Computer Methods and Programs in Biomedicine Update 5 (2024) 100142

Contents lists available at ScienceDirect

Computer Methods and Programs in Biomedicine Update

journal homepage: www.sciencedirect.com/journal/computer-methods-and-programs-in-biomedicine-update

Advancing clinical decision support: The role of artificial intelligence across six domains

Mohamed Khalifa [a,b,c,*], Mona Albadawy [d], Usman Iqbal [d,e,f]

[a] College of Health Sciences, Education Centre of Australia, Sydney, Australia
[b] Australian Institute of Health Innovation, Macquarie University, Sydney, Australia
[c] School of Population Health, La Trobe University, Melbourne, Australia
[d] School of Population Health, Faculty of Medicine and Health, University of New South Wales (UNSW), Sydney, Australia
[e] HICT, Department of Health, Tasmania
[f] Global Health & Health Security Department, College of Public Health, Taipei Medical University, Taiwan

ARTICLE INFO

Keywords:
Artificial intelligence
Clinical decision support
Healthcare
Personalised medicine
Predictive analytics
Telehealth

ABSTRACT

Background: Artificial Intelligence (AI) is a transformative force in clinical decision support (CDS) systems within healthcare. Its emergence, fuelled by the growing volume and diversity of healthcare data, offers significant potential in patient care, diagnosis, treatment, and health management. This study systematically reviews AI's role in enhancing CDS across six domains, underscoring its impact on patient outcomes and healthcare efficiency.
Methods: A four-step systematic review was conducted, involving a comprehensive literature search, application of inclusion and exclusion criteria, data extraction and synthesis, and analysis. Sources included PubMed, Embase, and Google Scholar, with papers published in English since 2019. Selected studies focused on AI's application in CDS, with 32 papers ultimately reviewed.
Results: The review identified six AI CDS domains: Data-Driven Insights and Analytics, Diagnostic and Predictive Modelling, Treatment Optimisation and Personalised Medicine, Patient Monitoring and Telehealth Integration, Workflow and Administrative Efficiency, and Knowledge Management and Decision Support. Each domain is crucial in improving various aspects of CDS, from enhancing diagnostic accuracy to optimising resource management. AI's capabilities in EHR analysis, predictive analytics, personalised treatment, and telehealth demonstrate its critical role in advancing healthcare.
Discussion: AI significantly enhances healthcare by improving diagnostic precision, predictive capabilities, and administrative efficiency. It facilitates personalised medicine, remote monitoring, and evidence-based decision-making. However, challenges such as data privacy, ethical considerations, and integration with existing systems persist. This requires collaboration among technologists, healthcare professionals, and policymakers.
Conclusion: AI is revolutionising healthcare by enhancing CDS in several domains, contributing to more efficient, effective, and patient-centric care. However, it should complement, not replace, human expertise. Future directions include ethical AI development, continuous professional development for healthcare personnel, and collaborative efforts to address challenges. This approach ensures AI's potential is fully harnessed, leading to a synergistic blend of technology and human care.

Introduction

In the evolving domain of healthcare, Artificial Intelligence (AI) is becoming a pivotal force in enhancing clinical decision support (CDS) systems. Its emergence signals a new era in health innovation, offering the potential to significantly transform patient care, diagnosis, treatment, and health management. This transformation is driven by the rapidly increasing volume and diversity of healthcare data, presenting both opportunities and challenges. AI's advanced algorithms and machine learning capabilities enable the processing and analysis of this data at an unprecedented scale and speed, making it a crucial tool for clinicians in making informed decisions [1,2]. AI's application is particularly impactful in the area of Electronic Health Records (EHR) analysis, where it can uncover vital insights, detect disease patterns, and

* Corresponding author at: College of Health Sciences, Education Centre of Australia, Address: Level 6, 1/3 Fitzwilliam St, Parramatta, NSW, 2150, Australia.
E-mail address: mohamed.khalifa@chs.edu.au (M. Khalifa).

https://doi.org/10.1016/j.cmpbup.2024.100142

Available online 17 February 2024

predict patient risks with remarkable precision. These capabilities are essential for improving clinical decision-making and are vital for advancing personalised medicine. AI's analytical strength allows for treatment customisation based on individual genetic profiles, lifestyle factors, and disease histories [3].

The role of AI extends to diagnostic procedures as well, where it addresses diagnostic errors by excelling in image-based diagnostics, thus enhancing the accuracy of clinical judgments. Additionally, the integration of AI in patient monitoring and telehealth, particularly highlighted during global health crises like the COVID-19 pandemic [4]. AI also redefines administrative efficiency in healthcare by automating tasks and optimising resource management. This automation allows healthcare professionals to focus more on patient care. Moreover, AI's role in knowledge management and decision support is crucial, synthesising the latest medical research into actionable insights, thereby supporting evidence-based practice [5]. Given these diverse roles of AI, a comprehensive examination of its potential to improve CDS is essential. Such extensive review would not only highlight AI's transformative impact but also address its challenges and future directions, influencing both current healthcare practices and future innovations.

