World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Review Article)

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AI in primary care: Opportunities and challenges for preventive healthcare

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World Journal of Advanced Research and Reviews, 2026, 29(03), 862-869

Publication history: Received on 10 January 2026; revised on 26 February 2026; accepted on 28 February 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.29.3.0140

Abstract

Background: Primary care systems face growing pressure from rising patient demand, increasing multimorbidity, expanding volumes of clinical data, and persistent workforce constraints. Artificial intelligence (AI)—including machine learning (ML) and deep learning (DL)—is increasingly deployed to support diagnosis, risk stratification, clinical decision support, and operational workflows in primary care.[1–5] However, concerns remain regarding external validity, bias, clinical integration, safety, and trust.

Objective: This systematic review synthesises evidence on how AI improves healthcare delivery in primary care settings compared with conventional clinician-only approaches, focusing on diagnostic performance, efficiency, workload, and patient-relevant outcomes.

Methods: A systematic literature search was conducted across PubMed, ResearchGate, Cochrane Library, and Google Scholar for publications from 2015 onwards using predefined keywords and Medical Subject Headings related to "artificial intelligence," "machine learning," "diagnosis," "patient outcomes," and "primary care." Eligibility criteria were structured using a PICO framework and screening was conducted in accordance with PRISMA 2020 principles.[6] Data were extracted into Microsoft Excel using a structured framework, and findings were synthesised narratively due to heterogeneity in study designs and outcomes. Study quality was appraised using the Critical Appraisal Skills Programme (CASP) checklists.

Results: Evidence indicates that AI can enhance primary care delivery by improving diagnostic and prognostic accuracy, accelerating clinical decision-making, enabling personalised risk assessment and treatment support, and reducing administrative burden through documentation and inbox-management assistance.[3–5,13–15] However, substantial limitations persist, including inadequate external validation of many models, high risk of bias in model development and evaluation, and implementation challenges related to explainability, data governance, and clinician and patient trust.

Conclusion: AI has meaningful potential to strengthen primary care by improving speed, precision, and operational sustainability, supporting early intervention and more person-centred care.[3–5] Real-world impact depends on rigorous validation across diverse populations, transparent governance, careful workflow integration, and sustained clinician oversight to ensure safety, equity, and trust.

Keywords: Artificial intelligence; Primary care; Family medicine; Machine learning; Deep learning; Clinical decision support; Patient outcomes

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1. Introduction

Artificial intelligence (AI) refers to the capacity of machines to perform tasks associated with human intelligence—including reasoning, learning, communication, and operation in both familiar and novel settings.[1] Contemporary healthcare discourse often uses AI interchangeably with machine learning (ML) and deep learning (DL), although these represent distinct technical approaches.[2] Machine learning describes algorithms that learn patterns from data to perform tasks without explicit human instruction.[2] Deep learning is a subset of ML that uses artificial neural networks to model complex relationships, producing outputs informed by reinforcement and iterative optimisation.[1]

In medicine, AI is widely presented as an opportunity to augment limited human processing capacity, improve diagnostic accuracy, streamline workflows, reduce errors, and strengthen patient monitoring.[3] This interest is reinforced by rapid growth in health-related data and escalating service demands.[4] AI methods support clinical decision-making by analysing large datasets, enhancing diagnostic precision, personalising treatment regimens, automating administrative processes, and optimising resource allocation.[4] Predictive analytics can assist planning and forecasting of service demand, supporting more efficient utilisation of finite resources.[5]

Primary care is positioned as the cornerstone of population health: it provides first-contact, accessible, continuous, comprehensive, and coordinated person-focused care intended to optimise health and reduce disparities. In this context, AI has the potential to strengthen primary care delivery by improving speed, precision, and reach—especially in settings with limited access to specialist interpretation such as radiology or pathology.[5] AI integration may enable insights from "clinical big data" and community-level datasets beyond human analytic capacity, with potential to reduce clinician workload while improving quality and consistency of care.[3]

This systematic review explores the existing evidence on AI in primary care, particularly its role in disease diagnosis and treatment, and evaluates how AI improves healthcare delivery compared with conventional methods.

