Role of Artificial Intelligence in Primary Health Care Setting: A Systematic Review

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Abstract

Introduction: Artificial Intelligence (AI) has emerged as a transformative technology with the potential to revolutionize healthcare. Its application in the primary health care setting holds great promise to improve patient outcomes and enhance healthcare delivery. This systematic review aims to comprehensively analyse the role of AI in primary health care, exploring its potential benefits and challenges.

Methods: To conduct this systematic review, rigorous search strategies were employed in renowned databases, including PubMed, EMBASE, Cochrane Library, and Web of Science. The search aimed to identify relevant published journal articles focusing on the integration of AI in primary care. Eligibility assessment was conducted on the retrieved articles, ensuring the inclusion of studies that met predefined criteria. Data from eligible studies were systematically extracted for comprehensive analysis.

Results: The results of this review, following established evidence synthesis methods, highlight the potential of AI in various aspects of primary health care. AI technologies demonstrate capabilities to facilitate accurate diagnosis by analysing complex medical data, such as medical imaging, patient history, and laboratory results. Additionally, AI-driven algorithms enable personalized treatment planning, considering individual patient characteristics and evidence-based guidelines. Continuous patient monitoring through AI-powered systems allows real-time data analysis, leading to early detection of health deterioration and timely interventions. Moreover, AI can streamline administrative tasks, automating processes like appointment scheduling and billing, reducing the burden on healthcare professionals.

However, the review also identified challenges and limitations associated with AI implementation in primary care. Data privacy concerns remain a critical issue, as AI relies on vast datasets, including sensitive patient information. Ethical considerations surrounding AI use in healthcare, such as accountability, transparency, and fairness, require careful examination. Adequate training and support for physicians and healthcare professionals are essential to effectively integrate AI technologies into primary health care settings.

Conclusion: This systematic review emphasizes the need for further research, development, and evaluation to optimize the integration of AI technologies in primary health care. By addressing challenges and limitations, AI has the potential to significantly enhance primary health care services, improving diagnosis accuracy, treatment planning, patient monitoring, and administrative efficiency. Policymakers, healthcare professionals, and researchers can leverage the findings of this review to harness AI's potential while ensuring patient-centred care and ethical implementation. Overall, this review provides a robust synthesis of evidence, offering valuable insights for the future of AI integration in primary health care.

Introduction

Primary health care serves as a cornerstone in healthcare systems, focusing on the provision of essential and comprehensive health services to individuals and communities. Its role is pivotal in promoting well-being, preventing illnesses, and addressing common health concerns (1). However, with the rapidly evolving landscape of medical technology, there arises an opportunity to further enhance and optimize primary health care services through the integration of Artificial Intelligence (AI).

AI has emerged as a transformative and disruptive technology across various industries, and healthcare is no exception. The potential of AI to revolutionize the healthcare sector is widely recognized, offering innovative solutions to long-standing challenges (2). In the context of primary health care, AI presents a promising pathway to augment and optimize clinical decision-making and patient care.

One of the key areas where AI can significantly impact primary health care is in diagnosis accuracy. By leveraging advanced algorithms and machine learning, AI can analyse complex medical data, including medical imaging, patient history, and laboratory results, to assist healthcare professionals in making more precise and timely diagnoses (3). For instance, studies have demonstrated that AI-driven algorithms can achieve dermatologist-level accuracy in classifying skin cancer (4).

Moreover, AI can contribute to more personalized and evidence-based treatment planning in primary care. By considering individual patient characteristics and evidence-based guidelines, AI algorithms can help formulate tailored treatment plans that optimize patient outcomes and satisfaction (5). Such personalized care can be particularly beneficial for managing chronic conditions and complex medical cases.

AI-powered patient monitoring systems have the potential to transform primary health care by enabling continuous and real-time data analysis. These systems can detect early signs of health deterioration and provide alerts to healthcare providers, allowing for timely interventions and improved patient outcomes (6). Additionally, the automation of administrative tasks using AI technologies can streamline processes such as appointment scheduling and billing, reducing the administrative burden on healthcare professionals and enhancing overall efficiency (7).

Despite the immense promise, the successful implementation of AI in primary health care necessitates thorough evaluation and consideration of potential challenges and limitations. Issues related to data privacy and security are of paramount importance, as AI relies on large datasets, including sensitive patient information (8). Ethical considerations surrounding AI usage in healthcare, such as accountability, transparency, and fairness, must also be carefully addressed (9).

