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Artificial intelligence in healthcare delivery: Prospects and pitfalls

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ABSTRACT

This review provides a comprehensive examination of the integration of Artificial Intelligence (AI) into healthcare, focusing on its transformative implications and challenges. Utilising a systematic search strategy across electronic databases such as PubMed, Scopus, Embase, and ScienceDirect, relevant peer-reviewed articles published in English between January 2010 till date were identified. Findings reveal AI's significant impact on healthcare delivery, including its role in enhancing diagnostic precision, enabling treatment personalisation, facilitating predictive analytics, automating tasks, and driving robotics. AI algorithms demonstrate high accuracy in analysing medical images for disease diagnosis and enable the creation of tailored treatment plans based on patient data analysis. Predictive analytics identify high-risk patients for proactive interventions, while AI-powered tools streamline workflows, improving efficiency and patient experience. Additionally, AI-driven robotics automate tasks and enhance care delivery, particularly in rehabilitation and surgery. However, challenges such as data quality, interpretability, bias, and regulatory frameworks must be addressed for responsible AI implementation. Recommendations emphasise the need for robust ethical and legal frameworks, human-AI collaboration, safety validation, education, and comprehensive regulation to ensure the ethical and effective integration of AI in healthcare. This review provides valuable insights into AI's transformative potential in healthcare while advocating for responsible implementation to ensure patient safety and efficacy.

Introduction

Artificial intelligence (AI) is not a novel concept in the healthcare sector and has already found widespread utilisation. Its integration is increasingly prevalent in healthcare delivery, with the potential to significantly enhance diagnostic precision, treatment efficacy, and overall patient care [1]. The creation of diagnostic tools is one area in which AI is already utilised in healthcare. AI algorithms can be trained, for instance, to analyse medical images like X-rays and CT scans for indications of disease or injury [2,3]. By doing so, medical professionals may be able to make more accurate diagnoses, identify problems earlier and therefore use less aggressive or more focused treatments [3,4]. The creation of personalised medicine is another healthcare area where AI is employed. AI can assist doctors in understanding how patient genetics, environment, and lifestyle affect their health by analysing vast volumes of medical data [5,6]. Using this information, medical professionals can create personalised treatment programmes that are more effective.

AI can also be applied to boost the effectiveness of healthcare systems. AI algorithms, for instance, can be used to extract patient medical records and pinpoint those most likely to develop specific ailments [7,8]. This can make it easier for healthcare practitioners to focus their resources to ensure patients receive the care they require. However, some challenges must be addressed before AI can fully realise its potential in the healthcare sector. The quality and quantity of training data, for instance, may impact the precision of AI-based diagnostic tools [9,10]. Applying AI in healthcare also raises ethical questions due to potential biases in algorithms and the possibility of job loss for healthcare personnel [11–13]. Concerns also exist related to the acceptability

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of AI-driven decision-making by healthcare practitioners [14].

Thus, this review embarks on an exploration of the integration of AI within the healthcare domain, driven by the emergence of novel applications and transformative implications. The rationale for delving into this study stems from AI's progressive integration into healthcare, signifying a paradigm shift with profound implications. The novelty of this review lies in its comprehensive analysis of AI's multifaceted impact on healthcare delivery, encompassing diagnostic precision, treatment personalisation, and healthcare system optimization. Furthermore, the study aims to spotlight AI's role in the creation of personalised medicine. In addition, this review comprehensively examines recent advancements, challenges, and ethical implications surrounding AI's integration into healthcare. By elucidating the multifaceted impact of AI, this research aims to navigate the nuances of its adoption in healthcare, providing insights into its implications and potential future trajectories. Ultimately, the study endeavours to shed light on the transformative potential of AI in revolutionising healthcare delivery.

Methods

This review employed a systematic approach to examine the current state of AI applications in healthcare. The search strategy encompassed a thorough exploration of electronic databases, including PubMed, Scopus, Embase, IEEE Xplore, and ACM Digital Library, using a combination of relevant search terms. The search terms utilised combinations of keywords such as "artificial intelligence," "AI," "machine learning," "deep learning," "healthcare," "medical imaging," "predictive analytics," "robotics," "virtual assistants," and "healthcare systems," among others. Boolean operators (AND, OR) were used to refine the search and ensure relevance to the review objectives.