Review question: *How does artificial intelligence improve healthcare delivery in primary care settings compared with conventional methods?*

2. Background: AI Applications Relevant to Primary Care

AI in primary care spans clinical and operational domains. Clinically, AI supports diagnostic prediction, risk stratification, symptom assessment, and clinical decision support.[3] Operationally, AI can reduce documentation burden and triage electronic communication, improving efficiency and clinician sustainability.[13],[15]

A review of AI in primary care identified multiple systems across engineering and medical literature, including: (i) an artificial neural network model predicting hypertension with reported accuracy of 85%; (ii) medication prescribing alerts via a clinical decision support system; (iii) primary diagnosis from chief complaints using probabilistic classifiers with moderate accuracy; (iv) question-and-answer systems using DL and natural language processing with lower accuracy; and (v) DL-based systems for COVID-19 prioritisation and early detection with reported high accuracy.[3] These developments are anticipated to improve operational effectiveness and quality of care, while also raising important challenges in clinical integration, ethics, and trust.[3],[5]

3. Methods

3.1. Design

A systematic literature review was conducted to synthesise evidence on the impact of AI on healthcare delivery in primary care settings. The review process followed PRISMA 2020 principles for transparency in screening and selection.[6] Narrative synthesis was used to integrate findings across heterogeneous study designs.[7]

3.2. Data sources and search strategy

A comprehensive search was conducted across electronic databases including PubMed, ResearchGate, Cochrane Library, and Google Scholar for publications from 2015 to the present. Medical Subject Headings (MeSH) and keywords were used, including combinations of: "artificial intelligence," "primary care," "patient outcome," "machine learning," and "diagnosis." The selected databases were used because they are commonly employed in medical literature retrieval.[6]

3.3. Eligibility criteria (PICO framework)

The PICO framework guided eligibility criteria and minimised bias in article selection.[11] Reviews that include complex study designs (e.g., diagnostic accuracy, observational evidence, qualitative studies) may be methodologically challenging; therefore, explicit PICO criteria were defined to improve reproducibility.[11]

- Population (P): Patients and healthcare providers in primary care settings
- Intervention (I): AI applications in primary care (diagnosis, symptom assessment, decision support, monitoring, or patient engagement)
- Comparison (C): Conventional primary care delivery without AI assistance
- Outcome (O): Improved healthcare delivery (e.g., diagnostic accuracy, efficiency, clinician workload, patient outcomes, satisfaction)

Inclusion criteria: Studies involving primary care clinicians or patients using AI tools for clinical or operational purposes; studies reporting outcomes relevant to diagnostic performance or delivery efficiency; studies comparing AI-assisted and conventional approaches where available.

Exclusion criteria: AI applications in non-clinical settings (e.g., pharmaceutical research); studies not focused on healthcare delivery; studies without full text access; non-English publications.

3.4. Study selection and PRISMA screening

Titles and abstracts were screened to determine relevance and alignment with eligibility criteria. PRISMA-based screening was applied to reduce reviewer bias and ensure the final selection directly addressed the review question.[6]

3.5. Quality appraisal

Critical appraisal was conducted for included studies using the Critical Appraisal Skills Programme (CASP) checklists.[8] This tool supports structured evaluation of methodological rigour, enables categorisation of study quality, and helps identify patterns and gaps in the evidence base.[8] However, CASP can oversimplify complex methodological issues and may introduce subjectivity.[8] Studies were rated using the CASP "yes/no/can't tell" framework and classified as low (0–4), medium (5–7), or high quality (8–10).[8]

3.6. Data extraction and synthesis

Data were extracted into Microsoft Excel using a structured framework aligned with established systematic review methods.[12] Extracted variables included authorship, year, setting, study design, population, intervention type, outcomes, key findings, limitations, and recommendations.[12] A narrative synthesis approach was used to integrate evidence across varied methodologies.[7]