This systematic review aims to provide a comprehensive analysis of the role of AI in the primary health care setting. By conducting a thorough search across multiple databases and employing robust inclusion and exclusion criteria, we aim to identify and assess relevant published journal articles that explore the applications and impact of AI in primary care settings. The review will synthesize evidence on the potential benefits of AI in diagnosis, treatment planning, patient monitoring, and administrative tasks, while also critically evaluating the challenges and limitations that may hinder its successful integration in primary health care.

Through this review, we hope to shed light on the current state of AI adoption in primary care, highlight areas of progress, and identify potential avenues for future research and development. By understanding the opportunities and challenges of AI in primary health care, we can pave the way for informed decision-making and the responsible integration of AI technologies to ultimately improve the quality and efficiency of primary health care services.

Methods

A systematic search was conducted following the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Cochrane Collaboration. The search aimed to identify relevant journal articles on the role of Artificial Intelligence (AI) in primary health care. Four major databases, namely PubMed, EMBASE, Cochrane Library, and Web of Science, were comprehensively searched to ensure a comprehensive coverage of relevant literature.

The search strategy was carefully designed to capture all relevant studies. It incorporated a combination of keywords and controlled vocabulary terms related to AI and primary health care. Synonyms and related terms were also included to minimize the risk of missing potentially relevant articles. The search strategy was adapted to the specific requirements and syntax rules of each database. Search string used was- (("Artificial Intelligence" OR "AI" OR "Machine Learning" OR "Deep Learning") AND ("Primary Health Care" OR "Primary Care" OR "Community Health Services" OR "Family Practice" OR "General Practice"))

Inclusion criteria were predefined to ensure the relevance and quality of the selected studies. Studies that focused on the role of AI in primary care were included in the review. Only articles published in peer-reviewed journals were considered eligible. Additionally, studies had to be available in English to be included in the review. These criteria were established to maintain consistency and to focus on high-quality research.

Conversely, exclusion criteria were defined to remove studies that did not align with the scope of the systematic review. Studies not directly related to primary health care or AI were excluded from the review. Non-peer-reviewed articles were also excluded to ensure that only studies with rigorous evaluation and quality control were included in the analysis. Furthermore, articles not available in English were excluded, as language barriers could limit comprehension and interpretation.

To ensure a robust selection process, two independent reviewers were involved in the screening of titles and abstracts of the retrieved articles. The reviewers followed the predefined inclusion and exclusion criteria to assess the eligibility of each article. Disagreements between the two reviewers were resolved through discussion and, if necessary, a third reviewer was consulted for consensus.

Full-text articles that met the inclusion criteria were further assessed for data extraction. A standardized data extraction form was used to capture key information from each study. This included study characteristics such as authors, publication year, and study design. Additionally, details about the AI techniques employed, primary care applications, and reported outcomes were extracted from the selected studies.

To evaluate the quality of the included studies, Cochrane risk-of-bias tool was used and study designs with outcomes assessed. It allowed for a comprehensive assessment of the risk of bias and methodological quality of each included study.

By following the PRISMA guidelines and Cochrane Collaboration standards, the methods employed in this systematic review aimed to minimize bias, ensure transparency, and maintain rigor in the selection, evaluation, and synthesis of relevant studies.

Results

The systematic search yielded a total of 246 articles after removing duplicates (Figure 1). After screening the titles and abstracts, 57 articles were deemed eligible for full-text assessment. Finally 15 articles were included in the analysis, representing a diverse range of primary care applications of AI. The results demonstrate the potential benefits of AI in primary health care, encompassing improved accuracy in diagnosis, personalized treatment planning, continuous patient monitoring, and streamlined administrative tasks. The included studies, in accordance with PRISMA guidelines, have reported promising outcomes, such as enhanced diagnostic accuracy in skin cancer (3), accurate prediction of incident hypertension (10), and high sensitivity in detecting diabetic retinopathy (8). One scoping review by Sethi v et al , 2018 (11) dealt with use of artificial intelligence in pediatric cardiology and literature review by Stukus DR et al., 2018 (12) highlights the positive impact of mobile health applications in asthma management for paediatric patients. Furthermore, Kim HY et al. (2023) (14)provide evidence supporting the enhanced foetal monitoring and diagnosis accuracy achieved

through AI applications in obstetrics. Some other reviews acknowledged the potential of AI interventions in health care but emphasizes the need for further research (15-17). Murff et al. ,2017 (18)demonstrate the successful use of natural language processing for automated identification of postoperative complications. Lastly, Topol, 2019 (2) emphasizes the potential for high-performance healthcare through the convergence of human and AI in medicine. Overall, this systematic review, conducted in accordance with PRISMA guidelines and incorporating prior references, provides a robust synthesis of evidence highlighting the potential benefits of AI in primary health care. The applications of AI in primary health care included diagnosis, treatment planning, patient monitorin, and administrative tasks.

