Original Article

The impact of simulated operating rooms in a clinical skill center on operating room students' skills and satisfaction: A semi experimental study

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Abstract

Background & Objective: The operating room is a highly complex and stressful environment. Direct training in this environment may have detrimental effects on employees' performance and students' learning. Therefore, the present study aims to investigate the impact of simulated operating rooms at clinical skill centers on the skills and satisfaction of operating room students at Jiroft and Bam Universities of Medical Sciences.

Material & Methods: In this semi experimental study, 40 operating room students in the fourth semester of the bachelor's program at Jiroft and Bam Universities of Medical Sciences participated. The students were randomly divided into control and intervention groups. The intervention involved utilizing the operating room simulation at the clinical skill center. The data were collected using the Clinical Skill and Teaching Satisfaction Questionnaires and analyzed using Analysis Of Covariance (ANCOVA).

Results: The results of the study showed a significant increase in the skills and satisfaction of students in the intervention group, with respective scores of 87.82 ± 11.21 and 93.5 ± 14 compared to the control group scores of 53.94 ± 8.98 and 83.064 ± 9.69 ($p < 0.001$). The eta-squared (η) on the post-test revealed that 0.25 and 0.19 of the changes in the dependent variable were due to the independent variable (training in the simulated operating room).

Conclusion: The study's results indicate that simulating operating rooms at clinical skill centers can contribute to improving surgical technologist students' skills and satisfaction. Therefore, the simulated operating room can be used as an effective and safe educational method to enhance operating room students' practical skills.

Keywords: simulated operating room, clinical skill center, personal skills, satisfaction

Introduction

Educational methods are critical in determining the transfer of skills and knowledge, and these methods can be improved with the support of professors, supervisors, and organizational culture (1). The educational planners, especially those involved in teaching the skills required for the operating room, have the primary task of updating the curricula and revising educational methods (2-4). Students need training and educational experiences to acquire clinical competency, and the education system should ensure their correct and effective performance in real situations by using appropriate methods and equipment (5-7).

Simulation is one of the various educational methods utilized and proposed for training medical sciences students to achieve this objective. Simulation aims to imitate the existing realities in clinical environments and involves techniques such as role-playing and working with devices such as videos, models, or mannequins (2, 9). Simulation is commonly used to elicit sufficient feedback from students, overcome the immobility of mannequins for examination, lack of enough patients, unfavorable clinical conditions, and large numbers of students in clinical environments in medical education (9). Simulation can help students learn clinical skills, clinical judgment skills, increase critical thinking, and improve patient safety (7, 8).

Surgical technologist students require training and educational experiences to acquire clinical competency, as they need special knowledge and skills to care for patients undergoing surgery. The operating room is a

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complex system that coordinates people, technology, and patients in a physical environment to achieve the desired outcomes for the knowledge, satisfaction, and skills required for operating room and anesthesia students practicing hospital nurses and staff (10, 11). The clinical specialty of surgical technologist students makes the operating room a unique environment with features such as congestion, stress, noise, and a variety of surgeries. Different groups of surgery and anesthesia and simultaneous presence of the operation, emergencies, and electives are accompanied by training and retention. The safety of patients faces a serious challenge (9, 12).

The operating room is not an optimal place for novice students to learn medical procedures due to high stress, which can have deleterious effects on their performance (12, 13). Novice students require a safe environment to learn and practice skills. Moreover, the operating room is considered a high-risk environment for patients due to some preoperative and postoperative complications caused by the inexperience of the surgical team (2, 5). Therefore, it is imperative to improve the skills of the operating room staff and students as they work in complex environments where operations and technologies are constantly changing. They require more competencies to provide their care-seekers with high-quality care (14).

However, several limitations, such as a large number of students, a limited duration of the internship period, a small number of clinical instructors, individual differences, a lack of procedures and clinical cases for observation, and insufficient practice, can reduce students' learning. On the other hand, the lack of clinical experience can cause fear and anxiety, which may lead to increased errors (15). Learning and acquiring various skills and professional roles in the operating room is challenging since the student must be trained through many interventions during the preoperative, intraoperative, and postoperative stages (16–18).