4. Results

4.1. Search yield and selection outcome

Database searches yielded 4,370 records from PubMed and 18,500 from Google Scholar, with no records retrieved from Cochrane or CINAHL in this search cycle. Duplicates and clearly irrelevant records were removed using automated filters, leaving 1,774 records for further consideration. Following title and abstract screening, 19 records were assessed for full text. Five studies were excluded due to access restrictions, and others were removed due to study design misalignment or failure to meet eligibility criteria. Eight studies met inclusion criteria and were included in the final synthesis, consistent with PRISMA reporting principles.[6]

4.2. Summary of included studies

Included evidence comprised systematic reviews and narrative reviews on ML prediction models and AI workflow impact in primary care, alongside broader healthcare AI reviews relevant to primary care delivery.[3]–[5],[13]

A prominent systematic review reported that most ML prediction models trained or validated using real-world primary healthcare data focused on diagnostic prediction, frequently targeting diabetes and Alzheimer's disease. However, the majority lacked external validation and demonstrated high risk of bias—limiting readiness for deployment across different settings. (Abdulazeem et al., as summarised in the included evidence set). These limitations align with broader concerns about generalisability and safety in clinical AI.[3],[5]

Table 1 Inclusion/Exclusion Criteria

S/N	PICO	Inclusion Criteria	Exclusion Criteria
Population (P):	Patients and healthcare providers in primary care setting.	Studies involving patients, general practitioners, nurses, or allied health professionals using AI tools in primary care.	AI applications in non-clinical settings (e.g., medical research, pharmaceutical industry).
Intervention (I):	Artificial Intelligence in Primary care	Studies on application of Artificial intelligence in diagnosis, symptom assessment, clinical decision support, or patient engagement.	Studies not focused on AI application in healthcare.
Comparison (C):	Conventional methods of care delivery	Studies comparing conventional care delivery with AI assisted care	Comparisons that is not related to Artificial intelligence in Healthcare
Outcome (O):	Improved healthcare delivery in primary care, satisfactory patient outcome	Studies that assess the impact of AI in primary care area such as diagnosis, drug prescription and personalized medicine	Outcomes not related to the use of AI

Table 2 Summary of Database Query strategy

S/N	PICO	Research Definition	Search Terminology
1	Population	Patients and healthcare providers in primary care settings.	"Patients in primary care settings using AI" OR "Healthcare providers using AI in primary care"
2	Intervention	AI applications in primary care, including diagnostic support and decision-making.	"Artificial intelligence in primary care" OR "Machine learning for diagnosis in primary care" OR "AI-based clinical decision support"
3	Comparison	Traditional clinician-based care or non-AI healthcare interventions.	"Physician-only diagnosis" OR "Traditional clinical decision-making"
4	Outcome	Clinical effectiveness, diagnostic accuracy, patient satisfaction, and healthcare efficiency.	"AI accuracy in diagnosis" OR "Impact of AI on primary care efficiency" OR "Patient trust and satisfaction in AI healthcare"

