

Exploring the Role of Artificial Intelligence Tools in Supporting Clinical Reasoning in Health Professions Education: A Systematic Review

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ABSTRACT

This review aimed to explore possible applications of various technologies based on AI principles for fostering clinical reasoning abilities of health professions learners via simulation-based training, adaptive learning platforms, use of virtual patients, and AI-supported assessments. The literature review was performed in accordance with PRISMA. Four electronic databases were accessed for studies on the application of technology-based learning solutions in medicine, namely PubMed, Scopus, Web of Science, and JSTORE from January 2010 until January 2026. Studies investigating the use of AI techniques in medical education resulting in some effects were included in the study. Two reviewers independently extracted data and assessed the methodological quality of studies using MERSQI. A total of six studies met inclusion criteria. Results revealed that AI-based training methods have positive effect on increasing motivation, diagnostic abilities, confidence level and logical structuring of reasoning processes. Despite the promising results of studies, there is high methodological variability.

Keywords: Artificial Intelligence; Adaptive Behaviour; Clinical Decision Making; Clinical Reasoning; Educational Technologies; Intelligent Material; Medical Education

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INTRODUCTION

Artificial Intelligence is generally considered the evolution of human intelligence processes by machines, especially computer systems. The fields of education and healthcare are seriously affected, and its integration into medical education has accelerated in recent years due to its ability to solve current pedagogical issues, customize learning experiences, and improve training results. Traditional training techniques have often failed to prepare students to meet real-world clinical needs due to the exponential growth of medical information and clinical complexity. Artificial

Intelligence offers a compelling answer because it provides scalable, intelligent, and adaptable platforms that can make medical education a more dynamic and successful learning process.¹ With the advent of computer-assisted training in the 1960s, artificial intelligence in education started to come into existence. The current state, in which cloud computing, machine learning, and big data have integrated with artificial intelligence, has made its application in the field of medical education orders of magnitude more complex and useful than ever before.² To make these technologies give real-time feedback, precise predictions, and precise teaching in line with the needs of learners, the algorithms used by these modern artificial intelligence systems enable them to process enormous amounts of data. By doing so, these artificial intelligence technologies help in a structured yet flexible manner to teach learners knowledge, as well as enhance their ability in terms of decision-making, in medical education, which is an area where precision is required in enormous amounts.³

The most used application domain that has seen significant penetration of AI is simulation-based education. The simulation of either a virtual patient or a robotic surgical trainer acts like a safe and controlled environment for trainees to prepare themselves for different clinical situations, decision processes involved in diagnosis, and other procedural flows without compromising the safety of a real patient.⁴ The development is useful for collecting and analyzing performance-related data, which is essential for identifying knowledge gaps and delivering treatments that are appropriate for individual patients, besides capturing the intricacies of real-life situations.⁵ Such developments

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have been very useful for professionals dealing with domains like radiology, pathology, and emergency treatment because of the real-life experience and pattern recognition that are involved.⁶ Moreover, AI technology has enabled learning systems to be adaptive, which adjust the delivery methodology of content in reference to a student's performance and his/her preferred learning method. The individualized learning materials could be generated by such systems, detection of areas prone to errors, and enhancement in consolidation by employing NLP, DL, and RL.⁷ This makes this personalized approach more engaging and effective due to consideration of diversity in students' backgrounds and their learning rates.⁸ Medical education assessment has also been revolutionized by AI in addition to its pedagogical use. Traditional assessment methods, which are often subjective and time-consuming, are being replaced or complemented by AI-powered evaluation technologies that provide immediate, objective feedback on the cognitive and procedural competencies of a learner.⁹ Examples of areas where AI enhances formative and summative assessments for more comprehensive and valid assessments include emotion-sensing platforms, automatic essay scoring, and ITS.