Methods

A systematic review was conducted to assess how AI enhances CDS using a four-step approach. The first step involved a comprehensive literature search across databases like PubMed, Embase, and Google Scholar. Keywords such as "artificial intelligence," "machine learning," "clinical decision support," and "healthcare" were used to identify relevant articles published in English since 2019. This ensured the inclusion of recent and pertinent studies, focusing on peer-reviewed articles, review papers, and clinical studies. The second step defined clear inclusion and exclusion criteria to refine the literature. Studies were selected if they specifically addressed AI's application in clinical decision-making, patient diagnosis, treatment recommendations, or its integration into healthcare workflows. Excluded were studies not directly related to CDS or lacking empirical evidence or clear methodologies. In the third step, data extraction and synthesis were carried out, gathering information on study design, AI technology, healthcare domain, population size, outcomes, and the effectiveness of AI interventions. This data was analysed to identify patterns, evaluate the efficacy of different AI approaches, and recognise research gaps. The final step involved analysing the extracted information to understand AI's current use in CDS, the outcomes achieved, and potential future applications.

Results: the AI six CDS domains and 12 functions

Using databases: PubMed, Embase, and Google Scholar, 915 papers were initially identified. Post deduplication, 717 unique papers remained. Applying specific inclusion and exclusion criteria led to the exclusion of 558 papers by title screenings. Of the remaining 159 papers,

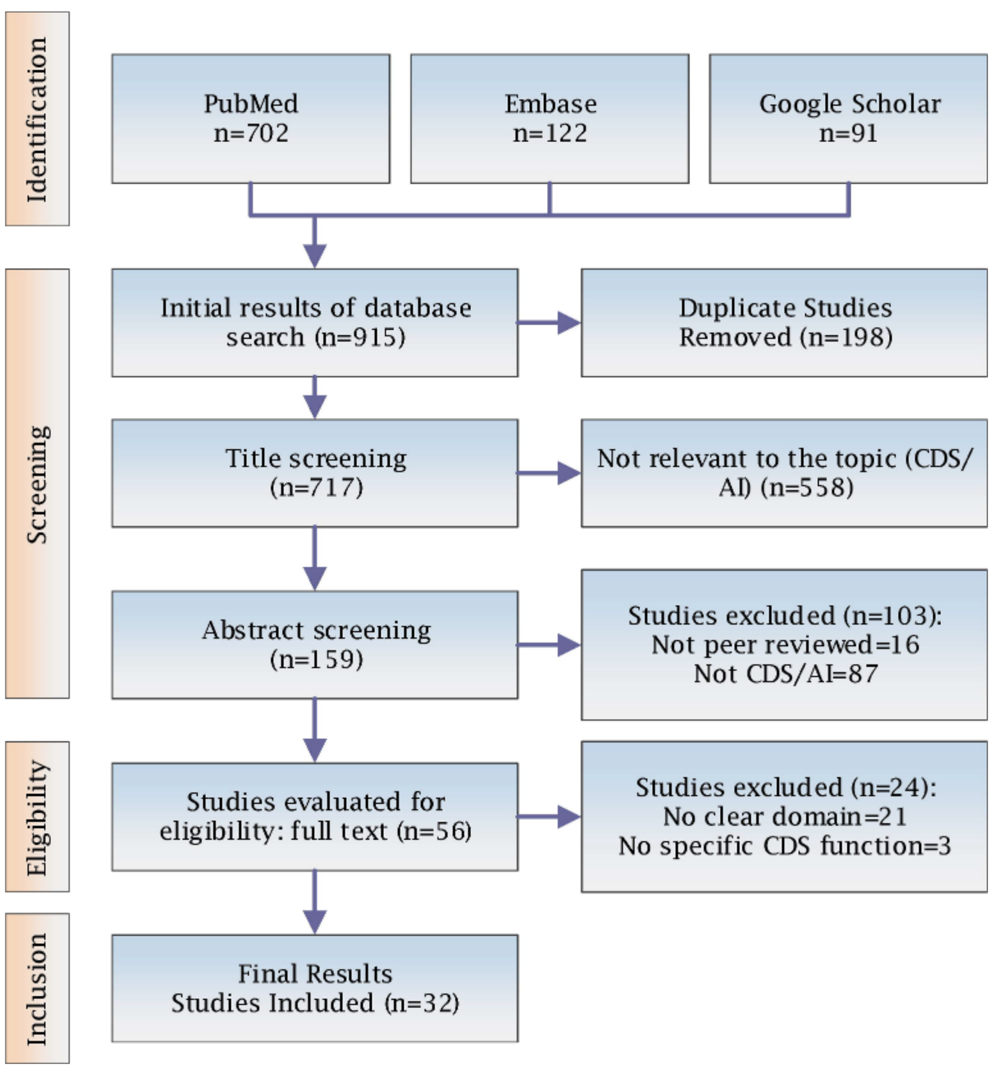

Fig. 1. PRISMA flowchart of study selection and inclusion process.

only 56 were assessed for full-text eligibility after initial abstract and peer-review screenings. Ultimately, 32 papers, discussing the roles of AI in improving CDS, were included in this review. Fig. 1 shows study selection and inclusion process.

