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Health professions students' perceptions of artificial intelligence and its integration to health professions education and healthcare: a thematic analysis

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Abstract
Artificial intelligence (AI) is being tightly integrated into healthcare today. Even though AI is being utilized in healthcare, its application in clinical settings and health professions education is still controversial. The study described the perceptions of AI and its integration into health professions education and healthcare among health professions students. This descriptive phenomenological study analyzed the data from a purposive sample of 33 health professions students at a university in Kazakhstan using the thematic approach. Data collection was conducted from March 30 to May 5, 2023, using an online questionnaire with four open-ended questions. Four significant themes describing the perceptions of the health professions students on AI and its integration into health profession education and healthcare was derived: enhanced interactive learning experiences, integrating artificial intelligence-powered diagnostic and decision-support tools into health professions education, AI technologies assist students in preparing for future roles in healthcare and integrating AI technologies presents several challenges. Health professions students perceived that integrating AI into health professions education and healthcare enhances their interactive learning experiences, increases knowledge and application of complicated medical topics, and prepares them for future healthcare roles.

Keywords Artificial intelligence · Healthcare · Medical artificial intelligence · Perceptions · Qualitative study

1 Introduction

Artificial intelligence (AI) is being tightly integrated into healthcare today. AI is a simulation of human intelligence by software that intends to rationalize and take actions with the best chance of achieving a specific goal (The Investopedia Team 2023). Scientists developed impressive algorithms with AI that mimic activities like learning, reasoning, and perception (The Investopedia Team 2023). AI has been integrated into medicine since the 1970s (Kaul et al. 2020). Since then, medical AI has expanded quickly as digitalized medicine has become more accessible. Now, AI is actively used in specialties like radiology, screening, primary care, and even surgery (Bohr and Memarzadeh 2020).

Even though AI is being utilized in medicine, its application in clinical settings is still controversial. Specialists criticize the application of AI due to a lack of experience in information technology skills and ethical issues including security and safety (Buch et al. 2018). This finding raises concerns about Kazakhstani healthcare professionals' attitudes toward and level of preparedness for using this technology. Researchers and medical practitioners have acknowledged the potential of medical AI in most countries. Its acceptance among health professions students, however, needs to be made clear. Before implementing AI, it is crucial to assess the mindset and readiness of future healthcare providers. Thus, this study explored the perceptions of health professions students on AI application in health professions education and healthcare.

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1.1 Background of the study

Medicine is a revolutionary field that changes every day. Despite being a promising field, AI has yet to be widely utilized at its full potential. However, the use of AI in medicine has made significant progress, especially in radiation therapy (Pillai et al. 2019), anesthesiology (Connor 2019), and predicting outcomes (Bayliss and Jones 2019). For example, Hosny et al. (2018) revealed that AI application in radiology is as effective as radiologists in detection and segmentation tasks in magnetic resonance imaging and ultrasonography, respectively. Additionally, AI has been applied in the healthcare industry to support and inform various medical processes and act as an alarm system for patients and associated workers (Briganti and Moine 2020). Moreover, AI can offer financial benefits in healthcare due to its application in surgical management and diagnosis, as well as non-financial benefits such as better quality of care, better patient experiences, broader access to healthcare, and higher clinician satisfaction (Sahni et al. 2023).

However, some issues make it challenging to integrate AI in healthcare. One of the crucial concerns about medical AI is data security and privacy. Previous incidences showed that health records are vulnerable. For instance, the incident where the National Health Service had transferred data on 1.6 million patients to DeepMind servers without the patients' agreement to create its algorithm became a huge issue (Khan et al. 2023). Moreover, rapid digitalization increases fear in healthcare specialists who are worried about replacement by AI. Therefore, most are skeptical or even hostile towards AI because of the threat.

Health professions students, defined as "students of any of the health professions (i.e., medicine, nursing, biomedical) across the continuum of healthcare education" (Accreditation Council for Continuing Medical Education 2021, para. 1), must be well-prepared due to the growing use of AI in clinical settings. According to international research, students have a positive attitude regarding the incorporation of AI into medical education (Banerjee et al. 2021; Bisdas et al. 2021; Kasetti and Botchu 2020). Bisdas et al. (2021) conducted a study in 63 countries and found that 69.9% of dentistry students believe that AI will play a crucial role in healthcare, and 85.6% of them were eager to incorporate AI into their medical curriculum. Another study conducted in Britain showed that students supported AI advances in radiology and were aware of AI applications in healthcare (Kasetti and Botchu 2020). Banerjee et al. (2021) also revealed that the majority of students (58%) thought that AI technologies had a generally good impact on their education and training, and the majority (92%) claimed that their present courses provide enough AI instruction. A cross-sectional study in the Philippines reported a favorable perception of using AI in nursing care among nursing students. The same study reported nursing students' positive attitudes toward AI and high intentions to utilize AI technology in their practice (Labrague et al. 2023).

