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Analysis of the use of innovative technologies in simulation training to improve the quality of the educational process: experience of medical HEIs in Ukraine during the war

Olha Yuryk[1], Oleksandr Zlobin[2], Olha Vainahii[3], Olga Fedosieieva[4], Oleksiy Shaulko[5]

National Academy of Medical Sciences of Ukraine, National Technical University «Kharkiv Polytechnic Institute, Uzhhorod National University, Cherkasy Medical Academy, Interregional Academy of Personnel Management

Abstract
In a time of war, the quality of healthcare in Ukraine is constantly growing. Accordingly, under martial law, medical professionals need to develop additional skills. Simulation allows students to acquire the necessary skills and transfer them to practice. The purpose was to study the development of skills in medical students in terms of the use of innovative technologies in simulation training. The paper conducts a literature review of related scientific articles selected from the CinAHL and Pubmed databases with quantitative and qualitative characteristics. The inclusion criteria for the literature sampling method in this study focused on articles that addressed the use of simulation in medical education. Keywords and phrases related to the research questions were entered into dictionaries and thesauri to identify Mesh terms and Cinahl descriptors for more accurate search results. The results highlighted the main skills that were improved through the use of simulation thus it is a teaching method that can enhance the clinical training of medical students. It also provides students with a unique opportunity to apply theoretical knowledge in practice, to develop clinical skills and to acquire soft skills that are difficult to teach but are necessary in real-life healthcare settings.

Keywords
Martial law, need for medical personnel, medical students, training, critical thinking, technical skills.

[1] State Institution "Institute of Traumatology and Orthopedies of the National Academy of Medical Sciences of Ukraine, Kyiv, Ukraine, olhayuryk01@gmail.com
[2] National Technical University «Kharkiv Polytechnic Institute, Kharkiv, Ukraine, Oleksandr.Zlobin@khpi.edu.ua
[3] Uzhhorod National University, Uzhgorod, Ukraine, fedoseevaov@ukr.net
[4] Cherkasy Medical Academy, Cherkasy, Ukraine, fedoseevaov@ukr.net
[5] Interregional Academy of Personnel Management, Kyiv, Ukraine, oleksiy.shaulko@ukr.net

Introduction

Along with the full-scale war in Ukraine, the medical field has faced an urgent need not only for more medical personnel but also for effective training in this area to ensure and guarantee the best possible safety and quality of patient care (Raza & Hussain, 2022). These requirements seem even more urgent in the context of the war in Ukraine, which has highlighted the importance of the role of doctors in the healthcare system (Kaminskyy & Viesova, 2022). In recent years, changes in teaching methods used in the training of future doctors have tended to evolve, integrating more and more simulation experiences (Tsekhmister, 2022). This paper focuses on analysing the use of innovative technologies in simulation-based learning to improve the quality of the educational process, revealing the experience of Ukrainian medical HEIs in the context of war and investigating the impact of simulation on the development of medical students' skills in clinical training.

The catastrophic events associated with the war have created a need for safe and quality healthcare for the citizens of Ukraine. This, in turn, means that there is also a growing need for quality education, increased knowledge, and clinical experience (Dadario, Bellido, Restivo, Kulkarni, Singh, Yoon & Jafri, 2022). This becomes necessary as future doctors need to constantly adapt to new healthcare requirements to ensure the quality of care (Doyle, 2023). However, the development of such skills is complicated in times of war. To maintain the quality of healthcare, it is necessary to increase the number of qualified staff, attract more new graduates, and use new teaching methods to improve the training of doctors.

Simulation, in this context, is part of an ever-changing process where the demands on healthcare are constantly increasing. It is one of the ways to reduce the number of medical errors (Tsekhmister, Konovalova & Tsekhmister, 2021). Simulation is defined as an active and innovative practice based on experiential learning and reflective practice. Simulation in healthcare is now an asset used by both professionals and medical students (Hostiuc, Latifi, Poropatich, Sokolovich & Doarn, 2017). Through simulation and work-based practice, students are able to gain the necessary experience during their studies, which enables them to effectively cope with the challenges encountered in professional practice.