Through careful qualitative analysis, this review describes six fundamental domains, and 12 relevant functions, where AI contributes to advancing CDS, each enhancing different aspects of CDS. The first domain, Data-Driven Insights and Analytics, shows how AI interprets complex data from EHR. AI's ability to detect patterns and anomalies in EHRs is instrumental for identifying health risks and personalising patient treatment plans. This analytical strength of AI extends beyond individual patient care, improving the efficiency of healthcare delivery through advanced data management [1,6]. Within the second domain, Diagnostic and Predictive Modelling, AI's impact is evident in its support for medical diagnostics, particularly through analysing medical images. AI enhances the precision and speed of diagnosis, significantly aiding in the early detection and treatment of diseases [7]. Moreover, AI's predictive analytics play a pivotal role in forecasting health outcomes and guiding preventive measures, underlining its preventive and strategic applications in healthcare settings [8]. The third domain, Treatment Optimisation and Personalised Medicine, discusses how AI refines treatment recommendations by evaluating the latest research and patient-specific information. This level of customisation in treatment approaches exemplifies the shift towards more individualised patient care, with AI at the forefront of this personalised medicine movement [9].

The fourth domain, Patient Monitoring and Telehealth Integration, highlights AI's role in expanding the scope of patient monitoring and virtual healthcare services. AI-driven devices monitor patient health remotely, offering continuous care and supporting the management of chronic conditions. Through telehealth, AI is also breaking down geographical barriers to healthcare access, showcasing its potential in making healthcare more inclusive [10]. In the fifth domain, Workflow and Administrative Efficiency, the focus is on how AI streamlines administrative tasks in healthcare facilities. By automating routine processes, AI enables healthcare staff to concentrate more on direct patient care, thereby improving patient experiences and operational workflows [11]. The sixths domain, Knowledge Management and Decision Support, considers AI's capacity to aid in evidence-based medicine. AI systems collate and analyse the latest medical information, enhancing the decision-making process for healthcare providers. Furthermore, AI fosters improved communication within healthcare teams, leading to more coordinated and comprehensive care for patients [12,13]. Table 1, and Figure 2 in the Appendix, show the six domains and 12 functions where AI can improve CDS. Table 2, in the Appendix, shows the summary of the 32 studies. Table 3, in the Appendix, shows the mapping the six CDS domains and 12 functions to the 32 studies.

Table 1
The six domains and 12 functions where AI can improve CDS.

SR	AI CDS Domain	AI CDS Functions
1	Data-Driven Insights and Analytics	Electronic Health Records (EHR) Analysis: Utilising AI to interpret complex patient data, detect anomalies, and extract meaningful insights. Big Data and Predictive Analytics: Leveraging large datasets to identify health trends, predict disease outbreaks, and assist in epidemiological research.
2	Diagnostic and Predictive Modelling	Diagnostic Assistance: Enhancing the accuracy of diagnoses, particularly in imaging-intensive fields like radiology and pathology. Risk Assessment and Predictive Analytics: Estimating patient risk for various conditions, helping in early intervention and personalised care planning.
3	Treatment Optimisation and Personalised Medicine	Evidence-Based Treatment Recommendations: AI algorithms analysing current research and clinical guidelines to suggest optimal treatment paths. Drug Interaction and Personalised Therapy: Managing medication safety and customising drug therapies based on individual genetic profiles.
4	Patient Monitoring and Telehealth Integration	Remote Patient Monitoring: Using AI-enabled devices for continuous monitoring of patient health, providing real-time data for proactive care. Telehealth and Virtual Care Enhancement: Improving telehealth services with AI-driven preliminary assessments and patient triage.
5	Workflow and Administrative Efficiency	Automated Administrative Processes: Streamlining tasks like patient scheduling, billing, and data management. Resource Management and Allocation: Using AI to optimise hospital staffing, resource allocation, and patient flow.
6	Knowledge Management and Decision Support	Evidence-Based Medicine Enhancement: Utilising AI to keep healthcare providers updated with the latest research, clinical trials, and treatment protocols. Enhanced Communication and Coordination: Facilitating better information exchange among healthcare teams and with patients, ensuring cohesive care delivery.

Discussion and detailed analysis

Domain one: data-driven insights and analytics

Function 1: EHR analysis

The integration of AI in EHR analysis is transforming modern healthcare by providing deep insights into patient care and management [6]. AI's ability to sift through extensive patient data enables the identification of patterns and anomalies crucial for patient health, particularly in chronic disease management where it helps in adjusting treatment strategies [14]. For example, GatorTron, a large AI-based clinical language model developed at the University of Florida in the US using over 90 billion words, showed superior performance in EHR natural language processing and analysis for concept extraction, relation extraction, and clinical inferences [15]. This technology plays a significant role in preventive healthcare by identifying patients at risk of diseases, facilitating early intervention, and potentially reducing disease incidence [16]. AI also personalises patient care by analysing complete health records, enhancing treatment efficacy and patient satisfaction [9]. Beyond clinical applications, AI streamlines administrative tasks in healthcare settings. It automates data entry, extracts information from clinical notes, and assists in coding and billing, thereby increasing efficiency and accuracy [11]. AI's application in EHR analysis is also enhancing CDS systems, offering improvements in alert logic and decision-making, a step towards advanced, learning health systems [17].