However, while some studies reported health professions students' favorable sentiments toward AI, there are other studies that reported unfavorable findings about students' medical AI attitudes, awareness, and readiness. For instance, Boillat et al. (2022) found relatively low levels of AI awareness and limited participation at educational or training events among medical students. Another study conducted in India demonstrated that most students were unaware of AI applications and their limitations in healthcare settings (Kansal et al. 2022). In addition, they felt that medical schools and hospitals should be the primary target of formal training programs for teaching AI to promote the coherent and accurate distribution of knowledge (Kansal et al. 2022). A similar finding was revealed by Qurashi et al. (2021), who found that most students never attended AI-based training nor used AI in their departments. Research conducted in Canada showed that 51.08% of students were unaware of what AI is and had the wrong understanding of it (Teng et al. 2022). However, in Kazakhstan in other central Asian countries, information on the attitudes, perceptions, and readiness of health professions students on AI in healthcare is scarce.

Therefore, this gap in the literature demand innovation in health professions education in this area, given that future healthcare personnel may need to employ AI applications more frequently. Future healthcare professionals must be prepared to employ technology to improve patient care. A thorough investigation of future healthcare workers' perceptions of medical AI is warranted, especially in countries with little available literature on medical AI and healthcare systems that have yet to fully embrace medical AI, such as Kazakhstan. Hence, this study is essential to provide knowledge about the perceptions of health professions students, who will be the future healthcare team members, on AI and its integration into health professions education and healthcare in the country and around the globe. The study provides foundational knowledge that can be used in developing educational interventions for health professions education to ensure a future healthcare workforce that is technologically and ethically competent to integrate AI into their practice.

1.2 Aim

The study described the perceptions of AI and its integration into health professions education and healthcare among health professions students.

2 Methods

2.1 Research design

A descriptive phenomenological design was employed in this study.

2.2 Participants and setting

The study was conducted at Nazarbayev University, School of Medicine (NUSOM) located in the capital of Kazakhstan. NUSOM is the first school of medicine that uses a US-style MD curriculum in the country. The university offers undergraduate (baccalaureate in nursing [BSN] and medical sciences [BMS]), Doctor of Medicine (MD), residency, and graduate programs (master's and doctoral levels), which are taught in English. NUSOM has its hospital, where its students attend their clinical practice. Students who are enrolled in the 2022 Spring semester, who are at least 18 years old and can communicate in English, were included in the study. Data from 33 health professions students were analyzed in this study. These samples were purposively selected from the sample on an online survey conducted to assess the students' attitudes toward and readiness for medical AI (Cruz et al. 2023). In this research report, the participants' ages ranged from 18 to 33 years old, with a mean of 23.33 (SD = 3.83). Most participants were females ($n = 24$, 72.7%), and nine were males (27.3%). Thirteen participants were MD students (39.4%); the other 13 were BMS students (39.4%), and the remaining were nursing students ($n = 7$, 21.2%).

2.3 Ethics

This research report was part of a study protocol approved by the university's Institutional Research Ethics Committee (submission number 679/17022023). The researchers complied with the policies and procedures of the ethics committee, as well as with the principles for the ethical conduct of studies among human participants according to the Declaration of Helsinki. Data collection was started after the dean of NUSOM approved the request for online data collection. Relevant information about the study was given to the participants through the recruitment email. The same email contained the link to the online informed consent, which contained the study's objective, procedures, risks, benefits, confidentiality and privacy, voluntary nature of participation, and points of contact for any questions. Participants clicked "I agree" in the informed consent if they volunteered to participate and were brought to the first part of the survey. Those who clicked "I disagree," which signified no intention to participate, were brought to the disqualification page. The data collection was entirely anonymous. All data were saved in a password-protected computer.

