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Efficiency of Various Forms of Simulation Training in the Training of Medical Professionals

Diana Denisova [a], Elena Strandstrem [b,*], Elvir Akhmetshin [c], Denis Nikolenko [d]

[a] Russian State Social University, Moscow, Russian Federation
[b] Russian Research Medical University named after N.I. Pirogov, Moscow, Russian Federation
[c] Elabuga Institute of Kazan Federal University, Kazan, Russian Federation
[d] Sechenov First Moscow State Medical University, Moscow, Russian Federation

Abstract

The purpose of the study was to investigate the effectiveness of simulation training in enhancing the knowledge and practical skills of emergency medical service (EMS) specialists. With the evolving landscape of healthcare, the demand for proficient professionals capable of managing medical emergencies has grown significantly. Universities are embracing innovative training methods, including simulation technologies, to prepare students effectively for these crucial roles. The study was conducted in the first semester of the 2021–2022 academic year, involving 120 university students in their 5th and 6th years of study. The paper sheds light on the positive effect of various types of simulation training on the level of training of emergency medical service specialists. The authors seek to demonstrate the necessity and efficiency of innovative technology in practicing practical and communication skills. Various forms of simulation training (medical team lessons, joint drills, masterclasses) are a highly efficient system of practical training for students. The results of the empirical study lead to the conclusion that various forms of simulation training (medical team lessons, joint drills, masterclasses) present a highly efficient system of practical training for students and enable students to improve their practical emergency medical care skills. Medical team classes are a priority form for practicing the algorithm of cardiopulmonary resuscitation. Joint drills are used to practice organizational and practical skills in coordinating the actions of various services in emergencies. Masterclasses should be used as an element of practical training with large audiences.

Keywords: simulation training, emergency medical care, team training, joint drills, masterclasses, mannequin, practical skills, theoretical knowledge.

* Corresponding author
E-mail addresses: e.b.strandstrem@mail.ru (E. Strandstrem)

1. Introduction

The remarkable pace of scientific and technological progress in medicine (Osadchuk et al., 2021) and the emergence of modern equipment and new technologies in emergency medical services (EMS) have changed the requirements for the professional level of doctors (Korotaeva, Kapustina, 2022), students, nurses, and paramedics (Baigireyeva et al., 2021). For all the above categories of professionals (both practicing and in training), improving the level of practical skills during EMS remains a necessity (Kavalerskii, Garkavi, 2015; Kovalev et al., 2020). To address this issue, special attention should be paid to practicing the algorithm for cardiopulmonary resuscitation (CPR) and the algorithm for EMS in polytrauma and other critical conditions (Stazhadze, Spiridonova, 2008). Regrettably, the classical forms of education (lectures, seminars, discussion of the situation at the patient's bedside, etc.) do not form in students a stable algorithm of actions in critical situations (Amir, 2023; Juliani et al., 2023). Because of this, doctors and medical teams have difficulties in mobilizing quickly and automatically providing quality EMS to the victim in such situations (Kaibyshev et al., 2016).

Therefore, medical universities need to provide the training of specialists focused (Kim, Oh, 2023), among other things, on EMS in emergency conditions at the pre-hospital and early in-hospital stages (Jacobson et al., 2021). In this, the main emphasis should be placed on forming quality practical skills and abilities in EMS. We believe that the simulation form of training, in which training proceeds in a special artificial imitation environment using mannequins or models, is the most appropriate for developing the necessary skills and abilities in medical staff (Nikolaeva, Suslennikova, 2022).

In connection with the above, we pose the following research question: does the use of various forms of simulation training contribute to students' mastery of knowledge and practical skills in providing EMS?

The article is organized as follows. The next section presents a review of the literature on the problem of using simulation training in medical education, including for the consolidation of knowledge and practical skills in providing EMS. Particular attention is paid to papers analyzing the advantages of simulation training compared to the traditional system of training. Next, the research methods and the results of the study are presented and discussed. The article is closed with theoretical and practical conclusions and limitations of the study.

