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REVIEW

Adapting Ukrainian Medical Education to the Challenges of War: A Scoping Review

Adaptación de la educación médica ucraniana a los desafíos de la guerra: una revisión de alcance

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ABSTRACT

Introduction: the war in Ukraine, which began in 2014 and escalated into a full-scale invasion in 2022, significantly transformed teaching methods in higher education. The skills acquired during distance learning amid the COVID-19 pandemic in 2019 proved valuable, especially in medical education, where mastering practical skills typically requires in-person practice at the patient's bedside, in operating rooms, and laboratories.
Method: to address the challenge of acquiring practical skills remotely, simulation methods were introduced, applicable both in simulation centers and through virtual simulation technologies. A systematic review was conducted to generalize and analyze research publications on the integration of simulation teaching methods into the medical education system. A total of 32 publications were selected according to systematic review standards. The literature search was conducted from 2019 to 2024 using the keywords "simulation learning," "virtual reality," "mixed reality," "medical education," and "distance learning" on the Scopus and PubMed platforms. The systematization of the analyzed literature was performed using the PRISMA program.
Results: the review identified the main areas of implementation of virtual simulation tools in the educational process. The analysis highlighted how these tools contribute to the development of practical skills and enhance the overall learning experience for medical students during distance learning.
Conclusions: the use of simulation training in medical education represents significant progress, improving the quality of training for medical professionals and ensuring the effective development of practical skills, even in remote learning conditions.

Keywords: Simulation Technologies; Crisis Management of Education; Integration of Military Medicine; Modernization of Educational Programs.

RESUMEN

Introducción: la guerra en Ucrania, que comenzó en 2014 y se convirtió en una invasión a gran escala en 2022, transformó significativamente los métodos de enseñanza en la educación superior. Las habilidades adquiridas durante el aprendizaje a distancia en medio de la pandemia de COVID-19 en 2019 resultaron valiosas, especialmente en la educación médica, donde el dominio de las habilidades prácticas generalmente requiere práctica en persona junto a la cama del paciente, en quirófanos y laboratorios.

Método: para abordar el desafío de adquirir habilidades prácticas de forma remota, se introdujeron métodos de simulación, aplicables tanto en centros de simulación como a través de tecnologías de simulación virtual. Se llevó a cabo una revisión sistemática para generalizar y analizar las publicaciones de investigación sobre la integración de métodos de enseñanza de simulación en el sistema de educación médica. Se seleccionaron un total de 32 publicaciones de acuerdo con los estándares de revisión sistemática. La búsqueda bibliográfica se llevó a cabo de 2019 a 2024 utilizando las palabras clave «aprendizaje por simulación», «realidad virtual», «realidad mixta», «educación médica» y «aprendizaje a distancia» en las plataformas Scopus y PubMed. La sistematización de la literatura analizada se realizó utilizando el programa PRISMA.
Resultados: la revisión identificó las principales áreas de implementación de herramientas de simulación virtual en el proceso educativo. El análisis destacó cómo estas herramientas contribuyen al desarrollo de habilidades prácticas y mejoran la experiencia de aprendizaje general de los estudiantes de medicina durante el aprendizaje a distancia.
Conclusiones: el uso de la formación mediante simulación en la educación médica representa un progreso significativo, ya que mejora la calidad de la formación de los profesionales médicos y garantiza el desarrollo eficaz de las habilidades prácticas, incluso en condiciones de aprendizaje a distancia.

Palabras clave: Tecnologías de Simulación; Gestión de Crisis de la Educación; Integración de la Medicina Militar; Modernización de los Programas Educativos.

INTRODUCTION

The war in Ukraine, which began in 2014 and escalated in 2022, affected all areas of life and created challenges for the health care system and the education sector. Medical facilities were burdened by the admission of a large number of wounded fighters, and medical education had to adapt to the educational process in crisis conditions.

Creating a continuous educational process in territories that were close to the front line and were constantly under fire was quite a difficult task. Medical educational institutions from the occupied territories were evacuated to safe places and resumed their work in a remote format. But the training of medical workers involves the acquisition of clinical experience, especially by senior students. Starting from the 4th year, students acquire practical skills necessary for future surgeons, resuscitators, and traumatologists, the need for which increased significantly during the war. The need to practice practical skills is a serious challenge in the training of specialists who are trained in the conditions of war. The experience of distance learning, which was obtained from the times of the COVID pandemic and showed its effectiveness, was also applied in the conditions of training during the war. The use of online platforms and digital technologies has become a key element in ensuring continuous learning.[1] The military actions in the east of Ukraine changed not only the form of the educational process, but there were demands to improve the training program for future medical specialists. In the educational programs, classes appeared in which medical students began to acquire special knowledge and skills necessary for work in the conditions of military conflicts, which include training in tactical medicine, providing first aid in combat conditions, evacuating the wounded, as well as working with the injured from explosions and other combat injuries.[2] The need for the training of rehabilitators has grown. One of the key areas of adaptation was the introduction of simulation training, which allows students to practice skills in conditions close to real ones.[3] The use of innovative technologies for teaching operations, providing emergency aid and treating combat injuries has become an integral part of the educational process.[4, 5]

In the research of Spooner et al.[6] the experience of implementing the STOMP (Simulation Training for Operational Medical Providers) educational program, which was used to train interns to provide primary medical care in the conditions of military operations, is described. Implementation of simulation trainings has demonstrated its effectiveness compared to traditional training.[6] Efficiency was assessed by the speed and quality of performance of ophthalmic procedures. During military operations, medical personnel must have the skills to provide rapid aid even in the absence of necessary medical equipment and in field conditions. Training of future doctors in simulation centers allows simulating the necessary conditions and preparing future doctors to provide qualified care in wartime conditions. Bleeding aid skills are essential in wartime and the technique is preferably learned in a training environment. Kirkpatrick et al.[7] studied the possibilities of simulation training when applying a wound clamp to simulated bleeding. The results were evaluated by the speed of the procedure and the stopping of bleeding. The use of remote monitoring during the thoracostomy procedure for tension pneumothorax on mannequins demonstrated the effectiveness of simulation training and the possibility of remote telemonitoring.