2.4 Data collection

The data were collected using a two-part online survey through the Survey Monkey platform. The results of the first part of the survey, which comprised two scales assessing the general attitudes toward AI and medical AI readiness, were reported in Cruz et al. (2023). In that study, the attitudes towards AI and medical AI readiness of Kazakhstani health professions students and the factors influencing the students' readiness were explored (Cruz et al. 2023). This article reports on the findings of the survey's second part, consisting of four open-ended questions: (1) "How do you think artificial intelligence can be incorporated into medical education to enhance student's learning experiences and prepare them for future roles in the healthcare system?" (2) "In your opinion, what are some potential benefits and drawbacks of using artificial intelligence in the healthcare system?" (3) "How do you envision the future of healthcare with the continued development and integration of artificial intelligence?" and (4) "In your opinion, what changes might we see in the roles of healthcare professionals, the delivery of care, and the overall healthcare landscape in relation to artificial intelligence?" The online survey was distributed to NUSOM students through email from March 30 to May 5, 2023. Due to the nature of the survey, the students can choose when and where to take the survey. A follow-up email was sent to the students every week.

2.5 Data analysis, trustworthiness, and rigor

The free-form text responses of the participants in the four open-ended questions of an online survey were analyzed using the thematic approach by Braun and Clarke (2019). The six steps for the thematic approach, namely "becoming familiar with the data," "generating codes," "generating themes," "reviewing themes," "defining and naming themes," and "locating exemplars were followed." We focused on familiarizing ourselves with the data in the initial phase of the analysis. We performed multiple reviews and transcriptions to understand the content of the data comprehensively. As we became more acquainted with the data, we began developing codes, which served as designations for segments sharing common meanings. Subsequently, we applied these codes to the generated data. Then, we carefully reviewed the data and assigned the suitable code to each corresponding segment. After all the codes were applied, initial themes emerged. We reviewed and refined these themes,

meticulously examining the data to ensure the inclusion of all relevant segments within the appropriate themes, and subsequently grouped similar themes into broader categories. Subthemes were also developed. Finally, we defined and named the themes, providing clear and concise descriptions for each subject while assigning labels that accurately reflected their content.

To guarantee the trustworthiness and rigor of the analysis. The researchers manually coded a subset of the data independently. The researchers communicate regularly and organize the themes in the codebook during the analysis process. The researchers discussed discrepancies in coding and came up with a consensus. Confirmability was observed by conducting peer debriefing sessions with other qualitative researchers to gain additional perspectives and insights. We also acknowledged and addressed our potential biases and assumptions during the analysis. Reflexivity was ensured through detailed reflective journals, documenting our reflections and decision-making processes throughout the analysis.

3 Results

Integration of medical AI in healthcare is inevitable as we are in the technological era. Thus, this study describes health professions students' perception of integrating medical AI in medical education. From the analysis of the data, 107 initial codes were extracted. The combination of similar meanings and concept codes led to 13 subthemes. Finally, four significant themes were derived: enhanced interactive learning experiences, integrating artificial intelligence-powered diagnostic and decision-support tools into health professions education, AI technologies assist students in preparing for future roles in healthcare and integrating AI technologies presents several challenges (Table 1).

3.1 Enhanced interactive learning experiences

Most participants mentioned that AI-powered health professions education can transform traditional learning experiences into interactive and engaging exercises. AI incorporates game-like elements such as challenges, rewards, and contests into educational activities. Students become active participants in learning by introducing elements such as quizzes, simulations, virtual patient scenarios, and learning games. AI promotes a sense of fun, accomplishment, and progress, motivating students to actively seek knowledge, overcome challenges, and achieve learning goals. Participants mentioned that AI improved realism and immersion, tailored learning, intelligent feedback assessment, enhanced learning with big data and research, and continued learning and updates.

