PROFESSIONAL EDUCATION:
METHODOLOGY, THEORY AND TECHNOLOGIES
Journal homepage: https://profedu.com.ua/en
Vol. 12, No. 1, 2026, 45-61
ISSN 2415-3729;
e-ISSN 2415-3737

Article's History: Received: 09.01.2026 Revised: 14.04.2026 Accepted: 12.05.2026 Published: 19.06.2026

UDC 378.46:004.946
DOI: 10.69587/pemtt/1.2026.45

Development of simulation centres as an innovative technology in postgraduate medical education: Theoretical and methodological foundations and practical dimension

Lanna Lukashenko
Doctor of Medical Sciences, Professor
Zaporizhzhia State Medical and Pharmaceutical University
69035, 26 Marii Prymachenko Blvd., Zaporizhzhia, Ukraine
https://orcid.org/0000-0001-9736-6989

Iryna Sokolovska*
PhD in Medical Sciences, Assistant Lecturer
Zaporizhzhia State Medical and Pharmaceutical University
69035, 26 Marii Prymachenko Blvd., Zaporizhzhia, Ukraine
https://orcid.org/0009-0008-2487-1675

Iryna Ganzhiy
Doctor of Medical Sciences, Professor
Zaporizhzhia State Medical and Pharmaceutical University
69035, 26 Marii Prymachenko Blvd., Zaporizhzhia, Ukraine
https://orcid.org/0009-0008-2490-5222

Abstract. The article aimed to determine the role of simulation centres in modernising postgraduate medical education and strengthening practical training to develop professional competencies among healthcare professionals. The research methodology was based on an applied pedagogical design incorporating theoretical-analytical and quasi-experimental components. The empirical stage was conducted from 16 to 27 February 2026 at the Educational and Research Institute of Postgraduate Education at Zaporizhzhia State Medical and Pharmaceutical University, involving 48 intern doctors who underwent an initial and final comprehensive assessment of their professional competencies. The results showed that simulation centres function as organised educational environments in medical education, where clinical scenarios, the safe practice of algorithms, team interaction, standardised assessment and debriefing ensure the formation of professional competencies. The methodological analysis substantiated the integration of simulation technologies into postgraduate medical education through a combination of competency-, activity-, scenario-, problem-, interprofessional and reflective approaches. Following simulation training, assessment demonstrated statistically significant improvements in intern doctors' results: theoretical preparedness increased from 12.4 ± 2.1 to 17.1 ± 1.8 points; practical actions, from 24.6 ± 4.3 to 34.8 ± 3.1 points; and self-assessment of professional readiness, from 18.2 ± 3.5 to 25.7 ± 2.8 points. The greatest increase was recorded in the reflective component (44.8%), indicating the effectiveness of debriefing. Further development of simulation centres should focus on virtual simulations, telesimulation, digital checklists, electronic portfolios, and artificial intelligence tools. A one-group quasi-experimental study in the system of postgraduate medical education demonstrated a statistically significant improvement in professional competency indicators among intern doctors after simulation training, particularly in terms of theoretical preparedness, practical actions, team interaction and reflective readiness. These results could be utilised by higher

Suggested Citation:
Lukashenko, L., Sokolovska, I., & Ganzhiy, I. (2025). Development of simulation centres as an innovative technology in postgraduate medical education: Theoretical and methodological foundations and practical dimension. *Professional Education: Methodology, Theory and Technologies*, 12(1), 45-61. doi: 10.69587/pemtt/1.2026.45.

Corresponding author (isokolovska@ukr.net)

medical education institutions, postgraduate education institutes, simulation centres, and clinical discipline teachers to develop, implement, and assess simulation training in professional development programmes for healthcare professionals

Keywords: debriefing; artificial intelligence; clinical scenarios; digital checklists; team interaction; professional competencies; patient safety

Introduction

Postgraduate medical education must ensure the renewal of knowledge and the reproducible readiness of healthcare professionals to perform clinical actions in situations where an error directly affects the patient's condition. Simulation centres facilitate the development of practical skills in a controlled environment, combining the practice of procedures, clinical algorithms, communication, and team interaction with the objective assessment of learning outcomes. The development of simulation centres is a prerequisite for strengthening the practical orientation of postgraduate training and for the structured continuing professional development of healthcare professionals. The absence of the systematic integration of simulation centres into postgraduate medical education can result in a discrepancy between theoretical training and clinical practice, uneven professional competency levels, and increased risks to patient safety. This complicates the provision of predictable quality medical care and poses challenges to the professional responsibility of healthcare providers.

In medical education in Ukraine, simulation-based learning should be considered a tool for preserving practical training, standardising clinical actions, and creating a safe environment for practising professional skills. A study by O. Yuryk *et al*. (2024) examined how Ukrainian higher medical education institutions used innovative simulation technologies to maintain practical training during wartime. The authors demonstrated that simulation-based learning not only ensured the continuation of the practical component of the educational process when access to clinical bases was limited, but also strengthened the opportunity to safely practise professional actions in a controlled environment. M. Chavarha *et al*. (2025) revealed how medical education was adapted to crisis conditions through organisational restructuring, digital support, and renewed methodological approaches. The results showed that simulation centres can ensure the continuity of practical training for healthcare professionals when access to the clinical environment is restricted. The article by Z.R. Kocherga *et al*. (2024) presented a development strategy for simulation-based learning through organisational, methodological, and resource conditions for its implementation in the educational process. Within this approach, the simulation centre is presented as an institutional environment combining technical equipment, scenario-based learning, pedagogical support, and control over the development of practical skills. The study by P. Ivanchov *et al*. (2024) considered integrated simulation-based training of surgical skills as a means of strengthening procedural training in medical universities. In that study, surgical simulation scenarios were presented as a means of combining intervention algorithms, technical accuracy, the sequence of clinical decisions, and safety controls during performance.

Integrating simulation technologies into postgraduate medical education is associated with a shift in focus from knowledge transmission to fostering practical, communicative, team-based, and reflective skills among healthcare professionals. A.S. Biduchak (2025) analysed team-oriented training in Ukrainian and European educational contexts. In this learning model, the simulation centre facilitates not only the practice of individual clinical actions, but also coordinated interprofessional interaction, the distribution of functions, communication, and joint decision-making in simulated clinical situations. The study by Y. Shpryakha *et al*. (2025) assessed the effectiveness of clinical simulation-based learning through the development of practical skills among medical students. The results obtained confirm that simulation training should be assessed not merely by participation, but by the dynamics of specific skills that can be evaluated using checklists and clinical scenarios. S. Shapovalov *et al*. (2025) linked the challenges of postgraduate medical education to the need to update the content, forms, and mechanisms of professional learning. This highlights the importance of simulation centres as tools for the regular practice of practical actions, clinical algorithms, and professional decisions throughout a doctor's career. Y. Nemyrovych *et al*. (2024) considered innovative educational technologies to be a factor in improving continuing professional development for doctors, as such approaches can adapt learning to the needs of adult professionals and increase its practical orientation. The researchers confirmed that simulation technologies can be integrated into both separate training modules and the system of continuous professional development, where flexibility, practical orientation, and the ability to repeatedly assess competencies are priorities.

International approaches to simulation-based medical education emphasise the need for evidence of its impact, the importance of debriefing, and the requirement to evaluate not only technical actions, but also clinical thinking, communication, and teamwork. C. Elendu *et al*. (2024) demonstrated the impact of simulation training on medical education in terms of its contribution to the development of clinical skills, professional confidence, and a safe learning environment. In postgraduate education, these findings highlight the importance of learning formats that enable healthcare professionals to update their theoretical knowledge and assess their preparedness for clinical situations. C. Patocka *et al*. (2024) evaluated the impact of targeted simulation training on learning outcomes, professional preparedness, and the quality of practical actions performed by healthcare professionals prior to the execution of clinical procedures. The authors demonstrated that short simulation sessions can quickly restore or reinforce practical skills prior to performing responsible clinical procedures. J. Berger-Estilita *et al*. (2021) analysed the communicative content of debriefing in simulation-based medical education using an analytical framework and a mixed-methods approach. The results showed that the effectiveness of simulation-based learning depends not only on the realism of the scenario, but also on the quality of the subsequent analysis, during which errors are transformed into professional experience.

While previous studies have adequately covered the organisational, technological, and methodological foundations of simulation-based learning, the connection between institutional development of simulation centres and professional competency development among postgraduate medical students remains underdeveloped. This study aimed to determine the significance of simulation centres as an innovative educational environment for renewing postgraduate medical education, improving practice-oriented training, and forming professional competencies among healthcare professionals. To this end, the following tasks were defined: analysing trends in the development of simulation centres in professional education and continuing learning for healthcare professionals; characterising methodological approaches to integrating them into postgraduate medical education and assessing their impact on professional competencies; assessing changes in professional competency indicators among intern doctors after using simulation technologies; and outlining prospects for developing simulation centres in an era of educational digitalisation.

