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THE DEVELOPMENT AND ROLE OF SIMULATION-BASED EDUCATION IN PEDIATRICS TEACHING IN BOGOMOLETS NATIONAL MEDICAL UNIVERSITY IN THE FRAME OF ERASMUS+ UKRAINEDIGITRANS PROJECT

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Medical education in Ukraine is currently undergoing substantial challenges associated with the limitations of traditional bedside teaching and the consequences of the ongoing full-scale war, which has significantly affected healthcare infrastructure and clinical training bases. The traditional model of training, often described as "see one, do one, teach one," no longer fully meets the requirements for developing clinical competencies, particularly in pediatric practice where many critical conditions occur relatively rarely. As a result, medical students and residents may have limited changes to learn and manage high-risk pediatric emergencies during their clinical training.

Simulation-based education has therefore become an important component of medical training. It provides a structured and safe environment in which learners can repeatedly practice clinical procedures, develop diagnostic reasoning, improve communication skills and strengthen teamwork abilities without placing patients at risk. In pediatric education, simulation methods include a wide range of options, i.e. low-fidelity task trainers, high-fidelity computer-controlled mannequins, standardized patient interactions, in situ simulations conducted within real clinical settings and immersive virtual reality environments. These approaches support active learning, enable reflective analysis through debriefing and allow standardized evaluation of clinical competencies.

Within the ERASMUS+ UkraineDigiTrans project, the introduction of simulation-based learning at Bogomolets National Medical University represents an important step toward modernization of pediatric medical education and alignment with European competency-based training standards. Further development of simulation infrastructure, systematic faculty training and expansion of interdisciplinary educational programs will be necessary to ensure the long-term sustainability of simulation-based learning and to strengthen the quality and resilience of pediatric medical education in Ukraine.

Key words: medical education, pediatric training, simulation-based education, clinical competency, patient safety, high-fidelity simulation, standardized patients, virtual reality, interdisciplinary training, ERASMUS+.

Бурлака Євгенія, Виговська Оксана, Кучеренко Інна, Благая Анна, Земсков Сергій. Розвиток та роль симуляційного навчання у викладанні педіатрії в Національному медичному університеті імені О. О. Богомольця в рамках проєкту ERASMUS+ UkraineDigiTrans

Медична освіта в Україні стикається з серйозними викликами через етичні обмеження та тривалий вплив повномасштабної війни на клінічні бази навчання. Традиційні підходи на основі наставництва, що спираються на принцип «побачив – зробив – навчи іншого», недостатні для забезпечення компетентності у критичній педіатричній допомозі. Симуляційна освіта пропонує структуроване, безпечне та ефективне рішення, що дозволяє багаторазово практикувати технічні навички, клінічне мислення, командну роботу та управління кризовими ситуаціями без шкоди для пацієнтів. Педіатричні симуляційні модальності варіюються від тренажерів низької достовірності до високодостовірних комп'ютеризованих манекенів, стандартизованих пацієнтів, симуляцій на робочому місці та занурювальних середовищ віртуальної реальності. Ці підходи підтримують комплексний розвиток компетенцій, рефлексивне навчання та стандартизовану оцінку, одночасно покращуючи міждисциплінарну співпрацю та безпеку пацієнтів. У межах проєкту ERASMUS+ UkraineDigiTrans впровадження симуляційної освіти в Національному медичному університеті імені О. О. Богомольця модернізує педіатричну підготовку та узгоджує її з європейськими стандартами компетентностей. Продовження інвестицій у симуляційну інфраструктуру, розвиток викладацького складу та міждисциплінарне навчання є критично важливим для забезпечення сталого покращення педіатричної медичної освіти та результатів охорони здоров'я дітей в Україні.

