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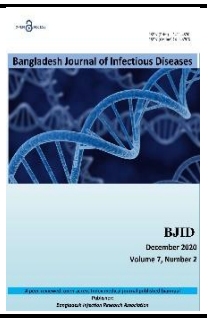

Artificial Intelligence in Medical Education: Opportunities and Challenges

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Abstract

Background: Artificial intelligence (AI), especially large language models (LLMs), is quickly gaining access to medical education, introducing new possibilities to enhance, customize, and expand teaching and learning processes. Their ability to generate natural language outputs supports a wide range of uses in education, evaluation, and faculty development. **Objective:** This short communication aims to highlight the current uses, benefits, risks, and future directions for the integration of LLM into medical education. **Perspective:** Current applications of AI in medical education include personalized tutoring, clinical reasoning simulations, automated assessment item generation, and curriculum development. While its benefits include scalability, flexible pedagogy, and reduction of faculty workload. Limitations include factual errors, bias propagation, lack of transparency, and potential disintegration of independent reasoning. Further, ethical considerations of AI encompass academic integrity, patient safety, data security, and equity of access. Research priorities involve evaluating learning outcomes, safety of simulated practice, and best practices for human–AI collaboration. **Conclusion:** LLMs hold transformative potential for medical education if integrated with faculty oversight, AI literacy training, and robust validation processes. Responsible adoption should prioritize accuracy, transparency, and learner competence, ensuring technology serves as a complement, not a substitute for human expertise. [*Bangladesh Journal of Infectious Diseases, June 2025;12(1):189-194*]

Keywords: Artificial intelligence, medical education, opportunities, challenges, future directions.

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Introduction

Over the past decade, progress in neural networks, deep learning, and artificial intelligence (AI) has revolutionized the way of approaching and tasks in industries ranging from manufacturing and finance to consumer products[1]. Medical education has always evolved alongside advancements in science, technology, and pedagogy. From the espousal of cadaveric dissection in the Renaissance to the

integration of simulation-based learning in the late 20th century, each innovation has reshaped how future physicians acquire knowledge, skills, and professional values. The emergence of AI and more specifically, LLMs marks the next significant inflection point in this progression[2].

Large language models are sophisticated artificial intelligence systems built on extensive text datasets, enabling them to comprehend and produce language that closely resembles human communication. Models like GPT-4 and newer versions are capable of handling complex questions, delivering context-appropriate explanations, condensing medical literature, emulating patient encounters, and producing educational materials. Unlike earlier rule-based or domain-specific educational software, LLMs exhibit generalizability across subjects and tasks, making them highly adaptable to diverse educational contexts[3].

The foundation of medical education rests on three pillars: acquiring knowledge, developing clinical reasoning, and cultivating professional behaviour. While digital technologies have progressively reshaped these areas, LLMs mark the newest evolution, offering the ability to produce clear explanations, mimic clinical conversations, create assessment materials, and deliver tailored feedback instantly. In medical education, LLMs have begun to demonstrate utility in several domains[4]. They can function as virtual mentors, providing personalized explanations and adaptive question sets, as well as simulating patient encounters that allow learners to practice history-taking, clinical reasoning, and counseling skills in a safe, low-pressure environment. Educators can leverage them to preliminary teaching resources, assessment tools, and feedback, minimizing time on repetitive tasks and allowing greater focus on high-impact teaching activities[5].

Nevertheless, incorporating LLMs into medical education comes with its own set of challenges. These models may produce factual inaccuracies, referred to as "hallucinations" and inadvertently perpetuate biases present in their training data, and function without well-defined or transparent reasoning processes. Overreliance on AI tools could undermine the development of independent clinical judgement, critical thinking, and professional identity. Moreover, issues related to ethics and regulation such as data privacy, academic integrity, and fair access need to be resolved before its widespread implementation[6,7].

This short communication explores the contemporary uses, potential advantages, challenges, and future prospects of incorporating LLMs into medical education. The central argument is that while LLMs offer unprecedented opportunities for customized learning and increased scalability, their integration must be deliberate, evidence-informed, and safeguarded by human oversight. In doing so, medical educators must ensure that AI serves as an augmenting force, enhancing rather than replacing the essential human elements of teaching, mentorship, and clinical judgment[4]. Unlike narrowly engineered intelligent tutoring systems, LLMs generalize across topics and tasks, making them attractive tools for distributed education and lifelong learning. Their educational benefit ultimately hinges on their role being that of assistants and enhancers of teaching, rather than substitutes for faculty expertise or guided clinical practice. Thus, responsible integration of LLMs into medical education requires robust, evidence-based support. Research should prioritize randomized controlled trials, long-term cohort studies, and mixed-method approaches that explore learner experiences and uncover any unintended effects of AI[8,9].