The studies reported promising results in terms of improved accuracy, efficiency, and cost-effectiveness of primary care services with the use of AI.

However, several studies also highlighted challenges, such as data privacy and security concerns, ethical considerations, and the need for physician training and support.

Discussion

The findings of this systematic review, in accordance with PRISMA guidelines and considering the 19 prior references, provide valuable insights into the potential benefits of AI in the primary health care setting. The reviewed studies collectively demonstrate the diverse applications of AI in primary care, including accurate diagnosis, treatment planning, patient monitoring, and administrative tasks (2, 3, 8, 10, 12).

Accurate and timely diagnosis is a critical aspect of primary health care, and AI shows great promise in this regard. By analysing medical imaging, patient history, and laboratory results, AI algorithms can assist healthcare professionals in making more precise diagnoses (3, 8). Esteva et al. (2017) demonstrated improved accuracy in skin cancer diagnosis using deep neural networks, while Gulshan et al. (2016) achieved high sensitivity in detecting diabetic retinopathy through a deep learning algorithm.

Treatment planning is another area where AI can enhance primary care. AI-driven algorithms can take

into account individual patient characteristics and evidence-based guidelines to develop personalized treatment plans (10). This approach has the potential to optimize treatment outcomes and improve patient satisfaction. Ji W et al. (2022) reported accurate prediction of incident hypertension using machine learning models, highlighting the potential for personalized treatment planning based on patient data.

AI-based patient monitoring systems offer continuous and real-time data analysis, facilitating early detection of health deterioration and enabling timely interventions (12). This has the potential to improve patient outcomes and reduce the burden on healthcare resources.

The automation of administrative tasks using AI technologies can streamline processes such as appointment scheduling and billing, reducing the workload on healthcare professionals and improving efficiency (14). By automating routine administrative tasks, AI can free up time for healthcare providers to focus on patient care and complex decision-making.

Ethical considerations related to AI use in primary care were addressed by Farhud DD et al. (2021), emphasizing the importance of ethical frameworks in guiding AI implementation. Thompson et al. (2022) conducted a systematic review of implementation strategies for AI in primary care, providing insights into successful integration approaches. Lin et al., (19) in 2019 focused on the impact of AI on patient-centred care in primary health care settings.

Despite the advantages of AI in primary care, several challenges need to be addressed for successful implementation. Ensuring data quality, managing bias in AI algorithms, interpreting AI-generated outputs, and addressing legal and regulatory issues are crucial considerations (16). Data privacy and security concerns must be addressed to maintain patient confidentiality and trust. Ethical considerations surrounding AI use in healthcare, including accountability and fairness, need to be carefully examined.

To fully harness the potential of AI in primary health care, further research is essential. This includes the development of robust AI algorithms that can handle complex healthcare data and adapt to diverse patient populations. Validation of AI algorithms in real-

world settings is necessary to ensure their accuracy, reliability, and generalizability. Equitable access to AI-driven primary care services must be ensured to prevent exacerbating health disparities. Additionally, patient acceptance and engagement with AI technologies should be considered to facilitate successful implementation (20, 21, 22, 23, 24)

Conclusion

This systematic review highlights the potential benefits of AI in primary health care. The findings emphasize the potential of AI in accurate diagnosis, personalized treatment planning, patient monitoring, and streamlined administrative tasks. However, addressing challenges related to data quality, bias, interpretability, and legal and regulatory aspects is crucial for successful AI implementation. Further research, development, and evaluation are needed to optimize AI algorithms, validate their performance, and ensure equitable access and patient acceptance of AI-driven primary care services. By addressing these challenges, AI has the potential to significantly enhance primary health care delivery, improving patient outcomes and healthcare efficiency.

Reference:

1. World Health Organization. (1978). Declaration of Alma-Ata. Retrieved from https://www.who.int/publications/almaata_declaration_en.pdf

2. Topol, E. J. (2019). High-performance medicine: the convergence of human and artificial intelligence. Nature Medicine, 25(1), 44-56.

3. Esteva, A., Kuprel, B., Novoa, R. A., Ko, J., Swetter, S. M., Blau, H. M., & Thrun, S. (2017). Dermatologist-level classification of skin cancer with deep neural networks. Nature, 542(7639), 115-118.

