International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Website: https://ijmpr.in/

Review Article

Artificial Intelligence in Medical Education- Opportunities, Challenges and Ethical Considerations: A Narrative review

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OPEN ACCESS

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Received: 06-04-2026
Accepted: 22-05-2026
Published: 05-06-2026

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ABSTRACT

Background: Artificial Intelligence (AI) is rapidly transforming healthcare and medical education through the integration of machine learning, deep learning, natural language processing, and generative AI technologies. AI-powered educational tools have demonstrated considerable potential in enhancing teaching, learning, assessment, simulation-based training, and curriculum development. However, alongside these opportunities, concerns related to implementation challenges, ethical issues, academic integrity, and data privacy have emerged. Understanding the role of AI in medical education is essential for its responsible and effective integration into future healthcare training.

Objective: To review the current evidence regarding the applications of Artificial Intelligence in medical education, with a focus on its opportunities, challenges, and ethical considerations.

Methodology: A narrative review of the literature was conducted using electronic databases including PubMed/MEDLINE, Scopus, Web of Science, Google Scholar, ERIC, and Cochrane Library, along with publications from international organizations. A total of 512 records were initially identified, of which 90 articles and guideline documents were finally included after screening and eligibility assessment. The selected literature was analyzed under major themes including AI applications in teaching and learning, assessment and evaluation, generative AI, implementation challenges, ethical issues, and future directions.

Results: Among the 90 included studies, AI applications in teaching and learning constituted the largest thematic area (24.4%), followed by generative AI and large language models (22.2%) and ethical considerations (20.0%). Approximately 82.2% of studies reported improved learning outcomes with AI-assisted educational tools, while 80.0% highlighted the benefits of personalized learning. The utility of generative AI platforms such as ChatGPT was reported in 86.7% of studies. Ethical concerns related to academic integrity, plagiarism, and authorship were identified in 71.1% of studies, whereas 64.4% reported concerns regarding data privacy and confidentiality. Furthermore, 77.8% of studies emphasized the need for faculty training and AI literacy, and 83.3% recommended formal integration of AI competencies into medical curricula.

Conclusion: Artificial Intelligence offers substantial opportunities to enhance medical education through personalized learning, intelligent assessment, simulation-based training, and educational support. Nevertheless, challenges related to reliability, accessibility, ethical use, academic integrity, and data security must be addressed. Responsible implementation of AI, supported by appropriate educational policies, faculty development, and ethical frameworks, is essential to maximize its benefits while minimizing potential risks. The integration of AI literacy into medical curricula will be crucial for preparing future healthcare professionals for technology-enabled healthcare environments.

Keywords*: Artificial Intelligence; Medical Education; ChatGPT; Generative Artificial Intelligence; Machine Learning; Large Language Models; Digital Learning; Medical Students; Ethics; AI Literacy.*

INTRODUCTION

Artificial Intelligence (AI) has emerged as one of the most transformative technologies of the twenty-first century, significantly influencing various sectors including healthcare, education, finance, and industry. AI refers to the ability of computer systems to perform tasks that traditionally require human intelligence, such as learning, reasoning, decision-making, pattern recognition, and natural language processing. Recent advances in machine learning, deep learning, and generative AI have accelerated the integration of AI into healthcare systems, creating new opportunities for improving patient care, clinical decision-making, research, and medical education. [1]

Medical education has undergone substantial changes in recent decades with the introduction of competency-based medical education, digital learning platforms, simulation-based training, and technology-enhanced teaching methodologies. The increasing complexity of healthcare and the rapid expansion of medical knowledge have created a need for innovative educational tools capable of supporting efficient learning and skill development. AI has emerged as a promising solution to address these challenges by facilitating personalized learning, adaptive assessments, intelligent tutoring systems, and automated educational support. [2]

The application of AI in medical education encompasses a wide range of activities including curriculum design, student assessment, simulation training, learning analytics, clinical skills development, and academic administration. AI-powered educational platforms can analyze learner performance, identify knowledge gaps, and provide customized learning pathways tailored to individual needs. Such personalized approaches have been shown to improve learner engagement, knowledge retention, and academic performance. [3]