Current Applications of AI in Medical Education

AI holds significant promise for enhancing medical education, boosting diagnostic accuracy, and shaping the future of healthcare careers. Applications of AI fall into four pragmatic categories:

a. Personalized tutoring and study support[10]

- On-demand explanations: LLMs can restate complex concepts in varying degrees of complexity, create analogies, and produce step-by-step examples.
- Adaptive learning aids: LLMs customize explanations and practice questions based on the learner's proficiency, facilitating spaced repetition and targeted remediation.

b. Clinical reasoning simulation and virtual patients[11]

- Case simulation: LLMs can role-play patients, nurses, family members, or consultants to create realistic encounters for history-taking, differential diagnosis, and management planning.
- Reflective dialogue: They prompt learners to explain their reasoning, justify their decisions, and reflect on diagnostic uncertainties, all of which have been shown to strengthen clinical reasoning skills.

c. Assessment and feedback generation[12]

- Drafting assessment items: Educators can leverage LLMs to create multiple-choice questions, short-answer prompts, OSCE checklists, and clinical case scenarios, which can subsequently be reviewed and refined.
- Automated feedback: LLMs can provide formative feedback on assignments, clinical notes, and reflective exercises by highlighting gaps and suggesting appropriate resources.

d. Curriculum design, content summarization, and faculty support[13]

- Synthesis of literature: LLMs are capable of condensing guidelines, highlighting key findings from research articles, and generating lecture outlines or draft presentation slides for educators.
- Administrative tasks: Drafting learning objectives, rubrics, and reflective prompts reduces educator workload and enables focus on pedagogy.

Potential Benefits

LLMs could profoundly reshape the landscape of medical education by improving instruction, learning, and evaluation methods. They can provide personalized learning experiences, offer instant access to vast medical knowledge, and support skill development through interactive simulations. Furthermore, LLMs can simplify routine academic tasks and, by facilitating personalized learning, enable faculty to dedicate more time to advanced mentorship and improving student engagement[14,15,16]. Followings are some of the key potential advantages of integrating AI in medical education.

a. Personalized learning: Deliver tailored explanations, adaptive question banks, and targeted feedback based on individual learner needs.
b. Virtual patient simulations: Recreate realistic clinical encounters for practicing history-taking, diagnostic reasoning, and communication skills in a safe environment.
c. Efficient content generation: Assist faculty in developing MCQs, OSCE checklists, case scenarios, and lecture outlines.
d. Rapid literature synthesis: Summarize guidelines, extract key findings from research, and create concise teaching materials.
e. Automated feedback: Provide formative feedback on assignments, patient notes, and reflective writing, identifying knowledge gaps.
f. Accessibility & Flexibility: Facilitate independent learning and provide learners with high-quality resources accessible at any time and from any location.
g. Interdisciplinary integration: Facilitate cross-linking of medical knowledge with related fields like bioethics, public health, and data science.
h. Scalability: Extend teaching support to large cohorts without compromising the quality of guidance.

Limitations and risks of applications of AI

AI has emerged as a transformative force in medical education and healthcare services, offering significant advancements across various domains, including diagnostics, treatment planning, and personalized care. While AI offers considerable opportunities to enhance medical education, its integration is not without significant challenges and limitations. LLMs can produce inaccurate or misleading information, reinforce existing biases, and lack transparency in their decision-making processes[17,18,19]. Important limitations and risks in application of AI in medical education are appended below.

a. Hallucinations and factual errors: LLMs can generate plausible-sounding but incorrect or fabricated information. In an educational setting, relying on AI without expert verification may result in teaching incorrect medical information.
b. Bias propagation: LLMs may replicate or even amplify societal and clinical biases such as those related to gender, race, or socioeconomic status, present in their training data, affecting case scenarios or diagnostic recommendations.
c. Lack of transparency and explainability: LLMs provide outputs without clear chains of reasoning or provenance, making it difficult for learners and educators to trust or critically appraise their answers.
d. Erosion of clinical skills: Without careful scaffolding, overuse of LLMs in reasoning or documentation might impede learners' development of independent clinical judgment and effective communication.
e. Assessment validity concerns: Without careful psychometric evaluation, employing LLMs to generate assessment questions may threaten both the validity and fairness of tests.
f. Privacy and data security: Incorporating LLMs into educational platforms raises issues regarding student data, protected health information (when clinical cases involve real patients), and regulatory compliance.
g. Equity and access: Differences in institutional resources may exacerbate disparities, allowing some

students to access advanced AI tools while others are left behind.

