Review Article

A Systematic Review of Artificial Intelligence in Healthcare: Opportunities, Advancements, and Challenges

Shazia Naz[1], Asdaq Asima Mehboob Khan[1], Shaista Faheem[2], Arham Yahya Khan[1], Rizwan Taj[1*]

[1]Pakistan Institute of Medical Sciences, Islamabad, Pakistan.

[2]Navel Hospital, Islamabad, Pakistan.

*Corresponding Author

Rizwan Taj
rizwantajpims@gmail.com

Abstract

Objective: To analyze opportunities, advancements, and challenges in the role of artificial intelligence in healthcare services.

Methodology: Studies published between 2020 and 2023 were systematically searched following PRISMA guidelines, and selected from major databases including PubMed, Scopus, and Google Scholar, by using specific Medical Subject Headings (MeSH) and key words related to AI and healthcare services. Selected studies included data on AI's contributions in addressing challenges and opportunities in healthcare. The systematic search and screening process identified a total of 200 records, from which 40 full-text articles were assessed for eligibility. Among these, 15 of them were selected for further review and analysis. The selected studies explored AI applications in clinical decision-making, diagnostics, telemedicine, vaccine research, robotics in neurorehabilitation, and ethical challenges.

Results: Out of the 15 studies included, 12 of them highlighted the advancements and opportunities, whereas 6 of them highlighted the challenges, as 3 out these 15 studies had overlapping results, and included data on both opportunities and challenges. AI's potential in enhancing diagnostics, treatment, patient care, vaccine research, and neurorehabilitation are the main opportunities and advancements observed, alongside challenges such as data security, bias, ethical concerns, and the need for regulatory standards.

Conclusion: From improving diagnostic accuracy and patient care to addressing challenges in healthcare delivery, AI technologies offer promising solutions. However, challenges such as data security, bias, ethical concerns, and regulatory standards remain critical areas requiring further attention and research.

Keywords: Opportunities, Advancements, Challenges, Artificial Intelligence, Healthcare Services.

Introduction

Artificial intelligence (AI) has become synonymous with computational technologies mimicking human intelligence, including cognitive processes such as learning, adaptation, engagement, and sensory comprehension. These technologies have transcended traditional boundaries, finding applications in diverse fields like medicine and healthcare. As early as the middle of 20th century, medical practitioners progressively took steps to integrate AI into diagnostic processes, marking the inception of AI's journey in healthcare.[1] Recent years have witnessed an exponential surge in AI's role in medicine, fueled by the exponential growth in computing capabilities and the abundance of digital data ripe for analysis and utilization.[2,3]

AI's impact on healthcare is multifaceted, influencing various aspects such as clinical practices, diagnostics, rehabilitation, surgery, clinical pharmacology, psychiatric medical services and predictive analytics. Particularly noteworthy is AI's contribution to clinical decision-making and disease diagnosis, actively utilizing vast datasets across modalities to enhance accuracy and efficiency.[4] Moreover, AI's role extends beyond data analysis; it further explores into drug invention, healthcare management, and personalized patient care, revolutionizing a new era of precision medicine.[5,6]

Therefore, despite the AI's potential in healthcare, challenges persist, necessitating rigorous studies to validate efficacy and optimize applications.[7] This paper adopts a structured literature review methodology to investigate opportunities, advancements, and challenges in the role of artificial intelligence in healthcare services.[8] Additionally, this research encompasses advancements in health care by AI specifically in the developed countries within recent time frame, where advancements in AI has changed the way people live. The objective of this systematic literature review was to analyze the opportunities and challenges in healthcare services in recent technological development.