Materials and Methods

The work's methodology was based on an applied pedagogical design that combined theoretical-analytical and quasi-experimental components. The theoretical-analytical component involved studying scientific approaches to developing simulation centres, the methodological foundations for integrating them into postgraduate medical education, and the role of simulation technologies in developing professional competencies among healthcare professionals. The quasi-experimental component aimed to assess the development of professional competencies among learners before and after they completed simulation-based learning. Zaporizhzhia State Medical and Pharmaceutical University in Ukraine, specifically its Educational and Research Institute of Postgraduate Education, was selected as the location for the empirical stage. The study period was from 16 to 27 February 2026. This time interval was chosen to ensure a complete cycle of simulation-based learning, with initial and final assessments of professional competencies conducted sequentially.

The theoretical-analytical component of the study was based on scientific works revealing the content, functions, and educational potential of simulation-based learning in medical education (Saleem & Khan, 2023; Ajemba *et al*., 2024). To clarify the institutional dimension of the problem, studies devoted to the organisational and pedagogical foundations of simulation centre operation were analysed (Carter & Al-Shanteer, 2025; Zeng *et al*., 2025). As the study was conducted in the context of postgraduate medical education, attention was given to works addressing the continuing professional development of healthcare professionals (Tavares *et al*., 2023; Abdool *et al*., 2025). The methodological basis for evaluating simulation-based learning outcomes was defined in relation to the competency-based approach in medical education (Zafošnik *et al*., 2024; Fisk *et al*., 2025). The communicative and team-based aspects of professional training were analysed based on sources examining team interaction in medical education (Kiessling *et al*., 2022; Sung & Hsu, 2025). The reflective component of the study was substantiated through works examining the role of debriefing in simulation training (Ahmad *et al*., 2023; Salik & Paige, 2023). In light of changes to the educational process, studies examining the digitalisation of medical education and the use of digital tools in specialist training were also analysed (Almousa *et al*., 2021; Sun *et al*., 2024). To compare national and international experience, sources devoted to international approaches to organising simulation training were also considered (Rossler *et al*., 2021; Watts *et al*., 2021). The analysis of these works made it possible to clarify the functions of the simulation centre as an educational environment, determine the conditions for its integration into postgraduate medical education and substantiate the components of assessing professional competencies among intern doctors. The content of the clinical scenarios was linked to the criteria for standardised assessment of practical actions, which made it possible to align the learning situations with the expected outcomes of the simulation training (Bahattab *et al*., 2023; Klein *et al*., 2025). The organisation of pedagogical support, the role of the teacher-facilitator and the structure of post-scenario analysis were substantiated with regard to approaches to facilitation and debriefing (des Ordons *et al*., 2022; Dieckmann *et al*., 2023).

A total of 48 intern doctors specialising in "General Practice – Family Medicine" and undergoing training at the research base took part in the empirical stage of the study. The sample was formed through purposive voluntary sampling, as it included doctors undertaking the relevant postgraduate training cycle, participating in simulation training, and consenting to the use of anonymised results for scientific purposes. Information about participant recruitment was provided during an organisational meeting before the training cycle began and via an information notice circulated among the intern doctors. Participants' ages ranged from 24 to 37 years, with an average age of 28.7 ± 3.4 years. The sample included 18 men and 30 women, reflecting the actual composition of the academic group of intern doctors, and this was not an additional criterion for sample formation. Inclusion criteria included being an intern doctor specialising in "General Practice – Family Medicine", participating in the full cycle of simulation training, completing initial and final assessments, and providing voluntary consent to participate in the study and to use anonymised results. The exclusion criteria were incomplete simulation training, absence of results from one of the assessment stages, refusal to participate, and impossibility of comparing initial and final data. All participants completed the simulation training and were included in the final analysis.

The empirical stage of the study was conducted in a training classroom equipped for simulation-based learning, team interaction and practical algorithms, at the research site. The study was conducted in accordance with the relevant ethical guidelines (European Commission, 2021; The Declaration of Helsinki, 2024). The simulation training comprised four sessions of three academic hours each, totalling 12 academic hours. Professional competencies were assessed using the authors' own instruments: a theoretical knowledge test, a self-assessment questionnaire on professional readiness, and an expert checklist for evaluating practical performance. These instruments underwent preliminary methodological verification before the main stage of the study. The content validity of the instruments was ensured through expert assessment of their structure, content, and alignment with the objectives of the simulation training. Five specialists were involved in the expert assessment: three clinical discipline teachers with experience of training intern doctors and two simulation-based learning specialists who had participated in the organisation and delivery of practice-oriented training in medical education. The experts analysed how well the test items, questionnaire statements and checklist criteria corresponded to the aims and objectives of the training, the components of professional competencies, the content of typical simulation tasks and the expected learning outcomes. The instruments were assessed according to the following criteria: content relevance; methodological appropriateness; clarity of wording for intern doctors; unambiguity of scaling; the possibility of objectively recording results; and suitability for comparing initial and final assessments. The correspondence between the test items and the content of the clinical algorithms, between the questionnaire statements and the indicators of subjective professional readiness, and between the checklist criteria and the practical, communicative and reflective actions performed during the simulation training was analysed separately. Following an expert discussion, the formulations of the test items, self-assessment indicators and practical assessment criteria were clarified. The pilot application of the instruments enabled the clarity of the instructions, the unambiguity of the scaling, and the convenience of recording results to be checked. To minimise subjectivity in expert assessment, the checklist was used in a standardised format with predefined criteria and the same assessment scale for all participants. To determine the cognitive component of professional competencies, a theoretical knowledge test was used to assess understanding of clinical algorithms, the sequence of actions, the principles of patient safety, and team interaction (Table 1).

Table 1. *Structure for assessing the theoretical preparedness of intern doctors*

Testing block	Content of assessment	Number of tasks
Clinical algorithm	Sequence of actions in a clinical situation	5 (1 point for each correct answer)
Initial assessment of the patient's condition	Determining examination priorities, recognising signs of an emergency condition, assessing risks	5 (1 point for each correct answer)
Patient safety	Compliance with rules for the safe performance of procedures, prevention of errors, risk control	4 (1 point for each correct answer)
Team interaction	Distribution of roles, transfer of information, coordination of actions within the team	3 (1 point for each correct answer)
Debriefing and error analysis	Understanding the importance of feedback, reflection and correction of subsequent actions	3 (1 point for each correct answer)

Note: *the test was administered before the beginning and after the completion of the simulation training; the final version was equivalent to the initial version in terms of structure, difficulty and distribution of thematic blocks*
Source: *compiled by the authors*

To assess the subjective-reflective component of professional readiness, a self-assessment questionnaire was used, which made it possible to identify how intern doctors assessed their own readiness to perform clinical actions, make decisions, engage in team interaction and analyse errors before and after the training (Table 2).

Table 2. *Self-assessment questionnaire of professional readiness of intern doctors*

Self-assessment indicator	Statement before training	Statement after training	Scale
Readiness to perform a clinical algorithm	I am ready to perform a clinical algorithm in a clinical situation	After the training, I am ready to perform a clinical algorithm in a clinical situation	1-5
Confidence in making clinical decisions	I am confident in making clinical decisions during an emergency condition	After the training, I am confident in making clinical decisions during an emergency condition	1-5
Readiness for practical actions	I am ready to perform practical actions in accordance with patient safety requirements	After the training, I am ready to perform practical actions in accordance with patient safety requirements	1-5
Team interaction	I am ready to interact with other team members while performing a clinical task	After the training, I am ready to interact with other team members while performing a clinical task	1-5
Professional communication	I am ready to communicate information clearly, ask clarifying questions and coordinate actions within the team	After the training, I am ready to communicate information clearly, ask clarifying questions and coordinate actions within the team	1-5
Reflection and error analysis	I am able to analyse my own errors after completing a clinical scenario	After the training, I am able to analyse my own errors after completing a clinical scenario	1-5

Note: *the questionnaire was administered before the beginning and after the completion of the simulation training; each of the 6 indicators was assessed on a five-point scale: 1 point – strongly disagree with the statement; 2 points – rather disagree; 3 points – partly agree/partly disagree; 4 points – rather agree; 5 points – strongly agree*
Source: *compiled by the authors*

To record the practical and communicative-team components of professional competencies, an expert assessment checklist was used. Practical actions were assessed by one teacher-facilitator with experience in conducting simulation-based learning. The facilitator assessed the actual performance of the clinical algorithm, technical accuracy, safety of actions, communication and decision-making during the simulation task using a standardised checklist with pre-defined criteria and the same assessment scale for all participants, which was used to minimise the subjectivity of expert assessment (Table 3).