"AI can be used to enhance learning since it will serve as a supportive learning material to generate answers to any questions regarding medicine or related fields. Also, AI makes learning fun." Student 17

"AI can use games and other methods to make learning engaging and interesting, especially case-based studies." Student 1

3.1.1 Enhanced realism and immersion

Artificial intelligence-powered virtual simulations can produce realistic, immersive learning environments that mimic real-world medical circumstances. These simulations give students hands-on experience in a secure and regulated setting, allowing them to practice clinical skills, decision-making, and critical thinking. Students can improve and perfect

Table 1 Themes and sub-themes

Themes	Subthemes
Enhanced interactive learning experiences	Enhanced Realism and Immersion
	Personalized learning
	Intelligent feedback and assessment
	Enhanced learning with big data and research
	Continuous learning and updates
Integrating AI-powered diagnostic and decision-support tools into health professions education	Diagnosing medical conditions correctly and efficiently
	Reducing medical error
AI technologies assist students in preparing for future roles in healthcare	Understanding AI applications in healthcare
	Integrating AI into clinical decision-making
Integrating AI technologies presents several challenges	Ethical considerations
	Technical constraints and dependability
	Human-AI interaction and decision-making
	Regulatory and legal framework

their diagnostic and treatment skills by interacting with AI-driven virtual patients, encouraging experiential learning and boosting their confidence.

"Medical simulation and virtual reality technologies can provide immersive and realistic training environments that allow students to practice procedures, surgeries, and diagnostic techniques without risking the safety of real patients. AI can enhance these simulations by providing feedback on student performance and identifying areas for improvement." Student 5

3.1.2 Personalized learning

As participants mentioned, AI-powered platforms encourage efficient learning, close knowledge gaps, and improve skill development by personalizing the learning experience to each student's needs and speed. AI algorithms may assess individual students' learning patterns, preferences, and performance data to provide personalized learning. This data can create personalized learning systems that provide customized learning content, adaptive exams, and targeted feedback. Personalized learning allows students to engage with the material more effectively, improving knowledge retention and skill acquisition.

"It can help systematize all the necessary data, recommend suitable literature, and recommend the best learning methods according to the student's preferences." Student 13

"AI helps us to have a personalized learning and simulation of clinical experience, going through medical cases tailored to the topic and regenerated to find out diagnosis and treatment." Student 14

3.1.3 Intelligent feedback and assessment

Most participants mentioned that AI-powered solutions can provide learners with quick and intelligent feedback during learning. This constant feedback loop enables students to monitor, adjust, and improve their performance. Intelligent assessment technologies can also track student progress, identify learning trends, and provide students and teachers with data-driven insights.

"AI can be simply used as a supportive learning material to generate answers to any questions regarding medicine or related fields. It also helps students to develop their plans and learning activities. It also facilitates student performance evaluation." Student 11

"AI can be used to analyze the outcome and try to understand why the outcome is good or bad depending on the result given by the AI." Student 17

"AI is a very good tool in generating ideas or constructing plans, so it can be used to help to have effective tools in evaluating our performance." Student 33

3.1.4 Enhanced learning with big data and research

AI is well suited for processing and analysing massive data sets, such as electronic medical records, medical literature, and clinical research. Students can use AI-powered tools to examine and evaluate vast volumes of data in a structured and comprehensible manner. This discovery allows them to comprehend population health patterns, uncover linkages, and form data-driven conclusions. Students develop abilities in data interpretation, research methods, and incorporating real-world discoveries into their medical practice due to their exposure to AI-powered tools.

"It helps in processing large amounts of medical data, and AI would be able to diagnose and find the treatment for the patient; following the latest health trends and evidence-based research, AI would tailor the best possible approach to the patient. Routine tasks such as filling out patient information daily/hourly would be automatized." Student 8

3.1.5 Continuous learning and updates

Medical knowledge evolves as new research and treatment guidelines are published regularly. The participants mentioned that they can benefit from up-to-date information and advice from AI-powered diagnostic and decision-support tools. These technologies can constantly learn from new data and incorporate the most recent discoveries into their algorithms. Students are exposed to the dynamics of medical practice and acquire a lifelong learning mindset by incorporating these tools into medical education.

"We can use machine learning to uncover beneficial insights from available medical data in less time (for research)." Student 18

"I think artificial intelligence technology will be able to help with research to find treatments for many currently incurable diseases." Student 33

"I think AI will help healthcare workers to enhance their understanding of different complex concepts and allow healthcare workers to access the latest scientific achievements more easily and faster." Student 22

3.2 Integrating AI-powered diagnostic and decision-support tools into health professions education

Integrating AI-powered diagnostic and decision-support technologies into health professions education might dramatically increase students' knowledge and application of complicated medical topics. AI-powered diagnostic and decision-support tools play a critical role in diagnosing medical conditions correctly and efficiently and reducing medical errors.