Methodology

Protocol and Registration

This review was conducted in accordance to the standard Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines 2020.[9]

Eligibility Criteria

The published research studies selected for this literature review were analyzed for their study design, publishing year, regional background of publication, core variable of interest i.e. discipline of healthcare affected by AI. The freely available studies in PDF form in English language were included in this review. The studies published in 2020 to 2023 including all types of studies, both qualitative and quantitative, were incorporated into review, as there was no significant literature on AI and its application in health

care before 2020. This led to a notable decrease in the number of relevant articles, as AI is still evolving. The electronic data base was created by searching the research articles with specific MeSH terms and key words in PubMed, Scopus, and Google Scholar. The used MeSH terms included artificial intelligence and healthcare services. Two authors (AMK and SF) performed study selection by evaluating the research studies through research title, abstract and full text studies, whereas the remaining two authors (AYK and RT) counterchecked the articles to identify the role of AI in specific health care domain. Both quantitative and qualitative studies were selected which included data on AI's contributions in addressing challenges and opportunities in healthcare. To reduce subjectivity, all four reviewers independently assessed the risk of bias for each study.[11] Discrepancies were resolved through discussion or by involving a third reviewer, ensuring a consensus was reached. The included research studies were firstly evaluated based on title and abstract. The in-depth reading of full text article done to collect the data. Three authors independently studied and extracted the data from selected studies in 15 days from 17th March to 2nd April 2023.

Study Selection

The study selected parameters such as role of AI in different disciplines of healthcare, ethical concern with AI based healthcare services, accuracy and precision of AI based healthcare services, and challenges to healthcare services due to incorporation of AI. The study selection procedure for the review followed the PRISMA guidelines, ensuring a transparent and systematic approach to data collection and analysis. Initially, a total of 200 records were identified through screening processes by using the search engines i.e. PubMed, Scopus, and Google Scholar.

Figure 1: PRISMA Diagram Showing the Study Selection Procedure for investigating the role of Artificial Intelligence in healthcare services

During the initial screening phase, records were assessed for relevance to the research topic based on the research titles and publication years. After this stage, 130 records were deemed potentially relevant for further evaluation. The screening process involved a detailed assessment of the 130 records based on predefined inclusion and exclusion criteria. This step resulted in the exclusion of 90 records, leaving 40 full-text articles for eligibility assessment. The full-text articles were thoroughly reviewed to determine their eligibility for inclusion in the study. Criteria such as relevance to AI in healthcare services and availability of quantitative and qualitative data were considered. Among the full-text articles assessed, 25 were excluded due to reasons such as lack of relevant data or not meeting inclusion criteria. As a result, 15 studies were considered suitable for this review. The PRISMA diagram visually represents each stage of the study selection procedure in Figure 1.

Results

The results of this study are presented and briefly explained in Table 1. Whereas 6 of them highlighted the challenges, as 3 out these 15 studies had overlapping results, and included data on both opportunities and challenges. AI's potential in enhancing diagnostics, treatment, patient care, vaccine research, and neurorehabilitation are the main opportunities and advancements observed, alongside challenges such as data security, bias, ethical concerns, and the need for regulatory standards.

Discussion

This systematic literature review investigates the recent advancements, trends, opportunities, and challenges of AI in healthcare, focusing on its impact on healthcare outcomes, patient care, diagnosis, treatment, and system optimization. Following PRISMA guidelines, the review analyzed studies from 2020 to 2023, highlighting AI's significant contributions to clinical decision-making, diagnostics, telemedicine, vaccine research, and neurorehabilitation robotics. Despite AI's transformative potential in improving diagnostic accuracy and patient care, the review identifies critical challenges, including data security, bias, ethical concerns, and regulatory standards, underscoring the need for ongoing research and ethical implementation to maximize AI's benefits in healthcare services.