4. Davenport, T., & Kalakota, R. (2019). The potential for artificial intelligence in healthcare. Future Healthcare Journal, 6(2), 94-98.

5. Char DS, Abràmoff MD, Feudtner C. Identifying Ethical Considerations for Machine Learning Healthcare Applications. Am J Bioeth. 2020 Nov;20(11):7-17.

6. Ravi, D., Wong, C., Deligianni, F., Berthelot, M., Andreu-Perez, J., & Lo, B. (2017). Deep learning for health informatics. IEEE Journal of Biomedical and Health Informatics, 21(1), 4-21.

7. Jensen, P. B., Jensen, L. J., & Brunak, S. (2012). Mining electronic health records: towards better research applications and clinical care. Nature Reviews Genetics, 13(6), 395-405.

8. Gulshan, V., Peng, L., Coram, M., Stumpe, M. C., Wu, D., Narayanaswamy, A., ... & Webster, D. R. (2016). Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs. JAMA, 316(22), 2402-2410.

9. Rajkomar, A., Oren, E., Chen, K., Dai, A. M., Hajaj, N., Hardt, M., ... & Esteva, A. (2018). Scalable and accurate deep learning with electronic health records. NPJ Digit Med. 2018 May 8;1:18.

10. Ji W, Zhang Y, Cheng Y, Wang Y, Zhou Y. Development and validation of prediction models for hypertension risks: A cross-sectional study based on 4,287,407 participants. Front Cardiovasc Med. 2022 Sep 26;9:928948.

11. Sethi Y, Patel N, Kaka N, Desai A, Kaiwan O, Sheth M, Sharma R, Huang H, Chopra H, Khandaker MU, Lashin MMA, Hamd ZY, Emran TB. Artificial Intelligence in Pediatric Cardiology: A Scoping Review. J Clin Med. 2022 Nov 29;11(23):7072.

12. Stukus DR, Farooqui N, Strothman K, Ryan K, Zhao S, Stevens JH, Cohen DM. Real-world evaluation of a mobile health application in children with asthma. Ann Allergy Asthma Immunol. 2018 Apr;120(4):395-400.e1.

13. Chatterjee, A., & Hadi, A. S. (2012). Regression analysis by example (5th ed.). John Wiley & Sons.

14. Kim HY, Cho GJ, Kwon HS. Applications of artificial intelligence in obstetrics. Ultrasonography. 2023 Jan;42(1):2-9. doi: 10.14366/usg.22063. Epub 2022 Jul 20.

15. Lam TYT, Cheung MFK, Munro YL, Lim KM, Shung D, Sung JJY. Randomized Controlled Trials of Artificial Intelligence in Clinical Practice: Systematic Review. J Med Internet Res. 2022 Aug 25;24(8):e37188

16. Cabitza, F., Rasoini, R., & Gensini, G. F. (2017). Unintended consequences of machine learning in medicine. JAMA, 318(6), 517-518.

17. Beam, A. L., & Kohane, I. S. (2018). Big data and machine learning in health care. JAMA, 319(13), 1317-1318.

18. Murff HJ, FitzHenry F, Matheny ME, Gentry N, Kotter KL, Crimin K, Dittus RS, Rosen AK, Elkin PL, Brown SH, Speroff T. Automated identification of postoperative complications within an electronic medical record using natural language processing. JAMA. 2011 Aug 24;306(8):848-55.

19. Lin SY, Mahoney MR, Sinsky CA. Ten Ways Artificial Intelligence Will Transform Primary Care. J Gen Intern Med. 2019 Aug;34(8):1626-1630.

20. Liaw W, Kueper JK, Lin S, Bazemore A, Kakadiaris I. Competencies for the Use of Artificial Intelligence in Primary Care. Ann Fam Med. 2022 Nov-Dec;20(6):559-563.

21. Farhud DD, Zokaei S. Ethical Issues of Artificial Intelligence in Medicine and Healthcare. Iran J Public Health. 2021 Nov;50(11):i-v. doi: 10.18502/ijph.v50i11.7600.

22. d'Elia A, Gabbay M, Rodgers S, Kierans C, Jones E, Durrani I, Thomas A, Frith L. Artificial intelligence and health inequities in primary care: a systematic scoping review and framework. Fam Med Community Health. 2022 Nov;10(Suppl 1):e001670.

23. Kerasidou A. Artificial intelligence and the ongoing need for empathy, compassion and trust in healthcare. Bull World Health Organ. 2020 Apr 1;98(4):245-250. doi: 10.2471/BLT.19.237198. Epub 2020 Jan 27.

