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РОЛЬ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В СОВЕРШЕНСТВОВАНИИ МЕДИЦИНСКОГО ОБРАЗОВАНИЯ: ВОЗМОЖНОСТИ И ВЫЗОВЫ

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THE ROLE OF ARTIFICIAL INTELLIGENCE IN ENHANCING MEDICAL EDUCATION: OPPORTUNITIES AND CHALLENGES

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Резюме. В статье проанализированы возможности и ограничения применения искусственного интеллекта в медицинском образовании. Рассмотрены виртуальные пациенты, анализ медицинских изображений, адаптивное обучение и AR/VR-тренажёры. Показано, что ИИ обеспечивает безопасную практику, круглосуточный доступ и объективную оценку, однако требует контроля достоверности, не заменяет наставничества и порождает этические риски.

Ключевые слова: искусственный интеллект, медицинское образование, виртуальные пациенты, симуляция, адаптивное обучение.

Abstract. The article analyses the opportunities and limitations of artificial intelligence (AI) in medical education. Virtual patients, medical image analysis, adaptive learning and AR/VR trainers are considered. AI is shown to provide safe practice, round-the-clock access and objective assessment, yet it requires reliability control, does not replace mentorship and raises ethical concerns.

Keywords: artificial intelligence, medical education, virtual patients, simulation, adaptive learning.

Relevance. Medical education is exceptionally demanding: a student must master a vast body of theoretical knowledge while simultaneously developing complex hands-on clinical skills. The traditional model of training a physician is limited by the availability of real patients, the number of qualified mentors and the high cost of error when practising invasive manipulations. Artificial intelligence (AI) already makes a significant contribution to healthcare delivery: modern systems interpret medical images with accuracy comparable to that of experts [1]. The same technology demonstrates considerable potential in the educational sphere, where tools are emerging that can actively guide the learner through the process of diagnostic reasoning and clinical decision-making [2]. Between 2020 and 2024 the number of publications on the use of AI in medical education grew several-fold, reflecting the rapid transition of the technology from theoretical concepts to practical validation [3]. At the same time, the rapid adoption of AI outpaces the understanding of its limitations, reliability risks and ethical consequences, which makes the systematisation of accumulated experience a relevant task.

Aim: to analyse the opportunities and limitations of artificial intelligence in enhancing medical education and to identify the conditions for its rational implementation.

Tasks:

1. To systematise the current applications of AI in the training of medical personnel.
2. To identify the key advantages of AI tools in education.

3. To determine the technical, ethical and pedagogical limitations and risks.
4. To evaluate the prospects for the development of AI in medical education.

Materials and methods. This work is an analytical review. The search for sources was carried out in the PubMed, Web of Science and Scopus databases, as well as in specialised scientific journals for the period 2019–2025. The following combinations of search terms were used: “artificial intelligence”, “medical education”, “virtual patient”, “adaptive learning”, “extended reality”. Peer-reviewed systematic and narrative reviews, as well as original studies describing the practical application of AI in the training of medical personnel, were selected. Methods of thematic analysis, generalisation and comparison of data were applied. Information on the applications, advantages and limitations of AI was structured into four functional groups, followed by a comparative analysis of opportunities and risks.

Results and their discussion. The analysis of the sources made it possible to distinguish four main applications of AI in medical education: virtual patient simulation, medical image analysis, personalised adaptive learning, and augmented- and virtual-reality (AR/VR) trainers.

Virtual patient simulation. AI-driven virtual patients and chatbots reproduce real clinical situations, allowing learners to practise history taking, examination and diagnosis in a safe environment [1]. Such systems provide realistic and repeatable clinical scenarios that supplement the limited opportunities for working with real patients. Some chatbots adapt their responses depending on the student’s questions, which increases the realism of the interaction and develops clinical communication skills without risk to the patient [4].

Medical image analysis. Deep-learning algorithms highlight significant findings on X-rays, CT and MRI scans, and the learner compares his or her own interpretation with the output of the system [1]. Importantly, not only the correct but also the erroneous responses of the AI have educational value: a case has been described in which a system falsely classified post-surgical scarring as pneumonia, and such “false positives” become learning episodes that foster a critical perception of the data [3]. Thus, AI-assisted imaging is used as a teaching aid rather than a substitute for medical judgement.

