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Integration of Artificial Intelligence in Medical Education: Opportunities, Challenges, and Ethical Considerations

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Dear Editor,

Artificial intelligence (AI) has the potential to revolutionize medical education by equipping future doctors with the latest technological advancements (1, 2). Studies have explored how AI can be integrated into educational frameworks, such as surgical skills training and case-based learning. Some research focuses on practical applications of AI in medical education, such as using AI-driven robotic systems for skill development and knowledge acquisition through simulations and assessments (3, 4). However, challenges exist in implementing these changes. Despite these challenges, AI technologies offer immense potential benefits by empowering healthcare professionals and improving patient care outcomes (5). To fully realize these benefits, continued exploration and adoption of AI in medical curricula are necessary. This letter to the editor aims to explore the opportunities, challenges, and ethical issues associated with the use of AI in medical education.

Opportunities

1. Artificial Intelligence-powered Virtual Patients

Artificial intelligence can be used to create virtual patients for medical students to practice diagnosing and treating various conditions. This provides a safe and controlled environment for students to learn and make mistakes without any real-world consequences (6).

2. Artificial Intelligence-based Human Body Model

Artificial intelligence-based robots can act as a human body model in medical education. Artificial intelligence-based medical education utilizes robots as human body models, simulates scenes, functions

as a medical encyclopedia, performs pharmacological simulations, and automatically assesses students' medical knowledge mastery (7).

3. Artificial Intelligence-based Anatomical Education and Presurgical Assessment

Several forms of surgical visualization technologies currently in use for anatomical education and presurgical assessment rely on different AI algorithms. Although arguably still in its early stages of widespread clinical application, AI technology enables personal evaluation and provides personalized feedback in surgical training simulations (2, 8).

4. Skillful Medicine-machine Interaction Training

The rise of AI in medicine will enhance clinical decision-making through data, necessitating skilled medicine-machine interaction. As medical knowledge increases, AI technologies are crucial for healthcare professionals to effectively utilize this knowledge in practice (1).

5. Specialized Postgraduate Artificial Intelligence Education Programs for Each Medical Specialty

The development of AI education programs tailored to each medical specialty is crucial for the proper utilization of AI models in clinical practice. A comprehensive review and revision of the undergraduate medical curriculum is necessary to extract significant information from expanding medical information, improve data science literacy, foster empathy and compassion for patients, and improve communication among healthcare providers (9).

6. Artificial Intelligence-driven Personalized Learning

Artificial intelligence technology can analyze a

student's learning style, strengths, and weaknesses to create a personalized learning plan, improving learning efficiency and accuracy. This approach aligns with traditional methods of disease diagnosis and treatment, addressing practical difficulties in reflecting actual disease progression. Artificial intelligence can recommend the most appropriate content, advise a well-designed long-term curriculum, and connect appropriate learners through suggestions and accurate performance evaluation (4, 5).

Artificial intelligence technology enables personal evaluation and personalized feedback in surgical training simulations, facilitating preoperative planning, intraoperative visualization, and guidance to improve patient safety. Human-computer interaction-based simulations augmented by AI could provide a cost-effective alternative to traditional training and allow clinicians to have greater access to training. High-fidelity simulation is the gold standard for acquiring and maintaining key resuscitation skills, but face-to-face training limits access and allows for "skills fade" (2, 10).

Many students believe that learning about AI would benefit their careers, and others believe that medical students should receive AI teaching or training. Implementing a reform in medical education requires students' awareness of the importance of AI in modern medical practice (9). Artificial intelligence medical training programs, such as HoloHuman, Ocular SIM, and HoloPatient, can enhance medical students' experiences by improving knowledge, understanding, practical skills, and social skills. Artificial intelligence is a key component in telemedicine/telehealth educational, clinical processes, helping to pinpoint inadequacies and drive them out, ultimately reducing costs and enhancing outcomes for learners and administrators (2).