Inclusion criteria comprised peer-reviewed articles published in English between January 2010 and the present, focusing on AI applications in healthcare. The rationale for selecting this timeframe lies in capturing the recent advancements and developments in AI technology and its applications in healthcare. The last decade has witnessed significant progress in AI research and its integration into healthcare systems, making it crucial to focus on articles published during this period to provide an up-to-date overview of the field. Articles were screened based on their relevance to the review objectives, with a focus on studies examining AI's impact on diagnostic precision, treatment personalisation, predictive analytics, automated tasks, and AI-driven robotics in healthcare settings. Non-peer-reviewed articles and those unrelated to AI in healthcare were excluded from the review.

The systematic search strategy yielded a total of 500 articles across the selected electronic databases, as follows:

PubMed: 120 articles
Scopus: 100 articles
Embase: 80 articles
IEEE Xplore: 120 articles
ACM Digital Library: 80 articles

After initial screening based on title and abstract relevance, a subset of articles meeting the inclusion criteria underwent full-text review. Across all databases, a total of 300 articles were screened, resulting in the exclusion of 200 articles based on predefined criteria. Subsequently, 100 articles were selected for full-text review. Through rigorous screening, 80 high-quality, relevant articles were included in the review, ensuring the incorporation of studies pertinent to the review objectives and enhancing the transparency and reproducibility of the review process.

Results

History of AI in healthcare

The use of AI in healthcare has a long history, going back to the early years of AI research in the 1950s and 1960s [15] Early AI efforts concentrated on creating expert systems, which were intended to imitate the capability of human experts to make decisions [16]. These systems could analyse data and offer recommendations, but their capabilities were constrained by the amount and quality of knowledge that could be stored in them [17].

The availability of large volumes of medical data and developments in computer technology fuelled a fresh interest in AI in healthcare in the 1980s and 1990s [15,18] which led to the creation of novel AI

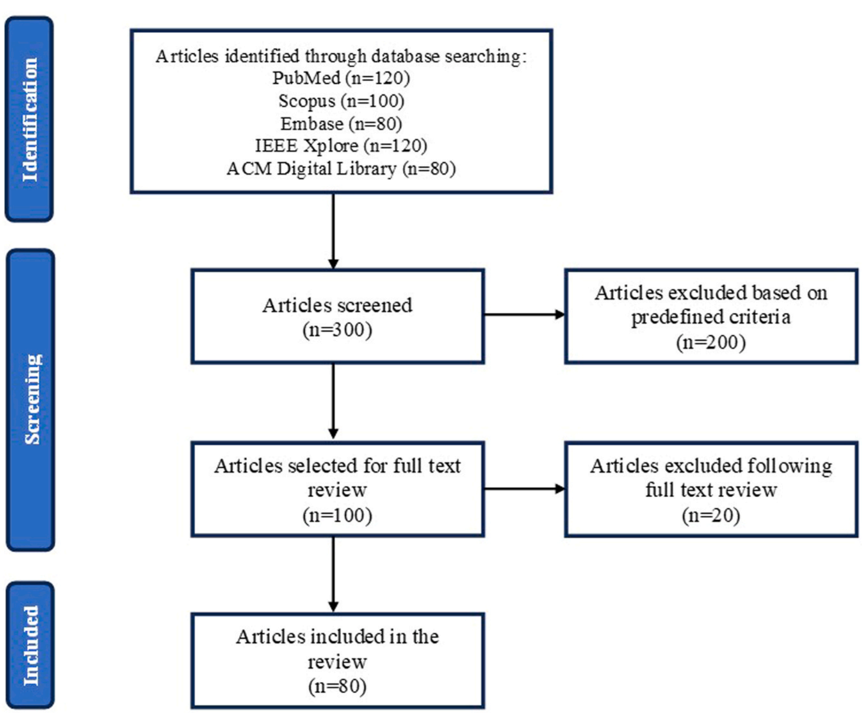

Fig. 1. PRISMA flowchart for selection of included studies.

techniques more adaptable and potent than expert systems, like neural networks and decision trees. Numerous applications, including decision support systems and diagnostic tools [8,13], were created using these principles, with the creation of an expert system for diagnosing breast cancer being one of the first significant achievements of AI in healthcare. The IDC-P (Intelligent Decision Support System for Breast Cancer Diagnosis) system, which included information from mammograms and other medical testing, successfully diagnosed breast cancer [19].