Ключові слова: медична освітаб педіатрична підготовка, симуляційне навчання, клінічна компетентність, езпека пацієнта, симуляція високої достовірності, стандартизовані пацієнти, віртуальна реальність, міждисциплінарне навчання, ERASMUS+

Introduction. Current Challenges of the Medical Education in Ukraine. Over the past several decades the approaches and structure of medical education have undergone significant transformation. Traditionally, medical training relied predominantly on the model in which learners acquired knowledge and skills through observation and supervised participation in patient care [1]. This approach, often summarized by the rule "see one, do one, teach one," emphasized training within real clinical environments. While this model provided valuable hands-on learning, it was largely dependent on the variable case availability. Moreover, it can cause challenges from patients and students side [1, 2].

In contemporary healthcare systems, several factors have exposed limitations of this traditional model. The number of medical students and residents has increased substantially. Clinical exposure to rare, complex or high-acuity conditions has not increased proportionally [3]. Restrictions in working hours, heightened service demands, ethical considerations and institutional priorities related to patient safety further limit opportunities for trainees to practice independently. As a result, learners may complete significant part of their education without sufficient exposure to critical cases or uncommon disease presentations.

Moreover, reliance on unsupervised experiential learning is no longer considered acceptable in many settings. These evolving expectations have created an urgent need for structured, safe, and effective experiential learning modalities. Simulation-based education has emerged as a powerful response to these challenges [3,4].

In Ukraine, the need for simulation-based medical education is particularly urgent. The ongoing full-scale war has placed unprecedented strain on the healthcare system, requiring rapid preparation of medical professionals for trauma care, mass casualty incidents, emergency surgery, critical care and rehabilitation [4, 5]. At the same time, many clinical training sites have reduced capacity. Moreover, patient safety considerations further limit opportunities for hands-on practice. There is also a growing need to align Ukrainian medical education with European competency-based standards, ensuring quality assurance, standardized assessment and measurable learning outcomes. Simulation provides a controlled and safe environment in which students and residents can practice high-risk procedures, interdisciplinary teamwork and crisis resource management without compromising patient safety. Strengthening simulation infrastructure, developing faculty competencies are essential steps in modernizing and strengthening the resilience of medical education in Ukraine [4-8].

Aim of the study**.** The aim of this article is to analyze the current challenges of medical education in Ukraine and to justify the implementation of simulation-based pediatric education as an effective tool for developing clinical competencies, teamwork, and critical incident management in children, while ensuring patient safety and alignment with European competency standards.

Medical simulations: an overview. By definition, simulation refers to the creation of scenarios or environments designed to closely replicate real-world clinical situations for the purposes of education, assessment or system of evaluation. Throughout the history, simulation has been used in high-risk fields where errors can have striking consequences. Medicine adopted simulation more formally in the

mid-20th century [9]. Early systems of medical simulations were limited and costly. Further technological progress has transformed the field. Today, medical simulation encompasses a wide range of modalities and fidelity. Fidelity refers to the degree to which the simulation replicates the real clinical systems. Low-fidelity simulators include static mannequins and partial task trainers used to practice specific procedures such as intubation, intravenous insertion, or lumbar puncture. These tools allow repetitive skill development in a focused manner [9, 10].

High-fidelity simulators include computer-controlled mannequins capable of mimicking complex physiological responses and clinical conditions. These advanced systems reproduce heart sounds, breath sounds, pulses, pupillary responses, speech and dynamic changes in vital signs etc. Physiological parameters can evolve in response to medications or interventions administered by learners. High-fidelity simulators require financial investment, technological innovation has made them increasingly accessible to academic and tertiary care centers [10].

Types of Simulations in Pediatric High Medical Education. Simulation-based education in pediatrics includes a spectrum of modalities that differ in complexity, fidelity and educational purpose. Together, these modalities allow structured development of technical skills, clinical reasoning, communication, teamwork and systems-based practice [11].

Low-fidelity simulation is primarily designed for acquisition and repetition of specific procedural skills. In pediatric training these include peripheral intravenous access, airway management, lumbar puncture and basic life support. Such models enable conduct practice in a safe environment and are particularly suitable for early-stage learners. Although they do not show full clinical realism. These types of simulations are effective for building technical confidence before transitioning to more complex scenarios.