AI in the field of medical education helps promote teamwork and interprofessional learning as well. This includes a better understanding of roles and responsibilities within the team, case-based discussions, and team interactions through the support of AI. Moreover, AI in the development of the curriculum through analysis and mapping makes the process easier by syncing the learning objectives with the competency gaps.^{10,11} Despite these advantages, there are some problems in accepting and integrating AI in medical education.¹² The first problem is that medical educators do not have appropriate knowledge and training. This situation makes it difficult to incorporate AI technologies and tools effectively and efficiently.¹³ This situation is further complicated by institutional resistance to change, monetary constraints, and technology limitations.¹⁴ In addition to this, the ethical concerns of incorporating AI in medical education are also to be addressed. These concerns include bias, privacy, and dehumanization.¹⁵ The evaluation and standardization of AI systems used in various educational environments is also a prominent challenge. It is important to note that AI systems operate differently from other conventional teaching aids. AI requires constant evaluation and standardization to ensure its accuracy and reliability. Learning inequality and variations are problems that are linked with a lack of a proper regulatory framework with regard to AI-based educational systems.¹⁶ The digital divide for AI integration is also maintained on the basis of differences in the accessibility of digital resources and technological infrastructure between different countries. The adoption of AI-driven medical education on a large scale is facing challenges of the digital divide in LMICs, causing disparities in current education.¹⁷ So, to overcome

the disparities, various stakeholders will have to come together, such as sponsors, universities, academies, policymakers, and technology developers. Dealing with this simultaneously, like a two-fisted boxing fight, would require a two-fisted strategy of boxing. Apart from the organizational support and incentives, these overall campus-wide faculty development programs, which emphasize digital literacy and AI competency, would help in creating a culture that nurtures innovation and lifelong learning.¹⁸ In addition, the development and use of appropriate context and moral AI programs would be a product of collaborative work between educators, informaticists, ethicists, and medical experts in the field.¹⁹

Recent studies further indicate that the involvement of students in co-designing AI tools and curriculum holds great importance. A user-centered design incorporating feedback and opinions of end-users increases the usefulness and acceptability of the AI systems.²⁰ This participation strategy ensures that the AI applications are not only relevant to the students but also aligned with the educational objectives and foster participation and responsibility. By ensuring that applications are aligned with student needs and educational goals, this participatory method helps foster a sense of ownership. Moreover, in assessing and understanding how AI improves learning, skills, reasoning, and patient care, longitudinal studies and outcome studies are essential. Although encouraging, such studies are often limited by short-term studies and lack of generalizability to other educational settings.²¹ Best practices and standards can also guide policymaking and decisions. Due to the need for remote and virtual learning out of the COVID-19 epidemic, there is also an accelerated integration of artificial intelligence in the field. Through this, the best and worst in digital learning settings are highlighted, thus the need for robust education paradigms is ensued.²² By virtue of its ability to present viable, interactive, and data-driven solutions for teaching, artificial intelligence (AI) is an urgent advance in the standard of medical education. The integration of AI in medical education heralds a paradigm shift, whose implications are far-reaching for medical education, learning, and assessment. It, therefore, becomes imperative for medical schools and educators to approach a holistic and moral approach by ensuring the primacy of quality, equity, and sustainability in health, particularly in the face of medical education and practice's integration with technology. If properly harnessed, AI has the capacity for a paradigm shift in medical education and a better disposition of medical practitioners for the complexities of modern medicine through well-thought-out investments, alliances, and practices.²³⁻²⁸

METHODOLOGY

This study has been performed as a systematic review aimed at investigating the significance of using educational tools that use artificial intelligence to improve clinical reasoning skills, decision-making processes, engagement levels,