3.2.1 Diagnosing medical conditions correctly and efficiently

Most participants mentioned that AI can assess large amounts of medical data, such as patient symptoms, medical history, and diagnostic pictures, to deliver accurate and efficient diagnoses. Students can learn to read and analyze clinical data more effectively by introducing AI-powered diagnostic tools into health professions education. These tools give students access to real-world situations and assist them in understanding the complex links between symptoms, diseases, and diagnostic procedures. Students gain expertise in pattern identification, differential diagnosis, and clinical reasoning through interactive learning experiences, ultimately boosting their diagnostic skills.

"Maybe it can help diagnose some diseases by analyzing symptoms and showing a list of possible diseases, and AI helps improve our knowledge and skills." Student 7

"AI can ease students to have an accurate patient diagnosis, help in recording data and analyzing patient symptoms and history, but it prevents a large number of mistakes in the hospital especially medical error and management." Student 15

"Benefits would include more precise diagnosis, more individual approach to each patient." Student 26

3.2.2 Reducing medical error

The participants mentioned that medical error is one of the common mistakes in medical decision-making, which are diagnostic errors and inadequate treatment strategies. Medical errors can be mitigated by AI-powered systems that provide objective analyses and alternate perspectives. These tools can assist students in identifying their mistakes and promoting a more methodical and comprehensive decision-making approach. By introducing AI into health professions education, students can build a more balanced, evidence-based mindset that leads to better clinical outcomes.

"It would benefit healthcare professionals and patients by decreasing professional errors." Student 21

"Less medical errors, because AI would check everything; less workload on hospitals because patients can do check-ups through AI on their computer/phone." Student 13

3.3 AI technologies assist students in preparing for future roles in healthcare

Exposing students to AI technology used in clinical practice may assist them in preparing for future roles in healthcare. AI technologies enhance students' understanding of AI applications in healthcare and clinical decision-making.

3.3.1 Understanding AI applications in healthcare

Students gain a greater understanding of AI's potential applications and advantages in healthcare by being exposed to AI technologies utilized in clinical practice. They will learn about AI-powered diagnostic systems, decision support tools, predictive analytics, robotics, and natural language processing applications. Students will discover how these technologies can enhance patient outcomes, increase efficiency, and address healthcare issues. Students learn to use AI appropriately and effectively in their future careers by understanding its potential and limitations.

"The number and quality of simulation centers can be increased. Use artificial intelligence to simulate an actual patient suffering from a specific disease. Also, it prepares us for our role as a medical practitioner in the future. AI is very important in understanding our responsibilities." Student 10

3.3.2 Integrating AI into clinical decision-making

AI technology can provide helpful insight and support. By being familiar with AI algorithms and their incorporation into clinical workflows, students learn to comprehend and implement AI-generated recommendations into their decision-making processes. They learn to critically analyze AI-generated outcomes, examine contextual aspects, and work with AI systems to make informed healthcare decisions. This concept prepares students for the changing healthcare scene, in which collaboration between healthcare practitioners and AI technologies is becoming more widespread.

"AI can be simply used as a supportive learning material to generate answers to any questions regarding medicine or related fields. It also helps students to develop their plans and learning activities. It also facilitates student performance evaluation." Student 20

"AI will help healthcare workers be more efficient and can take off some routine work burdens from healthcare workers. It will also enhance our understanding of the different complex concepts and will allow healthcare workers to access the latest scientific achievements in an easier and faster way." Student 18

3.4 Integrating AI technologies presents several challenges

Integrating AI technologies into health professions education and healthcare practice raises several issues that must be addressed to ensure responsible and successful use. Here are some of the significant issues that could develop during the integration process:

3.4.1 Ethical considerations

Participants stated that AI technology brings ethical questions about privacy, consent, transparency, responsibility, and justice. Using patient data in AI systems necessitates stringent privacy controls and informed consent. The decision-making process of AI systems must be transparent, especially in critical cases. Accountability for AI system outputs and questions of fairness and bias are crucial ethical considerations.

"With greater AI use, the greater responsibility comes. When talking about medicine, we talk about people's lives; that is why the question of who should take the responsibility for AI mistakes rises." Student 26

"My concern is about confidentiality and ethical issues of the AI use." Student 24

"AI can automate many repetitive tasks in the life of healthcare personnel (e.g., assist in diagnosis or imaging analysis). I am most concerned about data privacy regarding AI and the ethical aspects (e.g., privacy and choosing the right data to feed the AI)." Student 18

"My concern on using AI is data transparency and integrity issues." Student 31

3.4.2 Technical constraints and dependability

The study results show that the performance of AI systems strongly depends on the training data's quality and representativeness. There are technological constraints to AI algorithms that must be considered. Data biases or constraints might result in biased or incorrect outcomes. AI systems may also lack interpretability, making it difficult to grasp the reasoning behind their judgments.