High-fidelity simulations provide advanced computerized mannequins capable of reproducing dynamic physiological and pathological processes i.e. respiratory distress, arrhythmias, seizures or shock. This approach is widely used in neonatal resuscitation, pediatric advanced life support, trauma management and critical care scenarios. High-fidelity simulation are capable of development of clinical decision-making, situational awareness crisis situation management skills. It also provides ability to have a structured debriefing, which is essential for reflective learning [12].

Standardized patient simulation focuses on communication and professional competencies. Trained actors play parents or adolescent patients, allowing learners to practice history taking, counseling, shared decision-making and conduct difficult communications. This approach is particularly relevant in pediatrics, where interaction with caregivers plays a central role in clinical care [11, 12]. It is also commonly used in objective structured clinical examinations for assessment purposes.

Another type of simulation is in situ simulation. It can be conducted within real clinical environments, such as pediatric wards, emergency departments, surgery rooms or pediatric intensive care units. This format is helpful in the interdisciplinary teamwork training, decision making [13].

Finally, virtual reality (VR) training takes pediatric simulation to a fully immersive level. Learners wear a headset and enter a 3D environment. It can replicate high-pressure clinical settings, such as an Intensive Care Unit (ICU) or trauma incident. Inside this virtual space they interact with AI-powered pediatric patients, team members and medical equipment in real time. VR training doesn't replace traditional methods but it adds repetition, immersion and emotional engagement into the learning process.

Benefits of VR pediatric simulation include: unlimited practice in rare, high-risk pediatric scenarios, building muscle memory (in surgery tainings) and faster clinical decision-making. VR is a safe, controlled space to practice communication under pressure. Moreover, there is no need for physical space, equipment setup or live instructors [11, 14]. In Figure 1 we summarize types of simulations available for the medical training.

The figure presents the main components of simulation-based education, including immersive experiential learning in realistic environments, structured reflective debriefing, and opportunities for repeated, risk-free practice. It demonstrates how simulation contributes to the development of knowledge, technical skills, and professional attitudes; provides exposure to uncommon or high-risk clinical conditions; supports the evaluation of new equipment and treatment protocols; enables standardized assessment through consistent scenarios; and promotes multidisciplinary team training.

Thus, the integration of multiple simulation modalities within pediatric curricula supports comprehensive competency development while maintaining patient safety and educational consistency.

Benefits of Simulation in Pediatrics Learning. Simulations offer lots of advantages in pediatric medicine. Critical pediatric emergencies are relatively uncommon but require immediate, coordinated responses and therefore are in urgent need to learn during the studying in medical schools [15]. Medi-