Injuries while performing combat missions create a demand for surgeons. Wounded in combat often require urgent medical care, including surgical and life-saving interventions. Surgeons are critical to treating injuries

such as bullet wounds, shrapnel wounds, explosions, and other combat injuries. In the conditions of war, the need for qualified surgeons is increasing, at the same time, the approaches to the training of surgeons who will work in extreme conditions are changing. It is advisable to practice and improve practical skills during training in emergency conditions using innovative methods, such as virtual reality. Frederiksen et al.[8] investigated students' acquisition of surgical skills when using virtual reality simulators. Students had the opportunity to be in the operating room and perform surgical interventions. The use of simulated virtual reality in the educational process during the training of surgical specialists has demonstrated effectiveness in acquiring the necessary skills, but experts note that the cognitive load on students increases, which can reduce learning productivity.[9,10] The conducted research examines a separate issue regarding the introduction of simulation training into the educational process for mastering practical skills by students of medical educational institutions and is devoted to the review of the processes of adaptation of medical education in Ukraine to the challenges of war, as well as the analysis of the main directions of transformation of this important industry.

The purpose of our systematic review was to conduct a synthesis and analysis of publications on the introduction of simulation technologies into the educational process of medical institutions in order to effectively master practical skills.

METHOD

Sample and participants

The PRISMA programme (Liberati, Altman, Tetzlaff, Mulrow & Getzsche, 2009) was used for the systematic review and processing of the literature. The literature was searched using keywords in the Scopus and PubMed databases. For further processing, the articles with the highest h-index and h-median for the period from 2019 to 2024 were selected.

Tools and procedures

Using the systematic method, we conducted a narrative review of the literature on the topic of the introduction of simulation training in the educational process of medical institutions. The search for sources for the review was carried out on the Scopus and Pubmed platforms using specific keywords: "simulation learning", "virtual reality", "mixed reality", "medical education", "distance learning".These keywords were used because they are commonly associated with the research topic of simulation technology in medical education. Only articles published between 2019 and 2024 were reviewed to examine the issue of simulation training in distance learning under the conditions of war in Ukraine. Inclusion and exclusion criteria were applied: inclusion criteria: simulation technologies in the educational process of medical universities, reviewed articles were the results of original research. Articles that were freely available on the platform in full-text version were selected for further review. When working on each publication, we included in the article only reliable and verified data. During the processing of publications, we critically evaluated the received information, which helped to clarify problematic issues, and also identified promising research directions.

Data analysis

For processing, we chose 435 publications from 2019-2024, 221 of them were freely available. For further processing, we selected publications that had the following keywords: "Simulation training", "Medical education", "Virtual reality", "Augmented reality", "Mixed reality". There were 87 such publications. In the course of the detailed analysis, 32 sources were selected that proved to be relevant and contributed to the understanding of the use of simulation-based learning methods in medical education. The approach used allowed us to process publications on the subject of the study that have been publicly available in English over the past five years on the Scopus and PubMed platforms (figure 1).

Literature review

Military actions forced many universities in Ukraine to switch to distance education in 2022. The use of virtual simulation laboratories, or other technologies such as virtual or mixed reality allow students at medical universities to master practical skills even in distance learning conditions, when students have limited access to clinical bases. Virtual simulators, in particular, allow students to practice medical manipulations and clinical scenarios remotely. During the war, the load on medical institutions increases and the opportunity to learn practical skills on patients on clinical bases decreases, and the use of simulators allows you to practice performing important manipulations without risking people's lives and health, while ensuring a high level of training.

Jung Jae Lee's research examines the issue of training nurses in blood transfusion skills, which is one of the main forms of treatment in medical practice. Blood transfusion can be accompanied by side reactions, both immediate and remote, the nurse who directly performs this procedure must quickly react to the deterioration of the patient's condition and have the appropriate knowledge. The author cites data that students do not always

have the opportunity to be present during the procedure, since practical training is limited to a certain time, which may not coincide with the time for which the procedure is scheduled in the clinic. The authors suggest the use of virtual reality methods in order to improve students' practical skills. The study was conducted with the participation of a control and research group of nursing students who received information from a lecture in an online format in Zoom, about the technique, possible side reactions. The control group of students was limited to the lecture material, and the other group practiced the technique using virtual reality. An analysis of the knowledge and quality of practical skills of students who had the opportunity of virtual learning showed an improvement in the effectiveness of learning when using virtual reality, as well as students having confidence during the procedure and satisfaction with learning.[11]