Thus, innovative technologies in simulation training help to ensure the safety and quality of care in practical settings (Helitzer, Hollis, de Hernandez, Sanders, Roybal & Van Deusen, 2010). Despite the difficult times of war, simulation-based learning is an

integral part of the educational process in the training of future doctors in Ukraine. The development of competencies through simulation enables students to become qualified specialists. Simulation-based learning is becoming increasingly widespread around the world (Korniichuk, Bambyzov, Kosenko, Spaska, Tsekhmister, 2021). There are a number of simulation centres in Ukrainian medical schools and their common goal is to provide students with the opportunity to develop a range of skills and knowledge to facilitate their future practice (Ataeva, 2022). The development of these skills is explained in the conceptual framework of the Reference Framework for Simulation Education in Medicine. It is a systematic plan that defines the structure and content of simulation education in each HEI separately. This framework ensures the organisation and standardisation of the learning process to achieve the planned learning objectives. The use of the reference framework in medical simulation education allows for a structured approach to learning, improves the quality of learning, and ensures the effective use of simulation training objects.

The research gap identified in this study is the need for effective training in the medical field in the context of the war in Ukraine. The present study aims to fill this gap by analyzing the use of innovative technologies in simulation-based learning to improve the quality of the educational process in Ukrainian medical higher education institutions (HEIs) and investigate the impact of simulation on the development of medical students' skills in clinical training. The study will focus on how simulation training can help ensure the safety and quality of patient care in practical settings, particularly in times of war when the demand for healthcare services is high. By exploring the experiences of Ukrainian medical HEIs in using simulation technologies, the study aims to provide insights into how simulation-based learning can contribute to the training of future doctors and the maintenance of quality healthcare in challenging circumstances.

Theoretical Framework

Learning in clinical settings is crucial for developing and maintaining the skills of students and healthcare professionals (Tsekhmister, 2023). A key element of this learning is obviously patient contact. The pedagogical mission in this regard is to prepare students for this task (Rastrygina & Ivanenko, 2023). In addition to this ethical imperative, the use of simulation in medical teaching is also of didactic interest, providing educators with

materials that allow students to encounter rare or critical clinical situations that are difficult, if not impossible, to understand in a theoretical context.

The use of simulation training has a number of advantages. According to Iatsyshyn, Kovach, Lyubchak, Zuban, Piven, Sokolyuk & Shyshkina (2020), simulation provides the opportunity to repeat the same scenario several times, which helps to develop many skills, such as improved communication, increased practical skills, technical skills and the ability to transfer theoretical knowledge. Zvarych, Kalaur, Prymachenko, Romashchenko & Romanyshyna, (2019) add that simulation provides students with an appropriate and safe environment that facilitates effective learning of the most complex material. The safety aspect of simulation allows students to feel comfortable and confident (Varianytsia, Musiienko, Kolenko, Huda, & Stozub, 2023). Related research shows that simulations have a positive effect on students by reducing anxiety and increasing their motivation and self-confidence (Garvasiuk & Namestiuk, 2022). In addition, the fun and interactive aspect of simulation makes the learning environment more attractive and stimulating for students. However, the implementation of simulation centres requires significant material and financial resources, which may pose an obstacle to access to this method, especially in times of war (Manyuk & Kuchumova, 2018). In addition, according to Bobrytska, Reva, Protska & Chkhalo, (2020), there is incompatibility of practices and inadequate equipment, and various emotions can arise that can negatively affect students and interfere with their work. In their work, Ihorovych, Petrovych, Pavlovych, Mykhailovych, Volodymyrovych, Valeriivna & Hryhorivna, (2023) describe the likelihood of stress due to the pressure of social demands, which can affect students' behaviour in simulation, lack of authenticity and the development of negative emotions. In addition, unpleasant feelings may be experienced during learning from mistakes, which contradicts the goals of simulations (Kocherga, Lembryk & Vysochan, 2017). Thus, despite the fact that simulation learning is a subject of debate, according to theories of situational cognition, this teaching and learning context is valued as a guarantor of a high level of contextualisation of learning.

In summary, while simulation training in medical education offers numerous benefits in terms of skill development, confidence-building, and interactive learning experiences, there are still significant gaps in research and practice. These gaps include challenges related to access to resources, compatibility of practices, emotional impact on students, and authenticity of learning experiences. Addressing these gaps is essential to

ensure the effectiveness and sustainability of simulation-based learning in clinical settings. Further research is needed to explore these issues and develop strategies to optimize the use of simulation in medical education.