Table 3. *Expert assessment checklist of practical actions during the simulation task*

Assessment criterion	Content of the criterion	Maximum score
Initial assessment of the patient's condition	Sequential determination of the patient's condition, recognition of signs of urgency, determination of action priorities	5
Compliance with the clinical algorithm	Performance of actions in accordance with the defined sequence, absence of critical omissions	5
Technical accuracy of practical actions	Correct performance of manipulations, accuracy of movements, compliance with the technique of performance	5
Patient safety	Compliance with safety rules, risk control, preventio of actions that may worsen the patient's condition	5
Team interaction	Distribution of roles, coordination of actions, involvement of other team members	5
Professional communication	Clarity of information transfer, use o clarifications, correctness of team messages	5
Clinical decision-making	Selection of justified actions according to the situation, timeliness of decisions	5
Reflection during debriefing	Ability to explain one's own actions, identify errors and propose ways of correction	5

Note: *the checklist was used for expert assessment of practical actions during the performance of the simulation task before the beginning and after the completion of the training; each criterion was assessed on a five-point scale: 1 point – the action was not performed or was performed with errors that compromised patient safety or made it impossible to achieve the aim of the clinical stage; 2 points – the action was performed fragmentarily, with the omission of several mandatory elements or with a violation of the sequence of performance; 3 points – the action was performed generally in accordance with the criterion, but with individual omissions of elements or inaccuracies in the sequence; 4 points – the action was performed in accordance with the criterion, sequentially, with isolated inaccuracies that did not alter the clinical logic of performance; 5 points – the action was performed fully, sequentially, independently and in accordance with patient safety requirements*
Source: *compiled by the authors*

To detail the results of the expert assessment from the checklist, the communicative and teamwork components were identified separately. The communicative-team component was calculated as the mean of the two criteria, "Team interaction" and "Professional communication", each of which was assessed on a scale of 1-5. The reflective component was determined according to the "Reflection during debriefing" criterion, which was also assessed within the 1-5 point range. Self-assessment of professional readiness was analysed separately using a questionnaire. Therefore, it did not replace the expert assessment of practical, teamwork and reflective indicators. The training content aimed to practise clinical algorithms in typical emergency situations relevant to intern doctors specialising in "General Practice – Family Medicine". During the simulation sessions, participants practised the following: initial assessment of the patient's condition; determination of clinical action priorities; compliance with emergency care algorithms; performance of practical actions; professional communication; team interaction; and error analysis during debriefing (Table 4).

Table 4. *Organisational structure of the simulation training and assessment of professional competencies*

Stage of study organisation	Content of the stage	Instruments/result
Initial assessment	Initial assessment of the baseline level of preparedness of intern doctors. Testing of theoretical knowledge, self-assessment questionnaire of professional readiness and primary performance of the simulation task were conducted	Theoretical knowledge test; self-assessment questionnaire; expert assessment checklist of practical actions. Baseline indicators of the cognitive, practical and subjective-reflective components were determined
Orientation-algorithmic stage	Orientation in the simulation environment, familiarisation with working rules, practice of initial assessment of the patient's condition, determination of clinical action priorities and the team interaction algorithm	Briefing; performance of a basic simulation task; short debriefing. Understanding of the structure of the simulation task and the requirements for safe performance of actions was formed
Practice-procedural stage	Practice of the sequence of practical actions in a clinical situation, compliance with patient safety requirements, technical accuracy of procedure performance, correction of typical errors	Simulation task; expert observation; debriefing. The correctness of the clinical algorithm and the safety of practical actions were clarified
Communicative-team stage	Practice of professional communication, distribution of functions within the team, transfer of information, coordination of actions and clinical decision-making in a team format	Team simulation task; facilitated debriefing. The quality of interaction, communication and coordination of participants' actions was assessed
Integration stage	Comprehensive performance of the simulation task with integration of the clinical algorithm, practical actions, team interaction, professional communication and reflective analysis	Final simulation task; expert observation; concluding debriefing. Participants' readiness for the holistic performance of a professional task was recorded
Final assessment	Final assessment of professional competencies according to the same components as at the beginning of the study. Repeated testing, questionnaire completion and expert assessment of simulation task performance were conducted	Theoretical knowledge test; self-assessment questionnaire; expert assessment checklist. The dynamics of the cognitive, practical, communicative-team and subjective-reflective components were determined

Source: *compiled by the authors*

The training was conducted by clinical discipline teachers and a teacher-facilitator. They provided instruction and support for simulation sessions and debriefing, as well as recording results using checklists. After completing the training tasks, participants discussed the sequence of actions, clinical decisions, communication, distribution of roles, and errors related to patient safety. The assessment results were compared at the start and end of the simulation training. The results were statistically processed using Statistica 13.0 (USA). Quantitative indicators from testing, questionnaire completion and expert checklist assessment were analysed by assigning a score to each indicator; the mean value and standard deviation were then determined for each indicator. The dynamics between the initial and final assessments were evaluated according to the difference in mean scores, percentage increase, and level of statistical significance of the differences. Additionally, the effect size was determined for the main indicators as the standardised mean change d_{av}, which is calculated as the ratio of the difference between the final and initial mean values to the average standard deviation of the two measurements. The normality of the distribution was checked using the Shapiro-Wilk test. Paired statistical analysis was applied to each indicator since the results of the same interns before and after simulation training were compared using a one-group 'before-and-after' design. Differences between the initial and final assessments were analysed using paired comparisons: Student's t-test for dependent samples was used for normal distribution and the Wilcoxon test for non-normal distribution. Differences were considered statistically significant at $p < 0.05$.

Results and Discussion

Trends in the development of simulation centres in medical education

The development of simulation centres in medical education reflects a shift from fragmented individual practices to the creation of a controlled educational environment. In this environment, clinical scenarios, practical actions, team interactions, assessments and reflections form a comprehensive learning cycle. According to this logic, a simulation centre is not merely a technical base equipped with mannequins, trainers and digital tools; it is also a space for developing professional competencies. For postgraduate medical education, this is significant, as intern doctors require not only an update to their knowledge, but also verification of their ability to act in situations requiring rapid clinical decision-making, adherence to an algorithm, communication, and ensuring patient safety.

The analysis showed that simulation-based learning is used to repeatedly practise clinical skills, correct errors and perform actions repeatedly, which corresponds to the understanding of healthcare simulation as an effective way of learning in medical and health care education (Saleem & Khan, 2023). This organisation of learning enables the risky elements of training to be transferred from the real clinical environment into a controlled educational situation, where an error does not harm the patient, but instead provides a basis for professional analysis. This is consistent with the view of P. Abdool *et al*. (2025), who linked simulation-based education to continuing professional development, quality improvement and patient safety. Unlike traditional learning, where errors are often only identified in clinical practice, the simulation format enables them to be recorded in the learning environment, their causes to be explained, and safer algorithms for subsequent actions to be developed. In this context, the simulation centre becomes a pedagogical environment in which the technical improvement of clinical actions and the professional responsibility of doctors are developed.

Within the structure of the identified trends, a distinct shift towards viewing the simulation centre as an organisational and pedagogical infrastructure combining space, equipment, scenarios, teacher training, assessment criteria, and feedback can be observed (Rege, 2020; Carter & Al Shanteer, 2025). The effectiveness of such a centre is not determined by the number of technical resources available, but by its ability to ensure a consistent learning process, from setting an educational objective to assessing the outcome. A similar position was taken by A. Zeng *et al*. (2025), who linked the establishment of a medical simulation centre to the modernisation of medical education content, technological provision, and interdisciplinary training organisation. Therefore, the simulation centre should be considered an integral part of the educational programme, rather than a supplementary space for isolated practical training. This is particularly evident in postgraduate education, since adult professionals require clear objectives, practical content, objective assessment and the ability to immediately correlate the completed task with future clinical activity.

Analysis of simulation-based learning design showed that, provided defined objectives, algorithms of action, assessment criteria and expected outcomes are in place, clinical scenarios can ensure the standardisation of practical training. As a result, different participants undergo comparable learning experiences and teachers have a basis for more objective assessment of their actions. K. Rossler *et al*. (2021) further developed this position in their standards for simulation-enhanced interprofessional education, emphasising the importance of aligning learning objectives, team interaction, scenario design and feedback. P.I. Watts *et al*. (2021) approach complements this position by considering the design of simulation-based learning in terms of the structured nature of the scenario, the realism of the environment, defined roles, and assessment criteria. Thus, standardisation in a simulation centre does not entail the mechanical repetition of identical exercises; rather, it ensures methodological transparency, reproducibility, and comparability of training outcomes.

In competency-based medical education, the effectiveness of a simulation centre is assessed differently: participation in training is not the criterion, but rather the ability to perform a professional action according to defined criteria. In such a model, the clinical scenario enables the simultaneous assessment of knowledge of the algorithm, the technical correctness of actions, the quality of communication, the ability to coordinate within a team, and reflection after completing the task. This is consistent with the conclusions of P. Fisk *et al*. (2025), who investigated the relationship between simulation-based education and competency-oriented medical training in the context of emergency clinical situations. This approach explains why the simulation centre is particularly well-suited to postgraduate education: competence can be verified not only declaratively, but also through observable action. Accordingly, assessment should cover not only test-based knowledge, but also the performance of practical algorithms, decision-making, communication, and the ability to analyse one's own errors.

