

MINI-REVIEW

Artificial intelligence in health sciences education: A mini-review of clinical reasoning development and educator perceptions

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Abstract

Clinical reasoning forms the basis of practice in the health sciences, enabling professionals to collect and interpret patient data to support sound clinical decisions. Artificial intelligence (AI) and machine learning (ML) have emerged as strong tools, revolutionizing diagnosis, personalizing treatment, and enhancing therapeutic outcomes. However, very little research has been conducted concerning health sciences educators' perceptions regarding AI and its role in clinical reasoning skill development. This mini-review examines AI's growing prevalence in health sciences education, as well as the challenges and opportunities it presents. A systematic search of the scholarly literature identified studies related to AI applications in the teaching and learning of clinical reasoning. A number of recurring themes emerged from these analyses, including the potential for AI to transform the training of clinical skills, the ethical implications associated with AI implementation, contributions from the field of ML to clinical data analysis, and innovations in educational assessment. Thus, these findings highlight the need for ethical frameworks, interdisciplinary collaborations, and sustained research to enhance the benefits of AI. Proper integration of AI in health sciences education would significantly assist students in improving their clinical reasoning skills, enabling them to become competent practitioners so that, ultimately, patients may benefit in an increasingly digital health environment.

Keywords: Clinical reasoning; Artificial intelligence; Machine learning; Health sciences education; Personalized learning

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1. Introduction

Clinical reasoning is the basis of sound practice in the health sciences, comprising the cognitive processes by which health sciences practitioners collect and interpret patient data to make informed judgments. This key skill is essential for effectively identifying and treating patients, ultimately influencing patient outcomes.¹

In today's rapidly evolving health sciences, the integration of artificial intelligence (AI) and machine learning (ML) presents unprecedented opportunities to augment these

essential processes.² AI technologies have shown great promise for improving diagnostic accuracy, personalizing patient care, and optimizing treatment regimens. For example, AI-powered diagnostic systems can rapidly scan complex datasets, detecting patterns and abnormalities that human professionals may miss, thereby resulting in more accurate and timely diagnoses.³

Furthermore, AI's capacity to adapt educational content to individual learning needs has the potential to transform health sciences education by providing individualized learning experiences that adjust to each student's pace and style.⁴ This adaptability can help to develop more competent and confident health sciences professionals.⁵ However, as health sciences educators and practitioners negotiate this digital transition, understanding their attitudes and perceptions of AI adoption is critical. Despite the excitement surrounding AI's capabilities, there is a significant gap in the literature regarding how health sciences educators perceive the role of AI in education and its potential impact on clinical reasoning.⁶ The heterogeneity in educators' acceptance and comprehension of AI can have a substantial impact on its implementation and efficacy in educational contexts.⁷

Furthermore, empirical data on the effectiveness of ML models in improving clinical decision-making and educational outcomes are limited. While several studies discussed largely in terms of personal experience or theoretical benefits, few comprehensive studies have systematically analyzed the practical implications of these technologies.⁸

When integrated into the health sciences, AI and ML are transforming both clinical practice and medical education. In this review, we propose a conceptual framework that outlines key domains of AI's influence in the health sciences, namely, clinical reasoning, educational applications, and emerging priorities for research. Within this framework, the focus is on how AI could enhance some aspects of cognitive activities in diagnosis and clinical decision-making while providing adaptive, individualized learning situations. The framework also considers educators' perspectives, the impact on student learning outcomes, and gaps in empirical research that need to be filled to inform sound policy and decision-making regarding the curricula. By considering these interrelated domains, this framework is intended to serve as a guide for implementing, monitoring, evaluating, and subsequently scaling AI-driven educational innovations in the health professions (Figure 1).

This mini-review aims to fill these gaps by synthesizing existing research findings, investigating the implications of AI in health sciences education, and evaluating

the challenges and opportunities that come with its implementation. By highlighting these features, this review seeks to provide insights into using AI to train more competent health sciences professionals and improve patient outcomes in the age of digital health innovation. It also emphasizes the significance of integrating AI technologies with educational aims and ethical norms to maximize advantages while limiting risks. This review contributes to a more nuanced understanding of AI's transformational potential in health sciences education and clinical practice by examining existing studies in depth and identifying future research directions.

2. Review methodology

This section describes the methods used to identify and analyze literature on the integration of AI in health sciences education, as well as its impact on clinical reasoning.

