

Using Artificial Intelligence and Simulation Methods in Training Family Doctors

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Annotation. This article examines modern approaches to integrating artificial intelligence (AI) and simulation technologies into the postgraduate training and continuous professional development of general practitioners (family physicians). The relevance of this topic is driven by the growing complexity of clinical tasks, the need to minimize medical errors, and increase the availability of high-quality practical training. The aim of the study is to analyze the effectiveness and prospects of using AI-assisted simulators in developing and assessing the clinical competencies of family physicians. The methodology includes a systematic review of the scientific literature, comparative analysis, and data synthesis. The study revealed that the combination of AI and simulation training enables the creation of personalized, adaptive, and safe educational environments that facilitate the development of both technical and non-clinical skills (communication, decision-making). Based on the literature review, a conceptual model for integrating these technologies into the educational cycle has been developed and specific examples of their application are presented. The article contains an original diagram illustrating the AI-enabled learning cycle and a table comparing traditional and modern simulation formats. It concludes that the symbiosis of AI and simulation is a key driver of the transformation of medical education, enabling the transition to a competency-based model for training primary healthcare professionals.

Key words : artificial intelligence, simulation training, family medicine, medical education, clinical competencies, virtual patients, adaptive learning, skills assessment.

Introduction

Modern family medicine is characterized by high physician workloads, a wide range of pathologies, and the need for rapid decision-making under conditions of incomplete information. Traditional training methods based on passive information acquisition and clinical practice on real patients face a number of limitations: ethical risks, the variability of clinical cases, and the impossibility of standardized assessment. In this context, simulation-based training, supplemented by artificial intelligence technologies, is emerging as a revolutionary paradigm offering a solution to these problems. Artificial intelligence, defined as the ability of machines to perform cognitive functions associated with the human mind, is finding application in the creation of intelligent tutoring systems, the analysis of simulation data, and the generation of realistic clinical scenarios. Simulation methods, in turn, have evolved from simple simple task to high-tech virtual environments and standardized patients. The purpose of this study is to comprehensively analyze the capabilities, effectiveness, and prospects of integrating artificial intelligence and simulation methods into the educational process of training family physicians. To achieve this goal, the following objectives were set:

1. To review current literature on the use of AI and simulations in medical education.

2. To analyze the impact of these technologies on the formation of specific clinical competencies.
3. To develop a model of the educational cycle using AI.
4. To identify the strengths, limitations and future directions of this area.

The integration of technology into medical education has been a trend of the last decade. As Isaev et al. note, "simulation has ceased to be simply a tool for practicing manual skills and has become a comprehensive platform for modeling clinical reasoning." Classic simulators, lacking AI elements, often have a predetermined, linear scenario, which reduces their value for teaching decision-making under uncertainty.

The introduction of AI has enabled the creation of adaptive simulators. For example, systems based on natural language processing (NLP) allow trainees to interact with a virtual patient as if they were a real person. A study by Miller and colleagues found that "physicians trained using AI-assisted virtual patients showed 25% higher performance on complex case diagnostic tests compared to a control group using paper cases."

An important aspect is the use of AI for objective assessment. Traditionally, skill assessments on simulators were conducted by an expert instructor, which could be which could introduce subjectivity. Machine learning algorithms are capable of analyzing learners' actions in real time—from the sequence of diagnostic hypotheses to nonverbal communication cues—and providing detailed, objective feedback. This aligns with Smith's findings, emphasizing that "automated data analytics is the cornerstone of scaling a competency-based approach in education."

In the field of family medicine, simulators focused on managing patients with multimorbidity, providing preventive counseling, and working in an interprofessional team are particularly valuable. Research in this area is actively underway, but, as many authors note, there is a lack of randomized controlled trials demonstrating the long-term impact of such simulators on the quality of care for real patients.

Materials and Methods . This study was conducted as an analytical review using methods of systematization, comparative analysis, and synthesis of scientific information. A literature search was conducted in the electronic databases PubMed, Scopus, Web of Science, Google Scholar, and eLibrary using keywords relevant to the research topic. Publications were primarily reviewed over the past five years (2020-2025). Peer-reviewed articles, reviews, meta-analyses, and conference proceedings specifically devoted to the use of AI and simulations in primary care physician training met the inclusion criteria. As a result, 18 relevant sources were selected and analyzed.

Based on the analysis, a conceptual model was developed (Diagram 1) and a comparative analysis of simulation formats was conducted (Table 1).