Due to the development of improved AI techniques like deep learning and the accessibility of vast amounts of data, the use of AI in healthcare has significantly increased in recent years. Numerous applications, including diagnostic tools, predictive analytics, and personalised medicine [5,6], have been created using these principles. The creation of deep-learning algorithms to analyse medical images represents one of the most remarkable achievements of AI in healthcare [1,20].

These algorithms have been utilised to create high-accuracy diagnostic systems for various diseases, including cancer, heart disease and eye disease. Future healthcare uses of AI are likely to be even more cutting-edge as the field of AI develops [13]. For example, Neuralink is an emerging AI which functions by integrating a wireless brain chip into the human brain, offering individuals with significant paralysis the capability to manipulate devices such as robotic limbs and smartphones through their thoughts [67]. However, there are also worries about bias and errors in AI-based systems [21] and the need for thorough monitoring and evaluation. Nevertheless, these applications can improve patient outcomes and save costs [22]. As revealed by a recent review, integrating AI in healthcare significantly reduces expenses when compared to conventional methods of determining health diagnosis, resulting in a time savings between 3.3 h per day to 15.2 h per day and cost savings ranging from 1,667 USD per day per hospital to 17,881 USD per day per hospital [68].

Overall, AI works by simulating human intelligence. It operates through the collection, analysis, and interpretation of vast amounts of data, enabling it to learn from patterns and make decisions with minimal human intervention [69]. By harnessing algorithms and computational processes, AI systems can adapt and improve their performance over time. This self-improvement mechanism allows AI to achieve a level of precision and efficiency in tasks ranging from pattern recognition to predictive analysis. AI technologies such as Convolutional Neural Networks (CNNs) are utilised for medical imaging analysis, while Machine Learning Algorithms power predictive analysis in healthcare. Natural Language Processing (NLP) techniques are employed for charting purposes, and AI-powered chatbots and virtual assistants facilitate communication and support within healthcare settings. Additionally, AI-driven robots, integrating robotics and machine learning, are utilised for various healthcare tasks.

Table 1 below outlines specific AI technologies and tools employed within distinct applications in the healthcare system.

Table 1
Comprehensive Overview of AI Technologies and Tools in Diverse Healthcare Applications.

AI Application	Specific AI Techniques	Use Case	Example of tools
Medical Imaging Analysis [70,71]	DL: Convolutional Neural Networks (CNNs), Generative Adversarial Networks (GANs), &. Holistically Nested Networks (HNN) ML: Support Vector Machines (SVM)	• Segmenting and classifying tumors in radiology scans: Canny Edge Detection, K-Means Clustering, Convolutional Neural Networks (CNNs) • Radiomics: Uses image features to assess disease progression and treatment response.	– Google's DeepMind Health: Enhances image segmentation. – Zebra Medical Vision: Improves image quality in radiology. – Aidoc: AI assistance in detecting abnormalities in X-rays.
Predictive Analysis [71,72]	Machine Learning Algorithms: SVM, XGBoost, K-Nearest Neighbor, and Naïve Bayes	• Predicting the risk of developing chronic diseases: Logistic Regression, Support Vector Machines (SVMs), Random Forests • Anticipating patient readmission rates: Time Series Analysis, ARIMA Models, Neural Networks	– SAS Healthcare Analytics: Forecasts disease risks. – Optum360 predictive analytics: Optimizes resource allocation.
Charting [73,74]	Natural Language Processing (NLP)	• Summarizing patient records: Topic Modeling, Sentence Segmentation, Entity Extraction. • Generating clinical notes: Rule-based systems, Statistical language models, Recurrent Neural Networks (RNNs)	– Nuance Communications: Transcribes spoken words into EHR text. – Cerner PowerChart: Embeds AI support for clinical documentation.
Chatbots and Virtual Assistants [75,76]	AI-powered Chatbots and Virtual Assistants	• Resolving patient inquiries: Question answering systems, Chatbots with rule-based interactions • Scheduling appointments: Calendar management systems, Appointment booking chatbots	– Ada Health: AI chatbot for patient symptom assessment. – HealthTap: Offers AI-driven virtual assistants for medical information. – Woebot: AI chatbot designed for mental health support.
AI-driven Robots [77,78]	Robotics and Machine Learning Integration	• Surgical robots for minimally invasive procedures: Da Vinci Surgical System, ZEPHYR Surgical System • Drug delivery robots for precise dosing: Robotic systems for intravenous drug administration, Insulin delivery robots	– Intuitive Surgical (da Vinci Surgical System): AI-powered surgical assistance. – Xenex: Uses AI for disinfection robots in healthcare settings. – Aethon: Autonomous robotic solutions for healthcare logistics.