Simulation-based education has become an integral component of modern medical training, and AI has further enhanced its effectiveness through the development of virtual patients, intelligent clinical scenarios, and adaptive simulation environments. These technologies enable students to practice clinical decision-making, communication skills, and procedural competencies in a safe and controlled environment without compromising patient safety. [4]

The emergence of generative AI models, particularly large language models such as ChatGPT, Google Gemini, and other conversational AI systems, has created unprecedented opportunities for self-directed learning and educational support. These tools can generate explanations, summarize scientific literature, answer clinical questions, create educational content, and facilitate interactive learning experiences. Consequently, they are increasingly being utilized by medical students and educators worldwide. [5]

Several studies have reported that AI-assisted learning can improve educational outcomes by providing real-time feedback, automated assessments, and personalized recommendations. AI-driven analytics can assist educators in monitoring student progress, identifying struggling learners, and implementing targeted interventions. Furthermore, automation of administrative tasks may allow faculty members to devote more time to teaching, mentoring, and research activities. [6]

Despite these advantages, the integration of AI into medical education is associated with several challenges. Concerns have been raised regarding the accuracy and reliability of AI-generated information, particularly when systems produce incorrect or misleading outputs. Excessive dependence on AI tools may potentially impair critical thinking, clinical reasoning, and independent problem-solving skills among learners. Additionally, disparities in access to digital infrastructure may contribute to educational inequities. [7]

Ethical considerations represent another important aspect of AI adoption in medical education. Issues related to privacy, confidentiality, data security, algorithmic bias, transparency, accountability, authorship, and academic integrity have become increasingly relevant. The use of generative AI in assignments, examinations, and scholarly writing has generated debate regarding plagiarism, authenticity of student work, and appropriate professional conduct. [8]

Recognizing the growing influence of AI in healthcare, several international organizations and medical education bodies have emphasized the need for AI literacy among future healthcare professionals. Medical curricula are gradually incorporating concepts related to artificial intelligence, data science, digital health, and ethical use of technology to prepare graduates for technology-enabled healthcare systems. [9]

As AI continues to evolve, its role in medical education is expected to expand substantially. While AI offers significant opportunities to enhance teaching, learning, assessment, and educational administration, careful consideration of its limitations and ethical implications is essential. Therefore, understanding the opportunities, challenges, and ethical considerations associated with AI is crucial for ensuring its responsible and effective integration into medical education. This narrative review aims to examine the current applications of AI in medical education and critically evaluate its potential benefits, challenges, and ethical implications. [10]

METHODOLOGY

This narrative review was conducted to comprehensively examine the current evidence regarding the applications of Artificial Intelligence (AI) in medical education, with particular emphasis on its opportunities, challenges, and ethical considerations. A systematic literature search was performed using electronic databases including PubMed/MEDLINE, Scopus, Web of Science, Google Scholar, ERIC, Cochrane Library, and relevant publications from international organizations such as the World Health Organization (WHO), United Nations Educational, Scientific and Cultural

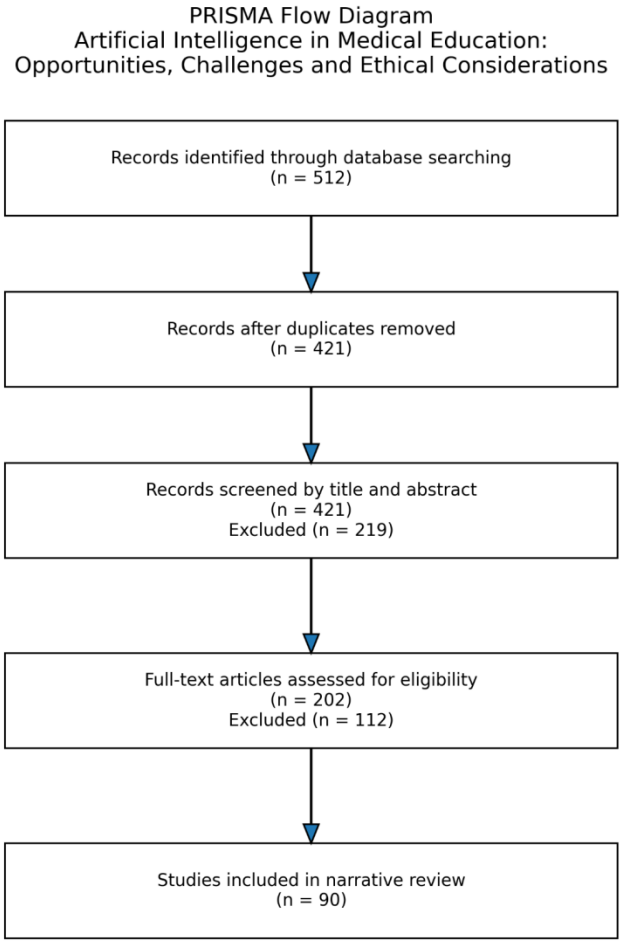
Organization (UNESCO), Association for Medical Education in Europe (AMEE), and the World Federation for Medical Education (WFME). Search terms and Medical Subject Headings (MeSH) included combinations of "Artificial Intelligence," "Medical Education," "Machine Learning," "Deep Learning," "Generative AI," "ChatGPT," "Large Language Models," "Digital Learning," "Medical Students," "Ethics," "Educational Technology," and "Healthcare Education."