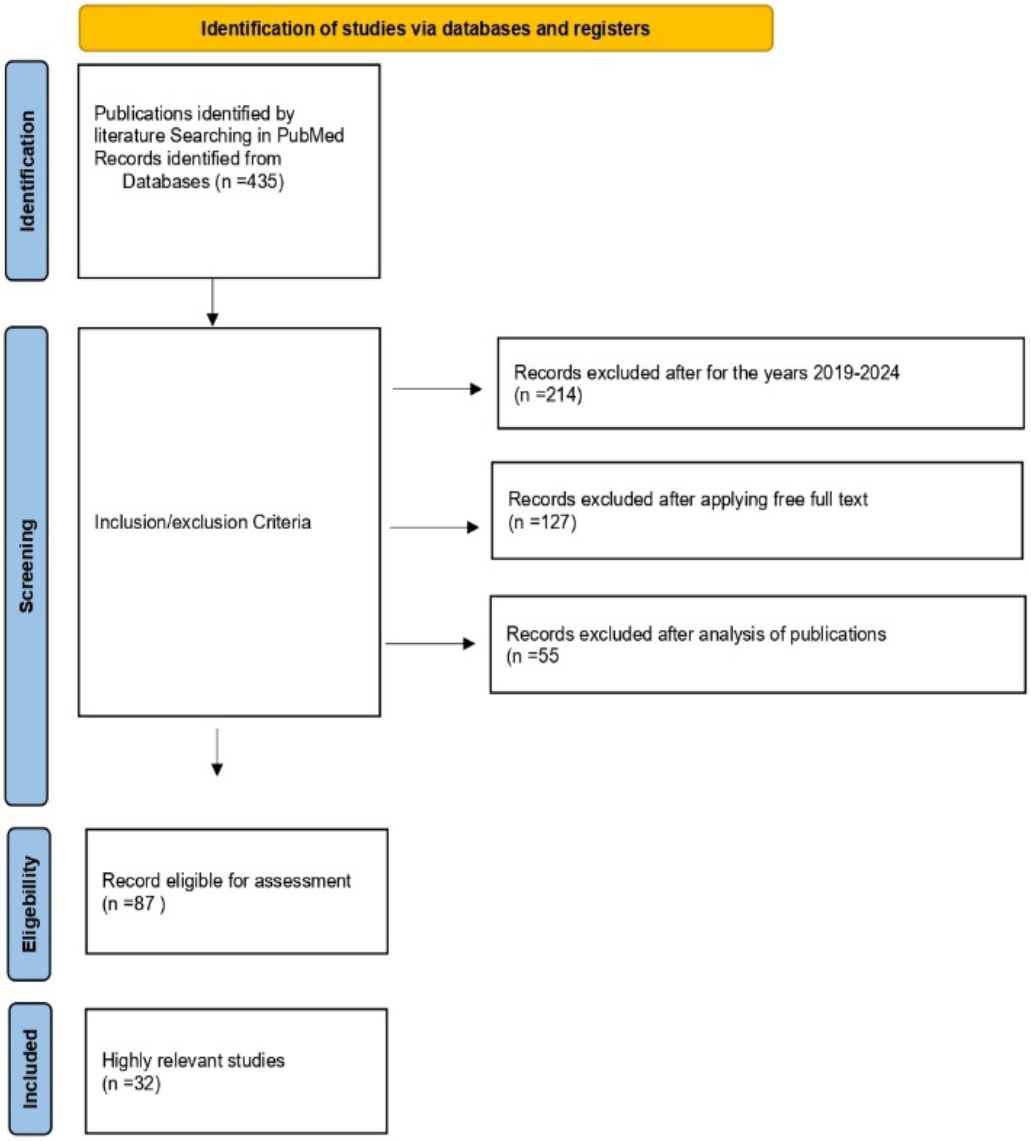

Figure 1. Selection and Analysis of Publications on Simulation Training Methods in Medical Education (2019-2024)

Liaw et al. research examines information about the importance of interprofessional communication between doctors and nurses, which significantly affects the quality of medical care. Sometimes, untimely assistance can cause insufficient communication between the medical team members when the nurses report changes in the patient's condition promptly. Usually, simulation training programs are used for teaching work in the health care team. Researchers have developed other approaches that allow the implementation of virtual reality tools into the initial environment for training medical students and nurses in communicative integration skills. The use of online technologies makes it possible to solve the issue of physical presence during training with the help of virtual reality. Also, it allows you to unite team members simultaneously. The authors demonstrated the effectiveness of the CREATIVE virtual reality program, which creates the experience of working in a medical team in a virtual hospital.[12]

Practicing practical skills with the help of simulation methods has shown its effectiveness when studying surgical specialties. Dean et al.[13] in his research, he provides data on the use of simulation training methods for senior students and junior doctors to practice the trabeculectomy procedure, which is used in ophthalmological practice to treat glaucoma. Experts are concerned about the decrease in the number of this procedure in recent years, which is associated with concern about possible complications and the increase in the use of drainage systems. Practicing practical skills with the help of simulation techniques allows the student to train until they reach the required level of competence. The authors provide reliable data that students and interns who underwent GLASS simulation training performed trabeculectomy in clinic conditions on patients with more confidence and quality, compared to interns who did not receive such an opportunity. Study participants demonstrated better skills in performing the procedure, greater confidence and satisfaction with the training received.[13]

The study[14] examined the effectiveness of using simulation training for surgical treatment of cataracts. Trainee doctors from Kenya, Tanzania, Uganda and Zimbabwe completed a 5-day simulation training course to improve their cataract surgery skills. The participants of the research group demonstrated an increase in professional competence, the number of complications in patients after the procedure was lower than in the control group. Mastery of surgical skills by students is an important task for achieving professional competence of future surgeons. Berger-Estilita et al.[15] studies studied the most effective strategy for mastering intravenous injections by medical university students. The study was conducted among 390 first-year students of medical faculties with the use of theoretical study and the creation of a mental image, the use of simulation simulators and written instructions. The authors came to the conclusion that there was no particularly reliable difference in the quality of the performance of this procedure among the students of the experimental groups. van der Leun et al.[16] studied the effective teaching of robotic surgery skills to medical students. Study participants were trained using virtual reality simulation followed by work on the da Vinci robotic device. The use of virtual reality improved the surgical skills of the study participants. Traditional training, when a student assists a surgeon, is currently being replaced by simulation training, which brings the clinical situation closer to the real one, but does not create a stressful situation for the student and the responsible surgeon, when the patient's life may depend on a mistake.

Gholinejadzirmanlou et al.[17] presents the results of a study among students who mastered surgical skills in vascular surgery. The author came to the conclusion that simulation training significantly improved student success, motivation to study, and confidence in knowledge, but the conclusions note that the best results are achieved by combining traditional and simulation training. The author considers the lack of unified models that would be included in the curricula of medical universities to be a drawback of simulation training The 2019 COVID pandemic prompted participants in the educational process to look for ways to continue their education. A feature of medical education is the need to acquire practical skills that are important for the formation of professional competencies of future doctors. Distance education allows you not to interrupt the educational process, but does not completely replace traditional education. The full-scale war in Ukraine also makes adjustments to the educational process. But the participants of the educational process, both teachers and future doctors, strive to obtain a quality education with the achievement of all professional competencies. Malik et al.[18] gives an example of improved distance learning with the introduction of HoloLens technology into the educational process, which allows the use of mixed reality, which uses elements of virtual reality and superimposes them on a real situation. According to the authors, the use of this method significantly improved motivation to study, student success and satisfaction with the educational process. Similar studies using mixed and virtual reality technologies in the study of bladder catheterization were conducted Schoeb et al.[19] by and demonstrate reliable results in improving student knowledge and increasing learning satisfaction.