Medical Imaging analysis

For the diagnosis and treatment of a variety of illnesses, including cancer, heart disease, and eye disease, medical imaging is a crucial tool. By automatically detecting and interpreting images, AI has the potential to increase the precision and effectiveness of medical imaging analysis [4,23]. Using deep learning algorithms - machine learning that employs neural networks to evaluate massive volumes of data - for image analysis is one of the most promising applications of AI in medical imaging [24]. These algorithms can be trained to spot patterns in images taken for medical purposes and to detect or predict the presence of disease or damage.

The creation of deep learning algorithms for the identification of skin cancer represents one of the most significant achievements of AI in medical imaging. Deep learning algorithms have been used to detect skin cancer with an accuracy level equivalent to that of human dermatologists [25]. Algorithms have also been utilised to create diagnostic tools for breast and lung cancer [26]. Such algorithms can accurately evaluate CT and MRI images to find tumours and other indications of malignancy.

AI-based algorithms may also increase the effectiveness of analysis of medical imaging. For instance, regions of interest in images can be automatically identified and marked using AI, which can reduce the time and labour needed for manual analysis [27]. AI-based algorithms have also been used to evaluate retinal images to detect eye conditions including glaucoma and diabetic retinopathy with great precision [28, 29].

However, like all technology, there are several difficulties with AI-based medical imaging analysis. One of the greatest constraints is the necessity for a lot of high-quality data to train and validate the algorithms. Concerns exist around the possibility of biases in the algorithms as well as the requirement for continual monitoring and review [12–14]. The reliance on data-driven techniques necessitates high-quality, varied datasets to mitigate biases and enhance model performance [70]. However, challenges arise from inconsistent imaging protocols across clinical settings, the vast array of clinical scenarios, and the unique characteristics of patient cohorts in different clinics [71]. The organisation and standardisation of data from diverse practices present significant hurdles. Moreover, the critical task of data curation, including accurate image labelling, is increasingly difficult due to the rapid growth in the volume of medical images and the expertise required for precise annotation [71]. These issues are compounded by privacy concerns and regulations that restrict the sharing of patient images across institutions, further complicating the development and application of AI in medical imaging [70,71]. The potential consequences of biases and limitations in AI applications for medical imaging include compromised diagnostic accuracy, the perpetuation of existing healthcare disparities, and a lack of generalisability across diverse patient populations. Inaccurate or biased AI models can lead to misdiagnoses or overlooked conditions, particularly in underrepresented groups, thereby affecting patient outcomes. Additionally, the difficulties in data sharing due to privacy concerns and the variability in imaging protocols can hinder the development of robust, universally applicable AI tools, potentially slowing the progress towards more effective and personalised healthcare solutions.

Predictive analytics

By identifying those at risk of disease and delivering tailored interventions, the use of AI for predictive analytics in healthcare offers the potential to improve patient outcomes and save costs [30]. In order to forecast future health outcomes, predictive analytics analyses data from electronic health records (EHRs), claims data, and other sources using statistical models and machine learning algorithms [31,32]. Risk stratification is an important use of AI for predictive analytics in the healthcare industry. Risk stratification entails identifying people who are highly susceptible to developing a specific ailment and offering targeted therapies [33]. AI can, for instance, be used to pinpoint those who are most at risk of acquiring diabetes, heart disease, or cancer and offer them individualised interventions like dietary adjustments, medication management, or screenings [33].