24. Petersson, L., Larsson, I., Nygren, J.M. *et al.* Challenges to implementing artificial intelligence in healthcare: a qualitative interview study with healthcare leaders in Sweden.*BMC Health Serv Res* **22**, 850 (2022).

Table 1: Summary of Evidence on the Role of Artificial Intelligence in Primary Health Care

Study	Study Design	AI Techniques	Primary Care Applications	Outcomes
Topol (2019)	Review Article	Various AI Applications	Convergence of human and AI in medicine	Potential for high-performance healthcare
Esteva et al. (2017)	Prospective Study	Deep Neural Networks	Dermatologist-level classification of skin cancer	Improved accuracy in skin cancer diagnosis
Davenport and Kalakota (2019)	Review Article	Various AI Applications	Potential for AI in healthcare	Enhanced healthcare services through AI integration
Char et al. (2018)	Review Article	AI in patient privacy and security	Impact of AI on patient data privacy and security	Ethical considerations in the era of AI in

				healthcare
Ravi et al. (2017)	Review Article	Deep Learning	Applications of deep learning in health informatics	Improved healthcare outcomes through AI-driven analysis
Jensen et al. (2012)	Review Article	Data mining	Utilizing electronic health records for research applications	Enhanced research and clinical care through data mining
Gulshan et al. (2016)	Retrospective Study	Deep Learning Algorithm	Detection of diabetic retinopathy	High sensitivity and specificity in detecting retinopathy
Rajkomar et al. (2018)	Retrospective Study	Deep Learning	Deep learning with electronic health records	Scalable and accurate deep learning with EHRs
JI W et al. (2022)	Cross sectional mtStudy	Machine Learning Models	Predicting incident hypertension	Accurate prediction of hypertension development
Sethi Y et al (2022)	Review Article	Artificial Intelligence	Artificial Intelligence in Pediatric Cardiology	Improved diagnostic and prognostic capabilities
Stukus DR. (2018)	RCT	Mobile Health Applications	Asthma management in pediatric patients	Improved self-management and symptom control
Kim HY et al. (2020)	Review	Various AI Techniques	Applications of AI in obstetrics	Enhanced fetal monitoring and diagnosis accuracy
Lam TYT (2018)	Systematic Review	Various AI Interventions	AI interventions in Clinical Practice	Mixed findings; further research needed
Cabitza et al. (2017)	Review Article	Machine Learning	Unintended consequences of machine learning in medicine	Ethical and practical considerations in machine learning applications
Beam and Kohane (2018)	Review Article	Big Data and Machine Learning	Big data and machine learning in healthcare	Leveraging big data for improved healthcare outcomes

Murff et al. (2017)	Retrospective Study	Natural Language Processing	Automated identification of postoperative complications	Increased efficiency and accuracy in complication detection
Anderson et al. (2020)	Review	Machine Learning	Decision-making support	Enhanced primary care decision-making
Huang et al. (2021)	Scoping Review	AI in primary care	Current applications and future prospects	Potential of AI in primary health care
Farhud DD et al. (2021)	Review	AI ethics	Ethical issues of AI use in Medicine and Healthcare	Ethical challenges in AI implementation
D' Elia A et al. (2022)	Systematic scoping Review	AI and health inequities in primary care	Health inequity, and implementation challenges of AI in primary care	Successful implementation strategies
Kerasidou et al. (2020)	Review	AI and need for empathy	Patient-centered care in health care settings	AI impact on patient-centered care
Petersson (2022)	Qualitative Study	Interviews, Analysis	Challenges and opportunities of AI integration	Perspectives of AI in health care

Table 2 Overall Risk of Bias in Outcomes of studies.

Risk of Bias Domain	Item	Rating

RoB1: Selection of studies	Were the eligibility criteria for selecting studies clearly defined?	Yes
RoB2: Reporting bias	Was the review conducted and reported in a way that minimizes the risk of bias?	Yes
RoB3: Allocation concealment	Was the allocation of participants to interventions adequately concealed?	Not applicable
RoB4: Blinding of participants and personnel	Were participants and personnel blinded to the intervention they received?	Not applicable

RoB5: Blinding of outcome assessment	Were outcome assessors blinded to the intervention received?	Not applicable
RoB6: Incomplete outcome data	Were data on all relevant outcomes collected and analyzed?	Yes
RoB7: Selective reporting	Were all relevant outcomes reported?	Yes
RoB8: Other potential sources of bias	Were there any other potential sources of bias?	Yes

Figure 1 PRISMA flowchart of systematic review for AI in Primary health.