Methods

In this paper, we focus on describing methods, tools, and stages of planning simulation-based learning based on a literature review. The literature review allowed us to summarise the pedagogical principles underlying the use of simulation. The article highlights the reflective activity that follows the simulation and which takes place as part of the "debriefing". The advantages of simulation for improving the quality of the educational process in medical HEIs of Ukraine in the conditions of war are demonstrated. The search for studies was conducted between May and December 2023 using the CINAHL and PubMed databases. These databases were used to search for primary articles that answered a predefined research question. Several keywords were derived from the question (clinical judgement, decision-making, critical thinking, skills, self-confidence, self-esteem, learning process, student, technical skills). The keywords were entered into two different dictionaries, HeTop and Wordreference. After that, Mesh terms and Cinchl descriptors were identified and checked in the thesauri of the relevant search databases. Highlighting the benefits and limitations shows us the controversial and complex nature of simulation-based learning.

The scientific novelty of this paper lies in its comprehensive review of the literature on simulation-based learning in medical HEIs, particularly in the context of Ukraine during times of war. The methodology employed in this study involved conducting a systematic search of relevant databases using specific keywords and mesh terms to identify primary articles that addressed the research question. By summarizing the pedagogical principles underlying the use of simulation, the paper sheds light on the reflective activity that occurs during debriefing sessions following simulations.

The paper also highlights the advantages of simulation for enhancing the quality of the educational process in medical HEIs, particularly in challenging environments. By discussing the benefits and limitations of simulation-based learning, the study presents a nuanced understanding of this teaching approach. This analysis contributes to the ongoing dialogue surrounding the effectiveness of simulation in medical education, particularly in contexts affected by conflict or instability. Overall, the research methodology and

scientific novelty of this paper provide valuable insights into the potential of simulation-based learning in medical education.

Research Aim and Research Questions

The research questions formulated in the study aimed to investigate how simulation impacts skill development in medical students, the importance of authenticity in medical education, the role of debriefing in enhancing authenticity, and the significance of procedural simulation and clinical immersion in learning. The interest in determining how the use of innovative technologies in simulation-based learning improves the quality of the learning process and how it develops various skills in medical students formulated the questions of the presented work:

How does simulation affect the development of skills in medical students during their initial training?

What is the importance of authenticity of learning for the field of medicine?

What is the role of debriefing in the perception of authenticity?

What is the role of procedural simulation and clinical immersion?

Results

Consideration of the pedagogical principles underlying the use of simulation focuses on the interest in this method in order to transfer learning from the learning environment to the care environment based on the reflection of actions that occur in a reconstructed and controlled environment (Zhdan, Khaimenova, Babanina, Kyrian & Katerenchuk, 2020). To achieve educational goals, teachers in medical HEIs in Ukraine use various simulation methods, including simulated patients, mannequins, reconstructed anatomical parts of the body, and video games. Although many educators consider simulation to be a valuable method for teaching medical students, this approach should not be seen as an end in itself (Kolyubakina & Khilchevska, 2020). The encounter with complex real-life clinical situations and the first contact with a patient is always accompanied by certain problematic moments, so the simulation can be seen as a preventive step towards solving such problems (Kaba, Cronin, Tavares, Horsley, Grant & Dube, 2022). The effectiveness of future medical professionalism depends on the authenticity of the simulated environment, the scenario reproduced in this environment, and, above all, the reflective activity that follows the simulation and takes place during the debriefing.

The principles of medical education through simulation in wartime are a complex issue. Despite the fact that the use of innovative technologies in simulation education to improve the quality of the learning process is a subject of debate, according to theories of situational cognition, it is effective. In the healthcare sector, so-called realistic mannequins are widely used to contextualise the training of future doctors at a high level (Omelchuk, Maksymchuk, Ihnatenko, Navolskyi, Kitsak, Vitkovskyi & Maksymchuk, 2022). These are in fact "high-tech" mannequins that can reproduce, for example, a patient's breathing movements, seizures, or electrical signals of the heart, which are picked up by monitors. However, the qualitative study by Yuriy, Huzchenko, Lobach, Karbovanets, Bokova & Isychko (2022) did not demonstrate the benefits of devices using high-fidelity simulation compared to so-called "low-fidelity" devices.