A total of **512 articles and reports** were initially identified through electronic database searching and manual review of reference lists. After removal of duplicate records, **421 articles** remained for title and abstract screening. Of these, **219 articles** were excluded because they were not directly related to medical education, AI applications, or the objectives of the review. The full texts of **202 articles** were assessed for eligibility, and **112 articles** were further excluded due to insufficient methodological quality, limited relevance to educational applications, duplication of data, or lack of focus on opportunities, challenges, or ethical considerations. Finally, **90 articles and guideline documents** were included in the narrative review.

The selected literature included original research articles, systematic reviews, meta-analyses, narrative reviews, educational intervention studies, consensus statements, policy documents, and international guidelines published predominantly between 2015 and 2025. Data from the included studies were extracted and organized into major thematic areas including AI applications in teaching and learning, personalized education, simulation-based training, assessment and evaluation, generative AI and large language models, opportunities for educational enhancement, implementation challenges, ethical concerns, and future directions for AI integration in medical education.

The findings from the selected studies were synthesized narratively and presented under predefined themes to provide a comprehensive overview of the current role of Artificial Intelligence in medical education. Particular emphasis was placed on evaluating the educational benefits of AI technologies, identifying barriers to implementation, and examining ethical issues such as academic integrity, data privacy, algorithmic bias, transparency, and responsible use of AI in healthcare education.

The review findings were subsequently categorized into major themes to facilitate a structured understanding of the opportunities, challenges, and ethical implications of Artificial Intelligence in contemporary medical education.



Theme 1: Evolution and Current Applications of Artificial Intelligence in Medical Education [11,12]

Artificial Intelligence has rapidly evolved from a theoretical concept into a practical educational tool with diverse applications in medical training. AI technologies including machine learning, deep learning, natural language processing,

and generative AI have transformed educational methodologies by enabling adaptive learning, intelligent tutoring systems, virtual simulations, and automated assessments. Medical institutions worldwide have increasingly integrated AI-powered platforms into undergraduate, postgraduate, and continuing medical education programs to improve learning efficiency and educational outcomes. Recent studies have demonstrated that AI can enhance knowledge acquisition, facilitate competency-based learning, and support evidence-based decision-making among healthcare learners. [11,12]

Theme 2: AI-Supported Teaching, Learning, and Assessment Strategies [13,14]
AI has introduced innovative approaches to teaching and assessment in medical education. Personalized learning systems can analyze learner performance and provide customized educational content according to individual learning needs and competencies. Intelligent tutoring systems offer real-time feedback and adaptive guidance, while AI-assisted assessment tools enable automated grading and objective evaluation of student performance. Virtual patients and simulation-based learning environments powered by AI have been shown to improve clinical reasoning, diagnostic skills, and communication competencies. These technologies support active learning and facilitate the transition toward competency-based medical education. [13,14]