A literature search was conducted across five electronic databases: PubMed, Scopus, Web of Science, Connected Papers, and Google Scholar. The search strategy used a combination of keywords and Boolean operators, including "artificial intelligence," "machine learning," "health sciences education," "clinical reasoning," and "medical education." The search was restricted to peer-reviewed, English-language original studies published between 2020 and 2025.

2.1. Inclusion criteria

- (i) Original studies addressing the integration of AI or ML technologies in health sciences education
- (ii) Research investigating AI's impact on clinical reasoning
- (iii) Studies providing insights into educators' perceptions of AI adoption.

2.2. Exclusion criteria

- (i) Systematic reviews, meta-analyses, editorials, and commentaries
- (ii) Studies unrelated to health sciences education or clinical reasoning
- (iii) Non-English publications and studies not available in full text.

2.3. Study selection process

The study selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The initial search identified 423 articles. After removing duplicates, 378 articles remained. Titles and abstracts were screened, resulting in the exclusion of 289 papers. The full texts of 89 studies were reviewed for eligibility, and 41 original studies were included in the final synthesis (Figure 2).

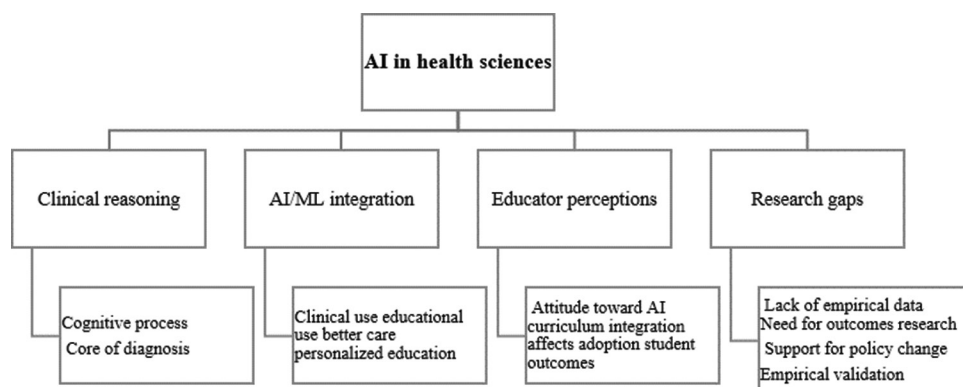


Figure 1. AI-driven clinical reasoning and education: A framework for integration and evaluation. Image created by the authors.
Abbreviations: AI: Artificial intelligence; ML: Machine learning.

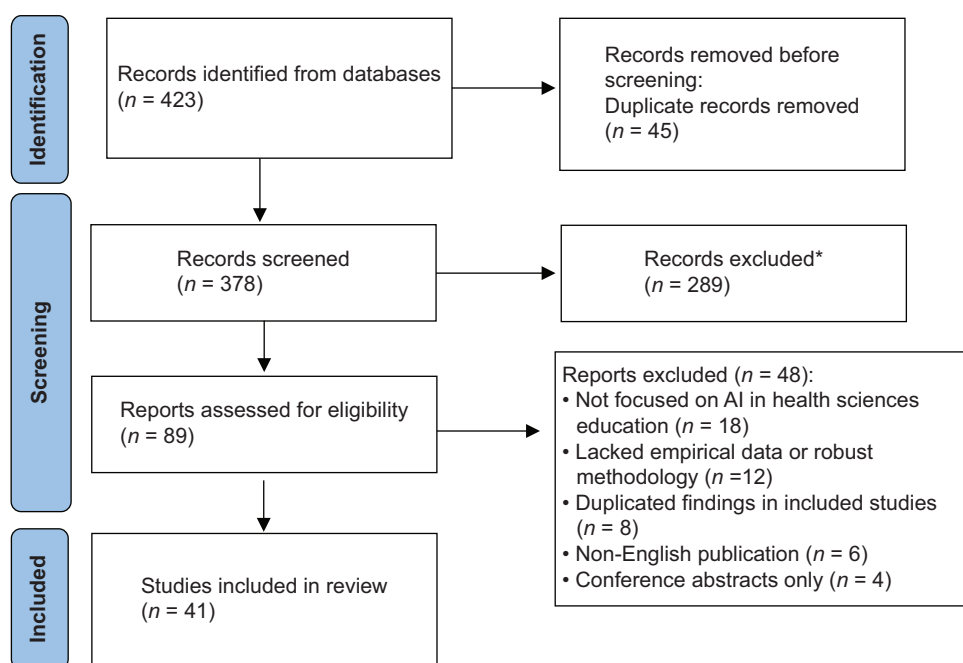


Figure 2. Study selection process following Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines. Image created by the authors.
Abbreviation: AI: Artificial intelligence.