Function 2: big data and predictive analytics

The integration of AI in Big Data and Predictive Analytics is revolutionising healthcare by converting large datasets into valuable insights for trend prediction, patient care improvement, and public health decision-making [1]. AI's role in disease prediction and management is particularly significant, as it analyses patterns in extensive data to predict disease outbreaks, identify at-risk populations, and foresee future healthcare needs, thereby aiding public health planning and disease prevention [18]. In clinical settings, AI's predictive analytics can anticipate patient outcomes, such as readmission risks or post-surgery complications, enabling personalised patient care and reducing hospitalisation duration and costs [8]. For example, Philips company has developed advanced predictive analytics tools which were capable of detecting early signs of patient deterioration in ICUs and general wards and predicting at-risk patients in their homes to prevent hospital readmissions. Such tools were found to support informed decision-making in clinical and administrative tasks, resulting in improved patient satisfaction and cost savings [19]. AI's predictive analytics also significantly contributes to health research by identifying correlations between factors like genetic markers and environmental influences on health, aiding in the development of new treatments and understanding complex health conditions [20].

Domain two: diagnostic and predictive modelling

Function 3: diagnostic assistance

The integration of AI in diagnostic assistance marks a significant advancement in medical technology, enhancing accuracy, efficiency, and patient outcomes. Particularly effective in image-based diagnostics, AI algorithms have demonstrated exceptional skill in interpreting medical images like X-rays, MRI scans, and pathology slides. In radiology and pathology, AI aids in detecting and diagnosing diseases such as cancer and neurological disorders with high precision, often spotting disease signs that might be missed by the human eye. Through investigations by several recent studies, AI algorithms were successful in supporting breast cancer grading through mammography, offering improved objectivity and reliability. They also assess histological features like tumour grade, through pathological specimens, and automate quantification of immunohistochemical markers, enhancing diagnostic accuracy, efficiency, and facilitating early cancer diagnosis [21–23]. AI not only reduces diagnostic errors and quickens the diagnostic process but also supports personalised medicine by analysing a patient's entire medical history alongside diagnostic images, leading to more tailored treatment plans [7,24].

Function 4: risk assessment and predictive analytics

AI in risk assessment and predictive analytics is revolutionising healthcare by enabling early intervention and personalised patient care. It analyses diverse data, including medical histories, genetic profiles, and social factors, to predict disease risks, facilitating timely actions against conditions like diabetes and heart disease. This personalised approach extends to chronic disease management, improving life quality and reducing complications [25]. At Mass General's COMPASS, the AI-based POTTER tool, co-developed by Massachusetts General Hospital, Harvard Medical School, and MIT, predicted surgical risks. It assessed emergency surgery mortality and morbidity probabilities, enhancing surgical decision-making, patient counselling, and resource management to improve patient outcomes [26]. Beyond individual care, AI aids public health research, identifying at-risk groups and guiding epidemiological studies [1].

Domain 3: treatment optimisation and personalised medicine

Function 5: evidence-based treatment recommendations

AI contributes to the standardisation of care, reducing variability and ensuring high-quality, evidence-based treatments across different settings. It personalises treatment plans by considering individual patient histories and genetics, enhancing the effectiveness of healthcare [27,28]. One example comes from a report by the National Institute for Health Research of the UK (NIHR), which highlights an AI application used in emergency departments for patients with potential heart attacks. This AI tool analyses routine clinical data along with a specific blood test that measures heart muscle damage. This capability can significantly reduce time spent in emergency departments, improve early treatment of heart attacks, and prevent unnecessary hospital admissions [29].

Function 6: drug interaction and personalised therapy

AI is revolutionising drug interaction and personalised therapy, significantly enhancing medication safety and effectiveness. It proficiently identifies potential drug interactions for patients on multiple medications, thereby preventing adverse effects [30]. In personalised medicine, AI's analysis of genetic data enables the customisation of drug therapies, tailoring medications to individual genetic profiles for optimal efficacy and minimal side effects. Additionally, AI assists in determining precise medication dosages based on patient-specific factors like age and kidney function. Beyond individual patient care, AI accelerates pharmaceutical research by identifying promising drug candidates, expediting the drug development process [31,32]. A notable example is the work conducted at the National University of Singapore. Researchers have developed an AI platform called QPOP, which is designed to personalise drug combination therapy for cancer patients, considering the genetic heterogeneity and diverse factors like ethnicity, age, and diet. It has improved the response rates to drug combinations in cancer treatment by accounting for individual differences in patients' genetic makeup and lifestyle factors [33].