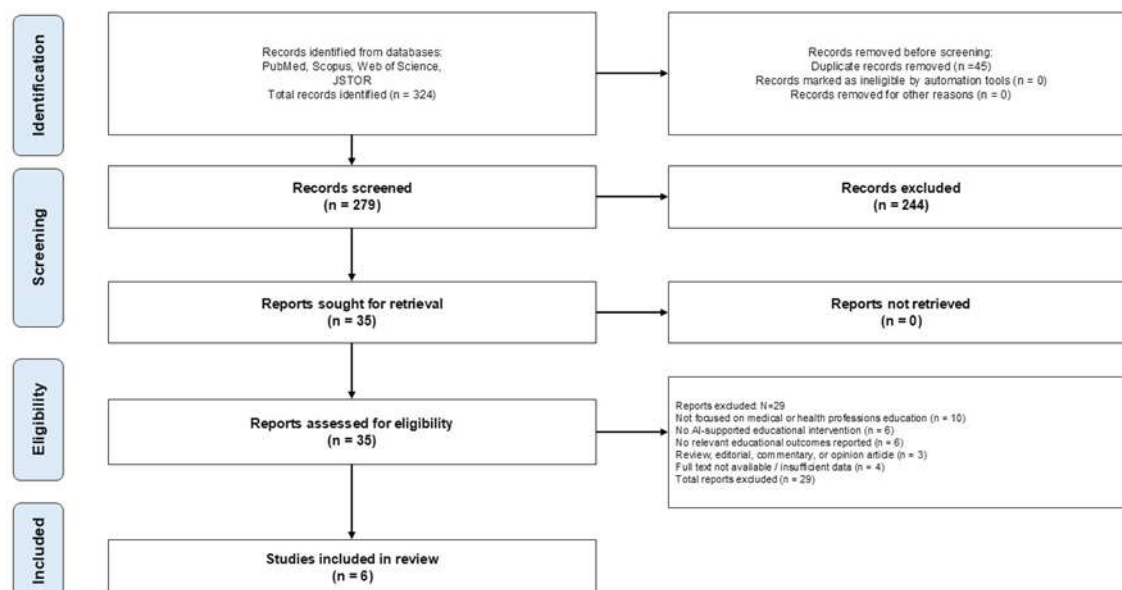
feedback mechanisms, and other educational outcomes. The systematic review has been carried out following the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines.²⁹ The systematic review mainly considered AI-based educational strategies including simulation-based learning systems, adaptive learning environments, virtual patients, machine learning-assisted assessment systems, and feedback mechanisms.

The review was guided by the following research question: How do artificial intelligence-supported educational tools influence clinical reasoning, decision-making, learner engagement, procedural learning, and assessment-related outcomes among medical and health professions learners? Eligible studies were included based on established criteria for inclusion and exclusion.³⁰⁻³¹ A study was eligible for inclusion if it was published from January 2010 to January 2026, if it was related to education within the fields of medicine, nursing, dentistry, or another health profession, studies which demonstrated the assessment of an educational method aided by artificial intelligence, having at least one outcome relating to clinical reasoning, diagnostic decision-making, procedure-based learning, information acquisition, engagement, feedback, or evaluation. Articles containing original research data or evaluative results, written in English, obtainable as full-text papers. Studies were excluded if they were conducted solely on the use of artificial intelligence in clinical decision-making and treatment without a learning element, those dealing with artificial intelligence purely theoretically without discussing any learning results, editorials, commentaries, opinions, letters, and descriptive reviews, those concerned with health professions education

outside healthcare, not containing any results about learners and duplicate papers or meeting abstracts lacking adequate methodology.