7. Intelligent Tutoring Systems

Intelligent tutoring systems have the potential to transform student learning by offering personalized guidance and creating tailored learning pathways based on individual learner's status and needs. The research on AI-powered intelligent tutoring systems for adaptive learning is gaining interest due to their ability to provide personalized feedback, thereby enhancing students' performance through a more customized approach. Moreover, as these systems continue advancing, they may also influence the different roles of educators and other professionals involved in supporting student education (11).

8. Role-plays With Intelligent Active Agents

Role-plays with intelligent agents can enhance students' computer interaction and responsibility, while AI can support personalized learning through

autonomous scoring and chatbots, thereby enhancing their learning experience.

Challenges of Integrating Artificial Intelligence Into Curricula:

The implementation of AI in medical education presents a myriad of challenges that necessitate careful consideration and resolution. These challenges encompass various facets, each requiring its own unique approach to be effectively addressed:

1. Ethical concerns: The utilization of artificial intelligence in medicine raises several crucial ethical considerations that demand thoughtful attention. Issues like privacy, bias, and accountability have come to the forefront as potential challenges associated with AI implementation. Developing comprehensive ethical guidelines and frameworks specifically tailored for integrating AI into medical education is vital to navigating these concerns. This becomes evident through a study conducted by Masoumian Hosseini et al., which aims to design an ethical framework catering to the use of AI within the context of medical education (2).

2. Faculty training: Research by Gentile et al. highlighted the crucial necessity of providing faculty members with comprehensive training in AI concepts and technologies. This is imperative for their successful integration of AI into the curriculum. Organizing specialized training programs and thought-provoking workshops can significantly contribute to expanding faculty members' repertoire of knowledge and honing their skills pertaining to AI (12).

3. Curriculum design: The successful incorporation of AI into medical curricula necessitates strategic and deliberate deliberation. A comprehensive curriculum should encompass specialized courses or modules that delve into the fundamental concepts, practical applications, and ethical implications of AI in medicine. Moreover, it should offer experiential learning opportunities to enable students to gain proficiency in utilizing advanced AI tools and technologies (4, 5).

4. Resources and infrastructure: The successful integration of AI in medical education necessitates allocating substantial resources and establishing robust infrastructure. This encompasses the acquisition and availability of cutting-edge AI software, high-performance hardware, and ample computational resources. Educational institutions must make diligent investments in these crucial elements to foster the seamless incorporation of AI technology (5, 13).

5. Evaluation and assessment: The integration of AI in medical education warrants an assessment of its efficacy. It is crucial to design rigorous evaluation methods that can quantitatively measure students' aptitude and

proficiency in the realm of AI. This entails formulating practical assignments, projects, and assessments tailored to gauge their ability to effectively apply AI tools within clinical scenarios (8, 10, 13).

6. Collaboration with AI experts: The successful implementation of AI in medical education necessitates the vital collaboration between esteemed medical educators and accomplished AI experts. Medical schools must establish robust partnerships with leading AI research centers or industry professionals. These alliances serve as a guarantee to seamlessly incorporate cutting-edge AI technologies into curriculum and pedagogical approaches, keeping abreast of the most effective practices (2, 3).

Addressing the aforementioned challenges necessitates a formidable collective endeavor involving educational institutions, esteemed faculty members, accomplished AI experts, and diligent regulatory bodies. By successfully grappling with these arduous obstacles, the seamless integration of artificial intelligence into medical education can unfold harmoniously - amplifying the process of knowledge acquisition while effectively equipping aspiring doctors for their forthcoming endeavors in patient care.

Ethical Considerations

Medical institutions must have the necessary technical infrastructure and expertise to support AI in medical education, clearly define learning purposes and objectives, including pedagogical and ethical considerations, and involve all relevant stakeholders in decision-making to discuss expertise, concerns, and moral, legal, and ethical issues, and focus on four biomedical ethics principles for successful AI integration in medical education (2, 3).