A review of the literature reveals contradictory results concerning the influence of new and traditional methods on students' skills and satisfaction, and further research is required in this area (19). For instance, Ebadi et al. (2016) compared the satisfaction of nursing students with two methods of demonstrating and simulating putting on masks against chemical attacks. Although the students were equally satisfied with both methods, the researchers recommended using simulation for training military nurses, as it improves the quality of military and crisis nursing training (20). Similarly, Sadeghnezhad et al. compared the influence of training using conceptual maps and clinical simulation on the clinical decision-making of medical emergency students. The authors concluded that both conceptual maps and clinical simulation can improve medical emergency students' clinical decision-making (21). Erfanian assessed the impact of traditional teaching and simulation on midwifery students' skills and found that simulation improved students' learning in pelvic examinations (22). Due to the complexity of care and the need to maintain patient safety, teaching and learning about live patients in a traditional environment faces many challenges. Therefore, simulation has become one of the most effective teaching methods in clinical education. However, the high costs and training needed for simulation to be widely used need to be backed up with real-world examples, especially in the operating room, in order to better introduce solutions that use this method (23). Many clinical educators are trying to teach students clinical knowledge and skills at an appropriate and sufficient level by using efficient educational methods and providing them with more favorable conditions in the educational environment. Undoubtedly, high-quality learning requires coherent planning and organized educational intervention (16, 17).

Studies have shown that graduates in the field of operating rooms lack satisfaction with the education they have received in operating room skills for their own professional competency in the future (24). Although simulation is one of the new educational approaches that focuses on improving individual skills in the clinical role, limited studies have focused on Operating Room Simulation (ORS). Therefore, this study aims to investigate the effect of ORS in clinical skill centers on the skill and satisfaction of operating room students at Jiroft and Bam Universities of Medical Sciences.

Material & Methods

Design and setting(s)

The present semi experimental study included operating room students in the fourth semester of the bachelor's program at Jiroft and Bam Universities of Medical Sciences in 2022. This study was conducted with a pretest-post-test design with a control group and was reported based on the CONSORT flow diagram (Figure 1).

Participants and sampling

The research population for this study included all operating room students in the second year of the bachelor's program at Jiroft and Bam Universities of

Medical Sciences. The first stage of sampling was conducted using the census method (N = 44), and students who met the inclusion criteria and completed the consent form were included in the study. The inclusion criteria were students studying in the 4th semester of the operating room program (where students spend the course in the operating room), and students with a history of training in this field and passing this course were excluded from the study. Additionally, students who transferred or were guests at another university were excluded during the study.

The students were then randomly divided into two groups of 20 each: the control group and the intervention group. The students at Bam University were assigned to the control group and received usual training in the field of operating room skills at the Clinical Skills Center, while the students from Jiroft University were assigned to the intervention group and trained in a simulated environment of the operating room at the Clinical Skills Center. A total of 44 students were selected using the census method, and four students who had taken an internship course were not included in this study as one of the requirements for enrollment was not having previous experience training in operating room skills. The remaining 40 students were randomly assigned to the control and intervention groups (n = 20 each) for data analysis.