By identifying patients who have a high chance of being readmitted to the hospital, AI-based predictive analytics can also be utilised to improve patient outcomes. AI can identify patients at high risk of readmission and offer targeted interventions to lower that risk by evaluating data from EHRs and claims databases [34]. Through classifying patients who are most likely to respond to particular therapies, AI can also be used to increase the effectiveness of healthcare. AI can pinpoint patients who are likely to respond to a certain treatment by examining data from EHRs and claims data, which can help optimise the use of resources and lower the cost of care [30]. For these applications to be effective, huge quantities of high-quality data must be available for the training and validation of algorithms. Concerns exist around the possibility of biases in the algorithms as well as the requirement for continual monitoring and review [13]. In predictive analytics for medical care, especially concerning acute diseases, several general biases and limitations emerge with potential implications for patient care. The effectiveness of these analytics tools is often constrained by the diversity and size of the datasets used to train them, which can limit their applicability across different patient demographics and disease types [79,80]. A reliance on domain experts for selecting which clinical features to include may result in missing critical predictors due to overlooked complex factors, such as comorbidities and environmental influences [79]. Furthermore, the complexity of deep learning models, while powerful, poses challenges in interpreting how these models make their predictions. This opacity can hinder clinicians' trust in the tools, as understanding the rationale behind recommendations is crucial for clinical decisions [79,80]. Addressing these issues by enhancing data representation, expanding dataset diversity, and improving model interpretability is essential to developing more accurate, trustworthy, and equitable predictive analytics in healthcare.

Charting, chatbots and virtual assistants

The process of charting involves entering patient data into electronic health records (EHRs). AI-enabled charting solutions can evaluate patient data and generate chart notes automatically, which can increase the accuracy of patient records and completeness while also saving time. Charting tools can be used to extract information from both organised and unstructured data, such as lab results and free-text notes [35].

Chatbots, often known as virtual assistants, are computer programmes that can have voice or text conversations with users. They can be used to inform patients, respond to their inquiries, and make appointments. Virtual assistants can help with patient triage, medication management, education, and assistance in the field of healthcare [36]. The creation of natural language processing (NLP) algorithms that can automatically extract information from unstructured data, like free-text notes, and structured data, like lab results, is one example of AI-powered charting tools [34–36]. These algorithms can be used to find pertinent data, like diagnoses and treatment plans, and automatically add these to a patient's electronic health record [34].

Virtual assistants in the healthcare sector, such as Babylon Health, Ada, and Infermedica[37] can help patients by triaging their symptoms, offering health information, and setting up appointments. Consequently, the adoption of AI-powered charting tools and virtual assistants has the potential to improve patient experience while also increasing the efficiency and accuracy of healthcare delivery. These technologies are still relatively new, so it remains crucial that constant monitoring and evaluation are necessary to guarantee their efficacy. While these AI applications are promising, they still have significant limitations to overcome. For example, chatbots and virtual assistants in healthcare face several challenges, including patient difficulties in using technology and a general lack of enthusiasm for following advice from digital platforms [75]. The impersonal nature of telemedicine may deter patients and doctors alike due to the reduced capacity for human connection. Moreover, integrating voice technology into healthcare necessitates further regulatory oversight, with a need for comprehensive guidelines that address security, privacy, and the risk of cyberattacks, as these technologies can be vulnerable to hacking, especially in the context of smart home devices interacting with personal assistants [76].

AI-driven robots

By automating repetitive processes and delivering targeted interventions, the use of AI robots in healthcare offers the potential to enhance patient outcomes and save costs. AI robots come in a variety of shapes and sizes, including exoskeletons, mobile robots, and humanoid robots. One of the primary areas where AI robots are being used in healthcare is rehabilitation [38,39]. Robots with AI can help patients with physical therapy exercises by offering individualised interventions to enhance their functional and motor capabilities [39].

AI robots can also be employed to help with physically strenuous or precise tasks, such as tele-surgery, in which a surgeon performs surgery using a robotic arm under remote control [40]. These robots can execute surgical treatments with higher precision and flexibility than traditional approaches, and they can be especially helpful for those that are challenging or impossible to accomplish with conventional surgical techniques.

AI robots can also be utilised in the geriatric care sector to assist the elderly with activities of daily living, including dressing, grooming, and bathing, as well as to provide companionship [41]. The use of AI robots for geriatric care is not widespread due to significant cost implications. "Eldercare robots" are more common in countries like Japan, with a significant ageing population [78]. AI robots can also be employed to help with jobs that are hazardous or challenging for humans to complete, including in contaminated environments or emergency response. They may move through dangerous situations, evaluating the situation and giving the emergency response team information in real-time [42].