2. Literature review

According to H. Al-Elq Abdulmohsen (2010), simulation-based training is a training method based on the simulation of any physical process using an artificial (e.g., mechanical or computer-based) system (Korotaeva, Kapustina, 2022; Scalese et al., 2008). Clinical skills training through the use of simulation dummies, simulators, and standardized patients have been the standard of medical education in the developed world for decades (Cant, Cooper, 2010).

Training with mannequins and simulators under the teacher's observation has long been part of educational practice in many world countries, but a lot of research is still being conducted to test the efficiency of this method (Lavrinenko et al., 2022; Mokhov et al., 2022). In particular, K.B. Boyd et al. (2006) find that simulation-based training that supplements and precedes clinical training ensures a higher level of clinical competence (Yespolova et al., 2019). A study by D.L. Rodgers et al. (2009) suggests that the use of high-tech simulation methods is more effective than traditional training. P.J. Morgan and D. Cleave-Hogg (2005) note that 71 % of medical schools use some form of mannequins or simulators to teach anesthesia to medical students. Around 80 % of these institutions utilize simulation training in postgraduate education. This popularity of simulation training owes to the opportunity for objective assessment of the speed of decision-making and determining the number of mistakes throughout the training process. Furthermore, the predominant part of interns believes that simulations play an important part in their current training programs (Shapiro et al., 2004). There are numerous studies describing the use of simulators in training medical personnel of various profiles (Falcone et al., 2008; Korndorffer et al., 2005; Sedlack et al., 2007).

Simulation training has several advantages compared to the traditional system of training:

- the possibility of objective registration of the parameters of professional actions performed for each specialist to achieve a high level of training. Some simulators are equipped with an indicative perception system based on the students' actions (from a single "yes" or "no" answer to complex feedback, for example, on the administration of a particular medication with the possibility of its registration and storage) (Crofts et al., 2007);

- development of skills with no risk for patients, especially in practicing invasive diagnostic and treatment manipulations (Nishisaki et al., 2007), reduced stress contact with the patient (Hobgood et al., 2010; Zairi et al., 2022) and independence of the work of clinics, and practicing actions in cases of rare pathologies that are not available at the time of the lesson (DeVita et al., 2005). In contrast to the traditional training system, in which a young medic can have perfect knowledge of the theory of some manipulation but no practical experience (Medeshova et al., 2022), the simulation technology allows them to practice the necessary algorithm of practical actions (Sannicandro et al., 2022) and use the obtained knowledge in the future when working with patients (Fritz et al., 2008);

- unlimited number of tries to practice the skill and eliminate mistakes. Once again, simulation technologies allow a student to repeat a particular skill until it becomes automatic, which improves their mastery and increases their level of competence (Ziv et al., 2007);

- conducting a real detailed pedagogical evaluation with an objective assessment of the achieved level of mastery (Okuda et al., 2008; Syed et al., 2021; Vorobeva et al., 2021).

The use of simulation training in disaster medicine arouses great interest among students in the training process and plays an important part in raising the professionalism of future medics (Smailov et al., 2022), as well as contributes to the assimilation of material, its quality and efficiency, and gives the opportunity to see, hear, and practice skills on a mannequin, which promotes students' motivation for training (Bolatov et al., 2022), because they are not afraid to try and make mistakes, ask questions, and speak with the teacher (Kovalev et al., 2020).

The goal of the present study is to identify the effective forms of simulation training and assess the efficiency of simulation training in teaching EMS to students.

The research objectives are:

1. To examine the positive impact of simulation training on the level of training of medical specialists, as well as the relevance and efficiency of the use of innovative technology in practicing practical skills,

2. To assess the efficiency of simulation training in teaching students to provide EMS based on an empirical study.

3. Methods

Study design. The study was conducted in the first semester of the 2021–2022 academic year. The research sample included 120 university students in their 5th and 6th years of study. The selection of students from the 5th and 6^{th} year of study was based on the fact that students in the 5th and 6th years of study are typically in the advanced stages of their medical education, having already undergone a substantial portion of theoretical and practical training. As a result, they possess a foundational knowledge base that provides a suitable platform for assessing the impact of simulation training on further skill development.

To achieve the goal of the study a qualitative-quantitative type of research was chosen, the main method of which was testing at the formation and assessment of knowledge and practical skills of students in the provision of emergency medical care.