The selected studies provide a diverse range of insights into the intersection of healthcare and technology, particularly in the context of opportunities and challenges posed by the COVID-19 pandemic. A comprehensive retrospective study involved patients to identify undiagnosed HCV cases using advanced predictive algorithms, surpassing traditional screening rates.[11] Jnr[12] and Bagabir et al.[16] highlighted the importance of telemedicine and virtual care during pandemics, emphasizing their role in reducing exposure risks and improving healthcare delivery remotely. The potential of AI-driven tools cannot be underestimated in managing pandemics like COVID-19, focusing on data-driven insights and its impact on vaccine research and development.[13] Hussaini et al.[17] provided a survey-based overview of AI applications in clinical services during the pandemic, showcasing advancements in medical data analysis accuracy us-
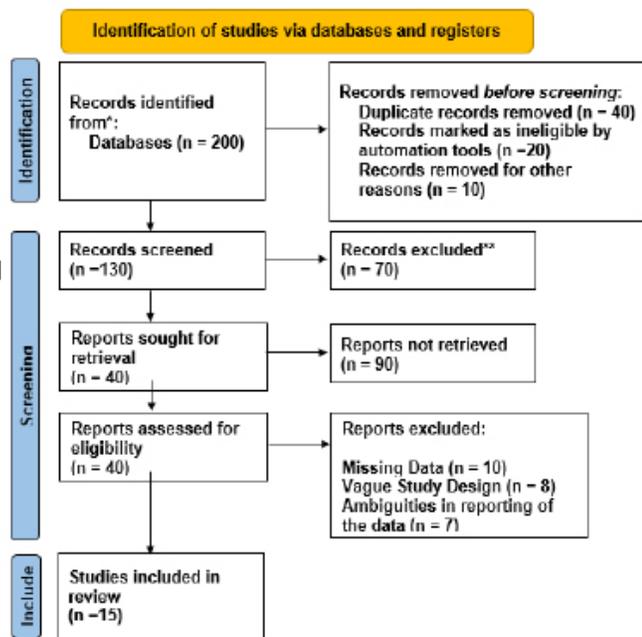
Table 1: Characteristics of Included Studies

s	Author(s)	Research Design	Research Population	Analysis Method	Outcomes
1	Doyle et al.[11]	Retrospective Study	Approximately 10 million patients in the US (2010-2016)	Logistic regression, random forests, gradient boosted trees, stacked ensemble	Using longitudinal medical claims and prescription data, predictive algorithms identified undiagnosed HCV patients with high precision (>95%) at low recall levels (10%). The stacked ensemble method achieved the best performance with 97% precision at over 50% recall, surpassing CDC screening rates.
2	Jnr[12]	Rapid Literature Review	Not specified	Not specified	Advocated for telemedicine during COVID-19 to enable remote diagnosis, treatment, monitoring, and follow-ups, highlighting its importance in reducing exposure risks and enhancing healthcare delivery during pandemics.
3	Santosh[13]	Conceptual Paper	Not specified	Not specified	Emphasized the need for AI-driven tools with active learning models using diverse data to detect and forecast COVID-19 outbreaks globally, highlighting AI's potential in managing big data during pandemics.
4	Hussain et al.[14]	Survey Study	Not specified	Neural networks, SVM, edge significant learning	Summarized AI applications in clinical services during COVID-19, emphasizing Big Data use, classifying AI techniques for pandemic data analysis, and highlighting AI-driven cloud computing benefits and advances in medical data accuracy (up to 90%).
5	Bajwa et al.[15]	Review Article	Not specified	Not specified	Outlined recent AI healthcare breakthroughs, focusing on building reliable AI systems, and proposed future directions to enhance population health, patient care, caregiver experience, and cost reduction.
6	Bagabir et al.[16]	Rapid Literature Review	Not specified	Not specified	Advocated telemedicine for remote COVID-19 care to reduce exposure, emphasizing its importance in pandemic healthcare.
7	Hassani & Silva[17]	Perspective Article	Not specified	Not specified	Discussed ChatGPT's potential in data science for workflow automation and improved decision-making, while addressing concerns about bias and plagiarism, emphasizing its ability to enhance productivity and accuracy.
8	Xu et al.[18]	Systematic Review	Not specified	Not specified	Reviewed recent advances in medical chatbot technology for cancer therapy, discussing diagnosis, treatment, patient support, workflow efficiency, and health promotion, while highlighting implementation limitations and concerns regarding ethical, security, technical, and regulatory standards.
9	Li et al.[19]	Deep Learning Model	Multimodal Longitudinal Electronic Health Records	Hierarchical Transformer-based Model (Hi-BEHRT)	Created Hi-BEHRT, a Transformer-based model, for precise clinical event prediction using multimodal EHR, outperforming existing deep learning methods in forecasting risks like heart failure, diabetes, chronic kidney disease, and stroke, particularly for patients with extensive medical records.
10	Wang et al.[20]	Perspective Article	Not specified	Not specified	Identified metaverse opportunities in healthcare, focusing on Me-TAI for better quality, accessibility, cost-effectiveness, and patient satisfaction. Discussed virtual scanning, data sharing, regulatory science, and medical interventions, addressing privacy, security, and disparity.
11	Yu et al.[21]	Not specified	Clinicians, Healthcare Institutions	Not specified	AI challenges at point-of-care in pandemics: optimization, resource allocation, and addressing flaws in tech, ethics, institutions.
12	Javaid et al.[22]	Not specified	Healthcare	Not specified	ChatGPT's healthcare potential: data reliability, privacy, ethics.
13	Sharma et al.[23]	Not specified	Pharmaceutical, Healthcare	Machine learning, AI	AI/ML accelerates COVID-19 vaccine R&D by identifying candidates and optimizing processes, expediting SARS-COV-2 drug discovery.
14	Lambercy et al.[24]	Not specified	Neurological Patients	Robotics, AI	COVID-19 challenges in neurorehabilitation, driving decentralized, AI-enhanced therapy with robotics.
15	Connelly et al.[25]	Not specified	Healthcare	Not specified	AI drawbacks in healthcare: data security, privacy, ethics, lacking universal guidelines.