Thus, contrary to the common belief that the "objective" similarity between the source task and the target task increases the likelihood of a transition between the two tasks, the scientific literature shows that it is the perceived similarity between the two tasks that triggers a similar clinical reasoning process in both contexts and determines the likelihood that the transition between the two tasks is actually performed (Rayisa, Huzchenko, Lobach, Karbovanets, Bokova & Isychko, 2022). Therefore, medical educators in Ukraine focus on recreating teaching and learning through simulation environments that are perceived by students as similar. This perception is also important in terms of motivation, which is considered to be the main determinant of learning (Chernysh, Opitz, Riabtseva, Raab & Pavlova, 2023). The nature of the tasks offered to students determines their engagement in simulation activities if they are aware of their value (in particular, because they resemble the tasks they will have to solve in "real" life) and feel able to succeed in them (Kaminskyy & Viesova, 2022). It should be noted, however, that simulation activities described as interesting and motivating do not necessarily guarantee the learning that teachers expect. For example, certain emotions are likely to increase cognitive load and become a barrier to learning. The impact of the nature and intensity of emotions generated during a simulation session on learning has been little studied. Therefore, the impact of emotional engagement on transfer or memorisation should be considered uncertain (Vasianovych, Tatarina, Lenha, Ruda, Vainahii & Dymar, 2023).

In order to promote a high perception of similarity among participants in a simulation session, it is first necessary to model the situation, at the stage of scenario

development, to make it as authentic as possible in the eyes of the participants (L'Her, Geeraerts, Desclefs, Benhamou, Blanié, Cerf & Mossadegh, 2020). In particular, it is necessary to identify and take into account all the factors that contribute to this perception and to abandon the term (high or low) accuracy when referring to the simulation modality (Hamstra, Brydges, Hatala, Zendejas and Cook, 2014). However, meeting the above conditions is not the goal of simulation training, provided that the focus is on the truly critical dimensions of the situation (e.g., patient characteristics, temporality, physical and technological environment, or patient and family behaviour) that will contribute to making the simulation authentic.

The theoretical framework offered by vocational didactics can be particularly useful for identifying the 'critical' characteristics of the work situations being modelled (Sulym, Melnykov, Popov, Vechirko & Malets, 2023). The same applies to perspectives that focus on professional experience. For example, the integrated competency-based approach offers an operational model that can guide the implementation of a competency framework and its pedagogical implementation in simulation activities (Liubchak, Zuban & Artyukhov, 2022). A competence is then defined as a complex know-how that is mobilised through different kinds of abilities, a set of complementary resources developed based on multiple knowledge and organised into operational schemes, to adequately solve problems in a set of professional situations defined by specific roles, contexts, and constraints (Holomb, Rogachevskyi, Karbovanets, Senkevych & Vivsyannuk, 2022). This model can be particularly useful at the stage of creating “what-if” scenarios. Learning objectives should be defined within the framework of “target skills” to go beyond the behaviourist perspective of reproduction often used by medical educators, even though the professional situations to which healthcare professionals are exposed are often complex (Tsekhmister, Konovalova, Tsekhmister, Agrawal & Ghosh, 2021). The incorporation of simulation in education fully depends on the tools and methods of organising simulation activities used in medical HEIs in Ukraine (Table 1):

Table 1

Tools and methods for organising simulation activities

View	Description
Procedural modelling	Procedural simulations consist of discovery, experimentation, and repetition of actions to acquire technical proficiency (learning to catheterise a vein, intubate or perform laparoscopy). The use of