Abbas, Kenth, & Bruce[20], who studied the application of advanced distance learning during the covid pandemic among students at medical universities, claims that simulation training has certain limitations, especially in conditions of war, pandemic. It is the application of virtual reality methods, which can also be considered as a simulation technology, that allows bridging the learning gap. Xin et al.[21] reviews the use of a virtual reality simulator to teach trainee surgeons the technique of screw placement in the treatment of spinal injuries. The author came to the conclusion that the introduction of a virtual simulation model into the educational process improved the success rate of young surgeons to 82,9 %, compared to the group where the technique of surgical intervention was studied from video material and was 74,2 %. The quality of the procedure increased by 23,1 %. The use of virtual reality technology in Logishetty et al.[22] research allows the surgeon to be placed in a virtual operating room for hip replacement surgery. To evaluate the effectiveness of using virtual reality in the educational process, efficiency criteria were used that determined the quality of surgical intervention, cognitive and motor skills during positioning of acetabulum components and femoral neck osteotomy. According to the results of the study, the author notes the progress demonstrated by trainee surgeons in acquiring surgical skills, which was demonstrated during the procedure and was determined by the correct sequence of actions, movements and spatial accuracy. Young professionals can transfer these skills to

a real physical environment. In other studies, the author provides data on the use of virtual reality, which helps to track and control the surgeon's movements in the operating room and allows the trainee doctor to immerse himself in the environment during hip arthroplasty. Evaluation of the implementation of virtual reality was determined using technical surgical efficiency. The number of errors in the orientation of the acetabular component and the time of the procedure were also evaluated.[23] The effectiveness of the use of virtual reality in the educational process was shown by the research of Hooper et al.[24] who described simulated virtual learning of the skills of hip arthroplasty.[24] Immersive virtual reality in the studies of Lohre et al.[25] showed effectiveness in training elderly orthopedic surgeons in performing manipulations on the shoulder joint. Seam et al.[26] the use of information technology in the intensive care unit indicates that simulation methods have improved patient care and overall competency of program participants.

The effectiveness of using virtual simulation technolog ies is highlighted in the works of other researchers.[27,28,29,30,31] Specialists consider the use of virtual simulation methods for mastering the technique of surgical manipulations, complex manipulations of emergency care, in pediatric surgery and obstetrics. The conclusions state that the use of innovative technologies allows practicing complex manipulations without risking the patient's life, which improves the quality of the procedure in the future, confidence, motivation for learning, satisfaction with learning, and reduces the number of errors during manipulations in real conditions.

RESULTS

The systematic review highlights the main areas of implementation of virtual simulation tools in the educational process:

1. The effectiveness of the application of simulation technologies on the success of students.
2. The influence of simulation technologies on the quality and accuracy of the manipulation procedures.
3. Peculiarities of pedagogical approaches when implementing simulation methods in the study programs of medical disciplines.
4. Study of factors that contributed to the growth of simulation training tools in the study of medical disciplines.
5. Consideration of programs of medical educational institutions that use simulation training to improve the practical skills of future doctors.

We also determined which methodological approaches were used by researchers when evaluating the quality of education when using simulation technologies (table 1).

Table 1. Methodological Approaches in Evaluating the Quality of Education Using Simulation Technologies

Author(s)	The effectiveness of the application of simulation technologies on the success of students	The influence of simulation technologies on the quality and accuracy of manipulation procedures	Peculiarities of pedagogical approaches in the implementation of simulation methods in the study programs of medical disciplines	Study of factors that contributed to the growth of simulation training tools in the study of medical disciplines	Consideration of programs of medical educational institutions that use simulation training to improve the practical skills of future doctors
Lee et al. [11]	+	+	+		+
Liaw et al. [12]	+	+			+
Dean et al. [13]	+		+		+
Berger-Estilita et al. [15]	-	-			
van der Leun et al. [16]	+	+			
Dean et al.[14]	+	+		+	+
Gholinejadzirmanlou et al.[17]	+	+		+	
Malik et al.[18]			+	+	
Abbas, Kenth, & Bruce[20]	+	+	+		+
Schoeb et al.[19]		+	+	+	+
Xin et al. [21]	+	+			
Logishetty et al.[22]	+	+		+	
Logishetty, Rudran, & Cobb[23]		+	+		
Spooner et al.[6]	+	+		+	
Kirkpatrick et al.[7]	+		+	+	
Kirkpatrick et al.[8]	+		+	+	

Frederiksen et al.[8]		+		+	+
Hooper et al. [24]		+	+		
Lohre et al. [25]	+		+		
Seam et al. [26]	+				+
Lei & Palm [27]	+				+
Plimon & Assadian [28]	+		+		
Davis & Warrington [29]			+		
Knowlin et al.[30]		+	+		
Sheen, Goffman, & Deering [31]	+				+
Sarboozi-Hosseinabadi et al.[32]	+		+		+
McCoy et al. [33]	+		+		
Laco & Stuart (2022)			+		
Gholinejadzirmanlou et al. [17]	+	+		+	
Fazlollahi et al. [35]	+			+	
Winkler-Schwartz et al. [41]			+	+	
De Backer et al. [42]	+		+		+
Galea et al. [39]	+	+			

During the study of the issue of the application of simulation methods in mastering the technique of medical manipulation, we considered the question in which medical fields the use of simulation methods was the largest (figure 2).