ing AI techniques. Similarly, Bajwa et al.[15] and Hassani & Silva[17] discussed recent AI breakthroughs and opportunities, proposing future directions for AI-augmented healthcare systems and addressing challenges such as bias and plagiarism in AI workflows. Xu et al.[18] and Li et al.[19] delved into specific technologies like chatbots and deep learning models for improved clinical predictions and patient support, albeit with considerations for ethical and regulatory standards. Other studies explored innovative approaches such as robotics in healthcare delivery and neurorehabilitation, respectively. They emphasized personalized adaptation and safe use of AI in patient care and therapy settings.[20-24] Connelly et al. highlighted potential drawbacks of AI in healthcare, focusing on data security, privacy, and ethical concerns, urging the establishment of universal guidelines for AI's ethical use in healthcare contexts.[25] These outcomes collectively shed light on the evolving landscape of healthcare technology, emphasizing the promising potential of AI, telemedicine, chatbots, and deep learning models in improving patient care, diagnosis, treatment, and overall healthcare delivery while also addressing critical concerns regarding data security, privacy, ethics, and regulatory standards.

Strengths and Limitations

While there are numerous studies on AI applications in healthcare, the research is often fragmented, focusing on specific aspects or technologies without providing a holistic view. This fragmentation creates a gap in understanding the comprehensive impact of AI across different domains of healthcare. Rapid advancements in AI technologies over the past few years necessitate an updated review. Previous reviews might not capture the latest innovations, ethical concerns, and regulatory changes that have emerged between 2020 and 2023. By identifying current opportunities and challenges, the review provides valuable insights that can guide future research directions, inform policymakers, and help healthcare providers make informed decisions about adopting AI technologies. However, this study also has certain noteworthy limitations. The quantitative analysis in the review is based on only five studies, which may restrict the generalizability and robustness of the numerical findings. This small sample size might not fully capture the range of quantitative impacts of AI in healthcare. Moreover, AI in healthcare is a rapidly evolving field, with new developments and technologies emerging continuously. The findings of this review might quickly become outdated, necessitating continuous updates to maintain relevance.

Conclusion

This systematic literature review emphasizes the transformative potential of AI in revolutionizing healthcare services. The reviewed studies collectively highlight AI's impact across various healthcare domains, including diagnostics, clinical decision-making, telemedicine, neurorehabilitation, and vaccine research. The integration of AI technologies showed promising outcomes in enhancing accuracy, efficiency, and patient care experiences within healthcare ecosystems. However, alongside these opportunities, significant challenges such as data security, ethical considerations, bias mitigation, and regulatory standards emerge as crucial areas of concern.