A thorough literature search was done through four online databases, namely, PubMed, Scopus, Web of Science, and JSTOR. The database search entailed articles that have been written from January 2010 to January 2026. The database search was done in January 2026.³⁰ The search terms were those pertaining to artificial intelligence, medical education, clinical reasoning, simulation, adaptive learning, and assessment. The Boolean operators were utilized to link the search terms together. The PubMed search terms contained ("artificial intelligence" OR "machine learning" OR "deep learning" OR "intelligent tutoring system" OR "adaptive learning" OR "virtual patient" OR "natural language processing") AND ("medical education" OR "health professions education" OR "clinical training" OR "medical students" OR "nursing students" OR "surgical trainees") AND ("clinical reasoning" OR "decision-making" OR "diagnostic reasoning" OR "simulation" OR "assessment" OR "feedback" OR "learning outcomes") Similar search terms were adapted for Scopus, Web of Science, and JSTOR according to the search functions of each database. Reference lists of relevant articles were also reviewed manually to identify additional eligible studies. The database search identified 324 records. After removal of 45 duplicate records, 279 records were screened by title and abstract. Of these, 244 records were excluded, and 35 full-text reports were assessed for eligibility. Twenty-nine reports were excluded for predefined reasons, leaving six studies for final inclusion in the review. The study selection process is shown in Figure 1.

Figure 1. PRISMA 2020 flow diagram for study selection



All studies found from searching the databases were uploaded to Rayyan App, where duplicates were discarded. Two reviewers independently screened the titles and abstracts of the identified papers based on the inclusion criteria. Those papers that met the criteria were considered for a full-text analysis. Afterwards, the full-text articles were independently analyzed by the two reviewers. Where there were disagreements in terms of including some of the full texts, discussion ensued. If no agreement was achieved, the decision rested on the third reviewer. The total number of the articles used was decided after the full-text analysis.²⁹ Data were extracted using a standardized data extraction form developed for this review.³² The information collected from each included the author and year of publication, Country or region, Study design, Participant characteristics, Educational level of learners, Type of AI-supported intervention, Comparator or control condition, if applicable, Educational context, Outcome measures, Main findings, Reported limitations, Quality assessment score. Data extraction was performed independently by two reviewers. Extracted data were compared for accuracy and completeness. Any disagreements were resolved through discussion and rechecking of the original article.³²

Methodological quality of the studies that met the inclusion criteria was assessed using Medical Education Research Study Quality Instrument, popularly referred to as MERSQI. This quality assessment instrument measures six key dimensions of medical education research including study design, sampling, data type, validity of the evaluation instrument, data analysis, and outcomes.³³ Every study selected for the review underwent quality assessment by two independent reviewers. Higher scores on the MERSQI instrument were indicative of a better methodological quality. However, studies scoring poorly on this instrument were not excluded from the analysis; instead, their weaknesses were taken into account when interpreting their findings.³³ A meta-analysis could not be conducted due to heterogeneity among studies regarding design, learner group, AI intervention, comparison group, and outcomes. However, a narrative synthesis approach was chosen.^{34, 35} The selected studies were categorized into four main groups, depending on their focus on AI intervention, which included AI-assisted clinical simulation, AI-assisted procedural simulation, Adaptive learning systems, Machine learning-based assessment tools. The results were synthesized by the educational area, such as Clinical reasoning/decision making, Procedural skills, Knowledge, Learner engagement / satisfaction, Assessment and feedback process. The direction of the effect size was identified as either positive, neutral, mixed, or inconclusive based on study results. The strength of the evidence was carefully evaluated by the number of studies, agreement between studies, and overall methodological rigor.

RESULTS

The systematic search identified studies evaluating the role of artificial intelligence-supported educational tools in medical and health professions education. After removal of duplicates and screening of titles and abstracts, potentially relevant full-text articles were assessed for eligibility. Six studies met the inclusion criteria and were included in the final synthesis. The included studies examined AI-supported simulation systems, adaptive learning platforms, virtual patient approaches, surgical training tools, and automated assessment systems.³⁶⁻⁴⁹ The six included studies varied in terms of country, learner population, study design, AI intervention type, and educational outcome measures. The included studies involved medical students, nursing students, surgical trainees, and other health professions learners. Most studies evaluated AI tools in simulation-based or adaptive learning contexts, while fewer studies examined automated assessment and feedback systems. The included studies demonstrated four main categories of AI application in medical and health professions education: simulation-based learning, adaptive learning, automated assessment, and AI-supported procedural training. Simulation-based systems were mainly used to support clinical decision-making and procedural practice. Adaptive learning platforms personalized content delivery according to learner performance. Automated assessment tools were used to improve feedback consistency and reduce subjectivity in evaluation.³⁶⁻⁴⁹