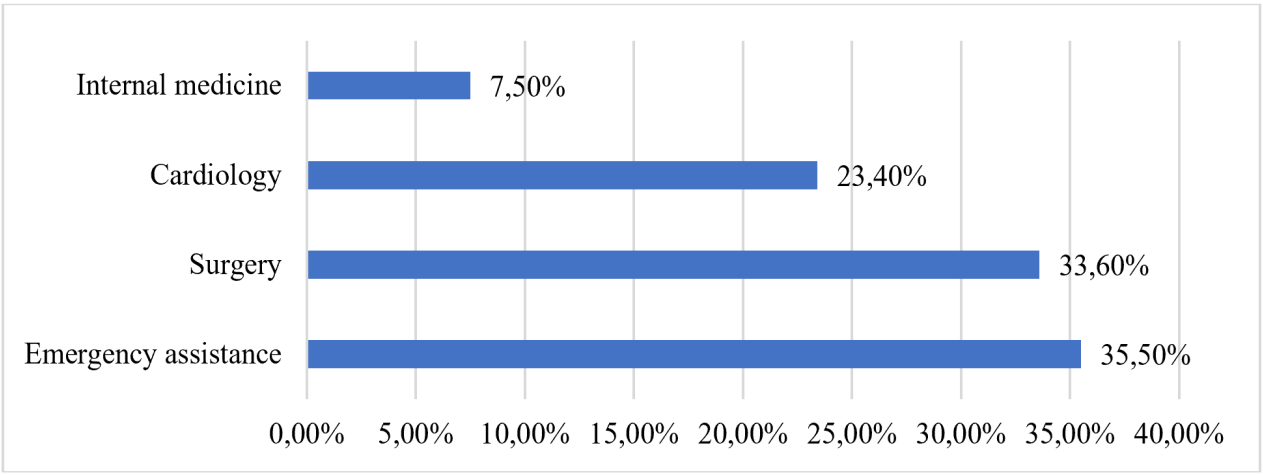

Figure 2. Medical Areas with the Introduction of Simulation Training

A high percentage of the use of simulation training was in the study of cardiology and amounted to 23,4 % .[41,42] The main issues that were considered in the publications. It was training in heart catheterization manipulations, as well as emergency care measures. The use of simulation training for mastering manipulations in general medicine was presented in 7,5 %. Also, when studying the issue of the introduction of simulation technologies into the educational process, it had certain features by country and is most represented in developed countries (USA, Great Britain, Germany).

The largest percentage (35,5 %) of the use of simulation training methods was in the study of emergency care measures. Mainly, the issues of studying the techniques of cardiopulmonary resuscitation, stopping bleeding, which is especially important when providing emergency aid to victims of military operations, were considered. The issue of the application of simulation methods in the study of emergency medicine is presented in the works of Sarboozi-Hosseinabadi et al.[32], McCoy et al.[33], Laco & Stuart.[34] Experts cite data from randomized studies and note that simulation training has shown its high efficiency. 33,6 % were presented publications in which the data of simulation training of surgical manipulations are presented. Data on the use of virtual reality when working in operating rooms are presented, which makes it possible to perform surgical manipulations

close to reality while in the conditions of a virtual operating room that fully simulates the situation. The use of simulation training in mastering the surgical skills of removing brain tumors during the training of neurosurgeons was highly effective.[35,40]

DISCUSSION

The education of medical university students has its own characteristics. For high-quality mastering of practical skills and knowledge, the form of classroom training with the possible remote form of lectures is more effective. However, studying in the conditions of war created challenges, and most universities switched to distance learning, which was successfully implemented in 2019. An alternative approach to mastering practical skills was the use of innovative learning technologies. On the one hand, future specialists were faced with the issue of improving measures to provide medical aid in wartime conditions. These skills can be practised in the conditions of a simulation centre, and on the other hand, distance learning does not provide a physical presence, and the requirements for mastering the techniques of performing medical manipulations remain. Innovative methods using augmented, virtual, and mixed reality can overcome the obstacle of acquiring the necessary knowledge.[36]

The effectiveness of simulation training application in all branches of medicine, particularly in surgery and anesthesiology, has been proven. Under conditions of limited access to clinical bases, especially during active hostilities, virtual simulations have become an important training tool. They enable the reproduction of clinical scenarios using computer programs and provide feedback on the accuracy of manipulations and decision-making. The experience of using Tele-education and artificial intelligence is interesting, during which the mastering of practical manipulations can be carried out at a distance of thousands of kilometres. [37] In a systematic review, Pietersen et al.[38] studied the issue of mastering surgical skills using simulation training. The authors emphasize the need to rebuild initial programs and introduce simulation teaching methods into the educational process, which demonstrate high efficiency in assessing the accuracy and quality of surgical manipulations. The application of virtual simulation training for students of medical universities in Ukraine is extremely relevant today since the war significantly limited the opportunities for ordinary practical classes.[39] Online platforms and virtual clinical scenarios allow continuing education even at a distance. It also expands access to international experience and the latest techniques.[43] Simulation learning in medical education is an important tool actively discussed among educators, medical professionals and students. The meta-analysis of Zeng et al.[44] provides data on the effective use of simulation training in mastering anesthesiology.

Simulations allow students to practice complex medical procedures without risk to patients. This is especially important in critical situations, where every mistake can have serious consequences. Arslan et al.[45] research presents data on student satisfaction with simulation training due to its realism, bringing students closer to real clinical conditions. Such conditions are specially created when using virtual and mixed reality when stimulators can reproduce human anatomy, physiological processes and clinical situations. The simulation allows you to constantly monitor the procedure and repeat until the desired level of skill mastery is achieved, which creates confidence and satisfaction from learning, which was reflected in the publications we reviewed and is confirmed in the meta-analysis by Davids et al.[46] who studied the acquisition of practical skills in the work of neurosurgeons. Modern simulation-based methods, such as laparoscopic simulator training, provide a safe and ethical environment for medical professionals to learn. However, research shows that the effectiveness of such programmes largely depends on the structure of the learning process and the role of the instructor in providing individual feedback that helps improve practical skills, especially in the early stages of training.[47] A comprehensive review of laparoscopic training systems highlights the importance of integrating augmented reality visualization to enhance guidance and assessment. The study by Hong, Rozenblit, and Hamilton[48] recommends the development of intelligent simulators that can improve training procedures and, ultimately, patient safety. Thus, the current use of virtual reality simulation training demonstrates a significant improvement in basic surgical skills, even after a short training period. This confirms the feasibility of integrating such methods into curricula, as they provide an effective and ethical platform for training medical professionals, even with limited resources and infrastructure.[49] Some researchers provide information that the use of simulation methods cannot fully reproduce clinical situations and replace the practice of practical skills at the patient's bedside and in the conditions of real operating rooms and hospital wards.[50,51]

CONCLUSIONS

In wartime, medical education in Ukraine adapted to changes and switched to a distance or mixed form of education, which allowed continuing the educational process but created certain problems in the qualitative acquisition of practical skills. There was a need to update training programs considering the need to acquire skills in providing medical aid in crises, on the battlefield, and during evacuations. It became important to update military medicine programs and create conditions for improving practical skills, especially for surgeons, traumatologists, and anesthesiologists. An important role was played by simulation centres that helped practice

many skills: applying stitches, cardiopulmonary resuscitation, and stopping bleeding. Learning in remote conditions requires new approaches, such as virtual laboratories, patients, and the possibility of staying in virtual operating rooms with the help of virtual and mixed-reality programs. The use of simulation training in medical education is significant progress that increases the quality of training of medical professionals. However, it is important to balance simulation and traditional teaching methods to ensure the comprehensive development of students and prepare them for real challenges in clinical practice.