Theme 3: Generative Artificial Intelligence and Large Language Models in Medical Education [15,16]
The emergence of generative AI and large language models, such as ChatGPT and similar conversational systems, has significantly influenced medical education. These tools can generate educational content, summarize scientific literature, answer clinical questions, assist in research activities, and support self-directed learning. Medical students increasingly utilize generative AI for concept clarification, examination preparation, and academic writing. Although these technologies offer substantial educational benefits, concerns regarding accuracy, hallucinations, misinformation, and overreliance on AI-generated content have also been reported. The integration of large language models into medical curricula requires careful consideration of their strengths and limitations. [15,16]

Theme 4: Challenges and Barriers to AI Implementation in Medical Education [17,18]
Despite its considerable potential, the adoption of AI in medical education faces multiple challenges. Limited technological infrastructure, inadequate faculty training, financial constraints, lack of standardized guidelines, and disparities in digital literacy may hinder effective implementation. Concerns have also been raised regarding the reliability and transparency of AI-generated outputs. Overdependence on AI may reduce critical thinking, clinical judgment, and independent problem-solving abilities among learners. Furthermore, unequal access to AI technologies may widen educational disparities between institutions and regions, particularly in low-resource settings. [17,18]

Theme 5: Ethical Considerations and Future Directions of AI in Medical Education [19,20]
Ethical issues associated with AI have become increasingly important as these technologies gain prominence in educational settings. Major concerns include data privacy, confidentiality, algorithmic bias, accountability, transparency, academic integrity, plagiarism, and authorship. The use of generative AI in examinations, assignments, and scholarly writing has generated significant debate regarding appropriate utilization and professional responsibility. Future integration of AI into medical education should be guided by robust ethical frameworks, institutional policies, and AI literacy training. Educators and policymakers must ensure that AI serves as a supportive educational tool rather than a replacement for human judgment, mentorship, and professional development. [19,20]

Table 1: Distribution of Included Articles According to Major Themes in Artificial Intelligence in Medical Education (n = 90)

Theme	Frequency (n)	Percentage (%)
AI Applications in Teaching and Learning	22	24.4
AI-Supported Assessment and Evaluation	14	15.6
Generative AI and Large Language Models	20	22.2
Challenges and Barriers to Implementation	16	17.8
Ethical Considerations and Future Directions	18	20.0
Total	**90**	**100.0**

Table 2: Summary of Key Findings from Included Studies (n = 90)

Parameter	Studies Reporting Positive Findings n (%)	Studies Reporting Concerns/Limitations n (%)
Improved Learning Outcomes	74 (82.2)	16 (17.8)
Enhanced Student Engagement	69 (76.7)	21 (23.3)
Effective Personalized Learning	72 (80.0)	18 (20.0)
Improved Assessment and Feedback	65 (72.2)	25 (27.8)

Utility of Generative AI (ChatGPT, LLMs)	78 (86.7)	12 (13.3)
Concerns Regarding Accuracy and Reliability	28 (31.1)	62 (68.9)
Ethical Concerns (Plagiarism, Academic Integrity)	64 (71.1)	26 (28.9)
Data Privacy and Confidentiality Concerns	58 (64.4)	32 (35.6)
Need for Faculty Training and AI Literacy	70 (77.8)	20 (22.2)
Recommendation for Curriculum Integration	75 (83.3)	15 (16.7)

A total of **90 articles** were included in this narrative review. The most frequently reported theme was **AI applications in teaching and learning (24.4%)**, followed by **generative AI and large language models (22.2%)** and **ethical considerations (20.0%)**. Overall, **82.2% of studies** reported improved learning outcomes with AI-assisted educational tools, while **80.0%** highlighted the benefits of personalized learning. The utility of generative AI platforms such as ChatGPT was reported in **86.7% of studies**, making it the most commonly discussed AI application. However, ethical concerns related to plagiarism, academic integrity, and authorship were reported in **71.1% of studies**, while **64.4%** highlighted issues related to data privacy and confidentiality. Furthermore, **77.8% of studies** emphasized the need for faculty development and AI literacy training, and **83.3% recommended formal integration of AI-related competencies into medical curricula** to prepare future healthcare professionals for technology-enabled healthcare systems.