3. Results

The analysis of these publications indicates a growing interest in AI within health sciences education and clinical training, with 41 articles published between 2020 and 2025, reflecting a gradual increase in research output over this period.

Figure 3 depicts the annual distribution of publications. The highest number of publications was observed in 2024, accounting for 25% of the total publications. In 2020 and 2021, each year contributed approximately 15.6%, followed by a slight decline in 2022 (12.5%), and a subsequent increase in 2023 (21.9%). For 2025, only 9.4%

of publications have been recorded to date, indicating that data for this year remain incomplete. Overall, these figures demonstrate an upward trend in research interest regarding the application of AI in health sciences, particularly over the past few years, suggesting increasing momentum in both research output and practical applications.

Furthermore, the results of the selected studies provide a detailed overview organized around the following important themes, including the potential for AI integration in health sciences education to transform clinical reasoning and educational outcomes. Studies show that AI can facilitate clinical skills training through simulation

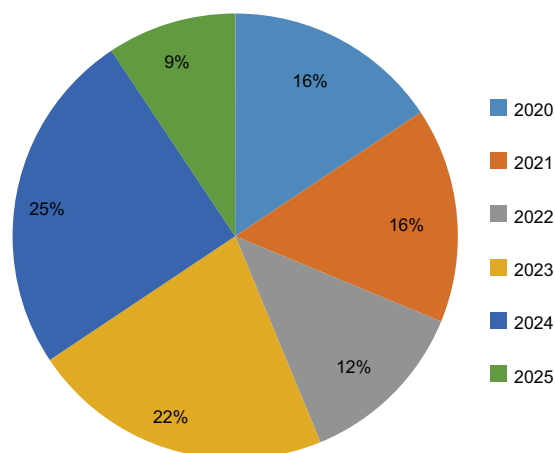


Figure 3. Distribution of publications on artificial intelligence in health sciences from 2020 to 2025. Image created by the authors.

and virtual patient encounters, boosting students' capacity to make accurate diagnoses and treatment decisions. Personalized learning methodologies offered by AI enable tailored training experiences that adapt to individual learning styles and learning pace, promoting competency growth among health sciences professionals.

Furthermore, AI-powered diagnostic systems show promising outcomes in improving diagnostic accuracy, reducing diagnostic errors, and optimizing patient care pathways. However, the use of AI in health sciences education raises ethical concerns and practical challenges, such as patient privacy, data security, and algorithmic biases, which may unintentionally perpetuate healthcare disparities. Educators have diverse viewpoints on AI integration, with some recognizing its potential to adapt teaching practices and improve learning outcomes, while others are uncertain about its reliability and ethical implications. Addressing these concerns is critical for ensuring responsible AI use in educational settings while upholding patient-centered care standards. Solutions to these ethical challenges may not be achieved solely through technical safeguards but also through dedicated training programs aimed at sensitizing future healthcare professionals about privacy, data integrity, and fairness in AI-assisted decision-making.

The effectiveness of ML models in health sciences settings is well-documented, particularly in clinical data analysis and decision support systems. ML algorithms demonstrate robust performance in analyzing complex clinical datasets, identifying patterns, and predicting patient outcomes. In educational contexts, ML-driven assessment tools enhance the evaluation of students' clinical reasoning abilities by providing objective metrics and feedback. These tools contribute to evidence-based

educational practices, supporting educators in assessing competency development and tailoring instructional strategies to meet learners' needs effectively. Synthesizing research across these areas demonstrates AI's potential to transform health sciences education by boosting clinical reasoning, supporting tailored learning, and improving diagnostic accuracy. However, integrating AI in health sciences settings presents considerable challenges, such as ethical concerns and diverse attitudes among educators. In future studies, overcoming these issues and effectively leveraging the performance of ML models will be important to realizing AI's full potential in healthcare education and clinical practice. This review emphasizes the importance of ongoing research and collaboration among educators, practitioners, and AI developers in optimizing AI's incorporation and impact in health sciences education (Table 1).