Future Implications

The review emphasizes the importance of establishing universal guidelines and ethical frameworks for AI's responsible deployment in healthcare settings. Addressing these challenges is paramount to ensure patient privacy, data integrity, and fair AI-driven decision-making processes. Furthermore, the review points out the need for continued research and validation of AI-driven innovations to optimize healthcare outcomes effectively. Future research endeavors should focus on refining AI algorithms, improving interoperability among healthcare systems, enhancing data quality, and addressing societal and ethical implications comprehensively. In conclusion, AI holds immense promise in transforming healthcare delivery, improving patient outcomes, and optimizing resource utilization. However, realizing this potential requires a collaborative effort among researchers, healthcare professionals, policymakers, and technology developers to navigate challenges effectively and harness AI's capabilities for the betterment of global healthcare systems.

References

1. Chidambaram S, Maheswaran Y, Patel K, Sounderajah V, Hashimoto DA, Seastedt KP, McGregor AH, Markar SR, Darzi A. Using artificial intelligence-enhanced sensing and wearable technology in sports medicine and performance optimisation. Sensors. 2022 Sep;22(18):6920.doi: 10.3390/s22186920.

2. Sharma R, Kshetri N. Digital healthcare: Historical development, applications, and future research directions. International journal of information management. 2020 Aug 1(1);53:102105.

3. Hirani R, Noruzi K, Khuram H, Hussaini AS, Aifuwa EI, Ely KE, Lewis JM, Gabr AE, Smiley A, Tiwari RK, Etienne M. Artificial Intelligence and Healthcare: A Journey through History, Present Innovations, and Future Possibilities. Life. 2024 Apr;14(5):557.

4. Wani SU, Khan NA, Thakur G, Gautam SP, Ali M, Alam P, Alshehri S, Ghoneim MM, Shakeel F. Utilization of artificial intelligence in disease prevention: Diagnosis, treatment, and implications for the healthcare workforce. InHealthcare 2022 Mar;24(4) 608-609. MDPI. doi: 10.3390/healthcare10040608

5. Ranchon F, Chanoine S, Lambert-Lacroix S, Bosson JL, Moreau-Gaudry A, Bedouch P. Development of artificial intelligence powered apps and tools for clinical pharmacy services: A systematic review. International Journal of Medical Informatics. 2023 Apr; 1(172):1-26. doi: 10.1016/j.ijmedinf.2022.104983

6. Forcier MB, Gallois H, Mullan S, Joly Y. Integrating artificial intelligence into health care through data access: can the GDPR act as a beacon for policymakers? Journal of Law and the Biosciences. 2019;6(1):317-335. doi: 10.1093/jlb/lsz013.

7. Alyabroodi Z, Abuasal S, Alamareen AA, Al-mashagbeh MH, Hakami H. The Impact of Artificial Intelligence on Healthcare Area—A Systematic Review. Artificial Intelligence, Internet of Things, and Society 5.0. 2023 Nov;9(1)485-494.

8. Lee D, Yoon SN. Application of artificial intelligence-based technologies in the healthcare industry: Opportunities and challenges. International Journal of Environmental Research and Public Health. 2021 Jan;18(1):271. doi: 10.3390/ijerph18010271

9. Parums DV. Review articles, systematic reviews, meta-analysis, and the updated preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines. Medical science monitor: international medical. Journal of Experimental and Clinical Research. 2021;Jul 27(1):475-481. doi: 10.12659/MSM.934475

10. Minozzi S, Dwan K, Borrelli F, Filippini G. Reliability of the revised Cochrane risk-of-bias tool for randomised trials (RoB2) improved with the use of implementation instruction. Journal of clinical epidemiology. 2022 Jan;1(141):99-105. doi: 10.1016/j.jclinepi.2021.09.021