"Excessive use of AI can make healthcare workers dependent on it. For example, if AI is used to determine a diagnosis, employees will gradually rely heavily on it. However, it is still a computer that can suddenly stop working. In addition, every medical case is different, so making a diagnosis and creating a treatment plan must also be individual and flexible. I think that artificial intelligence cannot adapt to different situations in the same way as the human brain can." Student 13

3.4.3 Human-AI interaction and decision-making

Students mentioned that AI technology should be developed to supplement rather than replace human decision-making. Ensure effective human-AI collaboration while maintaining the human oversight required to make critical decisions. Health professions students need to analyze, validate, and interpret AI-generated outcomes.

"I do not think that AI can replace medical workers, but it would certainly change how the health care system would operate, but there is a need to validate the AI-generated output by a human being." Student 15

"I do not think that AI will dramatically change the roles of healthcare professionals, yet it will simplify some processes. AI is a good way to generate a better solution, but medical practice will still rely on person-to-person communication." Student 25

3.4.4 Regulatory and legal framework

The rapid progress of AI technologies puts existing regulatory and legal frameworks under strain. As stated by the students, there is a need to create solid legal frameworks that handle the concerns of AI in healthcare, such as privacy, informed consent, liability, and accountability.

"I don't think it is about roles, but more about functions and who is accountable for the mistake of AI. Policy is needed." Student 27

"I think it will enhance healthcare services, but there is a need to develop a policy regarding AI use to ensure patient privacy." Student 13

"Some parts of the job can be transferred to IA. Documentations (financial, patient information, and statistics). But, policy should be made to ensure that medical practitioners will not be dependent on AI." Student 24

4 Discussion

This descriptive phenomenological study described the perceptions of health professions students on AI and its integration into health professions education and healthcare. The findings reflect four main themes from the analysis, offering a glimpse into their diverse perceptions of AI's integration in health professions education and healthcare among Kazakh health professions students.

First, the "Enhanced interactive learning experiences" theme has emerged due to several underlying factors, including heightened realism and immersion, personalized learning approaches, and the incorporation of intelligent feedback and assessment mechanisms. Specifically, participants in our study highlighted the value of virtual reality simulations and augmented reality scenarios in creating immersive learning environments. This finding was also reported in a study conducted in Northern India, which emphasized the role of AI in improved realism and immersion, tailored learning, enhancing medical student engagement, and skill acquisition (Kansal et al. 2022). Likewise, a strong appreciation among participants for personalized learning experiences facilitated by quizzes, simulations, virtual patient scenarios, and technology games was also reported. These sentiments echo the findings conducted in one study in Canada, which observed that AI-personalized learning improved

information retention and student satisfaction (Teng et al. 2022). However, a Malaysian study negates these findings as it identified a subset of students who felt overwhelmed by the number of choices in personalized learning modules (Basar et al. 2021). This discordance underscores the importance of balancing customization and a structured learning pathway to address varying preferences. Hence, clear guidance and support mechanisms are needed to prevent decision fatigue and ensure optimal learning experiences.

The students lauded the immediate and targeted feedback of interactive AI learning tools. Banerjee et al. (2021) found that intelligent feedback enhanced self-assessment skills and promoted a growth mindset among learners. Integrating AI-driven feedback and assessment mechanisms offers students timely and personalized insights into their performance (Banerjee et al. 2021). This fosters a proactive approach to learning, enabling students to identify their strengths and areas for improvement more effectively. However, while our study highlighted the benefits of intelligent feedback, the research of Tsamados et al. (2022) documented concerns raised by students about potential bias in algorithm-generated feedback, the ethical implications of AI algorithms in assessment, and the necessity for addressing algorithmic biases. This disparity underscores the need for transparent communication about feedback mechanisms, the iterative refinement of AI-driven assessment tools, and the provision of adequate support to students.