In emergency care scenarios, the simulation centre provides an environment in which to practise not only individual actions, but also team coordination. The outcome of professional actions in such situations depends not only on the technical skill of individual participants, but also on team coherence, role distribution, the speed of information transfer, and the ability to make joint decisions. These findings are consistent with those of T. Sung & H. Hsu (2025), who demonstrated the link between simulation-based interprofessional training and enhanced communication and safety in critical care settings. A. Kiessling *et al*. (2022) also found an association between interprofessional, simulation-based team training and participants' self-efficacy in emergency situations. In postgraduate education, this means that the simulation centre must develop not only the individual performance readiness of doctors, but also their ability to work in a team, coordinate actions, and maintain safe clinical processes.

Preparing for emergency conditions in a simulation environment requires consistent algorithms, timely decision-making, and safe action sequences. Such scenarios enable clinical pressure to be reproduced without risk to the patient, and allow assessment of whether the participant can act correctly within the appropriate time frame (Alinier *et al*., 2023). M.R. Klein *et al*. (2025) complement this position by linking the development of checklists in simulation-based learning to the need for standardised assessment of clinical skills. This position is methodologically justified since the effectiveness of simulation training cannot be determined by general impressions alone. It requires criteria that allow the sequence of actions, technical accuracy, safety, team interaction, and post-scenario reflection to be evaluated.

Alongside face-to-face training, there has been an increase in digital and hybrid formats of simulation-based learning. While digital tools do not replace the simulation centre, they do expand its capabilities by offering virtual scenarios, remote modelling, telesimulation and digital support for clinical situations (Herrera-Aliaga & Estrada, 2022). O. Almousa *et al*. (2021) also considered virtual reality and remote digital applications to be a hybrid system of clinical training. A shift in the research focus in simulation-based medical education can be traced in the bibliometric analysis by W. Sun *et al*. (2024) – from traditional educational modelling formats to digital and virtual simulations. For postgraduate education, this trend creates an opportunity to combine physical performance with digital modelling of complex or rare clinical situations that cannot always be reproduced in real educational processes.

The generalisation of the analysis revealed the following trends in the development of simulation centres in medical education: transitioning from trainer-based learning to organised educational environments; strengthening the relationship between simulation, patient safety and training quality; orientating towards measurable professional competencies; developing team-based training; standardising scenarios; and using digital formats. In postgraduate medical education, these trends ensure learning is organised as a complete cycle of professional improvement involving updating knowledge, performing a clinical scenario, expert assessment, debriefing, and correcting actions. According to this logic, the simulation centre emerges as an educational environment in which professional competencies are formed through repeated, observable and measurable professional actions.

Methodological approaches to the integration of simulation technologies into postgraduate medical education

Integrating simulation technologies into postgraduate medical education requires methodological coherence between learning objectives, clinical scenario content, expected professional competencies, assessment criteria, and post-scenario analysis. According to this logic, simulation training is not limited to demonstrating manipulations or performing a practical task once, but is instead structured as a sequential educational cycle involving updating knowledge, performing a professional action, receiving expert assessment, undergoing debriefing and correcting subsequent behaviour. This is significant for postgraduate training because intern doctors must not only know the clinical algorithm, but also be able to apply it in situations involving uncertainty, time constraints, team interaction and responsibility for patient safety.

The competency-based approach defines the basis for integrating simulation technologies, as it focuses learning on the ability to perform a professional action according to defined criteria rather than on the mere assimilation of theoretical information. Within this approach, the simulation scenario becomes a means of evaluating the practical, communicative, team-based and reflective elements of professional preparedness. G. Alinier *et al*. (2023) presented a methodologically similar approach, considering simulation as a means of developing clinical skills through practice-oriented tasks. This approach explains why competence in a simulation environment should be assessed through observable actions rather than formal training participation. This logic is justified for postgraduate education, since doctors must demonstrate their readiness for clinical decision-making, algorithm performance, communication and error analysis in professional situations.

The activity-based approach defines simulation-based learning as the process of carrying out professional tasks in an environment that closely resembles clinical practice. It assumes that learners do not merely become acquainted with algorithms, but sequentially perform practical steps, receive feedback, and repeatedly practise complex elements of actions (Elshama, 2020). This aligns with the competency framework of U. Zafošnik *et al*. (2024), where the learning outcome is linked to specific actions that must be developed and evaluated during the educational process. This comparison demonstrates that the activity-based approach provides a practical mechanism for implementing competency-based education. In postgraduate training, it enables the transfer of knowledge from theoretical understanding to controlled performance of a clinical algorithm.

The scenario-based approach provides the content-related and organisational basis for integrating simulation technologies into postgraduate medical education. A clinical scenario should include a learning objective, an initial situation, expected participant actions, possible errors, assessment criteria, and a post-scenario analysis stage. S.S. Elshama (2020) presented a methodologically related approach, considering simulation-based learning to be the reproduction of a professional situation involving the learner's active participation and sequential performance of a practical task. In this comparison, the scenario is not an arbitrary description of a clinical case, but rather a methodically constructed tool for developing professional behaviour. In postgraduate education, the scenario-based approach ensures that situations are modelled in which doctors determine priorities, select the sequence of interventions, coordinate communication, and explain clinical decisions.

The problem-oriented approach builds on the scenario-based logic by shifting the emphasis from mechanically reproducing an algorithm to solving a clinical task. In this model, the simulation situation involves a problem requiring analysis, risk differentiation, action selection and verification of their correspondence to the clinical context. In the context of continuing professional development, W. Tavares *et al*. (2023) specified this approach, considering simulation to be a strategy for maintaining doctors' professional readiness. This comparison demonstrates that problem-oriented simulation has educational, professional, and organisational value, as it fosters the ability to act in situations where an error could impact the quality of care. For an intern doctor, this means not merely knowing a standard algorithm, but being able to adapt it to a specific clinical situation.

Standardised assessment is essential for the methodologically correct use of simulation technologies in postgraduate education. A checklist enables assessment of specific parameters of professional action rather than a general impression of scenario performance: the sequence of the algorithm, technical accuracy, safety, communication, team coordination and decision-making. This is consistent with the approach of A. des Ordons *et al*. (2022), who demonstrated that the role of the simulation teacher involves more than just recording the outcome; it also involves facilitating educational analysis. This combination enables the distinction between control and pedagogical support: the checklist ensures an objective assessment, while the facilitator helps participants understand the causes of errors and how to correct them. In postgraduate education, this creates a basis for comparing initial and final levels of professional competency.

The interprofessional approach involves integrating simulation technologies into situations where the outcome depends on coherent action from several participants. In the context of postgraduate medical education, this encompasses role allocation, information exchange, decision-making coordination, mutual monitoring of activities, and ensuring a safe clinical process (Will & Essary, 2021). I. Salik & J. Paige (2023) elaborate on this logic by debriefing an interprofessional team after they have completed a simulation scenario. Thus, interprofessionality in simulation-based learning has organisational as well as communicative content, as it shapes doctors' ability to act within a system of interdependent professional decisions.

The reflective approach is implemented through debriefing, which transforms the completed scenario into a source of professional learning. Following the simulation task, the analysis encompasses not only correct and incorrect actions, but also the decision-making process, communication quality, role distribution, response to uncertainty, and the participant's ability to explain their behaviour. A. Biduchak (2025) developed this position, considering debriefing a method of practical training that structures post-scenario analysis and strengthens the educational value of the completed task. Compared to international approaches, this allows debriefing to be interpreted not as a final comment by the teacher, but as a separate methodological stage of simulation-based learning. For postgraduate education, the organisation of reflection is important because errors must be transformed from recorded facts into professional conclusions.

The effectiveness of scenario-, activity- and reflective-based approaches depends on the role of the teacher-facilitator. They provide instruction, support the logic of the scenario, observe participants' actions, organise debriefing, and help link the results of task performance to further professional development (Watts *et al*., 2021). This aligns with the debriefing practices outlined by P. Dieckmann *et al*. (2023), in which post-scenario analysis is viewed as a structured process aligned with the learning objectives of the simulation. This connection highlights the importance of facilitator training as an integral part of the simulation-based learning methodology. In postgraduate education, adult learners require reasoned feedback that helps them correlate the learning scenario with real clinical practice, as well as assessment.

Standardised patients or role-based modelling of clinical interactions strengthen the communicative component of simulation training. With their assistance, it is possible to practise gathering information, explaining clinical decisions, responding to patients' emotional reactions, briefing teams and safely transferring data. S. Kassutto *et al*. (2024) presented a related approach, describing a virtual simulation course in clinical skills as a format for practising practical readiness in a modelled environment. In this context, clinical skills are not just technical actions, but a combination of behavioural, communicative and procedural elements. In postgraduate medical education, this broadens the scope of simulation-based learning beyond manipulative training to encompass professional communication as part of clinical competence.