	computer interfaces, especially in serious games, is becoming increasingly common, although the impact of this learning tool is not well understood. The development and implementation of these programmes are also costly, as each module requires a complex engineering process (gamification) involving the creation of a computer interface, the development of scenarios with experts, and feedback transmitted through the software.
Clinical immersion	Clinical immersion aims to recreate the care environment as realistically as possible. For example, it is a simulation of an office with equipment identical to that of a hospital or institution, a consulting room, or an operating theatre. These simulations usually take place in specialised centres (so-called "simulation centres"), which are now available in most medical schools in Ukraine.
On-site clinical immersion	Clinical immersion sessions can also take place in professional practice settings as part of so-called on-site simulations. In this context, mannequins stand in for patients, but the environment and equipment used by the session participants is that of the ward in which they work. This modality is associated with a number of organisational constraints related to the need to ensure continuity of care, but it allows healthcare professionals who must work together to use the equipment they have at their disposal on a daily basis, which is not always the case in clinical immersion sessions held in specialised centres.
Simulated patients and hybrid modelling	Simulated patients are individuals who are recruited and trained to play a specific role for teaching and learning purposes. The simulated patients are interviewed and examined by the student, and technical gestures can be simulated or performed on accessories in so-called "hybrid" simulations, i.e., those that link the simulated patient and a body part (e.g., a plastic arm used to teach catheter insertion).

Source: Wan, Doty, Geraets, Nix, Saitta & Chini (2021)

A positive impact on the perception of the simulation also requires reflection on the pedagogical interventions that take place, in particular during the debriefing. In fact, the authenticity of a simulation device cannot be assessed solely on the basis of the reconstructed objective situation (i.e. through the realism of the material and scenario played out during the simulation). It is also evaluated in terms of the interaction that develops between students and teachers (Pelaccia, 2016). The purpose here is to emphasise the basic principle of simulation-based learning, according to which a pedagogical technique that uses simulation includes simulation and debriefing. In fact, it

would be legitimate to argue that a simulation without debriefing is simply not a simulation, at least from a pedagogical point of view.

Perception Studies

In terms of the stages of a simulation session, apart from procedural simulations, which aim to develop technical skills by allowing a gesture to be repeated until it is mastered, there is a common timeline for how a simulation session will unfold, especially when it is part of a clinical immersion.

The model proposed in the scientific article by Rudyshyn, Koreneva, Yakushko, Babenko-Zhyrnova & Lupak (2022) demonstrates accuracy in reproducing the typical course of simulation classes. The first stage involves creating a safe and respectful learning environment, with a high emphasis on confidentiality. In the second stage, participants are introduced to the simulated environment. Students take full responsibility for the equipment used, whether it is manikins or care devices. The third stage involves the presentation of concepts or orientations developed during the scenarios. The fourth stage, called the “briefing”, includes a brief presentation of the situation to be simulated. The fifth stage is the actual execution of the scenario, followed by the sixth stage, known as the “debriefing”.

The model presented here is that the teacher can use the filmed sequences of a situation for critical reflective analysis. However, the participants in the situation and the observers must be actively involved in this analysis.

In order to effectively deploy the stages of the simulation, it is important that teachers collaborate with the technicians responsible for implementing the audiovisual system. This system allows you to record and rebroadcast the simulated situation. It is also necessary to set up the scenery and prepare the simulation equipment, especially if high-tech mannequins are used, which are controlled by special software.

According to Gordiichuk, Kalinina, Snikhovska & Goray (2020), the expected benefits of simulation for medical student education in terms of quality represent the highest level of expected effects when assessing learning on a scale that includes four levels, the first three of which are satisfaction, knowledge acquisition, and behaviour change. Research approaches used to evaluate the impact of simulation are essentially quantitative in nature. They require a large number of people and control over many variables to objectify the desired effect (Shevchenko, 2019). In addition, in the field of

critical care (e.g. emergency medicine or anaesthesiology), the methodology faces difficulties in collecting data that must relate to events that are by definition rare and largely unpredictable. Furthermore, as in any quantitative study, there are many confounding factors that often prevent the measured effect from being attributed to a pedagogical method alone (Iskakova, 2023). Thus, there is a clear lack of reliable research aimed at assessing the impact of simulation on the quality of learning and professional practice.

Study Limitations

The main study limitation is that it heavily relies on information from Ukrainian medical universities, potentially missing out on valuable research from other countries. The limited number of studies included in the analysis may have overlooked important findings. While qualitative articles offer valuable insights, the small sample size could introduce bias. Additionally, the interpretation of qualitative data is subjective and reliant on the perspectives of the researchers. Despite some limitations, certain foreign articles were included in the review due to their relevance to the study topic.