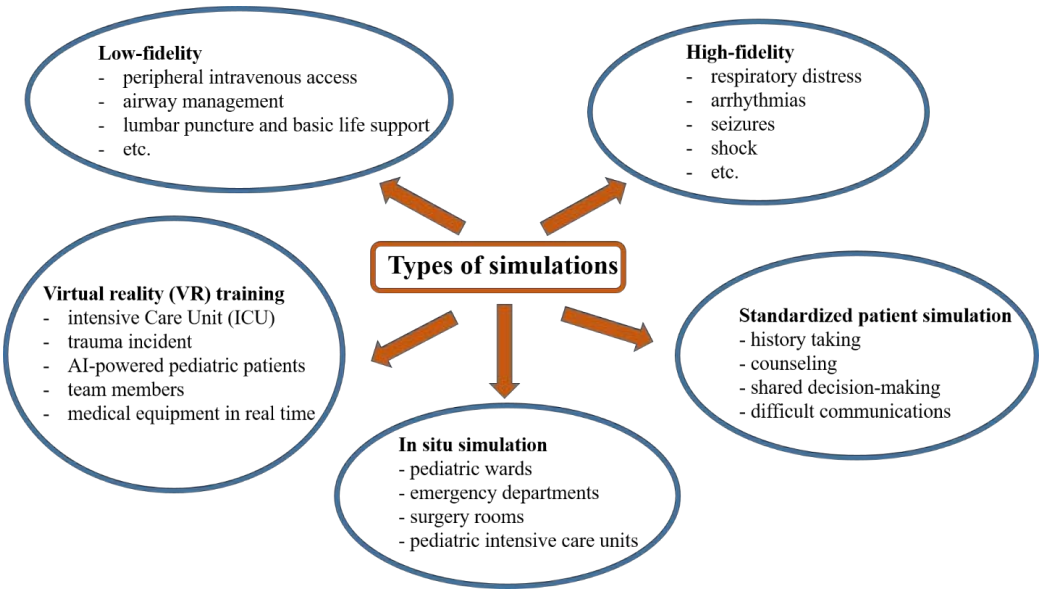

Fig. 1. Key functions and educational outcomes of simulation-based learning

cal doctors may encounter life-threatening pediatric events only partially during training. The rarity of such cases can lead to the lead to the lack of knowledge and skills mastery.

Simulation allows repeated exposure to high-risk, low-frequency events such as respiratory failure, septic shock, trauma, or neonatal resuscitation. Learners can practise both technical procedures and complex decision-making in a safe environment. Errors can occur without harm, and scenarios can be repeated until mastery is achieved [15, 16].

Simulation-based education provides immersive experiential learning in realistic environments combined with reflective learning through structured debriefing. It supports the development of knowledge, technical skills, and professional attitudes, enables on-demand exposure to uncommon conditions, allows risk-free practice with opportunities for repetition, facilitates the evaluation of new equipment, interventions, or treatment protocols, ensures standardized assessment through consistent clinical scenarios, and promotes multidisciplinary team training.

One of the most significant emerging benefits of simulation lies in team-based training and human factors education. Many adverse clinical outcomes result from communication failures, unclear leadership or misunderstanding in teamwork rather than purely technical deficiencies. Simulation enables multi-disciplinary teams to practice crisis resource management skills, improve coordination and identify latent safety threats within healthcare systems. Evidence suggests that structured team simulation training can improve team behavior and may contribute to reductions in medical error [17-19].

On the other hand, simulation-based education in pediatrics improves patient safety, clinical outcomes and the overall care experience [18]. By enabling healthcare providers to practice high-risk and rare scenarios in a controlled environment, it lowers the risk of medical errors and strengthens emergency care. Teams trained through simulation identify clinical deterioration earlier, initiate life-saving interventions more rapidly and work together more effectively during critical events. This leads to safer care, fewer complications and faster recovery for children. Simulation also enhances communication skills, supporting clearer explanations, empathetic interactions and better guidance for families during stressful situations. Furthermore, it promotes consistent training standards across institutions, including underserved and rare areas, helping ensure that children receive high-quality care regardless of location [19-22].

The figure shows the interrelated components of simulation-based education, including realistic clinical scenarios, active learner participation, facilitator guidance, structured debriefing, and feedback. It outlines how these elements interact to support skill acquisition, clinical reasoning, teamwork, and safe clinical practice.

Overall, simulation education supports competent clinicians, dependable healthcare systems and improved pediatric outcomes.

Discussion. The results of this study confirm the key role of simulation-based education in modern pediatric training in Ukraine. In the context of lim-