Thus, the integration of simulation technologies into postgraduate medical education should be based on several methodological approaches. The competency-based approach defines the expected outcomes, while the activity-based approach ensures the performance of professional actions. The scenario-based and problem-oriented approaches structure the clinical situation, and the interprofessional approach facilitates team interaction. Finally, the reflective approach ensures comprehension of actions through debriefing. A complete simulation-based learning model should incorporate a clinical scenario, standardised assessment criteria, a checklist of practical actions, facilitation, and role-based or standardised modelling of clinical interactions, as well as post-scenario analysis. This transforms simulation technologies from a separate training element into a systemic tool for developing professional competencies among healthcare professionals.

Implementation of training and the dynamics of professional competencies after simulation

Practical implementation of simulation training enabled assessment of changes in intern doctors' professional competencies according to cognitive, practical, communicative-team, and reflective components. Comparing the initial and final indicators showed positive changes across all assessment instruments. This reflects a statistically significant improvement in theoretical preparedness, quality of clinical performance, self-assessment of professional readiness, and ability to engage in teamwork after the training was completed by the sample group. Table 5 summarises the initial and final assessment indicators of the professional competencies of intern doctors.

Table 5. *Dynamics of professional competencies of intern doctors*

Assessment indicator	Initial assessment, M ± SD	Final assessment, M ± SD	Increase, %	p	Effect size, d_av
Theoretical preparedness, 0-20 points	12.4 ± 2.1	17.1 ± 1.8	37.9	<0.001	2.4
Practical actions according to the checklist, 8-40 points	24.6 ± 4.3	34.8 ± 3.1	41.5	<0.001	2.72
Self-assessment of professional readiness, 6-30 points	18.2 ± 3.5	25.7 ± 2.8	41.2	<0.001	2.37
Communicative-team component, 1-5 points	3.1 ± 0.7	4.3 ± 0.5	38.7	<0.001	1.97
Reflective component, 1-5 points	2.9 ± 0.8	4.2 ± 0.6	44.8	<0.001	1.84

Note: *M – mean value; SD – standard deviation; p – level of statistical significance of differences between the initial and final assessments; dav – standardised mean change, calculated as the ratio of the difference between the final and initial mean values to the average standard deviation of the two measurements; the dav values were interpreted as indicating a small effect size at d ≈ 0.2, a medium effect size at d ≈ 0.5 and a large effect size at d ≥ 0.8*
Source: *compiled by the authors*

The data in Table 5 showed that all assessed indicators increased significantly after the simulation training was completed. Further analysis of the effect size showed that the changes had a high degree of practical significance across all components, with effect size values exceeding 0.8 and ranging from 1.84 for the reflective component to 2.72 for practical actions according to the checklist. Theoretical preparedness increased from 12.4 ± 2.1 to 17.1 ± 1.8, representing a 37.9% increase. These dynamics suggest an improved understanding of clinical algorithms, the sequence of actions, the principles of patient safety, and the fundamental principles of team interaction. The reduction in standard deviation from 2.1 to 1.8 points suggests that the participants' theoretical preparedness became more consistent after the training. This suggests that after completing the simulation training, the group's average result increased while the variability of indicators among learners with different baseline levels of preparation decreased. A.S. Dzhumatovich & E. Salimrouhi (2025) also emphasised the importance of simulation-based education in medical training since it enables the combination of knowledge acquisition and professional action practice in a practical format.

The number of practical actions according to the checklist increased from 24.6 ± 4.3 to 34.8 ± 3.1 points, representing a 41.5% increase. This is one of the most reliable indicators, since it reflects the quality of clinical scenario performance as recorded by experts, rather than the subjective assessment of participants. These findings are consistent with the systematic review by M.N. Ajemba *et al.* (2024), which confirmed the positive impact of simulation-based training on the acquisition and retention of clinical skills in medical education. An increase in the checklist score indicates a better sequence when performing the algorithm, greater technical accuracy, compliance with safety requirements, timelier clinical decision-making, and more coherent actions in the simulated situation. The decrease in standard deviation from 4.3 to 3.1 points shows that practical preparedness became more consistent after training. Thus, the most pronounced positive changes were observed precisely in terms of professional performance, rather than merely theoretical preparedness. This is consistent with the approach of S. Archana *et al*. (2021), who linked the establishment of skills and simulation centres to the enhancement of practice-oriented medical education.

Self-assessment of professional preparedness increased from 18.2 ± 3.5 to 25.7 ± 2.8, a rise of 41.2%. This suggests that intern doctors rated their readiness to perform a clinical algorithm, make decisions, interact in a team, and analyse errors more highly after the training. However, this indicator should be interpreted with caution since self-assessment is subjective and cannot independently confirm the effectiveness of the training. However, it does have value in that it complements the results of testing and the checklist by showing the internal perception of professional readiness after practical experience. The consistent increase in self-assessment alongside the results of testing and expert assessment demonstrates that the rise in subjective professional readiness is accompanied by positive dynamics in cognitive and practical indicators.

The communicative-team component increased by 38.7%, rising from 3.1 ± 0.7 to 4.3 ± 0.5 points. This suggests that the participants improved their ability to distribute roles, transfer information, coordinate actions, and make decisions as a team. In postgraduate medical training, such dynamics highlight the importance of teamwork, as professional action in a clinical environment requires not only an individual's mastery of the algorithm, but also the coordination of decisions and communication within the team. The decrease in variability of the indicator after training suggests that team interaction became more structured and predictable. This may be due to the repeated performance of scenarios, the distribution of functions among participants, and the discussion of communication errors during debriefing. These dynamics are consistent with the findings of L.S. Mahmood *et al*. (2021), who demonstrated the role of interprofessional, simulation-based education in developing teamwork and communication skills.

The greatest percentage increase was recorded for the reflective component, at 44.8%, with the mean score rising from 2.9 (±0.8) to 4.2 (±0.6). Following training, participants demonstrated greater awareness of the sequence of their own actions, the causes of errors, the quality of clinical decisions, and methods for improving subsequent behaviour. The high dynamics of this particular component may be associated with the inclusion of debriefing after simulation scenarios. This created conditions for transitioning from simple task performance to comprehending professional action, ensuring a connection between simulation experience, error analysis, and subsequent correction of professional behaviour. Thus, positive dynamics were observed not only in the technical performance of the algorithm, but also in intern doctors' ability to analyse their own clinical behaviour after completion of the training. This is consistent with the approach of G. Şahin & T. Başak (2021), who viewed debriefing as a means of analysing experience, providing feedback, and correcting subsequent actions in simulation-based learning.

Overall, the results demonstrate statistically significant positive dynamics in the professional competencies of intern doctors after simulation training within the studied sample. The increase in theoretical preparedness, checklist indicators, self-assessment and the communicative, team and reflective components reflects an improvement in the cognitive, practical, subjective-reflective and behavioural components of professional readiness. The most notable changes are in practical actions according to the checklist and the reflective component, as these demonstrate positive dynamics in the performance, analysis and correction of the clinical algorithm. However, given the one-group quasi-experimental 'before-and-after' design without a control group, the results should be interpreted as indicating a statistically significant improvement in the indicators following training rather than as providing definitive confirmation of its causal effect.

Prospects for the digitalisation of simulation centres in medical education

The development of simulation centres in medical education is associated with a transition from local, trainer-based spaces to digitally supported educational environments. These environments combine face-to-face scenarios with virtual simulations, telesimulation, electronic assessment, digital checklists, remote debriefing, and analytics of learning outcomes. In postgraduate medical education, such a transformation is significant, as doctors require regular skill updates, access to different clinical scenarios, personalised feedback and standardised confirmation of professional readiness. The main directions of the digitalisation of simulation centres, their substantive content, and the expected educational outcomes are summarised in Table 6.

Table 6. *Directions of digitalisation of simulation centres in medical education*

Direction of digitalisation	Content of implementation	Expected educational outcome
Virtual simulations	Modelling of clinical scenarios in a digital environment for repeated practice of typical, rare and critical situations	Expansion of access to practical training and increased variability of clinical cases

Table 6. Continued

Direction of digitalisation	Content of implementation	Expected educational outcome
Virtual reality and telesimulation	Use of immersive environments, remote platforms and remote support for simulation scenarios	Support for hybrid learning and preservation of practical orientation in the absence of physical presence in the centre
Electronic clinical scenarios	Development of scenarios with digital logic of event progression, variable decisions and recording of participants' actions	Standardisation of scenario-based learning and strengthening of the relationship between the clinical decision and the outcome of the action
Digital checklists and standardised assessment	Electronic recording of clinical algorithm performance, safety, communication, team interaction and errors	Objectification of assessment, accumulation of data and comparison of competency dynamics
Artificial intelligence	Analysis of errors, decision-making pace, typical educational difficulties and individual learning trajectories	Personalisation of simulation training and early identification of competency deficits
Remote debriefing	Use of video recordings, digital platforms and remote facilitated post-scenario analysis	Deepening of reflection, feedback and analysis of professional errors
Hybrid model of the simulation centre	Combination of face-to-face scenarios, digital simulations, telesimulation, electronic assessment and outcome analytics	Transition from a local trainer-based space to a networked model of continuing zprofessional development

Source: *compiled by the authors on the basis of an analysis of scientific approaches to the digitalisation of simulation-based medical education by S.C. Watkins (2020), O. Almousa et al. (2021), E. Roach & A. Okrainec (2021), A. Bahattab et al. (2023), N. Komasawa & M. Yokohira (2023), W. Sin et al. (2024), A. Hamilton (2024), K. Tiazhkorob (2025)*

The data presented in Table 6 show how the simulation centre can develop in the context of educational digitalisation. Virtual simulations broaden the scope for practising clinical scenarios beyond the centre's physical boundaries, facilitating the modelling of rare, complex or high-risk situations that cannot be consistently replicated in a face-to-face setting. In postgraduate training, this allows for the repeated completion of scenarios, the comparison of different clinical decision-making variants, and the gradual improvement of professional performance. This approach aligns with that of Y. Fedorchenko *et al*. (2024), who linked virtual simulations to the modernisation of medical education due to the increased accessibility, interactivity, and technological flexibility they offer to the learning process. In the context of postgraduate training, virtual simulation does not simply replicate face-to-face training; rather, it offers variable, repeatable and controlled modelling of clinical decisions before or after physical simulation centre training.