While robotics shows great potential to improve efficiency and reduce medical errors associated with routine procedures, there are concerns about its cost implications. This is one of the major limitations of implementing (introducing and maintaining) such technologies in countries like India [77]. In a study that examined the cost implications of employing robotics in urology in Canada, the financial burden of incorporating robot-assisted prostatectomy was substantial, with initial acquisition costs exceeding $2 million USD and additional expenses related to operation, maintenance, and training [81,82]. The net cost of running a robotic surgery program can reach up to $3.5 million CAD over seven years for prostatectomy alone, with each robot-assisted procedure costing significantly more than its open or laparoscopic counterparts [81,82]. However, in the long term there are potential reductions in incremental costs through increased procedural volume [82]. In addition, cost savings have also been reported in the short run. For example, robot-assisted prostatectomy demonstrated early advantages over open and laparoscopic surgeries in terms of perioperative outcomes, including shorter hospital stays, less blood loss, and lower transfusion rates, as well as improved margins in prostate-confined tumours [81,83]. These benefits extend to better postoperative continence and sexual function, which significantly impact patient quality of life post-surgery [84].

By drastically reducing the time and expense needed to produce new pharmaceuticals, AI also has the potential to transform the drug development process. A variety of data sources, including scientific publications, clinical trials, and chemical databases, can be analysed using AI algorithms to identify prospective drug targets and predict the effectiveness and safety of novel compounds. Using AI-based algorithms to conduct computational chemistry enables the process of finding new drugs to be greatly accelerated, through anticipating the characteristics of micro molecules, such as their solubility, stability, and bioactivity [43]. Virtual screening is a different area where AI is being used in the drug discovery process. Large databases of compounds can be examined using AI-based algorithms to identify potential drug candidates that are highly likely to bind to a particular protein target [44,45].

In order to find potential drug targets for a variety of diseases, AI may also be used to analyse vast amounts of genetic data. For instance, cancer patient genomic data can be explored using AI-based algorithms to identify new therapeutic targets for customised therapy [46]. Additionally, by examining data from clinical trials and electronic health records, AI can be used to detect probable negative effects of medications (EHRs). AI can help increase the safety of new pharmaceuticals and lower the likelihood of adverse events by identifying potential side effects early in the drug development process [47]. The use of AI to identify new compounds and rule out others is based on the quality of the data available. Improving data quality and sharing data between databases is of critical importance in optimizing the algorithms used to inform drug discovery.

Specific examples of companies that provide healthcare-related AI technologies across North America, Africa, Europe, and Asia are provided in Table 2.

Discussion

While AI holds great promise for improving healthcare delivery, many challenges must be overcome before it can be broadly implemented. The absence of standardised and accessible data is a significant restriction. It can be challenging to transfer and analyse data across multiple institutions because many healthcare organisations have their own data storage systems and formats [60], and formal data sharing agreements may not be in place. The challenge is more significant in sub-Saharan Africa (SSA) and other under-developing/developing regions, where the electronic collection of healthcare data is not routine [61]. Thus, creating AI technologies specific to SSA's demographics could pose a challenge. In addition to data availability and quality issues, other hindrances in Africa are inadequate/unclear legal and policy frameworks and insufficient funding and infrastructure [62]. Health bodies in SSA can remove these barriers by reviewing current digital health policies that can serve restriction to AI adoption. Since AI relies on accessibility to high-quality clinical data, these health organisations must intentionally create a regulatory framework to manage health data and its collection. The advancement of AI technologies in developing countries could increase the already existing global health inequality gap.

The inability to interpret AI models is another concern due to the high technical knowledge requirement of understanding machine learning interpretability methods and its application to workflows, for instance, image classification, saliency maps and sensitivity analysis. The multi-perspective nature of AI models makes them challenging to describe the decisions and how they were reached by deep learning models as they can be challenging to interpret [63]. This can be especially difficult in the healthcare industry, where transparency and trust are essential [64]. AI models may also be biased, especially if they were developed with data unrepresentative of the population they would be applied to [11,12]. This may result in predictions and decisions that are

Table 2
Some healthcare AI-companies and their services.