The study was conducted in three stages.

The first stage of the study involved initial testing of the knowledge and practical skills of students in providing EMS.

At the second stage, several forms of simulation training were utilized in the training of students to develop their knowledge and practical skills in EMS:

1. Medical team lessons. This form of simulation training is used in work with EMS teams (doctor, feldsher, nurse aide, driver), students, and paramedics. Medical team lessons proved to be highly efficient in practicing the CPR algorithm because these classes allow practicing the clarity of distribution of duties in the team during CPR; the clarity of execution of the action algorithm commands and mutual understanding in the team during the change of team members every 2-3 minutes; opportunities to bring in witnesses as potential assistants in performing CPR; leadership skills.

2. Joint drills. This form of simulation training is used to practice the organizational and practical skills of coordinating the actions of various services. It has proven to be extremely

effective during emergency response skills training. Joint drills also help improve the stress tolerance of EMS teams.

3. Masterclasses. This most popular form of simulation training was used in work with large audiences. This form of simulation training is highly effective for practicing the practical skills of EMS to victims with various types of injuries, anesthesia of patients using various methods of local anesthesia, in case of the temporary stop of external bleeding, the need to install intraosseous access, and ensuring airway patency. Masterclasses consisted of the following stages of training: 1) determining the level of clinical skills at the start of the practical lesson; 2) learning to work on moulages (demonstration, explanation); 3) individual performance (practicing); 4) examination by the teacher of the level of practical skills mastery (discussion, evaluation); 5) teamwork (staging, interdisciplinary training); 6) debriefing (detailed analysis of the group's work according to the basic algorithm of actions).

In the classes, students obtained theoretical knowledge on the notion and classification of terminal states and studied the algorithms of the initial examination of a critical patient and the performance of CPR.

Students were also able to improve their practical skills in the restoration and maintenance of airway patency by noninvasive, minimally invasive, and invasive methods, performing quality chest compressions, intravenous or intraosseous administration of medications, and work with automatic external and professional defibrillators. Thus, during simulation training in different scenarios, students were trained to allocate responsibilities in the team during CPR; to understand each other during team member changes every 2-3 minutes; to ergonomically position rescuers during CPR; to use witnesses as potential assistants in CPR; to act as leaders.

The third stage involved the final testing of students' knowledge and practical skills on mannequins and dummies after the simulation training.

Data collection. During the first and third stages of the study, the following theoretical knowledge and practical skills were assessed (on mannequins and dummies):

- knowledge of the algorithm for the initial examination of a critical patient; the BLS algorithm; the basic CPR algorithm; basic medications used in CPR; causes that can lead to ineffective CPR (Kaibyshev et al., 2016; Kavalerskii, Garkavi, 2015; Stazhadze, Spiridonova, 2008);

- skills of quality performance of chest compressions; restoring airway patency; performing quality ventilation of the lungs; operating an automated external defibrillator; operating a professional defibrillator-monitor; assessing heart rate; obtaining intravenous or intraosseous access (Kavalerskii, Garkavi, 2015; Kavalerskii, Garkavi, 2015; Stazhadze, Spiridonova, 2008).

Materials. To achieve the purpose of simulation training, the study used:

1. Simon® S311 full body resuscitation mannequins; adolescent and infant CJIP mannequins (Laerdal); a mannequin for learning practical airway restoration skills Laerdal Airway Management Trainer; male arm replica with the venous network.

2. Additional equipment: AED Pro automatic external defibrillator, HeartStart MRx monitor/defibrillator (Philips); a set of air ducts to restore and maintain the passage of the respiratory tract; Rescue Pack for respiratory support; transport immobilization kit; bandaging material.

Statistical data analysis was performed using mathematical statistics methods. The mean sample values of quantitative characteristics were estimated (given in the text as M ± m, where M is the sample mean, and m is the error of the mean). The statistical significance of differences in the results of initial testing (IT) and final testing (FT) was assessed by calculating Student's t-test for connected samples.

In all statistical analysis procedures, the critical level of significance p was taken to be 0.05. Data were processed using the Statistica 6.0 application software package.