The second approach involves the use of virtual reality, remote platforms and telesimulation, changing the spatial logic of how the simulation centre operates. Rather than being limited to a classroom for face-to-face training, the centre is transformed into a hybrid environment in which instruction, scenario modelling, observation, debriefing and elements of assessment can be carried out remotely. This expands access to simulation training and allows teachers or experts to participate regardless of their physical presence at the centre, supporting the continuity of learning despite organisational or territorial constraints. The telesimulation experience presented by J.P. Gerstenberger *et al*. (2023) demonstrates its suitability for practice-oriented learning in a remote format. Therefore, not only does telesimulation strengthen the flexibility of the simulation centre, it also requires clear digital protocols, assessment criteria, and feedback organisation so that the remote format does not reduce the quality of practical training.

Electronic clinical scenarios offer a different development perspective since the digital environment enables ariability in the course of events to be embedded, participant choices to be recorded and clinical decisions to be connected to subsequent outcomes. Unlike a static scenario, an electronic scenario can contain multiple situational development trajectories depending on the actions of the intern doctor. A. Bahattab *et al*. (2023) proposed an approach to electronic simulation scenario design in which the digital scenario is considered a combination of theoretical basis, practical structure, and educational outcome. In postgraduate medical education, this means that digital scenarios can be used to demonstrate clinical cases and to train clinical thinking, decision-making, error analysis and repeated completion of situations with different decisions.

Digital checklists and electronic assessments enable standardised control of professional competencies. They make it possible to record specific parameters of clinical algorithm performance rather than the teacher's general impression, such as the sequence of actions, technical accuracy, compliance with safety requirements, communication, team interaction, and the timeliness of decisions. S.C. Watkins (2020) analysed simulation training in the context of competency assessment, certification and maintenance of professional fitness. Digital checklists in postgraduate medical education enhance the scope for such assessments by ensuring electronic documentation of actions performed, tracking changes in training levels and identifying areas for individual professional development. In the future, these data could be integrated into doctors' electronic portfolios, combining the results of testing, expert assessment, self-assessment and debriefing. This would strengthen the connection between simulation-based learning and continuing professional development.

Artificial intelligence in simulation-based medical education changes the way scenarios are constructed, errors are recorded, participants' actions are assessed, and feedback is provided, as demonstrated by A. Hamilton (2024). N. Komasawa & M. Yokohira (2023) also examined simulation-based education in the era of artificial intelligence, emphasising the need to adapt educational approaches to new digital tools. In simulation centres, artificial intelligence can analyse typical errors, decision-making speed, recurring difficulties and personalise learning trajectories. However, automated analytics should complement the teacher's expert assessment since pedagogical judgement is still necessary for interpreting the learner's clinical context, communicative behaviour and reflective readiness.

Remote debriefing is the latest development in the digital transformation of simulation-based learning. It involves using video recordings, digital platforms and remote facilitated analysis to repeatedly review key episodes of the scenario. This format enables post-scenario analysis to be more evidence-based, as participants can observe specific actions, decisions, communication errors, and instances of lost team coordination. E. Roach & A. Okrainec (2021) confirm that telesimulation can combine distance learning, assessment, and feedback. In postgraduate medical education, this enables debriefing to be organised not only immediately after a face-to-face scenario, but also remotely with repeated analysis of actions.

The simulation centre's hybrid model combines face-to-face clinical scenarios, digital simulations, telesimulation, electronic assessment and outcome analytics. In this model, the simulation centre functions as both a classroom for practical training and a digitally supported platform for continuing professional development. R. Yuriy *et al.* (2022) examined digital and simulation technologies in higher medical education through their innovative potential and ability to transform the presentation of educational material, organisation of practical training and assessment of learning outcomes. Y. Fedorchenko *et al.* (2024) linked the challenges of medical education under conditions of internationalisation and digitalisation to the need to update educational approaches, digital infrastructure, and training quality. When these approaches are compared, the hybrid model emerges as an organisational response to the need to combine practical, simulation-based training with digital learning support, remote supervision, and the accumulation of data on learners' professional development.

Thus, prospects for the digitalisation of simulation centres in medical education include virtual simulations, telesimulation, electronic clinical scenarios, digital checklists, remote debriefing, artificial intelligence, electronic portfolios, and hybrid learning formats. For postgraduate medical education, these developments allow for a more flexible, standardised and personalised approach to the professional development of doctors. While digitalisation does not eliminate the importance of face-to-face simulation centres, it does expand their functions, transforming them from spaces for practising practical actions into integrated systems for learning, assessment, analytics and support for continuous professional development.

Generalisation of the research results showed that, in postgraduate medical education, simulation centres should be considered an organised educational environment combining clinical scenarios, the practical performance of professional actions, team interaction, standardised assessment, debriefing and digital learning support. Theoretical analysis confirmed the methodological appropriateness of competency-, activity-, scenario-, problem-, interprofessional and reflective approaches. Empirical results demonstrated positive dynamics in theoretical preparedness, practical performance, self-assessment of professional readiness, team interaction and reflection among intern doctors after simulation training. Further development of such centres is associated with implementing virtual simulations, telesimulation, digital checklists, electronic portfolios, remote debriefing and artificial intelligence tools, thereby expanding the possibilities for continuing professional development of healthcare professionals.

Conclusions

The results of the theoretical analysis showed that, in medical education, simulation centres are gradually shifting from being trainer-based spaces to organised educational environments. This development is associated with the safe practice of clinical algorithms, preparation for emergency conditions, standardisation of practical skills, development of teamwork and risk reduction for patients. In postgraduate medical education, such centres provide technical training in individual actions and the formation of professional readiness through clinical scenarios, expert assessment, debriefing and the repeated improvement of actions. Methodological research into the integration of simulation technologies has demonstrated the effectiveness of combining competency-, activity-, scenario-, problem-, interprofessional and reflective approaches. The competency-based approach defines the expected learning outcomes, while the activity-based approach ensures the performance of professional actions. The scenario-based and problem-oriented approaches structure the clinical situation, the interprofessional approach coordinates the team, and the reflective approach facilitates error comprehension through debriefing. Therefore, simulation-based learning should be organised as a complete pedagogical cycle incorporating a clinical scenario, standardised assessment criteria, a checklist of practical actions, facilitation, team interaction, and post-scenario analysis.

The results confirmed positive developments in the professional competencies of intern doctors following the simulation training. Their theoretical preparedness increased from 12.4 ± 2.1 to 17.1 ± 1.8, their practical actions according to the checklist from 24.6 ± 4.3 to 34.8 ± 3.1, and their self-assessment of professional readiness from 18.2 ± 3.5 to 25.7 ± 2.8. The communicative-team component increased from 3.1 ± 0.7 to 4.3 ± 0.5, and the reflective component from 2.9 ± 0.8 to 4.2 ± 0.6. The reflective component demonstrated the most pronounced positive change – an increase of 44.8% – indicating an enhanced ability in intern doctors to analyse their own actions and determine ways to correct their professional behaviour following simulation scenarios. Statistically significant differences across all indicators demonstrate positive changes in the cognitive, practical, teamwork and reflective competencies of interns after simulation training within the studied sample. The development of simulation centres is associated with the digitalisation of the educational environment, including the introduction of virtual simulations, telesimulation, electronic clinical scenarios, digital checklists, remote debriefing, electronic portfolios, and artificial intelligence tools. These solutions broaden the scope of simulation centres, transforming them from local training spaces into hybrid platforms for continuing professional development. In postgraduate medical education, this creates conditions for the repeated practice of clinical decision-making, standardised assessment, personalised learning trajectories and the accumulation of data on doctors' professional development. Future studies should expand the sample size, involve several postgraduate medical education institutions and include a control group, as well as assessing the retention of formed competencies in the delayed period after training.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

References

[1] Abdool, P.S., Voore, P., Antinucci, R., Soklaridis, S., & Sockalingam, S. (2025). Role of simulation-based education in the integration of continuing education, quality improvement, and patient safety. *Academic Psychiatry*. doi: 10.1007/s40596-025-02289-2.