Personalised adaptive learning. Adaptive platforms monitor the student’s performance in quizzes and simulations and adjust the difficulty and topic focus in real time [1]. If the learner experiences difficulties, for example in interpreting chest X-rays, the system offers additional exercises on that topic. Surveys show that a considerable proportion of students regularly use AI chatbots, which in fact function as a personal tutor available at any time [4].

Augmented- and virtual-reality trainers. The combination of AI with AR/VR technologies provides an immersive practice of practical skills. An illustrative example is the ESIST system (Educational System for Instructorless Surgical Training), described in 2025: it combines a realistic 3D-printed organ phantom, an extended-reality headset and a convolutional neural network that analyses the laparoscopic camera feed [5]. In the study, 17 trainees practised a step of partial nephrectomy – placing a clamp on the renal artery; the neural network recognised in real time which structure (artery, vein, ureter or no structure) the clamp was placed on and autonomously, without an instructor, provided corrective prompts. All participants achieved successful completion of the procedure with high satisfaction, and the recognition accuracy approached 99.9 % [5]. Such trainers make it

possible to safely repeat manipulations, log the learner's actions and generate objective metrics of technique.

Advantages of AI in medical education. Generalisation of the data makes it possible to distinguish three key advantages. First, safe practice without risk to the patient: AI simulations and virtual patients make it possible to make mistakes in a “zero-risk” zone, which builds experience and confidence. Second, round-the-clock availability: unlike a teacher, AI systems have no time constraints and are not subject to fatigue, which is especially valuable for learners with irregular schedules and for practice between clinical shifts. Third, objectivity and standardisation of assessment: AI impartially records actions and their timing, measures technical metrics (for example, the amplitude of hand movements or the depth of compressions in cardiopulmonary resuscitation) and applies uniform criteria, helping to identify specific weaknesses and track progress [5].

Limitations and risks. Along with the opportunities, the review revealed significant limitations. **Reliability:** AI systems are not infallible and can produce plausible but incorrect information – non-existent treatment regimens or references to fabricated studies, which requires training students to critically verify the conclusions of AI [2]. **Lack of genuine empathy:** AI does not model the nuances of doctor–patient interaction and cannot replace human mentorship and emotional support. **Resource and infrastructure barriers:** the high cost of equipment, the requirements for computing power and internet access create a “digital divide” and may aggravate educational inequality between institutions. **Ethical risks and confidentiality:** training models on patient data is associated with the threat of leaks, problems of informed consent and algorithmic bias, including insufficient representativeness of training samples [6]. A summary analysis of the balance between opportunities and limitations is presented in Table 1.

Tbl. 1. Opportunities and limitations of artificial intelligence in medical education

Aspect	Description
Safe practice	Practising manipulations without risk to the patient; repeatability of scenarios
Availability	Round-the-clock access, absence of fatigue, individual pace
Assessment	Objective and standardised metrics of technique and progress
Reliability	Risk of plausible but incorrect conclusions; need for verification
Human factor	Lack of empathy; inability to replace mentorship
Resources and ethics	Cost, digital divide, data confidentiality, algorithmic bias

Future perspectives. Promising directions include continuous AI tutors that accompany the learner throughout the entire period of training and constantly adapt the material to his or her weaknesses and progress, as well as more immersive simulations of emergency and ethically complex scenarios. The combination of AI with VR will make it possible to create highly realistic training environments that dynamically reconfigure in response to the learner's actions while preserving the safety of practice. As AI architectures mature and the ergonomics of equipment improve, such systems are capable of transforming

both the learning process and the nature of the support provided to a specialist in real practice.

Conclusions:

1. Artificial intelligence is applied in medical education along four key directions – virtual patients, image analysis, adaptive learning and AR/VR trainers – and provides safe, repeatable and objectively assessable practice.

2. The possibility of autonomous, instructor-free training and objective assessment of a complex surgical skill with near-expert accuracy has been demonstrated, which confirms the educational potential of AI.

3. The implementation of AI is constrained by the risks of unreliable conclusions, the absence of genuine empathy, resource barriers and ethical problems of data protection, which requires quality control and pedagogical oversight.

4. AI should complement rather than replace traditional teaching; rational implementation presupposes content validation, training of students and teachers in the responsible use of the tools, and the preservation of core medical values – empathy and critical thinking.

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