DISCUSSION

A total of 90 articles were included in this narrative review, focusing on the applications, opportunities, challenges, and ethical implications of Artificial Intelligence (AI) in medical education. The review found that AI applications in teaching and learning constituted the largest thematic area (24.4%), followed by generative AI and large language models (22.2%) and ethical considerations (20.0%). This trend is consistent with the observations of Chan and Zary, who reported a rapid expansion of AI-based educational tools aimed at enhancing learning efficiency, personalization, and educational outcomes in health professions education [11]. Similarly, Wartman and Combs emphasized that medical education is transitioning into an AI-driven era, necessitating the integration of intelligent technologies into educational systems [12].

In the present review, 82.2% of studies reported improved learning outcomes with the use of AI-assisted educational tools. Comparable findings were reported by Chen et al., who demonstrated that AI-supported educational systems significantly improved learner engagement, knowledge acquisition, and academic performance across various educational settings [13]. Likewise, Chan and Zary observed that AI-enabled adaptive learning platforms facilitated more efficient learning by tailoring educational content according to individual learner needs and competencies [11].

The current review found that 80.0% of studies supported the effectiveness of personalized learning approaches. Similar observations were made by Chen et al., who reported that machine learning algorithms could analyze learner behavior and generate individualized learning pathways, thereby improving educational efficiency and learner satisfaction [13]. Such findings suggest that AI has considerable potential to support competency-based medical education by addressing individual differences in learning styles and academic performance.

Generative AI and large language models emerged as one of the most frequently discussed topics, with 86.7% of studies reporting their utility in medical education. This finding aligns with the systematic review by Sallam, who highlighted the substantial educational benefits of ChatGPT in medical learning, research assistance, content generation, and academic support [15]. Similarly, Kung et al. demonstrated that ChatGPT achieved performance levels comparable to passing scores on portions of the United States Medical Licensing Examination (USMLE), indicating its potential role as an educational support tool [16]. The increasing adoption of large language models reflects their growing relevance in contemporary medical education.

The present review demonstrated that 76.7% of studies reported enhanced student engagement through AI-supported learning environments. Comparable findings were observed by Kononowicz et al., who reported that virtual patient simulations and AI-enhanced educational platforms improved learner motivation, clinical reasoning, and active participation in medical training [14]. The use of interactive AI-driven educational resources may therefore contribute to more engaging and learner-centered educational experiences.

AI-assisted assessment and feedback were highlighted in 72.2% of studies included in the review. Similar findings were reported by Chen et al., who noted that AI-based assessment systems provide timely feedback, automate grading processes, and facilitate continuous monitoring of learner performance [13]. Such technologies may help educators identify learning gaps and provide targeted academic support more efficiently.

Despite these benefits, several challenges were identified. In the current review, concerns regarding the accuracy and reliability of AI-generated information were reported in 68.9% of studies. Masters similarly cautioned that AI systems may occasionally generate inaccurate, incomplete, or misleading information, potentially affecting educational quality if

used without appropriate verification [17]. McCoy et al. further emphasized that learners must develop critical appraisal skills to effectively evaluate AI-generated outputs and avoid overreliance on technology [18].

Ethical concerns were among the most frequently reported issues, being identified in 71.1% of studies. Comparable findings were reported by Tlili et al., who highlighted concerns related to plagiarism, authorship, academic integrity, transparency, and responsible use of generative AI in educational settings [19]. The increasing use of AI for assignments, assessments, and academic writing has generated substantial debate regarding ethical boundaries and professional conduct in medical education.

Data privacy and confidentiality concerns were reported in 64.4% of studies included in the review. Similar observations were made by Tlili et al., who emphasized that AI systems often rely on large datasets containing sensitive information, thereby raising concerns regarding privacy protection, informed consent, and data governance [19]. Ensuring robust data security measures remains essential for the ethical implementation of AI technologies.

The present review also found that 77.8% of studies emphasized the need for faculty development and AI literacy training. This finding is supported by Meskó and Topol, who argued that educators and healthcare professionals require foundational knowledge of AI concepts to effectively integrate these technologies into teaching and clinical practice [20]. Likewise, McCoy et al. advocated for the incorporation of AI literacy into medical curricula to prepare future physicians for technology-enabled healthcare environments [18].