[2] Ahmad, M., Page, M., & Goodsman, D. (2023). What is simulation-based medical education (SBME) debriefing in prehospital medicine? A qualitative, ethnographic study exploring SBME debriefing in prehospital medical education. *BMC Medical Education*, 23, article number 625. doi: 10.1186/s12909-023-04592-8.

[3] Ajemba, M.N., Ikwe, C., & Iroanya, J.C. (2024). Effectiveness of simulation-based training in medical education: Assessing the impact of simulation-based training on clinical skills acquisition and retention: A systematic review. *World Journal of Advanced Research and Reviews*, 21(1), 1833-1843. doi: 10.30574/wjarr.2024.21.1.0163.

[4] Alinier, G., Shehatta, A.L., & Makker, R. (2023). Simulation for clinical skills in healthcare education. In D. Nestel, G. Reedy, L. McKenna & S. Gough (Eds.), *Clinical education for the health professions: Theory and practice* (pp. 1395-1415). Singapore: Springer. doi: 10.1007/978-981-15-3344-0_93.

[5] Almousa, O., Zhang, R., Dimma, M., Yao, J., Allen, A., Chen, L., Heidari, P., & Qayumi, K. (2021). Virtual reality technology and remote digital application for tele-simulation and global medical education: An innovative hybrid system for clinical training. *Simulation & Gaming*, 52(5), 614-634. doi: 10.1177/10468781211008258.

[6] Archana, S., Nilakantam, S.R., Hathur, B., & Dayananda, M. (2021). The need and art of establishing skill and simulation centers to strengthen skill-based medical education: Learning insights and experience. *Annals of African Medicine*, 20(4), 247-254. doi: 10.4103/aam.aam_53_20.

[7] Bahattab, A., Caviglia, M., Martini, D., Hubloue, I., Della Corte, F., & Ragazzoni, L. (2023). Scenario-based e-simulation design for global health education: Theoretical foundation and practical recommendations. *Journal of Medical Internet Research*, 25, article number e46639. doi: 10.2196/46639.

[8] Berger-Estilita, J., Lüthi, V., Greif, R., & Abegglen, S. (2021). Communication content during debriefing in simulation-based medical education: An analytic framework and mixed-methods analysis. *Medical Teacher*, 43(12), 1381-1390. doi: 10.1080/0142159X.2021.1948521.

[9] Biduchak, A. (2025). Debriefing method in practical training of medical students. *Prospects and Innovations of Science*, 8(54), 1883-1889. doi: 10.52058/2786-4952-2025-8(54)-1883-1889.

[10] Biduchak, A.S. (2025). Implementation and prospects of team-based training in medical education in Ukraine and Europe. *Bukovinian Medical Herald*, 29(3), 113-117. doi: 10.24061/2413-0737.29.3.115.2025.18.

[11] Carter, S., & Al Shanteer, T. (2025). Simulation center design, development, and management. In L. Marshall Gillman & S. Widder (Eds.), *Trauma team dynamics: A trauma crisis resource management manual* (pp. 575-589). Cham: Springer. doi: 10.1007/978-3-031-86312-7_67.

[12] Chavarha, M., Suprunenko, S., Shpryakha, Y., Gai, L., & Glavatskyi, O. (2025). Adapting Ukrainian medical education to the challenges of war: A scoping review. *Health Leadership and Quality of Life*, 4, article number 664. doi: 10.56294/hl2025664.
[13] des Ordons, A.L., Eppich, W., Lockyer, J., Wilkie, R.D., Grant, V., & Cheng, A. (2022). Guiding, intermediating, facilitating, and teaching (GIFT): A conceptual framework for simulation educator roles in healthcare debriefing. *Simulation in Healthcare*, 17(5), 283-292. doi: 10.1097/SIH.0000000000000619.
[14] Dieckmann, P., Sharara-Chami, R., & Ersdal, H.L. (2023). Debriefing practices in simulation-based education. In D. Nestel, G. Reedy, L. McKenna & S. Gough (Eds.), *Clinical education for the health professions: Theory and practice* (pp. 699-715). Singapore: Springer. doi: 10.1007/978-981-13-6106-7_51-1.
[15] Dzhumatovich, A.S., & Salimrouhi, E. (2025). Simulation-based education as a tool for enhancing the quality of medical education. *Journal of Preventive and Complementary Medicine*, 4(1), 45-59. doi: 10.22034/jpcm.2025.511432.1214.
[16] Elendu, C., Amaechi, D.C., Okatta, A.U., Amaechi, E.C., Elendu, T.C., Ezeh, C.P., & Elendu, I.D. (2024). The impact of simulation-based training in medical education: A review. *Medicine*, 103(27), article number e38813. doi: 10.1097/MD.0000000000038813.
[17] Elshama, S.S. (2020). How to apply simulation-based learning in medical education? *Iberoamerican Journal of Medicine*, 2(2), 79-86. doi: 10.5281/zenodo.3685233.
[18] European Commission. (2021). *Ethics and data protection*. Retrieved from https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ethics-and-data-protection_he_en.pdf.
[19] Fedorchenko, Y., Zimba, O., Gulov, M.K., Yessirkepov, M., & Fedorchenko, M. (2024). Medical education challenges in the era of internationalization and digitization. *Journal of Korean Medical Science*, 39(39), article number e299. doi: 10.3346/jkms.2024.39.e299.
[20] Fisk, P., Hall, A.K., O'Brien, M., & Cheung, W.J. (2025). Simulation education in the age of competency-based medical education: A study of the use of simulation-based education in Canadian emergency medicine programs. *Canadian Journal of Emergency Medicine*, 27(8), 605-613. doi: 10.1007/s43678-025-00935-0.
[21] Gerstenberger, J.P., Hayes, L., Chow, C.J., & Raaum, S. (2023). Medical student experiential learning in telesimulation. *Journal of Medical Education and Curricular Development*, 10. doi: 10.1177/23821205231216067.
[22] Hamilton, A. (2024). Artificial intelligence and healthcare simulation: The shifting landscape of medical education. *Cureus*, 16(5), article number e59747. doi: 10.7759/cureus.59747.
[23] Herrera-Aliaga, E., & Estrada, L.D. (2022). Trends and innovations of simulation for twenty first century medical education. *Frontiers in Public Health*, 10, article number 619769. doi: 10.3389/fpubh.2022.619769.
[24] Ivanchov, P., Povch, O., Sydorenko, V., Kurbanov, A., & Lobodae, S. (2024). Integrated simulation training for surgical skill development in Ukrainian medical universities during war. *Academia*, 35-36, 9-27. doi: 10.26220/aca.5000.
[25] Kassutto, S., Clancy, C., Harbison, S., & Tsao, S. (2024). A virtual simulation-based clinical skills course. *The Clinical Teacher*, 21(4), article number e13727. doi: 10.1111/tct.13727.
[26] Kiessling, A., Amiri, C., Arhammar, J., Lundbäck, M., Wallingstam, C., Wikner, J., Svensson, R., Henriksson, P., & Kuhl, J. (2022). Interprofessional simulation-based team-training and self-efficacy in emergency medicine situations. *Journal of Interprofessional Care*, 36(6), 873-881. doi: 10.1080/13561820.2022.2038103.
[27] Klein, M.R., Loke, D.E., Barsuk, J.H., Adler, M.D., McGaghie, W.C., & Salzman, D.H. (2025). Twelve tips for developing simulation-based mastery learning clinical skills checklists. *Medical Teacher*, 47(2), 212-217. doi: 10.1080/0142159X.2024.2345270.
[28] Kocherga, Z.R., Pavlykivska, B.M., Tachynska, L.M., & Chura, Y.O. (2024). Simulation training: International experience and development strategy in Ukraine. *Art of Medicine*, 31(3), 231-235. doi: 10.21802/artm.2024.3.31.231.
[29] Komasawa, N., & Yokohira, M. (2023). Simulation-based education in the artificial intelligence era. *Cureus*, 15(6), article number e40940. doi: 10.7759/cureus.40940.
[30] Mahmood, L.S., Mohammed, C.A., & Gilbert, J.H. (2021). Interprofessional simulation education to enhance teamwork and communication skills among medical and nursing undergraduates using the TeamSTEPPS® framework. *Medical Journal Armed Forces India*, 77, 42-48. doi: 10.1016/j.mjafi.2020.10.026.
[31] Nemyrovych, Y., Kniazieva, O., & Melnyk, N. (2024). The impact of innovative educational technologies on the effectiveness of continuing professional development of physicians. In *World conference on future innovations and sustainable solutions*. Futurity Research Publishing. doi: 10.5281/zenodo.13805835.
[32] Patocka, C., Pandya, A., Brennan, E., Lacroix, L., Anderson, I., Ganshorn, H., & Hall, A.K. (2024). The impact of just-in-time simulation training for healthcare professionals on learning and performance outcomes: A systematic review. *Simulation in Healthcare*, 19(1S), 32-40. doi: 10.1097/SIH.0000000000000764.