11. Doyle OM, Leavitt N, Rigg JA. Finding undiagnosed patients with hepatitis C infection: an application of artificial intelligence to patient claims data. Scientific Reports. 2020 Jun;10(1):10521-10525. doi: 10.1038/s41598-020-67013-6

12. Jnr BA. Use of telemedicine and virtual care for remote treatment in response to COVID-19 pandemic. Journal of Medical Systems. 2020;44(7):132. doi: 10.1007/s10916-020-01596-

13. Santosh K. AI-driven tools for coronavirus outbreak: need of active learning and cross-population train/test models on multitudinal/multimodal data. Journal of medical systems. 2020;44(5):93. doi: 10.1007/s10916-020-01562-1

14. Hussain AA, Bouachir O, Al-Turjman F, Aloqaily M. Notice of retraction: AI techniques for COVID-19. IEEE access. 2020;8:128776-95. doi: 10.1109/ACCESS.2020.3007939.

15. Bajwa J, Munir U, Nori A, Williams B. Artificial intelligence in healthcare: transforming the practice of medicine. Future Healthcare journal. 2021;8(2):188-190. doi: 10.7861/fhj.2021-0095

16. Bagabir SA, Ibrahim NK, Bagabir HA, Ateeq RH. Covid-19 and Artificial Intelligence: Genome sequencing, drug development and vaccine discovery. Journal of Infection and Public Health. 2022;15(2):289-96. doi: 10.1016/j.jiph.2022.01.011

17.Hassani H, Silva ES. The role of ChatGPT in data science: how ai-assisted conversational interfaces are revolutionizing the field. Big data and cognitive computing. 2023 Mar 27;7(2):62.

18. Xu L, Sanders L, Li K, Chow JC. Chatbot for health care and oncology applications using artificial intelligence and machine learning: systematic review. JMIR cancer. 2021;7(4):27850-27855. doi: 10.2196/27850

19. Li Y, Mamouei M, Salimi-Khorshidi G, Rao S, Hassaine A, Canoy D, et al. Hi-BEHRT: hierarchical transformer-based model for accurate prediction of clinical events using multimodal longitudinal electronic health records. IEEE Journal of Biomedical and Health Informatics. 2022;27(2):1106-1117. doi: 10.1109/JBHI.2022.3224727

20. Wang G, Badal A, Jia X, Maltz JS, Mueller K, Myers KJ, et al. Development of metaverse for intelligent healthcare. Nature Machine Intelligence. 2022 Nov;4(11):922-929. doi: 10.1038/s42256-022-00549-6.

21. Yu M, Tang A, Brown K, Bouchakri R, St-Onge P, Wu S, et al. Integrating artificial intelligence in bedside care for covid-19 and future pandemics. British medical journal. 2021;375. doi: 10.1136/bmj-2021-068197

22. Javaid M, Haleem A, Singh RP. ChatGPT for healthcare services: An emerging stage for an innovative perspective. BenchCouncil Transactions on Benchmarks, Standards and Evaluations. 2023;3(1):100105.

23. Sharma A, Virmani T, Pathak V, Sharma A, Pathak K, Kumar G, et al. Artificial intelligence-based data-driven strategy to accelerate research, development, and clinical trials of COVID vaccine. BioMed research international. 2022;2022. doi: 10.1155/2022/7205241

24. Lambercy O, Lehner R, Chua K, Wee SK, Rajeswaran DK, Kuah CW, Ang WT, Liang P, Campolo D, Hussain A, Aguirre-Ollinger G. Neurorehabilitation from a distance: can intelligent technology support decentralized access to quality therapy?. Frontiers in Robotics and AI. 2021 May; 5 (8):612415. doi: 10.3389/frobt.2021.612415.

25. Connelly TM, Malik Z, Sehgal R, Byrnes G, Coffey JC, Peirce C. The 100 most influential manuscripts in robotic surgery: a bibliometric analysis. Journal of Robotic Surgery. 2020;14 (1):155-165. doi: 10.1007/s11701-019-00956-9