Domain 4: patient monitoring and telehealth integration

Function 7: remote patient monitoring

Remote patient monitoring (RPM) enhanced by AI is transforming patient care, especially for chronic conditions and post-operative recovery [34]. It enables continuous, real-time monitoring of health metrics like heart rate and glucose levels through wearable devices, providing immediate data for healthcare providers. This technology is crucial in chronic disease management, allowing for real-time interventions and personalised medication and lifestyle adjustments [35]. Tenovi company in California, US, has developed an AI-powered RPM system designed to assist patients with diabetes. The system continuously monitor crucial health metrics such as blood glucose levels, physical activity, and dietary habits then the AI algorithms generate personalised meal plans and exercise routines for patients. This tailored approach helps patients achieve better glycaemic control and reduces the risk of complications [36]. For post-operative patients, RPM aids in tracking recovery and reducing hospital visits [10].

Function 8: telehealth and virtual care enhancement

The integration of AI in telehealth is revolutionising healthcare, especially in areas with limited access to traditional healthcare. AI-enhanced telehealth improves access by offering virtual consultations and AI-driven preliminary assessments, overcoming geographical barriers. It also enhances patient triage and assessment, allowing for efficient direction of patients to appropriate care [37]. For chronic diseases, AI-powered telehealth enables continuous monitoring and management, reducing hospital visits. It also aids in mental health support through AI-powered chatbots and virtual therapists [38]. One specific example is an AI system used by doctors in India, designed by the US-based company Welltok. This AI system provided real-time analysis of the doctor's interactions with patients and made recommendations on improving care. This led to a more efficient patient management process, reducing call volume for health plans, providers, and employer benefit managers while offering an on-demand, customised experience. The AI chatbot used in this system, known as Concierge, helped increase resource efficiency, provide cost transparency, and direct customers to lower-cost alternatives. It achieved an accuracy rate of 98 % and was found to save consumers time by over 60 % [39].

Domain 5: workflow and administrative efficiency

Function 9: automated administrative processes

AI's automation of administrative processes in healthcare is markedly enhancing efficiency, accuracy, and patient satisfaction. AI algorithms accurately handle routine tasks like patient scheduling, billing, and data entry, reducing human error and speeding up processes [40]. In managing patient data, AI organises and categorises vast information, aiding healthcare providers in accessing and utilising patient records. It also extracts relevant details from unstructured data like clinical notes. AI's precision in medical billing and coding minimises errors and inefficiencies, reducing claim rejections [41]. AI in healthcare streamlines patient scheduling and reminders, enhancing experiences and engagement. It optimises operational efficiency and resource use [42]. For example, eviCore company in the US has developed software robots with machine-learning capabilities to automate functions ranging from hospital admissions to the billing process. This has proved to enhance productivity, reduce errors, and improve both operational and clinical efficiency, ultimately leading to reduced operating costs for hospitals and healthcare practices [43].

Function 10: resource management and allocation

AI plays a crucial role in enhancing healthcare resource management and allocation, significantly improving service efficiency and effectiveness [42]. It uses predictive analytics to forecast patient inflows, aiding in optimal staffing and managing wait times. AI is pivotal in optimising hospital bed management by predicting patient admissions and discharges, thereby improving patient flow and reducing wait times for beds. It also streamlines supply chain and inventory management, predicting usage patterns and automating reordering to avoid shortages [1]. For example, Productive Edge company in Chicago US, successfully used AI and automation to enhance healthcare administration, streamlining operations for better patient outcomes. By integrating AI with predictive analytics, they optimised healthcare services, reduced administrative costs, and improved accuracy in routine tasks like scheduling and billing [44]. Crucially, during crises like pandemics, AI guides the allocation of resources to areas in greatest need [45].

Domain 6: knowledge management and decision support

Function 11: evidence-based medicine enhancement

The integration of AI in evidence-based medicine (EBM) significantly advances healthcare by grounding clinical decisions in the latest, most reliable medical research and data [28]. AI's ability to analyse and synthesise vast amounts of medical literature and clinical studies helps healthcare professionals stay current with emerging research. It personalises treatment recommendations by considering individual patient profiles, thus aligning care with the most effective evidence-based options [46]. AI also enhances the development and updating of clinical guidelines and protocols, ensuring they reflect current best practices. As a decision-support tool, AI offers evidence-based insights, especially beneficial in complex or rare cases [47]. A specific example of AI in evidence-based medicine enhancement is its role in improving the retrieval and ranking of relevant medical evidence. AI's ability to manage and interpret large-scale, free-text evidence significantly assists in appraising and selecting the best available evidence for clinical use [48].

Function 12: enhanced communication and coordination

AI integration in healthcare communication and coordination greatly enhances the efficiency and effectiveness of healthcare delivery [49]. By acting as a central hub for patient information, AI ensures that all members of a healthcare team, especially in complex cases involving multiple specialists, have access to updated patient data. It improves patient-provider communication through automated systems for reminders, health tips, and facilitating telehealth [37]. Moreover, AI-driven platforms offer personalised health education, empowering patients for better health outcomes. However, challenges of maintaining human interaction and overcoming technological barriers need to be addressed [50]. Pepper Foster Consulting company in the US has developed AI tools to support healthcare care coordination through analysing patient data to identify risks and optimise care pathways and enhancing outcomes and efficiency. AI-driven virtual assistants improved patient engagement and satisfaction, addressed privacy, enhanced integration, and reduced bias challenges [51].