4. Discussion

Artificial intelligence has advanced the development and integration of AI within medical education in most of the reviewed studies. This indicates that AI has influenced the avenues through which it may transform education, enhance learning outcomes, and address emerging challenges in health professions education.

Most findings indicate that AI can improve the quality of diagnoses and clinical reasoning. García-Castro and Ruiz-Ortega,¹ King *et al.*,²¹ and Wysocki *et al.*²³ demonstrate how AI-assisted tools can improve students' diagnostic precision and critical thinking. In pathology, for example, AI-supported systems increased students' ability to interpret diagnostic material.¹⁹ Radiology education represents another major area of AI-related research.²⁵ Similarly, neurosurgery, with its advanced imaging and complex decisions, is likely to benefit from AI-assisted reasoning. AI can further support diagnosis, surgical planning, and personalized treatment approaches. The advantages of AI can enhance outcomes and help clinicians' decision-making in complex neurosurgical cases in relevant contexts.³⁷

Given the complex imaging and decision-making requirements specific to neurosurgery, it stands to reason that research into AI-based reasoning systems will increasingly extend to this field. Such developments may contribute to improved surgical planning, intraoperative guidance, and predictive analysis, leading to better clinical outcomes. This integration has the potential to enable targeted, personalized, and safe neurosurgical procedures.³⁸ Similarly, AI-based interactive learning methods hold potential for surgical education, offering adaptive simulations that support both technical and cognitive skill development.³⁸

Table 1. Included studies

Year	Title	Study design	Objective	Key findings	Reference
2020	Health care employees' perceptions of the use of artificial intelligence applications: Survey study	Quantitative	Explore healthcare employees' perceptions of AI	Identified mixed reactions regarding AI adoption	9
2020	Artificial intelligence education and tools for medical and health informatics students: Systematic review	Systematic review	Evaluate AI-based assessment tools in medical education	Found AI-assisted evaluations to be more objective and consistent	10
2020	Artificial intelligence for personalized preventive adolescent healthcare	Mixed methods	Investigate AI-driven feedback in clinical training	AI-generated feedback improved learning outcomes	11
2020	Ethical barriers to artificial intelligence in the national health service, United Kingdom of Great Britain and Northern Ireland	Qualitative	AI and ethical dilemmas in clinical reasoning	Highlighted the need for ethical AI training	12
2020	Shall I tell my mentor? Exploring the mentor–student relationship and its impact on students' raising concerns on clinical placement	Qualitative	AI's influence on clinical mentorship	Found AI provided valuable supplementary guidance	13
2021	Clinical reasoning and medical education: Scoping review	Review	Investigate clinical reasoning in medical education	Highlighted AI's role in enhancing diagnostic accuracy	1
2021	A quasi-experimental study of specialized training on the clinical decision-making skills and social problem-solving abilities of nursing students	Quasi-experimental	AI-enhanced simulation training in medical curricula	Improved decision-making skills among students	14
2021	Developing a medical artificial intelligence course for high school students	Survey	AI-based tutoring systems for medical students	Increased efficiency in self-paced learning	6
2021	Ensuring patient and public involvement in the transition to AI-assisted mental health care: A systematic scoping review and agenda for design justice	Systematic review	AI-assisted diagnostic training for nurses	Improved diagnostic accuracy in nursing students	15
2021	Validation of the general medicine in-training examination using the professional and linguistic assessments board examination among postgraduate residents in Japan	Mixed methods	AI-driven language processing in medical education	Improved students' understanding of medical terminology	16
2022	Personalized education and artificial Intelligence in the United States, China, and India: A systematic review using a human-in-the-loop model	Mixed methods	Examine AI's personalized education	AI improved tailored learning experiences	3
2022	Health care students' perspectives on artificial intelligence: Countrywide survey in Canada	Survey	Investigate students' perspectives on AI	Noted increased engagement with AI-driven education	17
2022	Intelligent agents based integration of machine learning and case base reasoning system	Experimental	Integration of ML with case-based reasoning	Improved diagnostic reasoning in simulated environments	18
2022	The explainability paradox: Challenges for xAI in digital pathology	Mixed methods	AI's role in pathology training	Enhanced diagnostic precision in pathology practice	19
2023	Advancing surgical education: The use of artificial intelligence in surgical training	Survey	AI's impact on surgical residency training	Reported improved efficiency in skill acquisition	20
2023	What works where and how for uptake and impact of artificial intelligence in pathology: Review of theories for a realist evaluation	Quantitative	AI in diagnostic skill development	Demonstrated improved diagnostic accuracy with AI assistance.	21

(Cont'd...)

