial evaluations. Time-lapse imaging devices provide a detailed record of the morphological changes of embryos by continuously capturing photographs during development. These time-lapse videos can be analyzed using AI systems to find trends and developmental benchmarks linked to successful implantation and growth.⁴⁶ Soon, AI's use may be extended into other areas of reproductive medicine, even though its use in the embryology lab is more common than in other fields. The effectiveness and speed of diagnosing and treating all reproductive disorders will surely increase with the widespread use of AI for accurate evaluation of infertile couples' characteristics, including their ovarian reserve, spermatogenesis, sperm parameters, age, endocrine status, and diagnostic tests.⁴⁸

5. Advantages of AI in healthcare

AI is mostly used in healthcare to improve patient safety, customize therapy, and make precise diagnoses. AI can offer real-time insights by analyzing large amounts of information, assisting physicians in making better decisions, and enhancing healthcare delivery across the board.⁴⁹ Healthcare overtreatment, which is characterized by needless procedures that endanger patients, is a serious financial and health issue. It causes patients to be put at unnecessary physical and psychological dangers and results in billions of dollars in wasted spending.⁵⁰ AI systems can increase productivity, decrease unnecessary variance in clinical practice, and prevent medical errors experienced by patients.⁵¹

AI has been used to deliver medical services to low-income and rural areas. AI-powered telemedicine can expand access to healthcare providers.⁵² Healthcare workers can focus on providing complex patient care using AI to automate repetitive chores like image processing. This increases dermatology clinic productivity. Visually similar dermoscopic images are provided to medical experts for case comparison through AI algorithms and content-based image retrieval, which enhances clinical judgment and reorganizes the diagnosis procedures.⁵³

6. Current challenges

It has previously been challenging to create extensive public databases of medical photographs, mostly due to the possibility of revealing protected health information. Protected health information is frequently concealed in the Digital Imaging and Communications in Medicine metadata, raising serious concerns, as it makes anonymization difficult and error-prone.⁵⁴

The historical datasets used to train ML algorithms may contain biases affecting patient outcomes, particularly regarding racial or socioeconomic disparities. Furthermore, not everyone may have equal access to AI-driven tools.⁵⁵ As an example of the dangers of biased data, dermatological AI systems have been shown to perform poorly on darker skin tones, and pulse oximeters have historically been less accurate for patients with greater melanin levels. It is imperative that regular fairness audits and various datasets become more common to address these problems. Beyond issues at the population level, the ergodicity problem presents a serious methodological constraint. Numerous big data analytics techniques combine data from various populations, exposing correlations at the macro level but frequently miss the subtle individual-level relationships that are crucial for treatment choices.²² For example, AI models forecasting therapeutic performance can perform well on population averages but fall short in providing precise recommendations for specific individuals.

In general, AI refers to a computerized system (hardware or software) that can carry out tasks or thinking processes typically associated with human intellect. Therefore, AI is not a single technological type, but rather a variety of types within a range of application domains, such as administrative tasks, patient involvement and adherence, and diagnosis and treatment. However, some issues and difficulties may arise during the implementation of AI technology, necessitating method optimization in conjunction with the environment.⁵⁶ [Table 1](#) summarizes the key challenges associated with AI implementation in healthcare and suggests practical mitigation strategies to address them.

As seen in [Table 1](#), overcoming these challenges requires more than just technological advancement. Critical elements such as ethical governance, equitable data access, legal clarity, and training of healthcare professionals must be integrated into AI deployment strategies. In particular, issues such as data bias and lack of transparency must be actively addressed to prevent AI systems from reinforcing health disparities.

Building on this consideration, the first obstacle is the significant technological constraints that limit the

Table 1. Challenges with artificial intelligence implementation in healthcare and overcoming strategies

Challenges	Description	Suggested solutions
Data privacy and security	Sensitive health data is at risk of breaches or misuse	Use of encryption, data anonymization, and strong governance frameworks
Algorithmic bias	AI models may produce biased outcomes against minority populations	Train on diverse datasets; implement fairness audits regularly
Lack of explainability (Black box issue)	Difficulty in understanding the AI decisions	Develop interpretable and explainable AI systems
Infrastructure gaps	Limited access to technology in low-resource settings	Invest in digital health infrastructure and cloud-based AI platforms
Ethical and legal uncertainty	Unclear accountability and regulatory oversight	Establish clear legal frameworks and ethical guidelines
Skill deficits in the workforce	Lack of technical knowledge among healthcare staff	Introduce AI training programs for clinicians and administrators
Integration into workflow	All tools not well-aligned with clinical processes	Co-design AI tools with healthcare providers for seamless adoption
Over-reliance on AI	It may reduce clinical judgment or human oversight	Encourage hybrid models where AI supports—not replaces—human decisions

Abbreviation: AI: Artificial intelligence.

application of AI. The second obstacle demonstrates the significant policy flaws preventing the adoption of AI. A second factor in the limited degree of practical implementation is the third barrier, which is the absence of clinical and economic impact measurement.⁵⁷ In controlled experiments, for example, certain AI systems have shown diagnostic accuracy; yet, there is still a lack of proof regarding cost-effectiveness and practical clinical benefits, which hinders wider institutional adoption.

AI exhibits adaptability, frequently developing and modifying algorithms without human assistance using neural networks. As a result, the reasoning underlying decision-making procedures might occasionally be difficult to understand.⁵³ Therefore, without knowing the reasoning behind forecasts, doctors may be reluctant to act on AI-generated insights in specialties such as cardiology and oncology.