Recommendation and future research

A promising direction is the improvement of distance learning technologies and introducing improved virtual simulation training programs into the educational process. Economically developed countries have experience using virtual operating rooms and other software to improve medical skills in various directions for student training, so an important step is to strengthen international cooperation to improve Ukrainian medical education. Specialized courses are being developed to improve students' knowledge of disaster, military, and emergency medicine. Increasing the mobility of students will provide an opportunity to adopt progressive experience and improve the quality of medical care.

REFERENCES

1. Kalachova TV, Salman O, Misiura O, Tretiak V, Safoshkina L, Honchar R. The ways to organize distance learning in higher military educational institutions of Ukraine and the world during overcoming the coronavirus infection pandemic COVID-19. Information Processing Systems [Internet]. 2021 [cited 2025 Feb 6];4(167):27-44. Available from: https://doi.org/10.30748/soi.2021.167.03

2. Halachev P. Academics' attitudes toward AI challenges in education: Tradition vs innovation. Futurity Philosophy [Internet]. 2023 [cited 2025 Feb 6];2(3):39-55. Available from: https://doi.org/10.57125/FP.2023.09.30.03

3. Kaldygozova S. Using mobile technologies in distance learning: A Scoping Review. . E-Learning Innovations Journal [Internet]. 2024 Mar 25 [cited 2025 Feb 21];2(1):4-22. Available from: https://doi.org/10.57125/elij.2024.03.25.01

4. Zhuravlova Y, Kichuk Y, Yakovenko O, Miziuk V, Yashchuk S, Zhuravska N. Innovations in education system: Management, financial regulation and influence on the pedagogical process. Journal of Curriculum and Teaching [Internet]. 2021 [cited 2025 Feb 6];11(1):163-73. Available from: https://www.sciedupress.com/journal/index.php/jct/article/view/21399

5. Yuriy R, Tatarina O, Kaminskyy V, Silina T, Bashkirova L. Modern methods and prospects for using artificial intelligence in disease diagnostics: A narrative review. Futurity Medicine [Internet]. 2024 [cited 2025 Feb 6];3(4). Available from: https://doi.org/10.57125/FEM.2024.12.30.02

6. Spooner MT, Delorey D, Miller KE, Greer JA. Effectiveness of the Ophthalmological Training Component of the STOMP (Simulation Training for Operational Medical Providers) Curriculum. Cureus [Internet]. 2021 Feb 10 [cited 2025 Feb 21]. Available from: https://doi.org/10.7759/cureus.13269

7. Kirkpatrick AW, Mckee JL, Netzer I, Mckee IA, McBeth P, Wachs JP, Ball CG, Glassberg E. A Randomized Trial of Mentored vs Nonmentored Military Medics Compared in the Application of a Wound Clamp Without Prior Training: When to Shut Up and Just Watch! Mil Med [Internet]. 2020 Jan [cited 2025 Feb 21];185(Supplement_1):67-72. Available from: https://doi.org/10.1093/milmed/usz251

8. Kirkpatrick AW, McKee JL, Netzer I, McBeth PB, D'Amours S, Kock V, Dobron A, Ball CG, Glassberg E. Transoceanic Telementoring of Tube Thoracostomy Insertion: A Randomized Controlled Trial of Telementored Versus Unmentored Insertion of Tube Thoracostomy by Military Medical Technicians. Telemed E Health [Internet]. 2019 Aug [cited 2025 Feb 21];25(8):730-9. Available from: https://doi.org/10.1089/tmj.2018.0138

9. Frederiksen JG, Sørensen SM, Konge L, Svendsen MB, Nobel-Jørgensen M, Bjerrum F, Andersen SA. Cognitive load and performance in immersive virtual reality versus conventional virtual reality simulation training of laparoscopic surgery: a randomized trial. Surg Endosc [Internet]. 2019 Jun 6 [cited 2025 Feb 21];34(3):1244-52. Available from: https://doi.org/10.1007/s00464-019-06887-8

10. Vovchenko OA, Lytvynova NA, Tsekhmister YV, Hoshovska DT, Vichalkovska NK. Socialisation of Adolescents

with Cognitive Disorders through Emotional Intelligence. J Intellect Disabil Diagn Treat [Internet]. 2022 Feb 9 [cited 2025 Feb 21];10(1):56-69. Available from: https://doi.org/10.6000/2292-2598.2022.10.01.7

11. Lee JJ, Tsang VW, Chan MM, O'Connor S, Lokmic-Tomkins Z, Ye F, Kwok JY, Ho MH. Virtual reality simulation-enhanced blood transfusion education for undergraduate nursing students: A randomised controlled trial. Nurse Educ Today [Internet]. 2023 Jul [cited 2025 Feb 21]:105903. Available from: https://doi.org/10.1016/j.nedt.2023.105903

12. Liaw SY, Ooi SW, Rusli KD, Lau TC, Tam WW, Chua WL. Nurse-Physician Communication Team Training in Virtual Reality Versus Live Simulations: Randomized Controlled Trial on Team Communication and Teamwork Attitudes. J Med Internet Res [Internet]. 2020 Apr 8 [cited 2025 Feb 21];22(4):e17279. Available from: https://doi.org/10.2196/17279

13. Dean WH, Gichuhi S, Buchan JC, Makupa W, Mukome A, Otiti-Sengeri J, Arunga S, Mukherjee S, Kim MJ, Harrison-Williams L, MacLeod D, Cook C, Burton MJ. Intense Simulation-Based Surgical Education for Manual Small-Incision Cataract Surgery. JAMA Ophthalmol [Internet]. 2020 Nov 5 [cited 2025 Feb 21]. Available from: https://doi.org/10.1001/jamaophthalmol.2020.4718