[33] Rege, R.V. (2020). Developing a state-of-the-art simulation-based education center. In J. Paige, S. Sonesh, D. Garbee & L. Bonanno (Eds.), *Comprehensive healthcare simulation: Interprofessional team training and simulation* (pp. 157-171). Cham: Springer. doi: 10.1007/978-3-030-28845-7_11.
[34] Roach, E., & Okrainec, A. (2021). Telesimulation for remote simulation and assessment. *Journal of Surgical Oncology*, 124(2), 193-199. doi: 10.1002/jso.26505.
[35] Rossler, K., Molloy, M.A., Pastva, A.M., Brown, M., & Xavier, N. (2021). Healthcare simulation standards of best PracticeTM simulation-enhanced interprofessional education. *Clinical Simulation in Nursing*, 58, 49-53. doi: 10.1016/j.ecns.2021.08.015.
[36] Şahin, G., & Başak, T. (2021). Debriefing methods in simulation-based education. *Journal of Education & Research in Nursing*, 18(3), 341-346. doi: 10.5152/jern.2021.57431.
[37] Saleem, M., & Khan, Z. (2023). Healthcare simulation: An effective way of learning in health care. *Pakistan Journal of Medical Sciences*, 39(4), 1185-1190. doi: 10.12669/pjms.39.4.7145.
[38] Salik, I., & Paige, J.T. (2023). *Debriefing the interprofessional team in medical simulation*. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK554526/.
[39] Shapovalov, S., Zinchenko, O., Petukhova, I., & Kas, I. (2025). Postgraduate medical education in Ukraine: Addressing modern challenges. *Wiadomości Lekarskie*, 12, 2823-2829. doi: 10.36740/WLek/214417.
[40] Shpryakha, Y., Abramchuk, O., & Moroziuk, O. (2025). Effectiveness of clinical simulation training in developing practical skills of medical students. In *International conference on next-generation innovations and sustainability 2025*. Futurity Research Publishing. doi: 10.5281/zenodo.14968886.
[41] Sun, W., Jiang, X., Dong, X., Yu, G., Feng, Z., & Shuai, L. (2024). The evolution of simulation-based medical education research: From traditional to virtual simulations. *Heliyon*, 10(15), article number e35627. doi: 10.1016/j.heliyon.2024.e35627.
[42] Sung, T.C., & Hsu, H.C. (2025). Improving critical care teamwork: Simulation-based interprofessional training for enhanced communication and safety. *Journal of Multidisciplinary Healthcare*, 18, 355-367. doi: 10.2147/JMDH.S500890.
[43] Tavares, W., Piquette, D., Luong, D., Chiu, M., Dyte, C., Fraser, K., & Clark, M. (2023). Exploring the study of simulation as a continuing professional development strategy for physicians. *Journal of Continuing Education in the Health Professions*, 43(3), 188-197. doi: 10.1097/CEH.0000000000000470.
[44] The Declaration of Helsinki. (2024). Retrieved from https://www.wma.net/policies-post/wma-declaration-of-helsinki/.
[45] Tiazhkorob, K. (2025). Virtual simulations as an innovative technology for the modernization of medical education. *SAP Gamification and Augmented Reality*, 3, article number 97. doi: 10.56294/gr202597.
[46] Watkins, S.C. (2020). Simulation-based training for assessment of competency, certification, and maintenance of certification. In J. Paige, S. Sonesh, D. Garbee & L. Bonanno (Eds.), *Comprehensive healthcare simulation: Interprofessional team training and simulation* (pp. 225-245). Cham: Springer. doi: 10.1007/978-3-030-28845-7_15.
[47] Watts, P.I., Hallmark, B.F., & Beroz, S. (2021). Professional development for simulation education. *Annual Review of Nursing Research*, 39(1), 201-221. doi: 10.1891/0739-6686.39.201.
[48] Watts, P.I., McDermott, D.S., Alinier, G., Charnetski, M., Ludlow, J., Horsley, E., & Nawathe, P.A. (2021). Healthcare simulation standards of best practiceTM simulation design. *Clinical Simulation in Nursing*, 58, 14-21. doi: 10.1016/j.ecns.2021.08.009.
[49] Will, K.K., & Essary, A. (2021). Competency-based interprofessional continuing education focusing on systems thinking and health care delivery for health care professionals. *Journal of Continuing Education in the Health Professions*, 41(2), 153-156. doi: 10.1097/CEH.0000000000000330.
[50] Yuriy, R., Huzchenko, S., Lobach, N., Karbovanets, O., Bokova, S., & Isychko, L. (2022). Modern digital learning and simulation technologies in higher medical education: Definitions, innovative potential. *Amazonia Investiga*, 11(60), 53-61. doi: 10.34069/AI/2022.60.12.6.
[51] Yuryk, O., Zlobin, O., Vainahii, O., Fedosieieva, O., & Shaulko, O. (2024). 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. *Academia*, 35-36, 73-91. doi: 10.26220/aca.5003.
[52] Zafošnik, U., Cerovečki, V., Stojnić, N., Belec, A.P., & Klemenc-Ketiš, Z. (2024). Developing a competency framework for trainingS with simulations in healthcare: A qualitative study. *BMC Medical Education*, 24, article number 180. doi: 10.1186/s12909-024-05139-1.
[53] Zeng, A., Chen, X., Wu, Q., Lin, X., Peng, X., & Ye, Q. (2025). Exploration and practice of Medical Simulation Center construction under the background of new medical sciences. *Frontiers in Public Health*, 13, article number 1619348. doi: 10.3389/fpubh.2025.1619348.

Розвиток симуляційних центрів як інноваційної технології післядипломної медичної освіти: теоретико-методологічні засади та практичний вимір

Ланна Лукашенко
Доктор медичних наук, професор
Запорізьки державний медико-фармацевтичний університет
69035, бульв. Марії Примаченко, 26, м. Запоріжжя, Україна
https://orcid.org/0000-0001-9736-6989
Ірина Соколовська
Кандидат медичних наук, асистент
Запорізьки державний медико-фармацевтичний університет
69035, бульв. Марії Примаченко, 26, м. Запоріжжя, Україна
https://orcid.org/0009-0008-2487-1675
Ірина Ганжий
Доктор медичних наук, професор
Запорізьки державний медико-фармацевтичний університет
69035, бульв. Марії Примаченко, 26, м. Запоріжжя, Україна
https://orcid.org/0009-0008-2490-5222

Анотація. Мета статті полягала у визначенні ролі симуляційних центрів у модернізації післядипломної медичної освіти, посиленні практичної підготовки та розвитку професійних компетентностей медичних працівників. Методологія дослідження ґрунтувалася на прикладному педагогічному дизайні з теоретико-аналітичним і квазіекспериментальним компонентами; емпіричний етап проведено 16-27 лютого 2026 року на базі Навчально-наукового інституту післядипломної освіти Запорізького державного медико-фармацевтичного університету серед 48 лікарів-інтернів із вхідним і підсумковим комплексним оцінюванням професійних компетентностей. Результати дослідження показали, що симуляційні центри в медичній освіті функціонують як організоване освітнє середовище, у якому клінічні сценарії, безпечне відпрацювання алгоритмів, командна взаємодія, стандартизоване оцінювання та дебрифінг забезпечують формування професійних компетентностей. Методологічний аналіз дав змогу обґрунтувати інтеграцію симуляційних технологій у післядипломну медичну освіту через поєднання компетентнісного, діяльнісного, сценарного, проблемно-орієнтованого, міжпрофесійного та рефлексивного підходів. Оцінювання після симуляційного тренінгу засвідчило статистично значуще покращення результатів лікарів-інтернів: теоретична підготовленість зросла з 12,4 ± 2,1 до 17,1 ± 1,8 бала, практичні дії – з 24,6 ± 4,3 до 34,8 ± 3,1 бала, самооцінка професійної готовності – з 18,2 ± 3,5 до 25,7 ± 2,8 бала. Найбільший приріст зафіксовано за рефлексивним компонентом – 44,8 %, що свідчить про результативність дебрифінгу, тоді як подальший розвиток симуляційних центрів доцільно пов'язувати з віртуальними симуляціями, телесимуляцією, цифровими чек-листами, електронними портфоліо та інструментами штучного інтелекту. Отримані дані засвідчили статистично значуще покращення показників професійних компетентностей лікарів-інтернів після симуляційного тренінгу, зокрема теоретичної підготовленості, практичних дій, командної взаємодії та рефлексивної готовності в умовах одногрупового квазіекспериментального дослідження в системі післядипломної медичної освіти. Результати можуть бути використані закладами вищої медичної освіти, інститутами післядипломної освіти, симуляційними центрами та викладачами клінічних дисциплін для розроблення, впровадження й оцінювання симуляційних тренінгів у програмах професійного розвитку медичних працівників

Ключові слова: дебрифінг; штучний інтелект; клінічні сценарії; цифрові чек-листи; командна взаємодія; професійні компетентності; безпека пацієнта