Table 1. (Continued)

Year	Title	Study design	Objective	Key findings	Reference
2023	Artificial intelligence teaching as part of medical education: Qualitative analysis of expert interviews	Survey	AI acceptance among healthcare educators	Noted growing but cautious acceptance of AI	22
2023	Assessing the communication gap between AI models and healthcare professionals: Explainability, utility, and trust in AI-driven clinical decision-making	Mixed methods	AI-driven assessments in clinical reasoning	Found AI improved critical thinking skills	23
2023	Artificial intelligence in nursing and midwifery: A systematic review	Qualitative	AI in real-time clinical decision support	Reported faster and more accurate diagnostic suggestions	24
2023	Exploring the integration of artificial intelligence in radiology education: A scoping review	Review	AI-assisted radiology education	Improved image interpretation skills among trainees	25
2023	AI in medical education: Medical student perception, curriculum recommendations and design suggestions	Quantitative	AI-supported knowledge retrieval for medical students	Increased efficiency in accessing and applying knowledge	26
2024	Artificial intelligence and pharmacy education: a survey to assess the knowledge, application, and perspective of B. Pharm. Students from India	Quantitative	AI integration in pharmacology education	Enhanced learning outcomes and medication safety knowledge	27
2024	The future of medical education: A review of the opportunities and challenges of artificial intelligence integration	Review	AI in continuing medical education	Found AI improved knowledge retention	4
2024	Generative AI in education: A study of educators' awareness, sentiments, and influencing factors	Qualitative	Educators' awareness and sentiments about AI	Highlighted diverse opinions, with concerns regarding ethical implications	28
2024	The role of artificial intelligence in increasing the health literacy of patients	Review	Role of AI in increasing digital literacy	Emphasized the need for training healthcare professionals in AI literacy	29
2024	Perceptions of faculty and students about use of artificial intelligence in medical education: A qualitative study	Qualitative	Faculty perceptions of AI in medical training	Noted concerns regarding AI replacing traditional teaching methods	30
2024	Artificial intelligence in medical problem-based learning: Opportunities and challenges	Experimental	AI-driven case studies in problem-based learning	Found AI-enhanced cases more engaging and informative	31
2024	Artificial intelligence-driven virtual patients for communication skill development in healthcare students: A scoping review	Review	AI-powered virtual patients for clinical training	Increased engagement and realism in case scenarios	32
2024	Medical student experiences and perceptions of ChatGPT and artificial intelligence: Cross-sectional study	Cross-sectional study	AI-enhanced peer learning in medical schools	Improved peer-to-peer engagement	33
2025	Integrating artificial intelligence into medical curricula: perspectives of faculty and students in South Korea	Review	Impact of AI on medical curriculum structure	Suggested AI integration improves curriculum adaptability	34
2025	The Application of AI in clinical nursing, yields several advantageous outcomes	Quantitative	AI in evidence-based medicine training	Improved accuracy in clinical decision-making	35
2025	Japanese cross-ministerial strategic innovation promotion program "innovative AI hospital system": How will the 4 th industrial revolution affect our health and medical care system?	Survey	AI in medical programs	Found AI-enhanced learning materials beneficial.	36

Abbreviations: AI: Artificial intelligence; ML: Machine learning.

Another main attribute in which AI excels is its customizability and adaptability related to learning experiences. AI is now capable of customizing the educational intervention even more specifically and can be positioned between knowledge retrieval and self-directed study, according to Bhutoria³ and Li and Qin.²⁶ This was also noted by Kim *et al.*,³⁴ who highlighted the role of AI in increasing curriculum flexibility and responsiveness.

Artificial intelligence may contribute to increased student engagement, as shown in studies by Rowe and Lester,¹¹ Teng *et al.*,¹⁷ and Bowers *et al.*,³² which indicate that AI systems in feedback and virtual patient simulations are associated with higher student engagement. Similarly, by integrating AI-enhanced problem-based and peer learning approaches, Chen *et al.*³¹ and Alkhaaldi *et al.*³³ describe how such methods can make education more interactive and immersive.