AI challenges in CDS and current efforts

The integration of AI in healthcare, particularly in CDS and telehealth, brings transformative potential but also numerous challenges. Data privacy and security are paramount, as AI systems require access to sensitive patient data, necessitating advanced encryption and anonymisation to mitigate breach risks [52,53]. Additionally, AI algorithms risk perpetuating biases if trained on non-representative datasets, leading to inequitable care. Efforts are underway to diversify datasets and develop transparent, accountable algorithms [47,54]. Interoperability issues arise from incompatible data formats across healthcare systems, impeding AI's data access and analysis, with initiatives like the Fast Healthcare Interoperability Resources (FHIR) standard seeking resolution [42,49]. Regulatory, legal, and ethical concerns also evolve, debating liability and human oversight, with no global consensus on guidelines and standards [4,20,30,42]. Technical challenges, including significant computational resource and expertise requirements, are barriers, particularly in resource-limited settings [4,5,7,52]. Skepticism about AI's reliability and effectiveness persists among healthcare providers and patients, with concerns about AI replacing human decision-making. Continuous learning and adaptation are essential for AI systems to remain relevant, necessitating ongoing data collection and analysis [23,55].

In telehealth, the reliability of AI assessments is challenged by the varying accuracy, calibration, and resolution of wearable devices and remote monitoring tools, and the data processing biases introduced during transmission [5,37]. Efforts to enhance device quality, develop explainable AI models, and implement robust data handling protocols are in progress [56,57]. The digital divide, due to disparity in access to and utilisation of AI technologies and AI driven services among different groups, communities, or regions, further exacerbates health disparities. Addressing this, governments, and other organisations are improving internet infrastructure, providing affordable technology, and conducting educational programs to increase digital literacy [58,59]. However, challenges persist, including technological limitations, ethical and privacy concerns, and the need for integration with existing healthcare systems. The collaborative effort among technologists, healthcare professionals, policymakers, and ethicists aim to maximise AI's benefits while minimising risks in healthcare [60].

Conclusion and recommendations

AI is revolutionising healthcare by enhancing CDS in efficiency, effectiveness, personalisation, and proactivity. It provides rich, actionable insights from EHR, improves predictive analytics, and aids in patient care. AI excels in diagnostic and predictive modelling, aiding in medical imaging and disease risk prediction for early detection and personalised healthcare strategies. It also offers evidence-based treatment recommendations and personalised therapies based on individual genetics. Additionally, AI improves chronic disease management and telehealth, especially in remote areas, streamlines administrative tasks, optimises resource management, and supports evidence-based medicine. However, challenges include data privacy, ethical considerations, and integration with existing systems, emphasising the need to complement rather than replace human expertise in healthcare.

Future directions involve developing ethical, transparent, and user-friendly AI systems. Continuous professional development for healthcare personnel to keep pace with technological advancements is vital. Collaborative efforts between technologists, clinicians, and policymakers are essential to address these challenges effectively. By doing so, AI can be harnessed to its full potential, leading to a more efficient, effective, and equitable healthcare system, blending advanced technology with fundamental human values. This thoughtful and ethical leveraging of AI signifies a healthcare revolution that aligns advanced technology with core human values, promoting a synergistic relationship between technology and human expertise.

CRediT authorship contribution statement

Mohamed Khalifa: Methodology, Funding acquisition, Formal analysis, Conceptualization. **Mona Albadawy:** Project administration, Supervision, Writing – review & editing. **Usman Iqbal:** Writing – review & editing, Methodology, Conceptualization.

Declaration of competing interest

The authors declare no conflicting interests to declare regarding the publication of this manuscript.

Declaration on the use of AI in the writing process

The authors of this manuscript declare that in the writing process of this work, no generative artificial intelligence (AI) or AI-assisted technologies were used to generate content, ideas, or theories. We utilised AI solely for the purpose of enhancing readability and refining language. This use was under strict human oversight and control. After the application of AI technologies, the authors carefully reviewed and edited the manuscript to ensure its accuracy and coherence. The authors understand the potential of AI to generate content that may sound authoritative yet might be incorrect, incomplete, or biased. Considering this, the authors ensured that the manuscript was thoroughly revised by human eyes and judgment. In line with Elsevier's Authorship Policy, the authors confirm that no AI or AI-assisted technologies have been listed as an author or co-author of this manuscript. The authors fully comprehend that authorship comes with responsibilities and tasks that can only be attributed to and performed by humans, and authors have adhered to these guidelines in the preparation of this manuscript.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.cmpbup.2024.100142.