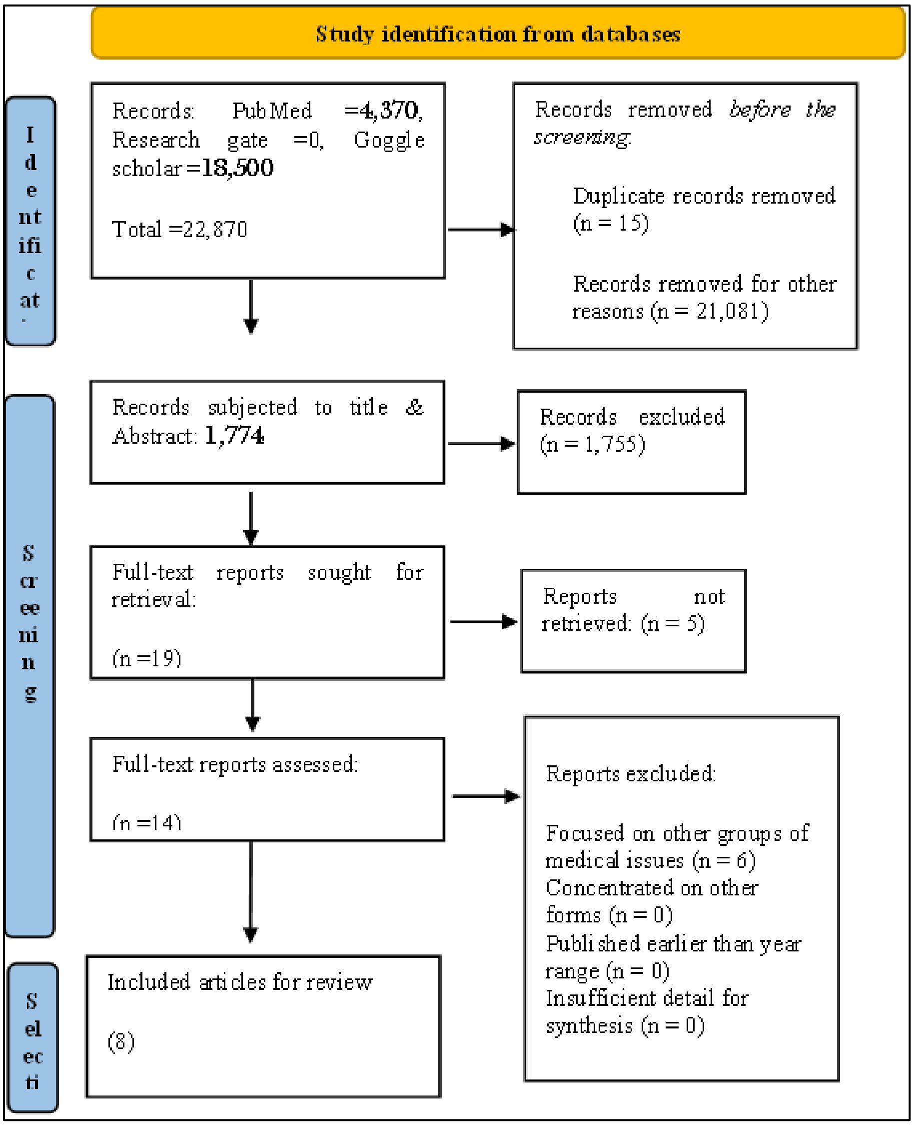

Figure 1 prisma flow diagram

Table 3 summary of details from selected articles

S/n	Names	Title	Aim	Type of study	Country	Findings
1	Abdulazeem et al	A systematic review of clinical health conditions predicted by machine learning diagnostic and prognostic models trained or validated using real-world primary health care data	To identify health conditions targeted by ML prediction models in primary health care (PHC) and assess their characteristics	Systematic Review		Most studies (77.3%) focused on diagnostic prediction. Common conditions: diabetes mellitus (19.8%), Alzheimer's disease (11.3%). Majority (76.4%) lacked external validation. High risk of bias in 90.8% of studies

	Darius Turcian, Vasile & Stoicu-Tivadar	Artificial Intelligence in Primary Care: An Overview	To review how artificial intelligence is being used in primary care and family medicine and explore potential for further development.	Literature Review	Romania	The study found several AI systems supporting primary care including: Diagnosis prediction models Clinical Decision Support Systems (CDSS) - Chatbot-style Q&A systems for patient communication - Mobile and telemedicine apps AI improves speed and accuracy, but faces challenges like clinical integration, ethical concerns, and trust issues.
	Johnny & John (2025)	The Impact of AI on Healthcare Efficiency: From Diagnosis to Post-Treatment Monitoring	To explore how AI improves healthcare efficiency, from diagnosis to post-treatment monitoring.	Review	Multiple countries	AI enhances diagnosis speed, optimizes treatment plans, and improves patient monitoring, but data bias remains a challenge.
	Sivashankar et al. (2024)	Smart Healthcare: Integrating Artificial Intelligence for Better Patient Outcomes	To analyze how AI integration in healthcare enhances patient outcomes and medical decision-making.	Observational study	Multiple countries	AI-driven tools improve predictive analysis and personalized treatments but require better regulatory frameworks.
	Tewes (2022)	Artificial Intelligence in the American Healthcare Industry: Looking Forward to 2030	To examine the future impact of AI in the U.S. healthcare system by 2030.	Review	U.S.	AI adoption is expected to reduce healthcare costs, enhance early diagnosis, and improve workflow efficiency.
	Urmimala Sarkar & David W. Bates	Using Artificial Intelligence to Improve Primary Care for Patients and Clinicians	Discuss how AI can increase efficiency in primary care processes for clinicians and patients	Review	US	AI can enhance primary care by improving efficiency, reducing clinician workload, and optimizing patient outcomes through advanced technologies