Another subtheme was AI which enhances learning with big data and research. AI tools utilize extensive data for research purposes, which possess significant potential for both students and the healthcare industry. This finding is supported by the study of Seo et al. (2021), who found that AI-powered research tools amplify students' engagement with innovative research methods. This implies the AI's role in equipping students with data-driven research skills and highlights the AI's transformative potential in expanding the research perspective. Another subtheme developed was continuous learning and updates, indicating that continuous education in the healthcare environment is influenced by technology. This implies adopting a continuous learning mindset to remain up-to-date with advancing AI technologies. Continuous learning guarantees that healthcare professionals remain adaptable and capable of effectively integrating AI tools into their clinical practice (Frąckiewicz 2023; Kansal et al. 2022). However, AI continuous learning challenges students since they must allocate more time for ongoing AI education amid their busy schedules (Bergmann et al. 2019). The challenges brought about by the rigorous curriculum and intensive training that medical students must undergo can hamper the integration of medical AI education into the curriculum (Bergmann et al. 2019). Hence, medical universities must review their curriculum and provide an opportunity to integrate medical AI education.

Second, another essential theme derived from the analysis was “integrating AI-powered diagnostic and decision-support tools into health professions education." Specifically, incorporating AI-powered diagnostic tools allows students to refine and improve their diagnostic skills. These findings concur with studies by Bayliss and Jones (2019) and Connor (2019), who reported that AI-powered diagnostic tools enhance efficiency and accuracy. This alignment suggests a consensus on the potential of AI to augment diagnostic tools. In contrast, the work of Buçinca et al. (2021) suggests that overreliance on AI could challenge students' clinical development reasoning. Hence, students must balance AI assistance and critical reasoning judgment, guaranteeing that technology reliance does not overshadow their medical expertise. The subtheme of reducing medical errors underscores the importance of AI-powered tools in enhancing patient safety. The AI systems integration has the potential to cultivate a culture of error prevention, harmonizing with the healthcare organization focusing on quality improvement and patient well-being (Pillai et al. 2019; Banerjee et al. 2021). These findings also agree with the study of Ahuja (2019), which elaborates on the AI potential to minimize medical errors through data-driven insights. This indicates AI's role in improving patient safety.

Thirdly, the theme “AI technologies assist students in preparing for future roles in healthcare” underscores the growing significance of AI in molding the education and training of future healthcare professionals. With the emergence of AI-powered tools and applications, students are presented with unique learning opportunities that extend beyond traditional methods (Bayliss and Jones 2019; Frąckiewicz 2023). This theme acknowledges that future healthcare professionals need to be well-versed in AI technologies to navigate the evolving landscape of modern medicine. As AI technologies continue to permeate various aspects of the medical field, it becomes crucial for students to grasp AI's underlying principles and potential use (Ahuja 2019; Lomis et al. 2021). Likewise, integrating AI into healthcare education better equips students for their roles in an evolving healthcare landscape (Charow et al. 2021). The exposure to AI-driven decision-making mirrors the technological advancements they will encounter in their professional careers (Charow et al. 2021). Pillai et al. (2019) explained that AI integration could improve patient outcomes, as students trained in AI-assisted clinical decision-making might make more accurate diagnoses and treatment plans. By immersing students in understanding AI's role in healthcare, educators facilitate a strong foundation that students can build upon as they enter the professional sphere. However, despite comprehensive knowledge about AI applications and training students in effectively integrating AI tools, not all institutions may have equal access to the latest AI tools, potentially leading to disparities in education quality (Grassini 2023). Hence, specific

measures are warranted in addressing the potential disparities in access to AI tools among different institutions, which is crucial to ensuring equitable education quality.

Finally, the theme “integrating AI technologies presents several challenges" was highlighted, encompassing four essential subthemes. Specifically, the students noted ethical considerations arising from integrating AI technologies. This subtheme agrees with previous studies reported that although AI presents transformative potential, it also raises concerns regarding patient privacy, data security, and the potential biases embedded in algorithms (Tsamados et al. 2022; Buçinca et al. 2021). Likewise, another study noted that determining who is accountable in cases of AI-generated errors or unexpected outcomes remains unclear (Novelli et al. 2023). This presents a notable challenge in formulating a clear ethical framework for AI-assisted decision-making. Thus, academicians and healthcare institutions must prioritize teaching students about the ethical implications of using AI in healthcare. The subtheme "technical constraints and dependability" highlights the challenges associated with the reliability and accuracy of AI technologies. This subtheme implies that while AI can improve healthcare practices, technical limitations, and potential errors must be acknowledged. These findings further support the previous studies on educating students about AI's technical limitations to recognize situations where human intervention remains essential (Boillat et al. 2022; Briganti and Moine 2020).