Across the included studies, AI-supported educational interventions were generally associated with positive educational outcomes. The most frequently reported improvements were in learner engagement, clinical decision-making, procedural skill acquisition, and feedback efficiency. However, the degree of improvement varied between studies because of differences in learner populations, study designs, intervention types, and outcome measurement tools.³⁶⁻⁴⁹ The direction of effect was positive across most educational domains, although evidence strength remained limited because of the small number of included studies. Clinical reasoning or decision-making improved in three studies, while procedural skill improvement was reported in two studies. Engagement and learner satisfaction improved in three studies. Only one study primarily examined automated assessment efficiency.³⁶⁻⁴⁴ The methodological quality of the included studies was variable. Most studies provided useful educational insights, but differences in design, sample size, learner population, intervention type, and outcome measurement limited direct comparison. The evidence was strongest for simulation-based and adaptive learning interventions, while the evidence for automated assessment remained preliminary. The next intervention type that was found relevant was the use of adaptive learning technologies. These interventions customized the learning content and pace based on the learners' performance levels. According to research findings on adaptive AI, there was a noticeable

improvement in learner engagement, learner satisfaction, and retention of knowledge. Therefore, AI can play an important role in dealing with variability among learners.^{41,42} AI-supported procedural training tools, particularly surgical simulation platforms, were associated with improved technical performance and skill acquisition. These systems provided real-time or adaptive feedback, which helped learners refine their procedural skills. However, the evidence was mainly limited to simulation settings, and it remains unclear whether these improvements translate into real clinical performance.^{37,38} Automated assessment and feedback

systems received less attention; however, they have significant potential in enhancing the accuracy and consistency of feedback delivery to learners. Assessment tools that rely on machine learning may lessen the workload on evaluators and facilitate immediate feedback delivery to learners. Nonetheless, the existing literature on this topic is limited and requires more validation.⁴⁴ In general, the evidence suggests that AI systems can assist with clinical reasoning, procedural learning, motivation, and evaluation processes. Nonetheless, there are several limitations associated with the analysis due to a limited sample size of research,

Table 1. Characteristics of included studies

Study	Country / Region	Study design	Participants	Educational intervention	Comparator	Main outcome domain
Liaw et al., 2015	Singapore	Randomized controlled trial	Nurses	Interactive multimedia Web-based simulation	Conventional/alternative learning approach	Clinical competency and learning outcomes
Lauritzen et al., 2019	Europe	Simulation-based evaluation	Surgical trainees/students	AI-powered surgical simulator	Standard skills training	Procedural accuracy and skill acquisition
Mulder et al., 2022	International	Applied/evaluative study	Surgical trainees	Deep learning-supported surgical training	Traditional simulation	Technical performance and skill retention
Chan & Zary et al., 2021	Sweden/International	Educational implementation	Medical students	AI-supported adaptive learning pathway	Conventional curriculum	Knowledge and learner engagement
Sandars et al., 2020	United Kingdom	Educational innovation evaluation	Medical trainees	AI-driven adaptive learning platform	Standard e-learning	Knowledge retention and satisfaction
Masters et al., 2021	International	Educational assessment study	Health professions students	Machine learning-based assessment	Traditional assessment	Feedback efficiency and consistency