References

[1] M. Khalifa, M. Househ, Utilizing health analytics in improving the performance of hospitals and healthcare services: promises and challenges, Mult. Perspect. Artif. Intell. Healthc.: Opport. Chall. (2021) 23–39.
[2] G. Krishnan, et al., Artificial intelligence in clinical medicine: catalyzing a sustainable global healthcare paradigm, Front. Artifi. Intell. 6 (2023).
[3] C.J. Kelly, et al., Key challenges for delivering clinical impact with artificial intelligence, BMC Med. 17 (2019) 1–9.
[4] S. Abdallah, et al., The impact of artificial intelligence on optimizing diagnosis and treatment plans for rare genetic disorders, Cureus 15 (10) (2023).
[5] A. Al Kuwaiti, et al., A review of the role of artificial intelligence in healthcare, J. Pers. Med. 13 (6) (2023) 951.
[6] N.S. Abul-Husn, E.E. Kenny, Personalized medicine and the power of electronic health records, Cell 177 (1) (2019) 58–69.
[7] R. Najjar, Redefining radiology: a review of artificial intelligence integration in medical imaging, Diagnostics 13 (17) (2023) 2760.
[8] S.B. Golas, et al., Predictive analytics and tailored interventions improve clinical outcomes in older adults: a randomized controlled trial, npj Digit. Med. 4 (1) (2021) 97.
[9] K.B. Johnson, et al., Precision medicine, AI, and the future of personalized health care, Clin. Transl. Sci. 14 (1) (2021) 86–93.
[10] A. Spaulding, et al., Postsurgical remote patient monitoring outcomes and perceptions: a mixed-methods assessment, Mayo Clinic Proceed.: Innov. Qual. Outcome. 6 (6) (2022) 574–583.
[11] A. Bohr, K. Memarzadeh, *The Rise of Artificial Intelligence in Healthcare applications*, in *Artificial Intelligence in Healthcare*, Elsevier, 2020, pp. 25–60.
[12] M. Khalifa, Clinical decision support: strategies for success, Procedia Comput. Sci. 37 (2014) 422–427.
[13] M. Khalifa, O. Alswailem, Clinical decision support knowledge management: strategies for success, ICIMTH 213 (2015) 67–70.
[14] M. Dave, N. Patel, Artificial intelligence in healthcare and education, Br. Dent. J. 234 (10) (2023) 761–764.
[15] X. Yang, A. Chen, N. PourNejatian, A large language model for electronic health records, npj Digit. Med. 5 (1) (2022) 2022, 194.
[16] N. Ghaffar Nia, E. Kaplanoglu, A. Nasab, Evaluation of artificial intelligence techniques in disease diagnosis and prediction, Discov. Artifi. Intell. 3 (1) (2023) 5.
[17] S. Liu, et al., Using AI-generated suggestions from ChatGPT to optimize clinical decision support, J. Am. Med. Inform. Assoc. 30 (7) (2023) 1237–1245.
[18] Y. Kumar, et al., Artificial intelligence in disease diagnosis: a systematic literature review, synthesizing framework and future research agenda, J. Ambi. Intell. Human. Comput. (2022) 1–28.
[19] Philips, Predictive Analytics in Healthcare: Three Real-World Examples, 2020. Available from, https://www.philips.com/a-w/about/news/archive/features/20200604-predictive-analytics-in-healthcare-three-real-world-examples.html.
[20] S.A. Alowais, et al., Revolutionizing healthcare: the role of artificial intelligence in clinical practice, BMC Med. Educ. 23 (1) (2023) 689.
[21] S. Shafi, A.V. Parwani, Artificial intelligence in diagnostic pathology, Diagn. Pathol. 18 (1) (2023) 109.
[22] T. Habuza, et al., AI applications in robotics, diagnostic image analysis and precision medicine: current limitations, future trends, guidelines on CAD systems for medicine, Informat. Med. Unlock. 24 (2021) 100596.
[23] K. Dvijotham, et al., Enhancing the reliability and accuracy of AI-enabled diagnosis via complementarity-driven deferral to clinicians, Nat. Med. 29 (7) (2023) 1814–1820.
[24] Y.Y. Aung, D.C. Wong, D.S. Ting, The promise of artificial intelligence: a review of the opportunities and challenges of artificial intelligence in healthcare, Br. Med. Bull. 139 (1) (2021) 4–15.
[25] G.D. Miner, et al., Practical Data Analytics For Innovation in Medicine: Building Real Predictive and Prescriptive Models in Personalized Healthcare and Medical Research Using AI, ML, and Related Technologies, Academic Press, 2023.
[26] Massachusetts, Predicting Surgical Risk Using Artificial Intelligence, 2021. Available from, https://www.massgeneral.org/compass/patient-and-provider-education/artificial-intelligence-risk-modeling.
[27] S. Tutun, et al., An AI-based decision support system for predicting mental health disorders, Inform. Syst. Front. 25 (3) (2023) 1261–1276.
[28] A.J. Nowak, Artificial Intelligence in Evidence-Based Medicine, 2022.
[29] NIHR, New Report on 10 Promising AI Interventions for Healthcare, 2023. Available from, https://www.nihr.ac.uk/news/new-report-on-10-promising-ai-interventions-for-healthcare/34020.