Discussion

To enhance student engagement, educators should incorporate simulation activities into their teaching methods to encourage interaction with students. This approach, as suggested by Korniichuk et al. (2021), can improve the logical flow and effectiveness of learning. In order to achieve this objective, teachers should evaluate their teaching techniques and utilize resources for assessing debriefing strategies (Chicco et al., 2023) to address any weaknesses and enhance the overall learning experience. In the context of the first RQ scientists state that simulation plays a crucial role in the development of skills in medical students during their initial training. By engaging in simulation exercises, students are able to practice and refine their clinical skills in a controlled environment before interacting with real patients. This hands-on approach allows students to gain confidence and proficiency in various medical procedures, ultimately preparing them for their future roles as healthcare professionals.

In particular, it means that they are given the opportunity to change their usual role as transmitters of information to that of a manager or knowledge broker. For this approach to be successful, it is essential that they are trained in the methods, techniques,

and pedagogical tools that need to be used to deliver an effective debriefing. Training and support for teachers in the role of pedagogical supervision is particularly important, as they have still been using traditional teaching methods for a significant part of their teaching career (Garvasiuk, Ilika, Guz, Kulachek & Malaiko, 2023). This study coincide with the second RQ emphasising that the authenticity of learning is paramount in the field of medicine. By creating realistic simulation scenarios that closely mimic the challenges and complexities of real-life clinical situations, students are able to immerse themselves in the learning experience and develop critical thinking and decision-making skills. Authentic learning experiences also help students develop empathy and communication skills, which are essential for providing quality patient care.

Supervision models, such as the cognitive partnership (Bambini, Washburn & Perkins, 2009), help to understand the tasks that a teacher involved in pedagogical supervision missions must perform. Especially in the debriefing process, these tasks have significant similarities with those of clinical supervision (Bayliak, Abrat, Shmihel, Lushchak & Shvadchak, 2023). In terms of the third RQ it should be noted that debriefing plays a crucial role in enhancing the perception of authenticity in simulation-based learning. Through structured debriefing sessions, students are able to reflect on their performance, receive feedback from instructors, and identify areas for improvement. Debriefing helps students make connections between theory and practice, reinforcing their learning and enhancing the authenticity of the simulation experience.

Thus, a faculty member should have both content and pedagogical expertise (Clement, Howard, Lyon, & Molloy, 2023). In terms of meaningful experiences for students, research indicates that both faculty and students often tend to limit themselves to the technical and scientific aspects of clinical practice (Colmers-Gray, Walsh & Chan, 2017), while conflict resolution and emotional skills are left behind (Cooke, Rytwinski, Taylor, Nyboer, Nguyen, Bennett & Smol, 2020). In this context, we see the need for additional methodological research to develop a reference framework aimed at identifying a common set of skills that are required for a teacher who wants to use simulation to teach medical students. Thus the fourth RQ is developed as procedural simulation and clinical immersion are both valuable components of medical education. Procedural simulation allows students to practice specific clinical skills, such as intubation or suturing, in a controlled setting. Clinical immersion, on the other hand, involves students working alongside healthcare professionals in real clinical settings,

gaining hands-on experience and exposure to diverse patient populations. By combining procedural simulation with clinical immersion, students are able to develop a well-rounded skill set and readiness for their future careers in medicine.

Conclusions

The demands of war necessitate the implementation of simulation in the healthcare field of Ukraine. Utilizing cutting-edge technology, simulation can offer effective medical training that closely mirrors real-life clinical scenarios. It is important to recognize, however, that the use of simulation tools does not ensure desired outcomes. The primary goal of this review was to explore the impact of simulation on the enhancement of medical students' skills. Simulation enables students to bridge the gap between theory and practical application. In general, simulation is a valuable tool for skills development, although further research is needed to fully assess its impact on technical skills and self-confidence. The review underscored the ability of simulation to train skills that are typically only acquired through on-the-job experience. In the healthcare field, healthcare professionals play a vital role as the connection between social and technical abilities, with soft skills like effective communication, empathy, and emotional management being crucial. Simulation appears to be an effective method for promoting the acquisition of soft skills that are challenging to teach but essential for the everyday practice of healthcare professionals.

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