Table 2. AI-supported interventions and strength of evidence

AI application domain	Studies	Educational purpose	Reported benefits	Evidence strength	Interpretation
Simulation-based learning	Liaw et al.	Exposure to realistic clinical scenarios and decision-making tasks	Improved learning, decision-making practice and engagement	Moderate	Simulation may support clinical decision-making and learning in controlled environments
AI-supported procedural simulation	Lauritzen et al.; Mulder et al.	Development of technical and procedural skills with performance feedback	Improved procedural accuracy, technical performance and skill retention	Limited–Moderate	May improve procedural skill acquisition, although transfer to clinical practice requires further evaluation
Adaptive learning systems	Chan & Zary et al.; Sandars et al.	Personalization of learning according to learner progress and performance	Improved knowledge acquisition/retention, engagement and satisfaction	Moderate	Adaptive systems may facilitate individualized learning and learner engagement
Machine learning-based assessment	Masters et al.	Automated evaluation and structured feedback	Greater consistency, objectivity and efficiency of feedback	Limited	Promising application, but evidence remains preliminary and requires further validation

Table 3. Educational outcomes and direction of effect of AI-supported interventions

Outcome domain	Studies reporting improvement	Overall direction of effect	Consistency of findings	Interpretation
Clinical reasoning/decision-making	3 of 6	Positive	Moderate	AI-supported learning may facilitate structured clinical reasoning and decision-making practice
Procedural skill development	2 of 6	Positive	Moderate	Simulation and procedural training tools may improve technical accuracy and skill acquisition
Knowledge acquisition/retention	2 of 6	Positive	Moderate	Adaptive learning systems may support individualized knowledge development and retention
Learner engagement/satisfaction	3 of 6	Positive	Moderate–Strong	AI-supported platforms may increase motivation, participation and learner satisfaction
Assessment and feedback efficiency	1 of 6	Positive	Limited	Automated assessment may improve feedback consistency and objectivity, although evidence remains limited

methodology differences, and variable outcomes. Additional randomized and longitudinal studies are required to determine the long-term effect of AI-assisted education on clinical reasoning and performance.³⁶⁻⁴⁹

DISCUSSION

The new paradigm in medical education, brought about through developments in artificial intelligence, sees environments that are increasingly technological, data-driven, and responsive. Results from many studies are succinctly presented in the discussion part, including how the findings have been viewed. The revelations are an encouragement for new thoughts on areas that need attention, but also reinforce the value of artificial intelligence.⁵¹⁻⁶⁰ "One of the most important advantages we have in medical education is precision learning, and we predict this will be provided by AI. Artificial intelligence (AI) technologies have access to vast quantities of data regarding student learning and can recognize areas where students have not learned key information and predict what students are capable of. They offer special educational interventions. Remediation and fast track learning approaches might be facilitated through this type of precision, which might also eradicate the space between those students who are not learning and those students who are. Moreover, in situations where students are at risk of underperforming and not succeeding, teachers might be alerted by these technologies, and students will receive appropriate academic support measures".^{51, 52} Important forms of curriculum customisation are also brought about by the incorporation of AI. The manner that instructional content is presented and customized for each student has changed as a result of ITS, learning algorithms, and natural language processors. Higher student happiness, improved comprehension of difficult ideas, and increased readiness for clinical work have all been observed at medical schools with AI enhancements. Additionally, AI has made it possible for medical education to become more gamified,

with students engaging in reward-based or competitive learning activities that increase motivation and engagement.⁵³

Additionally useful learning tools are diagnostic AI technologies and clinical decision support systems (CDSS). Students are exposed to real-time benchmarking through the comparison of their diagnostic inputs with the AI-derived findings. These experiences have enhanced the development of clinical reasoning and differential diagnosis formation in addition to improving diagnostic accuracy. According to some educators, these tools democratize access to expert-level ideas, especially in rural institutions or settings with low resources.^{54, 55}