5. Discussion

5.1. AI and early intervention in primary care

Early intervention is central to primary care. AI can accelerate time-to-decision by rapidly processing patient records, imaging, and structured data, reducing delays inherent in manual review.[4] AI tools may provide outputs within minutes, compared with hours or days required for traditional workflows.[4] Evidence from AI in primary eye care demonstrates the feasibility of high-performing virtual assistants supporting screening and classification tasks in clinical settings, with reported accuracy exceeding 95% in specific use cases.[14]

In primary care, rapid triage and decision support can improve timely diagnosis and earlier treatment initiation. Turcian and Stoicu-Tivadar observed that AI systems show potential to reduce execution time and minimise human error, particularly where ML/DL algorithms are applied in a data-centric approach.[3] Such capabilities are relevant for chronic disease risk identification, symptom-based triage, and prioritisation of care.

5.2. Operational efficiency and clinician workload reduction

Clinician workload in primary care is increasingly driven by documentation and electronic messaging. AI can target operational pain points by assisting with inbox management, documentation, between-visit panel management, and decision support.[13] The increasing volume of patient messages through electronic health records disproportionately burdens primary care clinicians, and interventions to declutter inboxes are increasingly prioritised.[15] Chatbots and automated sorting systems may reduce time spent on generic queries and administrative messaging, potentially improving clinician sustainability and access.

5.3. Comprehensiveness, person-centredness, and continuity

Primary care emphasises holistic, continuous, person-centred care. AI can support personalised care planning through analysis of longitudinal histories and real-time monitoring data.[4,5] Decision support tools that account for patient context may offer more tailored recommendations than traditional generic algorithms.[13] Precision medicine approaches enabled by AI can align interventions with individual risk profiles and treatment response patterns.[4,5]

IoT-enabled monitoring may also enhance continuity by enabling remote supervision of key parameters and providing prompts for adherence and follow-up.[4] This can reduce unnecessary face-to-face visits while maintaining clinical oversight and patient engagement.

5.4 Limitations and risks: validation, bias, trust, and governance

Despite potential benefits, AI in primary care requires careful governance. Many ML models lack external validation, limiting generalisability across populations and settings.[3] Such gaps raise safety concerns, particularly if deployment occurs without robust evaluation. The broader literature highlights the need for trust, transparency, and clear accountability in clinical AI.[3,5]

The "black box" nature of some models may undermine clinician confidence, particularly when explainability is limited or user interfaces are poorly designed.[3] The implementation of AI must therefore ensure interpretability where possible and embed human oversight to prevent harm.

6. Conclusion

AI is increasingly shaping primary care delivery by improving data management, enhancing diagnostic and triage efficiency, supporting personalised care, and reducing administrative burden.[3–5,13,15] These advances may strengthen early intervention, continuity, and equity of access—core goals of primary care. However, evidence also highlights persistent limitations, including insufficient external validation, bias risk, integration challenges, and issues of trust, explainability, and governance.[3,5] Effective implementation requires clinician oversight, rigorous evaluation, and strong safeguards for patient data and safety. As AI capabilities mature, responsible integration into primary care may substantially improve system performance and patient outcomes while preserving accountability and person-centred care.

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