The potential for AI to replace human judgment in crucial healthcare decisions presents an ethical dilemma. AI can assist medical professionals by providing data-driven insights, but it should never replace human expertise in complex medical issues. However, the proper application of AI systems necessitates making sure that they support human decision-making in healthcare rather than taking its place. To effectively utilize AI's potential, information and communication technology infrastructure must be strengthened by increasing access to high-speed internet and modernizing medical equipment in many areas.⁵²

A further ethical concern relates to the potential dehumanization of healthcare caused by over-reliance on AI systems. Automated decision-making tools may

inadvertently reduce patient-doctor interaction, leading to a more impersonal healthcare experience.⁵⁵ Telemedicine studies have demonstrated that, even when efficiency increases, patient satisfaction levels sharply decrease when automated chatbots take the role of medical interaction. This indicates that rather than replacing human interaction, technology must be utilized to enhance it. Over-reliance on AI systems may reduce medical personnel's clinical skills and impair their ability to independently identify and assess skin diseases, which would reduce their capacity for clinical judgment and critical thought.⁵³

7. Future recommendation

Current ML techniques are very similar to real-world scenarios. Algorithms can perform tasks previously only possible by humans due to the robust technological improvements. Medicine can be impacted by ML's capacity to turn data into understanding, which may replace a large portion of radiologists' and anatomical pathologists' roles.⁵⁸

However, there are serious ethical questions about patient privacy, data security, algorithm openness, and equitable access to AI-assisted services concerning the use of AI in healthcare. Thus, legislative frameworks and guidelines should be created to protect patients' rights, safety, and well-being to ensure the responsible development, implementation, and supervision of AI processes in healthcare.⁵⁵ AI is expected to make significant future contributions to the advancement of personalized medicine. AI-based health products are expected not only to see broader adoption but also to be developed in conjunction with emerging computational

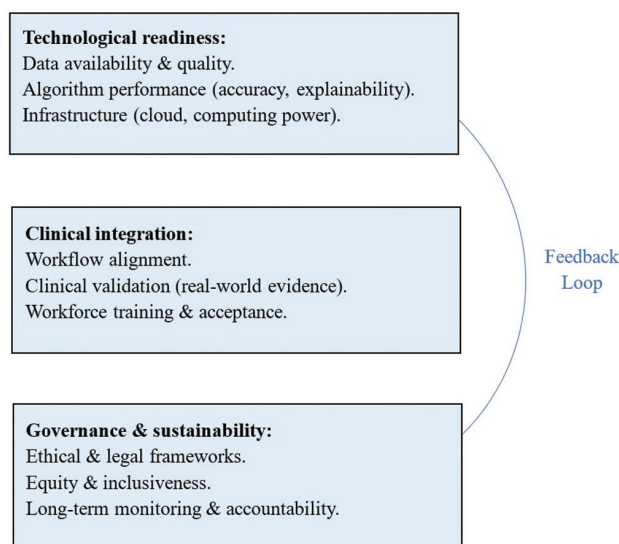


Figure 4. A three-tier framework for artificial intelligence adoption in healthcare. The model emphasizes technological readiness, clinical integration, and governance and sustainability, connected through a feedback loop to ensure continuous improvement.

technologies, such as quantum computing, which enable faster processing and greater data capacity. Advances in health monitoring equipment capable of collecting high-resolution and comprehensive data will likely generate the large datasets required to support more accurate predictive models.²²

Brief descriptions of specific applications are insufficient to fully embrace AI in healthcare. To represent this complexity, we provided a three-tiered structure (Figure 4) that connects clinical integration, governance and sustainability, and technology readiness. This paradigm offers a critical perspective on enduring difficulties and opportunities. The three levels are interconnected: integration without strong technology compromises safety,^{30,41,51} governance without integration postpones clinical impact,^{15,32} and technological preparedness without governance threatens dangerous innovation.^{22,55} For adoption to be sustainable, all layers must see balanced progress. This framework provides several stakeholders with a roadmap. Limited governance models in reproductive AI represent one example of an evidence gap identified by researchers.^{46,48} Policymakers can develop regulations that balance innovation with ethical safeguards.^{54,57} Meanwhile, administrators and clinicians can evaluate whether AI tools are socially responsible, therapeutically practical, and technically sound.^{15,32,51}

8. Conclusion

AI is reshaping the healthcare landscape by introducing advanced tools and systems that enhance diagnostic accuracy,

streamline clinical workflows, and support personalized medicine. As AI technologies continue to evolve, their integration into diverse branches of healthcare demonstrates immense potential to improve health outcomes and system efficiency. However, the adoption of AI is not without challenges. Ethical concerns, data privacy issues, algorithmic bias, and infrastructural limitations must be addressed through thoughtful regulation, transparent design, and inclusive development practices. Collaboration between technologists, healthcare professionals, policymakers, and patients is essential to fully harness the benefits of AI in healthcare. Moving forward, the focus should be on creating explainable, equitable, and robust AI systems that complement human expertise. This review concludes that our proposed three-tier framework—technological readiness, clinical integration, and governance and sustainability—offers a balanced roadmap for sustainable AI adoption in healthcare. With careful stewardship, AI can become a powerful ally in achieving more accessible, accurate, and patient-centered healthcare worldwide.

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Conflict of interest

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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Further disclosure

The authors declare that AI-assisted tools were used for language editing of the manuscript. The authors are fully responsible for the scientific content and conclusions.

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