4. Results and discussion

Table 1 provides data on the assessment of the students' knowledge and practical skills before and after the use of various forms of simulation training.

Data in Table 1 demonstrate that students in the 5th and 6th years had sufficient theoretical knowledge of the basic CPR algorithm and basic medications used in advanced CPR. Students in both years of study also demonstrated sufficient practical skills in performing quality chest compression. However, before the various forms of simulation training with dummies and mannequins, 5th-year students did not have enough skills in restoring the passage of the respiratory tract, operating automatic external or professional defibrillator, performing peripheral vein catheterization, or using intra-bone access.

Table 1. Assessment of students' knowledge and practical skills

Practical skills and theoretical knowledge	Assessment of the students' knowledge and skill levels, %					
	year 5			year 6		
	IT	FT	t-test	IT	FT	t-test
Knowledge of the algorithm for the initial examination of a critical patient	55.1 ± 1.4	97.3 ±3.1*	4,567*	85.3 ± 2.0	99.8 ± 0.6*	3,225*
Knowledge of the BLS algorithm	86.3± 2.4	92.5 ± 3.1	0,892	89.1 ± 3.8	98.3 ± 2.0	0,135
Ability to perform quality chest compression	88.1 ± 1.2	94.5 ± 1.0	0,765	89.5 ± 1.8	91.7 ± 1.2	0,274
Ability to restore the passage of the respiratory tract	32.9 ± 2.2	76.5 ± 2.2*	6,836*	55.4 ±2.1	77.6 ± 1.8*	3,493*
Ability to perform quality ventilation of the lungs	32.7 ± 2.2	76.3 ± 2.2*	6,458*	57.2 ±2.1	87.4 ± 1.8*	3,288*
Ability to operate an automatic external defibrillator	18.6 ±2.0	79.7 ± 2.4*	12,293*	64.6 ± 2.5	92.9 ± 2.5*	3,461*
Knowledge of the basic CPR algorithm	48.1 ± 2.4	82.3 ±3.1*	4,527*	76.5 ± 3.8	92.3 ± 2.0*	2,988*
Ability to operate a professional defibrillator-monitor	16.4 ±2.0	68.7 ± 2.4*	10,341*	58.6 ± 2.5	82.9 ±2.1*	4,517*
Ability to assess heart rate	38.4 ± 2.6	79.6 ± 2.2*	5,542*	54.5 ± 2.7	86.7 ±2.1*	4,025*
Ability to obtain intravenous or intraosseous access	17.4 ±2.0	62.7 ± 2.4*	6,931*	48.6 ± 2.5	82.9 ±2.1*	4,884*
Knowledge of basic medications used in CPR	78.5 ± 2.4	88.5 ± 2.2	0,688	85.6 ± 2.4	89.6 ± 2.0	0,214
Knowledge of potential causes of ineffective CPR	72.5 ± 2.2	89.3 ± 2.0	1,242	88.6 ± 2.4	90.6 ± 2.0*	0,562

Note: IT – initial testing; FT – final testing; * – probability of difference from the previous stage, $p < 0.05$.

In our view, these results are associated with reduced opportunities for senior-year students to gain practical skills in operation rooms and intensive care units, as has been pointed out by J.F. Crofts et al. (2007). However, the simulation training course enabled the 5th-year students to improve these practical skills.

Practical lessons with simulation training for practicing EMS skills were based on modern approaches to training and consisted of three sections. The first section of the class was devoted to the thorough theoretical study of the order of actions (algorithms) in performing manipulations. The second section of the practical class involved the direct practice of the skills on a mannequin or dummy under the teacher's guidance. The third and final section of the class consisted in summarizing the results of the lesson using the method of debriefing.

This algorithm of training was also utilized in a study by M.J. Shapiro et al. (2004), which shows that teamwork based on simulation training improves the work of the clinical team.