1. Informed Consent and Autonomy

One of the most crucial ethical considerations in the field of medicine pertains to informed consent. This principle is deeply ingrained in medical ethics, necessitating that patient receive comprehensive and clear information about their proposed treatment before providing their consent. The use of AI in clinical education and training may lead to the development of AI algorithms, making it crucial to obtain informed consent from patients before their data is used. Autonomy is a fundamental principle in medical bioethics, promoting the right to self-determination and rational judgments. However, the integration of AI into medical education presents significant challenges to users, including students, educators, and medical professionals (2, 3). Advanced computational models like ChatGPT can sometimes generate information that is not factual, causing hallucinations. To minimize this issue, medical institutions should have mechanisms to transparently

signal their limitations and uncertainties, ensuring full autonomy and non-maleficence among learners. Dependence on AI technology may also hinder the development of essential decision-making skills and clinical judgment. The complexity and opacity of AI algorithms can make it difficult to comprehend how they arrive at specific decisions, potentially reducing informed judgments about the appropriateness of AI-generated recommendations or diagnoses. Medical institutions should promote professional responsibility and accountability, empowering users to make rational judgments and moral decisions. Universities should offer AI models as an add-on to the medical curriculum, allowing students to decide at any time whether or not to use AI applications (1, 5, 13).

2. Non-maleficence

Non-maleficence is a principle that emphasizes the importance of not causing harm and minimizing potential negative consequences. Also, AI algorithms in medical education must be carefully designed, validated, and evaluated to produce accurate and reliable results that do not mislead users and put patients at risk. Medical institutions should outline the limitations of any AI application used and point out the risks of applications without transparency and systems trained on biased or unrepresentative datasets (5). Medical data experts, such as physicians and medical educators, have a special ethical responsibility as they can detect bias in data, validate models, and train students in AI sufficiently to detect errors themselves. Medical institutions should provide AI-independent information to enable students to make informed decisions without the use of AI or compare AI-generated data. Privacy and confidentiality of sensitive data must be warranted when AI applications work with real patient data. Institutions should handle individual results with confidentiality, including decentralized storage of data and evaluation of individual skills. As AI in medicine is a rapidly evolving area of research, ethical guidelines should be continuously monitored and adjusted to address new risks or harms associated with AI (1, 3).

3. Beneficence

The principle of beneficence in biomedical ethics emphasizes the obligation to promote and protect individual welfare. In medical education, beneficence involves providing appropriate training on AI applications to maximize benefits for all stakeholders, including students, educators, and experts. This empowers autonomy, justice, and non-maleficence by enabling informed decision-making and effective integration of AI. Collaboration with stakeholders is essential for the most beneficial implementation of AI in medical education.

Regular assessment and optimization of AI applications are crucial for maximizing benefits and minimizing potential harms (10, 12).

4. Justice

The principle of justice in AI development requires fairness, equity, and equal treatment for all individuals. By 2024, 60% of AI data will be synthetic, but 40% will still be based on real data. To ensure fair practices, medical institutions should control data-sharing agreements and establish an equity and social justice framework. This framework should guide AI technologies, ensuring they are accessible and individualized to meet the needs of diverse users. This can be achieved through financial assistance, scholarships or subsidies, inclusive design, and diverse training data. Collaborations with educational institutions from diverse backgrounds can also help. Besides, AI tools in medical education should undergo regular audits to detect and correct potential biases and inequities, ensuring unbiased and fair educational content (14).

Finally, AI has the potential to revolutionize medical education by providing personalized and adaptive learning experiences. It can identify students' strengths and weaknesses, resulting in tailored learning plans. Also, AI offers real-time feedback, enhancing knowledge retention and skill development. However, extensive research is needed to understand its long-term impact and ethical considerations surrounding AI integration in medical education. As known, AI can significantly improve medical education by equipping doctors with the necessary skills for the evolving healthcare environment. However, challenges like ethical considerations, faculty development programs, curriculum design, and resource allocation must be addressed. Despite these obstacles, AI offers significant advantages by empowering healthcare professionals and improving patient care outcomes (1, 5, 9).

Footnotes

Authors' Contribution: M. M. H., K. Q., and S. T. M. H. were responsible for the study conception. S. T. M. H. critically reviewed the article and was responsible for collecting information. All authors read and approved the content of the manuscript but participated in its preparation.

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