[30] O. Khan, et al., The future of pharmacy: how AI is revolutionizing the industry, Intell. Pharm. 1 (1) (2023) 32–40.
[31] R. Qureshi, et al., AI in drug discovery and its clinical relevance, Heliyon (2023).
[32] D. Paul, et al., Artificial intelligence in drug discovery and development, Drug Discov. Today 26 (1) (2021) 80.
[33] Millar, A. *Using AI to personalise drug combination therapy*. 2018; Available from: https://www.pharmaceutical-technology.com/features/ai-drug-combination-therapy.
[34] J.M. Helm, et al., Machine learning and artificial intelligence: definitions, applications, and future directions, Curr. Rev. Musculoskelet. Med. 13 (2020) 69–76.
[35] W.-H. Wang, W.-S. Hsu, Integrating artificial intelligence and wearable IOT system in long-term care environments, Sensors 23 (13) (2023) 5913.
[36] Tenovi, How is AI Used in Remote Patient Monitoring?, 2023. Available from, https://tenovi.com/ai-in-remote-patient-monitoring/.
[37] A. Amjad, P. Kordel, G. Fernandes, A review on innovation in healthcare sector (telehealth) through artificial intelligence, Sustainability 15 (8) (2023) 6655.
[38] A. Ahmed, et al., Thematic analysis on user reviews for depression and anxiety chatbot apps: machine learning approach, JMIR Format. Res. 6 (3) (2022) e27654.
[39] P. Sun, How AI Helps Physicians Improve Telehealth Patient Care in Real-Time, 2023. Available from, https://telemedicine.arizona.edu/blog/how-ai-helps-physicians-improve-telehealth-patient-care-real-time.
[40] A. Spatharou, S. Hieronimus, J. Jenkins, Transforming Healthcare with AI: the Impact on the Workforce and Organizations, 10, McKinsey & Company, 2020.
[41] V. Kilanko, The transformative potential of artificial intelligence in medical billing, A Glob. Perspect. (2023).
[42] F.M. Dawoodbhoy, et al., AI in patient flow: applications of artificial intelligence to improve patient flow in NHS acute mental health inpatient units, Heliyon 7 (5) (2021).
[43] eviCore, How Artificial Intelligence Can Make Hospital Administration More Efficient, 2023. Available from, https://www.evicore.com/insights/how-artificial-intelligence-can-make-hospital-administration-more-efficient.
[44] E. Roth, The Future Of Healthcare Administration: AI And Automation, 2023. Available from, https://www.productiveedge.com/blog/the-future-of-healthcare-administration-ai-and-automation.
[45] M. Van der Schaar, et al., How artificial intelligence and machine learning can help healthcare systems respond to COVID-19, Mach. Learn. 110 (2021) 1–14.
[46] H. Siala, Y. Wang, SHIFTing artificial intelligence to be responsible in healthcare: a systematic review, Soc. Sci. Med. 296 (2022) 114782.
[47] N. Naik, et al., Legal and ethical consideration in artificial intelligence in healthcare: who takes responsibility? Front. Surg. 9 (2022) 266.
[48] Y. Peng, et al., AI-generated text may have a role in evidence-based medicine, Nat. Med. (2023) 1–2.
[49] J.T. Kelly, et al., The Internet of Things: impact and implications for health care delivery, J. Med. Internet Res. 22 (11) (2020) e20135.
[50] J. Bajwa, et al., Artificial intelligence in healthcare: transforming the practice of medicine, Fut. Healthc. J. 8 (2) (2021) e188.
[51] P. Foster, AI in Care Coordination: Transforming Healthcare Efficiency and Outcomes, 2023. Available from, https://www.pepperfoster.com/our-insights/ai-in-care-coordination.
[52] A. Alanazi, Clinicians' views on using artificial intelligence in healthcare: opportunities, challenges, and beyond, Cureus 15 (9) (2023).

[53] B. Murdoch, Privacy and artificial intelligence: challenges for protecting health information in a new era, BMC Med. Ethic. 22 (1) (2021) 1–5.
[54] T. Davenport, R. Kalakota, The potential for artificial intelligence in healthcare, Fut. Healthc. J. 6 (2) (2019) 94.
[55] A. Choudhury, Toward an ecologically valid conceptual framework for the use of artificial intelligence in clinical settings: need for systems thinking, accountability, decision-making, trust, and patient safety considerations in safeguarding the technology and clinicians, JMIR Hum. Fact. 9 (2) (2022) e35421.
[56] A. Saranya, R. Subhashini, A systematic review of explainable artificial intelligence models and applications: recent developments and future trends, Decisi. Analyt. J. (2023) 100230.
[57] D.B. Olawade, et al., Using artificial intelligence to improve public health: a narrative review, Front Public Health 11 (2023).
[58] V. Božić, Risks of Digital Divide in Using Artifical Intelligence (AI), 2023.
[59] V. Božić, Artifical intelligence as the reason and the solution of digital divide, Lang. Educ. Technol. 3 (2) (2023).
[60] J. Iqbal, et al., Reimagining healthcare: unleashing the power of artificial intelligence in medicine, Cureus 15 (9) (2023).