For successful mastery of the second part of the practical class, the training utilized a four-step method, which has been found effective in the training of nurses (Cant, Cooper, 2010) and surgical residents (Boyd et al., 2006). At the first stage, the teacher, according to the proposed scenario on the lesson topic, demonstrates the skills on a mannequin without explanations in real time. Any commentary in this case will only distract and disrupt the demonstration. It is of principal importance that at this stage students see exactly the right way to perform the skills. Students may have questions immediately after the demonstration, but the discussion has to be postponed until the end of the next stage. At the second stage, the teacher demonstrates the skills again but slower, explaining each step. This approach gives students the chance to see the actions of the teacher once again, but this time with a detailed explanation, and ask their questions once the demonstration is complete. The third stage involves the teacher performing the skills one more time but upon the correct commands of students. Incorrect commands are ignored, which prompts students to analyze and search for the right solution. At this stage, students are actively involved in the work, having the opportunity to once again observe the algorithm of performance. The stage is completed with feedback with answers to questions and a quick summary and identification of key steps. Mistakes must be immediately corrected by the teacher. Failure to follow this rule can lead to the embedding of errors, which are then difficult to correct, in practical activities. At the final fourth stage, students demonstrate the performance of the practical skills independently on a mannequin and take on responsibility for the accuracy of their performance. After the fourth stage, each student must repeat the skills, which ensures the formation of EMS skills.

Thus the high precision of performance is achievable with the repeated demonstration of the practical skills by the teacher and their further repeated practice by students. The multi-step approach, as demonstrated by the results of training with simulators for laparoscopic suturing (Korndorffer et al., 2005) and emergency obstetric care (Crofts et al., 2007), allows mastering the difficult material, dividing it into simple components, and building a complex algorithm step by step. The skill is mastered in stages, from simple movements to independent complex performances.

The practical lesson was completed with a summary using the debriefing method, during which teachers together with their students analyzed their actions, highlighting not only the technique but various moments associated with communication and teamwork, the decision-making process, the role of the leader, the distribution of tasks, etc. The teachers and students together identified the successes and positive aspects and key problems and concluded what exactly has to be changed for the team to work better and more efficiently.

Thus, simulation training addresses a much wider range of tasks than the simple simulator-based practice of motor skills for specific manipulations and procedures (Zhang et al., 2020). Of no smaller importance is the development of students' soft skills, specifically leadership and organizational qualities and the ability to make decisions and work in a team (Zairi et al., 2022). The constant increase in the quality requirements for the provision of EMS requires doctors and medical personnel to have not only a perfect theoretical basis but also a certain amount of practical experience. For this reason, the introduction of simulation training in Russian medical universities as one of the basic methods is a new direction in today's training of highly qualified top and middle-level medical personnel and a promising tool to improve the training of future medics through a combination of theoretical knowledge and practical skills, the development of a medical worker as a professional and an integrated person.

However, it's important to acknowledge some limitations of this study. While the study aimed to investigate the positive impact of simulation training on the level of training of medical professionals and the effectiveness of innovative technologies in developing practical skills, other potential effects or factors influencing the learning outcomes of participants have not been widely studied. The research primarily focused on specific aspects of simulation training and its direct impact on improving practical skills and knowledge acquisition.

5. Conclusion

The conclusions drawn from this study align closely with the objectives that were set out to examine the impact of simulation training on the level of training of medical specialists, particularly in the context of enhancing practical skills.

The results of the study demonstrate that different forms of simulation training (team lessons, joint drills, masterclasses) contribute to the assimilation of students' knowledge and practical first-aid skills and present a highly effective system of practical training. Medical team lessons are a priority form of training for practicing the algorithm of CPR. Joint training is utilized to practice organizational and practical skills in coordinating the activities of various services in emergencies. Masterclasses should be utilized as an element of practical training for large audiences.

The results indicate that simulation training significantly enhances students' ability to execute critical practical tasks and respond effectively to emergency medical situations. This empirical validation emphasizes the potential of simulation training as a pedagogical tool that not only bolsters theoretical knowledge but also cultivates the confidence and competence required to deliver efficient emergency medical services.

The theoretical significance of the study is provided by the identification of the potential of different forms of simulation training in the practice of higher medical education. The practical significance of the study is provided by the fact that its results can be used in organizing the training of students in emergency medical care. Prospective further research in this sphere may be the study of the readiness of medical university graduates to work in emergencies.

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