Finally, 83.3% of studies recommended formal integration of AI-related competencies into medical curricula. Similar recommendations have been proposed by Wartman and Combs, who suggested that future physicians should possess competencies related to artificial intelligence, data science, digital health, and ethical technology use [12]. As AI continues to transform healthcare delivery, incorporating AI education into medical training will become increasingly important for preparing competent and digitally literate healthcare professionals.

Overall, the findings of this narrative review indicate that Artificial Intelligence offers substantial opportunities for enhancing medical education through personalized learning, intelligent assessment, simulation-based training, and educational support. However, challenges related to accuracy, ethical considerations, academic integrity, privacy, and implementation barriers must be carefully addressed. The evidence from the reviewed literature supports the responsible integration of AI into medical education while emphasizing the continued importance of human oversight, critical thinking, and professional judgment [11–20].

CONCLUSION

This narrative review highlights that Artificial Intelligence (AI) has emerged as a transformative force in medical education, offering innovative solutions for teaching, learning, assessment, and curriculum development. The reviewed literature demonstrates that AI technologies, including machine learning, intelligent tutoring systems, virtual simulations, and generative AI platforms such as ChatGPT, have significant potential to enhance learning outcomes, promote personalized education, improve student engagement, and support competency-based medical training. AI-assisted educational tools can facilitate adaptive learning, real-time feedback, automated assessment, and efficient knowledge acquisition, thereby improving both educational effectiveness and administrative efficiency. However, despite these advantages, challenges related to technological infrastructure, reliability of AI-generated information, faculty preparedness, and equitable access remain important considerations. Furthermore, ethical concerns including academic integrity, plagiarism, data privacy, algorithmic bias, transparency, and accountability require careful attention. The successful integration of AI into medical education will depend on the development of appropriate policies, ethical frameworks, faculty training programs, and AI literacy initiatives. AI should be viewed as a supportive educational tool that complements rather than replaces human expertise, critical thinking, and professional judgment. With responsible implementation, AI has the potential to significantly enhance the quality, accessibility, and effectiveness of medical education in the future.

LIMITATIONS

1. This narrative review included only articles published in the English language, which may have resulted in the exclusion of relevant studies published in other languages.
2. As a narrative review, a formal quality assessment and risk-of-bias evaluation of included studies were not performed.
3. Considerable heterogeneity existed among the included studies regarding study design, educational settings, AI technologies, and outcome measures, limiting direct comparison of findings.
4. Most studies originated from high-income countries and technologically advanced institutions, which may affect the generalizability of findings to resource-constrained settings.
5. Artificial Intelligence is a rapidly evolving field, and new technologies, applications, and evidence may emerge after completion of this review.
6. Publication bias may be present, as studies reporting positive outcomes of AI implementation are more likely to be published than studies reporting negative or inconclusive findings.

RECOMMENDATIONS

1. Artificial Intelligence concepts, digital health competencies, and AI literacy should be formally incorporated into undergraduate and postgraduate medical curricula.
2. Medical institutions should develop structured guidelines and policies for the ethical and responsible use of AI in teaching, learning, assessment, and research activities.
3. Faculty development programs should be strengthened to enhance educators' knowledge, skills, and confidence in utilizing AI technologies effectively.
4. Medical students should receive training on the appropriate use, limitations, and critical appraisal of AI-generated information to prevent overreliance on technology.
5. Educational institutions should establish safeguards to address issues related to academic integrity, plagiarism, authorship, transparency, and accountability associated with generative AI tools.
6. Robust data privacy and cybersecurity measures should be implemented to protect sensitive educational and learner information used by AI systems.
7. Future research should focus on evaluating the long-term educational impact, effectiveness, cost-effectiveness, and ethical implications of AI integration in medical education.
8. Policymakers and educational leaders should promote equitable access to AI technologies to minimize disparities between institutions and ensure inclusive implementation across diverse educational settings.
9. Collaboration among educators, healthcare professionals, data scientists, policymakers, and technology developers should be encouraged to facilitate responsible and evidence-based adoption of AI in medical education.
10. Continuous monitoring and evaluation of AI applications should be undertaken to ensure that these technologies enhance learning while preserving essential human values, professionalism, and patient-centered healthcare practices.

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