Company	AI Function	Year and locations commissioned	Reference
Viz.ai	Aneurysm detection software	2018, USA	[48]
PathAI	Precision pathology	2016 USA	[49]
Buoy	Symptom assessment chatbox	2014 USA	[50]
Beth Israel Medical Center	AI-powered microscope to detect blood infection	2017 USA	[51]
Iterative Health	Precision gastroenterology	2017 USA	[52]
VirtuSense	Movement anomaly detection	2012 USA	[53]
RxAll	Drug authentication	2016 Africa	[54]
Viebeg Technologies	Healthcare facilities procurement	2018 Rwanda	[55]
Lunit	Detection of abnormalities in chest radiographs	2013 South Korea	[56]
Promaton	Dental diagnostics	2017 Netherlands	[57]
Aidence	Lung cancer detection via precise imaging	2017 Netherlands	[58]
Chronolife	Health monitoring and prediction	2019 France	[59]

unfair or inaccurate.

Additionally, some AI models may lack robustness, making them susceptible to manipulation by hostile instances and less likely to generalise effectively to new data [65,85]. The absence of rules and regulations for AI in healthcare is also a concern. As the use of AI within healthcare is still relatively new, there are no clear guidelines for its creation, distribution and application. This could result in a lack of clarity and uncertainty over how to effectively deploy AI in this context [13].

While these are potential downsides, these challenges can be mitigated by proper regulation, design, and implementation of AI systems, as well as by involving healthcare professionals, ethicists and other stakeholders in the development process [66]. To overcome these restrictions and guarantee that AI is created and applied in a responsible and ethical manner, more research is required.

Addressing the limitations and challenges of AI in healthcare requires multifaceted solutions and ongoing research efforts. One critical challenge is the lack of standardized and accessible data, especially in regions like sub-Saharan Africa where electronic healthcare data collection is not routine [61]. To overcome this, health bodies in these regions can review and establish digital health policies that facilitate AI adoption and ensure proper management of health data. Additionally, efforts should focus on developing AI technologies tailored to the demographics and healthcare systems of these regions. Another concern is the interpretability of AI models, which requires high technical knowledge and can be particularly challenging in healthcare where transparency and trust are crucial. Addressing this challenge involves developing interpretable AI methods and involving healthcare professionals in the interpretation process. Furthermore, mitigating bias in AI models and ensuring their robustness against manipulation are essential steps in improving AI's reliability and fairness in healthcare. Establishing clear rules and regulations for AI in healthcare is also necessary to provide guidance on its creation, distribution, and application. Ultimately, overcoming these challenges and ensuring responsible and ethical AI implementation requires collaboration among stakeholders and continued research efforts in the field.

Table 3 provides a comprehensive overview of the advantages and disadvantages of AI in healthcare systems, explores potential users, and highlights the implications associated with the integration of AI technologies in healthcare delivery.

Recommendations for the future direction of research in this field can be delineated into several key aspects, such as:

1. Ethical and Legal Frameworks: Future research should prioritize the development and implementation of robust ethical and legal frameworks governing AI in healthcare. This involves in-depth exploration of region-specific policies, guidelines, and regulations to ensure the responsible and ethical use of AI technologies. Studies should focus on identifying potential biases within algorithms and establishing protocols for transparency, fairness, and accountability in AI-driven decision-making processes.
2. Human-AI Collaboration: Research efforts should delve into optimizing the collaboration between AI technologies and healthcare professionals. This involves investigating strategies for seamless integration of AI tools into existing healthcare workflows, fostering trust, and ensuring effective communication between AI systems and human caregivers. Studies can explore training programs that enable healthcare professionals to understand and effectively utilize AI-generated insights while retaining the pivotal role of human judgment in patient care.
3. Safety and Effectiveness: Emphasis should be placed on continual assessment and validation of AI tools in healthcare settings to ensure their safety, efficacy, and accuracy. Longitudinal studies and real-world applications are pivotal to monitor the performance of AI algorithms, identify potential shortcomings, and refine these tools over time. Research should focus on developing standardized protocols for evaluating and validating AI technologies in clinical settings.
4. Education and Training: Future research should prioritize education and training initiatives for healthcare professionals and stakeholders. This involves developing educational programs to enhance understanding, acceptance, and proficiency in utilizing AI tools in healthcare. Addressing the concerns and knowledge gaps surrounding AI technologies among healthcare professionals is vital for their successful adoption and integration into clinical practice.
5. Regulation and Governance: Research efforts should advocate for comprehensive regulatory frameworks and governance mechanisms specific to AI in healthcare. Collaboration between policymakers, regulatory bodies, technologists, and healthcare stakeholders is crucial for formulating guidelines that balance innovation and regulation, ensuring the ethical deployment and ongoing oversight of AI technologies in healthcare.