Next, the subtheme of "human-AI interaction and decision-making" reveals some challenges that arise when healthcare professionals collaborate with AI technologies in clinical decision-making processes. These challenges encompass practical and ethical dimensions, highlighting the intricacies of integrating AI into healthcare practices. According to Buçinca et al. (2021), one of the concerns is the potential for over-reliance on AI-generated outlook among healthcare professionals. The over-reliance on AI might diminish the emphasis on clinical reasoning judgment (Buçinca et al. 2021; Tsamados et al. 2022). This could lead to overlooking nuances that AI might not capture, reducing the holistic and personalized approach crucial to patient care. Heavy reliance on data-driven AI might discourage healthcare professionals from using their natural intuition and experiential expertise judgment, which is vital for diagnosing complex cases or situations deviating from typical patterns (Norori et al. 2021; Petersson et al. 2022). Esmaeilzadeh et al. (2021) reported that patients might perceive AI reliance as a lack of empathy, resulting in reduced trust in the healthcare professional.

Lastly, the subtheme "regulatory and legal framework" sheds light on the regulatory challenges of integrating AI into healthcare. These findings conform with the study by Petersson et al. (2022), which showed that one of the primary concerns is the need for more precise and comprehensive guidelines designed explicitly for AI integration in healthcare. Existing regulatory frameworks might not sufficiently address the complexities introduced by AI technologies, resulting in uncertainty among healthcare professionals, educators, and institutions (Petersson et al. 2022; Siala and Wang 2022). Traditional legal frameworks might not encompass the distinct situations introduced by AI's role in healthcare decision-making, creating ambiguity surrounding AI's regulatory landscape. Iqbal and Biller-Andorno (2022) further explained that the regulatory and legal landscape differs across different jurisdictions, creating difficulties in establishing globally standardized AI guidelines integration in healthcare. Addressing these challenges is essential in fostering a supportive environment that allows AI technologies to be used in healthcare practices while protecting patient rights and maintaining professional integrity. Hence, the need for proactive regulatory adaptation, comprehensive data protection measures, and clear guidelines on liability and accountability is warranted.

4.1 Limitations

Although this study provided a valuable perspective into health professions students' perceptions of AI integration in medical education and healthcare, it is essential to acknowledge some limitations in interpreting the findings. The data collection method utilized an online survey with open-ended questions. Although this approach allowed participants to provide rich narratives, it also introduced the potential for response bias. Also, this data collection method in qualitative studies limited direct interaction between researchers and participants and inhibited the deeper exploration of the participants' experiences. As a result, we focused on describing the students' point of view of the phenomenon rather than their experience. This study was conducted within the context of Nazarbayev University's health professions students. The educational setting, technological framework, and cultural factors unique to this institution may have influenced the participants' perceptions and experiences, which may differ from students of other higher educational institutions in the country and central Asia. Future investigation should be conducted in more diverse samples and settings, utilizing a mixed-methods approach to address these limitations and contribute to a more comprehensive understanding of health professions students' AI integration viewpoints.

5 Conclusions

This study has demonstrated four key themes that describe the health professions students' perceptions of AI integration in medical education and healthcare: enhanced interactive learning experiences, integration of AI-powered diagnostic

and decision-support tools into health professions education, AI role in preparing students for their future roles in healthcare, and challenges of integrating AI technologies in healthcare. The integration of AI-powered diagnostic tools is viewed as essential for enhancing diagnostic accuracy and decision-making. Students acknowledged the AI's role in equipping them for future healthcare roles, empowering them to navigate changing healthcare industry demands. However, AI integration challenges, including ethical concerns and the proper training needs, highlighted the complexity of its implementation. As AI technologies reshape healthcare, collaboration among academicians, healthcare institutions, and policymakers is essential to harness its benefits while addressing the challenges. These findings provide insights into shaping curriculum development and pedagogical strategies, guiding AI integration in healthcare education. Ultimately, these findings contributed to the ongoing dialogue on AI's transformative potential, emphasizing the informed and ethical practice needs in molding the future of healthcare education.

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Declarations

Conflict of interest The authors declare no conflict of interest.

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