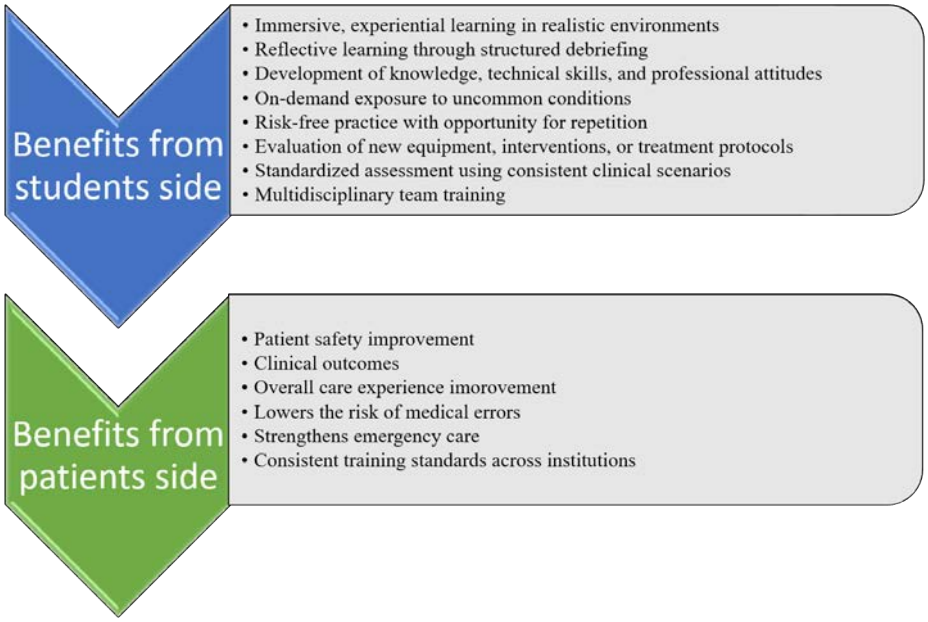

Fig. 2. Structure and elements of simulation-based education

ited clinical resources and increasing patient safety requirements, full-scale russian aggression the traditional apprenticeship model of "see one, do one, teach one" is insufficient to ensure full clinical competence [5-8]. Simulation-based learning allows students and residents to gain practical experience in a controlled environment. Under these circumstances students can repeatedly practice both technical skills and clinical decision-making in complex and rare scenarios.

The integration of various simulation types, i.e. from low-fidelity trainers to high-fidelity mannequins, standardized patients, in situ simulations and virtual reality provides comprehensive competency development, including clinical reasoning, teamwork and crisis management. Structured reflective debriefing after simulation sessions is particularly important, as it promotes knowledge consolidation, error awareness, and professional behavior improvement [9, 11].

One of the most significant benefits of simulation-based education is the development of interdisciplinary teamwork and preparedness for critical events [9,10]. Evidence shows that many adverse clinical outcomes are associated not only with technical errors but also with communication failures, unclear leadership, and inadequate team coordination. Simulation training allows latent safety threats to be identified, crisis resource management skills to be practiced, and team interaction to be improved [12-14].

Within the framework of the ERASMUS+ UkraineDigiTrans project, the implementation of simulation-based education at Bogomolets National Medical University modernizes pediatric training and aligns it with European competency standards. Experience demonstrates that combining multiple simulation modalities ensures standardized assessment of knowledge and skills, which is essential for quality assurance in education and patient safety improvement.

At the same time, sustainable implementation of simulation-based education requires further investment in infrastructure, faculty development and interdisciplinary training programs. Supporting and expanding simulation methods nationally could significantly enhance the quality of pediatric education and improve pediatric healthcare outcomes in Ukraine, particularly under conditions of limited clinical resources and high-risk scenarios.

Thus, simulation-based education is an effective tool that integrates patient safety, clinical competency development and alignment with international standards, making it an essential component of modern pediatric medical training.

Conclusions

1. Simulation-based education has become an essential component of modern pediatric medical training. It addresses the limitations of the traditional apprenticeship model by providing structured and safe opportunities for experiential learning, ensuring exposure to complex and high-risk clinical situations while maintaining patient safety.

2. The integration of low- and high-fidelity simulation, standardized patients, in situ training and virtual reality enables comprehensive competency development. Simulation also enables standardized assessment and supports alignment with competency-based educational standards.

3. Within the framework of the ERASMUS+ UkraineDigiTrans project, the implementation of simulation-based education at Bogomolets National Medical University contributes to the modernization of pediatric training in Ukraine and its harmonization with European educational standards.

4. Continued development of simulation infrastructure, faculty training and interdisciplinary collaboration will be necessary to ensure sustainability and long-term impact on medical education and pediatric healthcare outcomes.

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