Training Cycle Using AI-Assisted Simulation

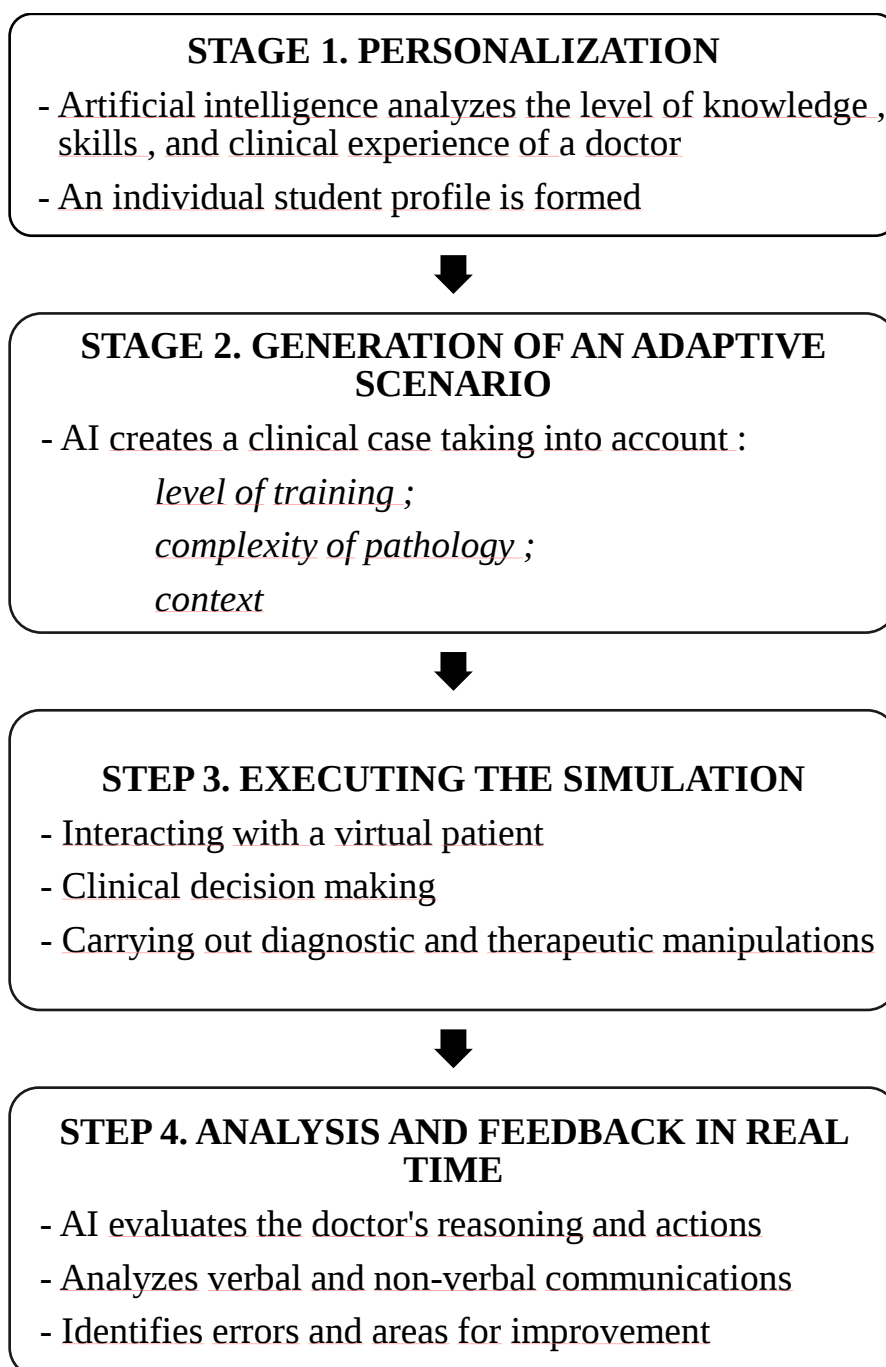


Figure 1. Family physician training cycle using AI-assisted simulation

Results : The analysis revealed several key areas for the effective use of the combination of AI and Family Doctor simulation in the training of family doctors.

Diagnostics and clinical reasoning. AI systems are capable of generating nonlinear clinical cases, where the virtual patient's condition dynamically changes depending on the doctor's actions. This teaches how

to formulate and test diagnostic hypotheses, avoiding cognitive errors, restr such as prematurely dismissing a diagnosis.

1. **Communication skills.** Using NLP and emotion analysis, AI can evaluate not only the verbal component of communication (e.g., the use of open-ended questions, empathy), but also paralinguistic aspects (tone, tempo of speech). This is especially important for rehearsing difficult conversations, such as delivering bad news or motivating people to change their lifestyle.
2. **Procedural practice.** AI-powered virtual and augmented reality (VR/AR) allows for practicing skills such as joint puncture or ultrasound examination, with tactile feedback and movement precision assessment.
3. **Resource management and teamwork.** Multiplayer simulators allow you to simulate the work of an interdisciplinary **team (doctor- nurse-administrator)**, where AI acts as virtual colleagues or patients, creating unpredictable situations and evaluating team interactions.

For clarity, we present a comparative analysis of various simulation formats in Table

Table 1.

Simulation format	Level of realism/ immersiveness	Key competencies to be developed	The Role of AI	Limitations
Standardized patient (SP)	High (real communication)	Communication, anamnesis, empathy	Limited (recording and subsequent analysis of speech is possible)	High cost, variability in implementation, difficulty in scaling
Low-fidelity simulators (phantoms)	Medium (tactile)	Manual skills (injections, sutures)	Absent or minimal	Does not develop clinical thinking
Virtual patient (without AI)	Intermediate (visual, cognitive)	Diagnostics, decision making according to a linear scenario	Absent	Predictability, lack of adaptability
Virtual patient (with AI)	High (cognitive, adaptive)	Clinical reasoning, diagnosis under uncertainty, communication (with NLP)	Key: scenario generation, adaptation, evaluation, feedback	Dependence on the quality of the algorithm, development cost
VR/AR simulators with AI	Very high (fully immersive)	Manual skills in anatomical context, procedures, surgery	Key: motion tracking, haptic feedback, navigation	High cost, possible impact on the vestibular system

As the table shows, the greatest potential for the comprehensive development of family physician competencies is concentrated in formats that actively utilize AI—intelligent virtual patients and VR/AR simulators.

Conclusions . This study confirms that the symbiosis of artificial intelligence and simulation methods represents a new quality stage in the training of family physicians. This approach enables a transition from episodic, often fragmented training to a continuous, personalized, and data-driven process of developing clinical competencies.

Key benefits include:

- Creating a safe and controlled environment for practicing any clinical situations, including rare and critical ones.
- The ability to assess skills objectively, standardized and detailed.
- Formation of individual educational trajectories based on the analysis of data on the student's progress.

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