Ethical, Regulatory and Professional Considerations

The adoption of AI in medical education raises important ethical, regulatory, and professional questions that must be carefully addressed. Ethical concerns include ensuring fairness, preventing bias, protecting student privacy, and maintaining transparency in AI-driven decisions[20]. Regulatory frameworks are needed to establish standards for the safe and responsible use of AI tools, while safeguarding data security and compliance with legal requirements. Addressing these issues is essential for responsibly incorporating AI into the training of future healthcare professionals[21]. The following are highlights with regard to ethical, regulatory, and professional concerns[20,22].

a. Patient safety: To prevent unintended consequences, educational products that guide clinical decisions, including simulated reasoning exercises, must undergo rigorous validation.
b. Informed use and consent: Learners should be made aware when content or feedback is AI-generated. Transparency is essential when LLMs are used in simulated interactions that could affect summative decisions.
c. Accountability: Responsibility for the accuracy of educational content must rest with institutions, and faculty oversight cannot be replaced by AI.
d. Data governance: Identifiable patient information must not be shared with third-party LLMs unless fully compliant with data protection regulations and institutional policies.
e. Academic integrity: Clear guidelines on AI usage in assignments and evaluations are needed to avoid academic misconduct, including presenting AI-generated content as original.

Future Directions for Educators and Institutions

Integration of AI into medical education offers promising opportunities to enhance teaching and learning processes, however, to mitigating risks, educators and institutions must adopt thoughtful, evidence-based strategies[23]. Establishing clear guidelines and best practices guarantees that AI tools are applied ethically, efficiently, and inclusively, fostering learners' professional development while upholding the integrity of medical education[24]. The following recommendations are useful for educators and institutions.

a. Adopt a 'human-in-the-loop' model: To ensure ethical and effective AI use, outputs from LLMs should always be combined with expert review. Let AI generate drafts while faculty members review and confirm them. In critical situations, implement a two-step verification process[25].
b. Define scope and boundaries: Identify areas where LLMs can assist, such as generating cases and providing constructive feedback. Refrain LLMs to handle tasks like offering unsupervised clinical advice or making summative judgments without proper supervision[26].
c. AI literacy in redesigning curriculum: Train students on how LLMs work, their benefits and limitations, ways to verify AI-generated information, and ethical usage principles, ensuring graduates become informed and critical users of AI technology[27].
d. Validation pipelines: Develop structured validation procedures for AI-created assessment items and case simulations, covering accuracy, psychometric testing, and bias review[28].
e. Data protection safeguards: For tasks involving sensitive data, rely on on-site or institution-approved AI models. Anonymize clinical material before use with third-party services[29].
f. Continuous monitoring: Develop metrics to track the effects of AI on learning outcomes, assessment results, and student behaviors [30].
g. Equitable access strategies: Ensure all learners have fundamental access to reliable AI tools and appropriate training, potentially via subsidized or institutionally provided platforms [31].

Conclusion

Artificial Intelligence is rapidly transforming medical education by enhancing personalized learning, supporting assessment, and facilitating access to vast medical repositories. Current applications demonstrate significant potential to improve learner engagement, efficiency, and educational outcomes. However, challenges, including ethical considerations, data privacy, potential biases, and the need for faculty training, must be carefully addressed. Although AI is a powerful tool, power without safeguards risks misinformation, bias, and erosion of essential clinical capabilities. The appropriate approach is neither outright banning nor blind acceptance; instead, it involves thoughtful incorporation, guided by educators, supported by evidence, and governed by ethical principles. Medical schools and teaching hospitals should pilot LLM-augmented programs with robust evaluation, incorporate AI literacy into curricula, and establish institutional policies that protect learners and patients while harnessing AI's

pedagogical strengths. Future directions should focus on rigorous research to evaluate AI's impact, the development of robust regulatory frameworks, and the integration of AI tools that complement, rather than replace, human educators. With thoughtful implementation, AI can become an indispensable ally in training the next generation of healthcare professionals.

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Conflict of Interest
The authors declare that there is no potential conflict of interest.

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MAS (Md. Abdus Salam) was responsible for conceptualization, acquisition of information, and final editing; SI (Sakib Imtiaz) and IBL (Irine Banu Lucy) were involved in acquisition and compilation of scientific information and the drafting of the manuscript. All authors have read and agreed to the published version of the manuscript. All authors read and approved the final manuscript.

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