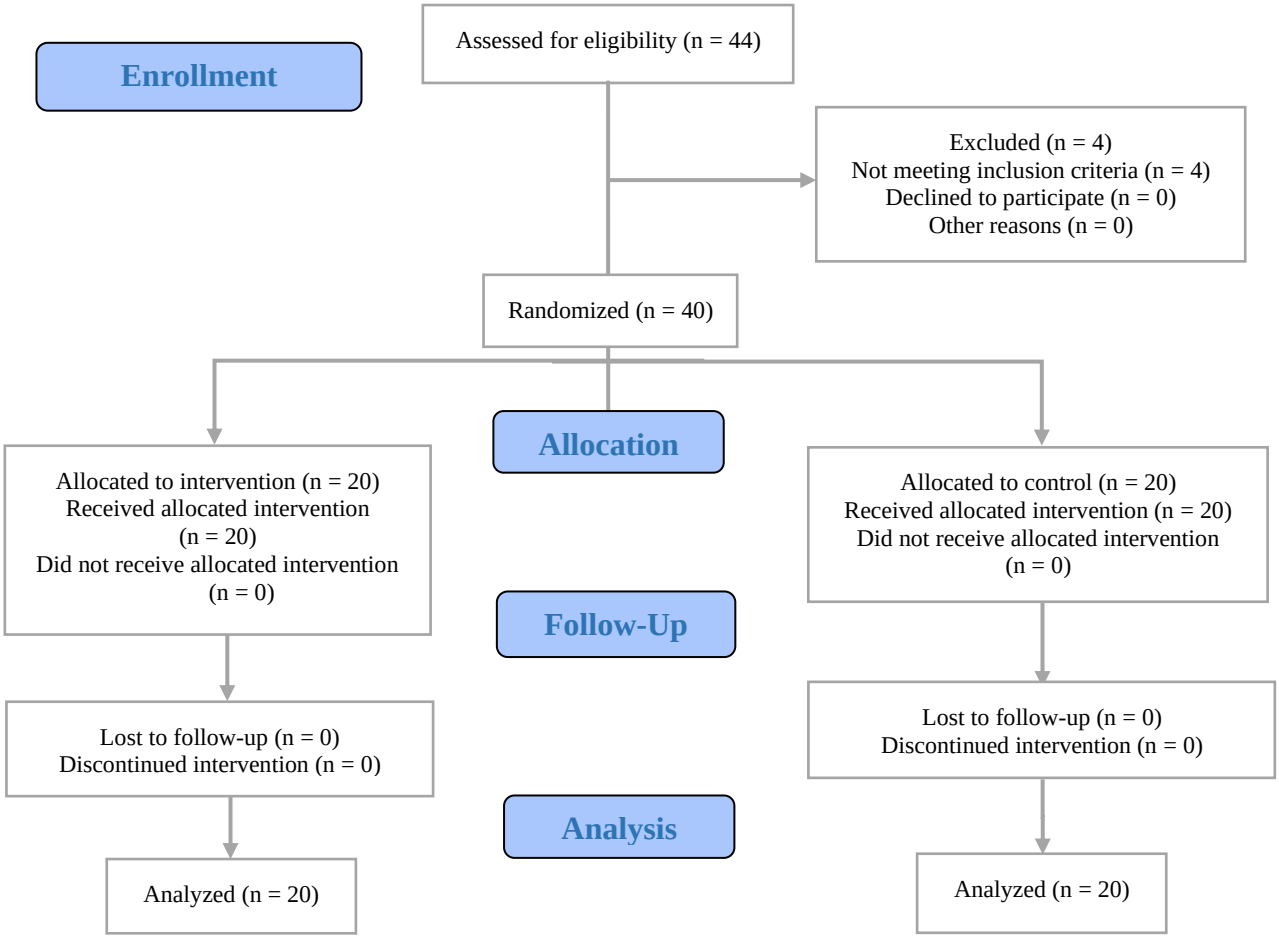

Figure1. Explanation of sample size and sampling

Tools/Instruments

To evaluate the students' clinical skills, the present study used the Clinical Skill Questionnaire developed by Mahdavi et al. in 2017 (25). The questionnaire contains 38 items with four subscales: sterilization and infection control (seven items), the scrub nurse's tasks (14 items), the circulator nurse's tasks (nine items), and caring for the patient in the recovery room (eight items). The items were scored on a four-point Likert scale and observed and evaluated by the lecturer. The students' clinical skills were categorized as very good if they provided a

complete explanation or correct demonstration of the clinical behavior, good if they missed one part of the procedure, moderate if providing a relative explanation or demonstration of the behavior, and poor if not answering or demonstrating the behavior. The validity and reliability (r = 0.85) of the questionnaire were confirmed by Mahdavi et al. In the present study, the validity was again checked and confirmed by the professors, and Cronbach's alpha coefficient was calculated as r = 0.77.