Weidener and Fischer²² and Salih³⁰ have examined educators' perceptions of AI, including their optimism about its potential to change current teaching methods and the ethical considerations associated with its use in the clinical settings.^{12,28} Here, the emphasis is on policy development and retraining for implementation within an institution's strategies.

The acceptance, adoption, and ethical implications of AI have therefore been thoroughly deliberated on both from the faculty standpoint and from the institutional viewpoint. Moreover, Guerrero *et al.*²⁰ and Ahmed *et al.*³⁵ emphasized interprofessional and specialized education in AI to improve procedural and decision-making outcomes in surgical and nursing training. In the same vein, innovations such as three-dimensional anatomical models based on AI¹⁴ and diagnostic simulations^{15,36} were found to help strengthen the application of knowledge to clinical performance.

These technologies enable students to participate in realistic, complex clinical scenarios, receive quick feedback, and improve their clinical reasoning processes while ensuring patient safety. AI-enabled personalized learning approaches help address a wide range of learning needs, supporting unique training experiences that better prepare healthcare professionals for real-world situations. By adapting to each student's learning style and pace, AI can identify areas where they struggle and deliver targeted instructional interventions, improving overall learning efficacy.³⁹

However, educators' perceptions of the adoption of AI vary significantly, ranging from optimism about the technology's potential to transform teaching practices

and improve learning outcomes to concerns about ethical issues such as patient privacy, data security, and algorithmic bias.²⁸ Some educators are excited about AI's potential to produce more engaging and successful educational experiences, while others are concerned about the risks associated with data breaches, misuse of personal health information, and the perpetuation of current biases in healthcare⁹. Addressing these problems necessitates strong ethical frameworks and coordinated initiatives to appropriately incorporate AI into courses. To reduce biases and preserve patient rights, institutions must design and enforce stringent data management policies, maintain transparency in AI algorithms, and involve a wide range of stakeholders in the creation and implementation processes.

Future research should focus on building comprehensive ethical guidelines that address the complex issues regarding AI integration in health sciences education. Furthermore, it is critical to investigate novel pedagogical approaches that take advantage of AI's capabilities to improve learning outcomes. Longitudinal research to measure AI's long-term effects on clinical reasoning abilities and professional competency will provide valuable insights into the technologies' effectiveness and sustainability. Interdisciplinary collaboration among educators, physicians, AI developers, and ethicists will ensure that AI applications are both technically and ethically sound. Continuously reviewing AI technologies to improve usability and efficacy in educational contexts is critical for keeping up with advances and ensuring the relevance of educational programs.⁴⁰

By making progress in these areas, healthcare education may fully leverage AI's potential to prepare competent professionals and increase clinical reasoning skills while maintaining ethical and equitable healthcare practices. This proactive and comprehensive strategy will not only improve educational quality but also foster trust and acceptance among educators and students, resulting in better patient care outcomes. Future studies should also evaluate the economic aspects of implementing AI systems with strong ethical and data protection measures, as cost remains a key factor influencing large-scale adoption in educational institutions.

5. Limitations

This review has several limitations. First, it only included English-language studies published between 2020 and 2025, which may have excluded relevant earlier or non-English literature. Second, due to the heterogeneity of the methodologies across the selected papers, direct comparisons of outcomes were not possible.

6. Conclusion

This mini-review on AI's incorporation into health sciences education emphasizes its transformative potential as well as the importance of addressing related challenges. AI technologies have considerable potential to improve clinical reasoning education by boosting diagnostic accuracy, facilitating individualized learning experiences, and, ultimately, improving patient care outcomes. To ensure responsible and equitable use, AI adoption in educational contexts must take into account ethical concerns such as patient privacy, data security, and algorithmic bias.

Educators may maximize the benefits of AI technology in preparing healthcare workers for evolving healthcare environments by aligning AI integration with educational objectives and developing strong ethical frameworks. Moving forward, it is critical to prioritize ongoing research and cross-disciplinary collaboration in order to enhance AI applications, evaluate their performance over time, and include feedback from educators and practitioners. Through these initiatives, AI can be effectively used to increase clinical reasoning skills, improve healthcare delivery, and maintain ethical standards in health sciences education and practice.

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Conflict of interest

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

Not applicable.

Consent for publication

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Availability of data

Data are available from the corresponding author on reasonable request.

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