14. Dean WH, Buchan J, Gichuhi S, Philippin H, Arunga S, Mukome A, Admassu F, Lewis K, Makupa W, Otiti J, Kim MJ, Macleod D, Cook C, Burton MJ. Simulation-based surgical education for glaucoma versus conventional training alone: the GLAucoma Simulated Surgery (GLASS) trial. A multicentre, multicountry, randomised controlled, investigator-masked educational intervention efficacy trial in Kenya, South Africa, Tanzania, Uganda and Zimbabwe. Br J Ophthalmol [Internet]. 2021 Jan 25 [cited 2025 Feb 21]:bjophthalmol—2020-318049. Available from: https://doi.org/10.1136/bjophthalmol-2020-318049

15. Berger-Estilita J, Blülle R, Stricker D, Balmer M, Greif R, Berendonk C. Refreshing medical students' intravenous-cannulation skills: a blinded observer three-arm randomised comparison of mental imagery, part-task trainer simulation and written instructions. BMJ Open [Internet]. 2022;12(6):e057201. Available from: http://dx.doi.org/10.1136/bmjopen-2021-057201

16. van der Leun JA, Siem G, Meijer RP, Brinkman WM. Improving robotic skills by video review. J Endourol [Internet]. 2022;36(8):1126–35. Available from: http://dx.doi.org/10.1089/end.2021.0740

17. Gholinejadzirmanlou M, Aghazadeh Attari AM, Sheikhalipour Z, Lotfi M, Ghaffarifar S, Qayumi K. An appropriate simulation-based training for surgical technology students. Nurse Educ Pract [Internet]. 2023;70(103680):103680. Available from: http://dx.doi.org/10.1016/j.nepr.2023.103680

18. Malik R, Abbas JR, Jayarajah C, Bruce IA, Tolley N. Mixed reality enhanced otolaryngology case-based learning: A randomized educational study. Laryngoscope [Internet]. 2023;133(7):1606–13. Available from: http://dx.doi.org/10.1002/lary.30364

19. Schoeb DS, Schwarz J, Hein S, Schlager D, Pohlmann PF, Frankenschmidt A, et al. Mixed reality for teaching catheter placement to medical students: a randomized single-blinded, prospective trial. BMC Med Educ [Internet]. 2020;20(1):510. Available from: http://dx.doi.org/10.1186/s12909-020-02450-5

20. Abbas JR, Kenth JJ, Bruce IA. The role of virtual reality in the changing landscape of surgical training. J Laryngol Otol [Internet]. 2020;134(10):1–4. Available from: http://dx.doi.org/10.1017/S0022215120002078

21. Xin B, Huang X, Wan W, Lv K, Hu Y, Wang J, et al. The efficacy of immersive virtual reality surgical simulator training for pedicle screw placement: a randomized double-blind controlled trial. Int Orthop [Internet]. 2020;44(5):927–34. Available from: http://dx.doi.org/10.1007/s00264-020-04488-y

22. Logishetty K, Gofton WT, Rudran B, Beaulé PE, Cobb JP. Fully immersive virtual reality for total hip arthroplasty: Objective measurement of skills and transfer of visuospatial performance after a competency-based simulation curriculum. J Bone Joint Surg Am [Internet]. 2020;102(6):e27. Available from: http://dx.doi.org/10.2106/JBJS.19.00629

23. Logishetty K, Rudran B, Cobb JP. Virtual reality training improves trainee performance in total hip arthroplasty: a randomized controlled trial. Bone Joint J [Internet]. 2019;101-B(12):1585–92. Available from:

http://dx.doi.org/10.1302/0301-620X.101B12.BJJ-2019-0643.R1

24. Hooper J, Tsiridis E, Feng JE, Schwarzkopf R, Waren D, Long WJ, et al. Virtual reality simulation facilitates resident training in total hip arthroplasty: A randomized controlled trial. J Arthroplasty [Internet]. 2019;34(10):2278–83. Available from: http://dx.doi.org/10.1016/j.arth.2019.04.002

25. Lohre R, Bois AJ, Athwal GS, Goel DP, Canadian Shoulder and Elbow Society (CSES). Improved complex skill acquisition by immersive virtual reality training: A randomized controlled trial: A randomized controlled trial. J Bone Joint Surg Am [Internet]. 2020;102(6):e26. Available from: http://dx.doi.org/10.2106/JBJS.19.00982

26. Seam N, Lee AJ, Vennero M, Emlet L. Simulation Training in the ICU. Chest [Internet]. 2019 Dec [cited 2025 Feb 21];156(6):1223-33. Available from: https://doi.org/10.1016/j.chest.2019.07.011

27. Lei C, Palm K. Crisis resource management training in medical simulation. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 [cited 2025 Feb 6]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK560833/

28. Plimon M, Assadian A. Translation gegen die Einbahn – Entwicklung von Simulationsmodellen für die gefäßchirurgische Ausbildung. Gefasschirurgie [Internet]. 2022;27(5):361–4. Available from: http://dx.doi.org/10.1007/s00772-022-00920-2

29. Davis D, Warrington SJ. Simulation training and skill assessment in emergency medicine. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 [cited 2025 Feb 6]. Available from: https://pubmed.ncbi.nlm.nih.gov/32491627

30. Knowlin LT, Laskay NMB, Jules NP, Godzik J, Chang TP, Spurrier RG. Advances in pediatric surgery simulation-based training. Children (Basel) [Internet]. 2023;11(1). Available from: http://dx.doi.org/10.3390/children11010034

31. Sheen J-J, Goffman D, Deering S. Simulation in obstetric emergencies. Obstet Gynecol Clin North Am [Internet]. 2022;49(3):637–46. Available from: http://dx.doi.org/10.1016/j.ogc.2022.04.005

32. Sarboozi-Hosseinabadi S, Sharifzadeh G, Hosseini SM. Evaluating CPR training: simulation vs. webinars for Iranian emergency medical technicians during COVID-19. BMC Emerg Med [Internet]. 2024;24(1):46. Available from: http://dx.doi.org/10.1186/s12873-024-00967-2