Future research should focus on interdisciplinary collaboration encompassing ethical, legal, technical and sociocultural dimensions. By addressing these recommendations, researchers can pave the way for the responsible and effective integration of AI tools in healthcare, while ensuring ethical, safe and trustworthy implementation of these transformative technologies. By embracing AI responsibly and proactively, healthcare systems can pave the way for a future where technology-driven innovations drive improvements in patient outcomes and

Table 3
Advantages, Disadvantages, Users, and Implications of AI in Healthcare Systems.

Feature	Advantages	Disadvantages	Potential Users	Implications
Enhanced Diagnosis and Treatment [86]	Accurately identify rare diseases and complex medical conditions	May require large amounts of training data, which may not always be available	Physicians, specialists, pathologists	Improve diagnostic accuracy and reduce misdiagnosis
Personalised Healthcare [87]	Tailor treatment plans to each patient's unique needs and preferences	Potential oversight of the significance of patient-provider interaction and shared decision-making	Patients, caregivers	Enhance patient engagement and improve adherence to treatment plans
Predictive Analytics [88]	Identify patients at high risk of developing chronic conditions or experiencing adverse events	Accuracy of predictive models may vary depending on the data used and the complexity of the prediction	Physicians, hospitals, health systems	Proactively intervene to prevent adverse events and improve population health
Automated Tasks [89]	Free up healthcare workers from routine tasks, allowing them to focus on more complex clinical duties	May lead to job displacement and skill obsolescence among certain healthcare professionals	Hospital staff, administrative personnel	Streamline workflows, improve efficiency, and reduce the burden on healthcare providers
Chatbots and Virtual Assistants [85]	Provide 24/7 access to healthcare information and support, including appointment scheduling, medication reminders, and symptom tracking	May not always be able to understand complex medical queries or provide adequate support for emergencies	Patients, caregivers	Improve patient satisfaction, reduce wait times, and enhance patient engagement
AI-Driven Robots [90]	Perform minimally invasive procedures with greater precision and dexterity	May require significant upfront investment and ongoing maintenance	Surgeons, pharmacists, telemedicine providers	Revolutionize healthcare delivery, reduce surgical complications, and improve patient recovery

population health.

Implications of the review

The findings of this review underscore the growing importance of integrating AI technologies into clinical practice. Healthcare professionals need to familiarize themselves with these tools to harness their potential effectively. Training programs and continuing education initiatives should be developed to ensure healthcare providers are equipped with the necessary skills to leverage AI for improved patient care. This review highlights the need for further research into the development and validation of AI algorithms for various healthcare applications. Future studies should focus on refining AI models, addressing issues related to bias and interpretability, and evaluating the long-term impact of AI interventions on patient outcomes. Collaborative research efforts between academia, industry, and healthcare institutions are essential to advance the field of AI in healthcare.

AI has the potential to revolutionize preventive healthcare by enabling more accurate risk stratification, early detection of diseases, and personalized interventions. Policymakers and healthcare leaders should prioritize investments in AI-driven preventive strategies, such as predictive analytics and population health management tools, to mitigate the burden of chronic diseases and improve population health outcomes. The adoption of AI in healthcare necessitates the development of robust regulatory frameworks to ensure patient safety, privacy protection, and ethical use of data. Policymakers must work collaboratively with stakeholders to establish guidelines for the design, implementation, and evaluation of AI technologies in healthcare. Additionally, policies should address issues related to data sharing, interoperability, and reimbursement to facilitate the widespread adoption of AI solutions.Top of Form

Conclusion

In conclusion, the integration of AI tools into healthcare holds immense potential for enhancing patient outcomes, streamlining processes, and driving cost efficiencies. However, it is imperative to recognize that AI should complement rather than replace human expertise and decision-making in healthcare settings. Moreover, the ethical and legal implications surrounding the deployment of AI technologies demand careful consideration, necessitating the development of region-specific policy frameworks. While AI offers unprecedented opportunities, its implementation should proceed cautiously, guided by robust regulation to safeguard against potential risks and ensure the ethical use of these transformative technologies. By striking a balance between innovation and regulation, healthcare stakeholders can harness the full benefits of AI while upholding patient safety, efficacy, and ethical standards.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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