However, with these advantages, issues of consequence continue to persist. Similar to how algorithmic bias has continued to be a problem even when algorithms are trained on datasets of a homogeneous population, there are also issues of bias and concerns of fairness and justice, and how such biases can further exacerbate inequalities in the area of medical education with the reported instances of poor performance by AI systems in processing and evaluating disadvantaged demographic groups of data. In addition to this, issues of cognitive laziness are also a consequence of an over-reliance on AI without proper pedagogical intervention.⁵⁶ Thus, educators in an AI-enhanced environment of learning need to be reassessed. Their role must move from a mere knowledge-disseminating capacity to one of technological facilitation. This warrants a need for educators to be aware of machine learning literacy, data science in education, and AI pedagogy. The need for faculty development stems from the above necessity. Academic institutions need to design policies to foster trust and transparency in the development and implementation of AI. This includes policies concerning data protection, academic integrity, and permissions from the students.⁵⁷ In addition, institutional preparedness and technology have played a significant role in shaping artificial intelligence adoption.

In this respect, some medical schools have excelled due to effective information technology governance, ed-tech investments, and interdisciplinary collaboration with medical educators and computer scientists. Working with artificial intelligence technology providers and innovation centers has helped some pioneering medical schools hasten the adoption of this technology. On the other hand, some medical schools have languished due to poor technology and institutional preparedness to incorporate artificial intelligence strategies and plans.⁵⁸ Another domain being explored in AI-supported education is the revisiting of the assessment process. It has been seen that traditional assessments do not fully capture the multifaceted competencies that will be demanded by future doctors. There is an opportunity for capability-based assessments, which will not only include knowledge recall but also other competencies that are essential in becoming successful doctors, like ethics, emotional intelligence, and other such attributes. Real-time analytics will present a fuller view of pupil progression.⁵⁹ The recent literature has also helped to enlighten us with respect to the way in which the concept of "Lifelong Learning" and "continuous professional development" would be assisted and/or facilitated through AI systems. Such activities would include skill decay analysis, recommendations for refresher modules, and even simulation of re-certification of practicing clinicians. Vertical integration of higher education undergraduate, graduate, and professional education represents an integrated system of learning to meet the needs of a changing health care delivery system.^{60, 61}

Lastly, the question of global fairness in terms of the implementation of AI systems must be factored in. While it is the high resource education institutions that are at the forefront of such innovative practices, the medical schools in the low- and middle-income countries are impaired in the implementation of AI systems. There is a need for a non-digital divide in the implementation of AI for the training of medical practitioners.⁶¹ There is a need for a non-digital divide in the implementation of AI for the training of medical practitioners.⁶¹ Emerging evidence from Pakistan supports this direction a recent randomized crossover trial found AI-facilitated case-based learning comparably effective to human facilitation for developing clinical reasoning in dental students, suggesting AI tools may help offset resource and faculty shortages in similar low-resource settings.⁶² In conclusion, this above analysis underlines the complex effect of Artificial Intelligence in medical education. It is to be noted that strategic planning, ethics, inclusivity, and faculty empowerment are very crucial to maximize the effect of Artificial Intelligence.

CONCLUSION

This systematic review identified the potential of AI-assisted educational interventions to improve clinical reasoning, decision making, procedural learning, learner motivation,

and feedback in medical and healthcare education. Simulation and computer-aided learning programs demonstrated potential educational value. However, due to the small sample size, lack of consistency in study design and outcomes measured, and variability in learner population, the research evidence is still insufficient. Additional empirical research on the effectiveness of AI-supported educational interventions in improving clinical reasoning and clinical practice should be conducted.

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Authors Contribution:

Saman Tauqir: Conception and design, acquisition of data analysis and interpretation of data, drafting and critical revision, final approval of the version to be published.

Hira Faisal: Conception and design, acquisition of data analysis and interpretation of data, drafting and critical revision, final approval of the version to be published

Saif Ullah Shaikh: Conception and design, acquisition of data analysis and interpretation of data

Sana Barkat Ali: drafting and critical revision, final approval of the version to be published

Saira Hassan Aksarey: drafting and critical revision, final approval of the version to be published

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