33. McCoy CE, Rahman A, Rendon JC, Anderson CL, Langdorf MI, Lotfipour S, et al. Randomized controlled trial of simulation vs. Standard training for teaching medical students high-quality cardiopulmonary resuscitation. West J Emerg Med [Internet]. 2019;20(1):15–22. Available from: http://dx.doi.org/10.5811/westjem.2018.11.39040

34. Laco RB, Stuart WP. Simulation-based training program to improve cardiopulmonary resuscitation and teamwork skills for the Urgent Care Clinic staff. Mil Med [Internet]. 2022;187(5–6):e764–9. Available from: http://dx.doi.org/10.1093/milmed/usab198

35. Fazlollahi AM, Yilmaz R, Winkler-Schwartz A, Mirchi N, Ledwos N, Bakhaidar M, et al. AI in surgical curriculum design and unintended outcomes for technical competencies in simulation training. JAMA Netw Open [Internet]. 2023;6(9):e2334658. Available from: http://dx.doi.org/10.1001/jamanetworkopen.2023.34658

36. Metu IC, Agu NN, Eleje LI. Students' perceptions of and preferences for assessment feedback in higher education: Implication for evaluators. Futurity of Social Sciences [Internet]. 2024 [cited 2025 Feb 6];2(2):21-37. Available from: https://doi.org/10.57125/FS.2024.06.20.02

37. Sayed R. Assessing the influence of artificial intelligence on business development strategies: A sectorial analysis. Law, Business and Sustainability Herald [Internet]. 2023 [cited 2025 Feb 6];3(1):4-17. Available from: https://lbsherald.org/index.php/journal/article/view/41

38. Pietersen PI, Bjerrum F, Tolsgaard MG, Konge L, Andersen SAW. Standard setting in simulation-based training of surgical procedures: A systematic review: A systematic review. Ann Surg [Internet]. 2022;275(5):872–

82. Available from: http://dx.doi.org/10.1097/SLA.0000000000005209

39. Galea R, De Marco F, Meneveau N, Aminian A, Anselme F, Gräni C, et al. Amulet or Watchman device for percutaneous left atrial appendage closure: Primary results of the SWISS-APERO randomized clinical trial. Circulation [Internet]. 2022;145(10):724–38. Available from: http://dx.doi.org/10.1161/CIRCULATIONAHA.121.057859

40. Stulberg JJ, Huang R, Kreutzer L, Ban K, Champagne BJ, Steele SR, et al. Association between surgeon technical skills and patient outcomes. JAMA Surg [Internet]. 2020;155(10):960–8. Available from: http://dx.doi.org/10.1001/jamasurg.2020.3007

41. Winkler-Schwartz A, Yilmaz R, Mirchi N, Bissonnette V, Ledwos N, Siyar S, et al. Machine learning identification of surgical and operative factors associated with surgical expertise in virtual reality simulation. JAMA Netw Open [Internet]. 2019;2(8):e198363. Available from: http://dx.doi.org/10.1001/jamanetworkopen.2019.8363

42. De Backer O, Iriart X, Kefer J, Nielsen-Kudsk JE, Aminian A, Rosseel L, et al. Impact of computational modeling on transcatheter left atrial appendage closure efficiency and outcomes. JACC Cardiovasc Interv [Internet]. 2023;16(6):655–66. Available from: http://dx.doi.org/10.1016/j.jcin.2023.01.008

43. Cherniaieva O, Orlenko O, Ashcheulova O. The infrastructure of the internet services market of the future: Analysis of formation problems. Futurity Economics & Law [Internet]. 2023 [cited 2025 Feb 6];3(1):4-27. Available from: https://doi.org/10.57125/FEL.2023.03.25.01

44. Zeng Q, Wang K, Liu W-X, Zeng J-Z, Li X-L, Zhang Q-F, et al. Efficacy of high-fidelity simulation in advanced life support training: a systematic review and meta-analysis of randomized controlled trials. BMC Med Educ [Internet]. 2023;23(1):664. Available from: http://dx.doi.org/10.1186/s12909-023-04654-x

45. Arslan S, Kuzu Kurban N, Takmak Ş, Şanlialp Zeyrek A, Öztik S, Şenol H. Effectiveness of simulation-based peripheral intravenous catheterization training for nursing students and hospital nurses: A systematic review and meta-analysis. J Clin Nurs [Internet]. 2022;31(5–6):483–96. Available from: http://dx.doi.org/10.1111/jocn.15960

46. Davids J, Manivannan S, Darzi A, Giannarou S, Ashrafian H, Marcus HJ. Simulation for skills training in neurosurgery: a systematic review, meta-analysis, and analysis of progressive scholarly acceptance. Neurosurg Rev [Internet]. 2021;44(4):1853–67. Available from: http://dx.doi.org/10.1007/s10143-020-01378-0

47. Tee Y-S, Cheng C-T, Li P-H, Hsieh M-J, Liao C-H, Fu C-Y. Optimizing modern surgical simulation through instructor feedback - insights from a retrospective observational study in a tertiary hospital. BMC Med Educ [Internet]. 2024;24(1):1109. Available from: http://dx.doi.org/10.1186/s12909-024-06090-x

48. Hong M, Rozenblit JW, Hamilton AJ. Simulation-based surgical training systems in laparoscopic surgery: a current review. Virtual Real [Internet]. 2021;25(2):491–510. Available from: http://dx.doi.org/10.1007/s10055-020-00469-z

49. Sparn MB, Teixeira H, Chatziisaak D, Schmied B, Hahnloser D, Bischofberger S. Virtual reality simulation training in laparoscopic surgery - does it really matter, what simulator to use? Results of a cross-sectional study. BMC Med Educ [Internet]. 2024;24(1):589. Available from: http://dx.doi.org/10.1186/s12909-024-05574-0

50. Tsekhmister Y. Medical informatics and biophysics in medical universities of European countries: A systematic review and meta-analysis. Electron J Gen Med [Internet]. 2024;21(2):em570. Available from: http://dx.doi.org/10.29333/ejgm/14197

51. Korniichuk OY, Bambyzov LM, Kosenko VM, Spaska AM, Tsekhmister YV. Application of the case study method in medical education. Int J Learn Teach Educ Res [Internet]. 2021;20(7):175–91. Available from: http://dx.doi.org/10.26803/ijlter.20.7.10

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