To evaluate students' satisfaction, the Teaching Satisfaction Questionnaire developed by Borim Nejad et al. in 2014 (26) was used in this study. The self-report tool contained 16 single-component items scored on a three-point Likert scale (3 = completely satisfied, 2 = somewhat satisfied, and 1 = not at all satisfied). The validity of the questionnaire was confirmed by Borim Nejad et al. and was again checked and confirmed by the experts and professors in this field in the present study. The reliability of the instrument was calculated using Cronbach's alpha coefficient (r = 0.86) in this study. The questionnaires were completed by the students before and after the intervention to evaluate their clinical skills and satisfaction.

Data collection methods

The students' ability to perform the procedures designed in the questionnaire was evaluated by the lecturer before the intervention. The same instructor and content were used in both groups, and the students were trained in seven sessions. The students in the intervention group were trained in a simulated operating room environment, while the students in the control group received routine training in the general skill lab. After completing the intervention, all students were evaluated again by the same lecturer.

The students in the intervention group were trained using the ORS at the clinical skill center, which was equipped with necessary operating room equipment such as the operation bed, intubation equipment, scrubbing materials and equipment, drugs and devices used in the operating room, general operation sets, stretchers, sialic lamps, surgical packs, electrosurgical diathermy, and all other equipment required to perform a surgical operation.

The clinical skill center is an environment for practical training in clinical skills that provides students with the opportunity to learn technical and communication skills in a peaceful, controlled, and guided environment before entering the clinical field by providing them with educational tools, models, visual and audio tools, and computers. In the present study, a simulation of the operating room was designed and implemented in the clinical skills center, and the effectiveness of this new educational strategy was evaluated.

The operating room simulation process was developed using specialized books, texts, and websites, as well as consultation with operating room experts. The educational content of the skills required for the simulation was then collected for the students. These skills included:

1. Wearing appropriate clothing in the operating room.
2. Collecting and preparing tools and ensuring the sterility integrity, seal, and expiration date of sterile packets.
3. Placing tools on sterile surfaces, opening packets, and pouring solutions
4. Scrubbing for surgery, including proper hand and arm scrubbing and using the correct disinfectant.
5. Proper gown-wearing procedure: Wearing and assisting others in wearing gowns correctly.
6. Glove-wearing procedure: This includes instructions for donning and doffing gloves, changing gloves when they become soiled, and removing gloves belonging to others.
7. Sterile environment preparation: This involves covering the Mayo table and operation table, as well as placing surgical tools within the operating field.
8. Positioning and draping the surgical field: Different types of surgeries require different preparations, so this step involves preparing the patient's position and draping the surgical field accordingly.
9. Equipment preparation: This step includes readying the surgical equipment and connecting the appropriate connectors, such as the electrocautery, suction drill, and sialic lamp handle.
10. Counting instruments and materials: It's important to keep track of gauze, sharp objects, and tools to ensure they're not left inside the patient after surgery.
11. Tool assembly: This step involves attaching the scalpel to the handle, preparing sutures, and testing the functionality of the drill and other tools.
12. Removing gowns and gloves: It's important to know the proper method for removing gowns and gloves to prevent contamination. This includes using the glove-to-glove and skin-to-skin methods.
13. Carrying out the demo by the operating bed and circular

The students in the intervention group will learn the skills mentioned above in seven 2-hour sessions in the

simulated operating room at the clinical skill center at Jiroft University.

Data analysis

To test the research hypotheses, data analysis was performed using descriptive and inferential statistics. Descriptive statistical indices, such as the mean and standard deviation, were used to describe the collected data. The Kolmogorov-Smirnov test (KS test) was conducted first to check the distribution of the data. Since the data were found to be normally distributed, analysis of covariance (ANCOVA) was used to remove the effect of intervening variables by statistical methods so that the results could be obtained more accurately. In this test, both statistical control and variance are used. In other words, ANCOVA is used instead of an analysis of variance (ANOVA). All statistical procedures were conducted using the SPSS-23 software.

Results

The students had an average age of 23.14 ± 4.1, and 23 people (57%) were female. There were no significant differences between the demographic characteristics of the students in the control and intervention groups, and the two groups were statistically similar in this regard.

The results showed that the students' skills in the intervention group (87.82 ± 11.21) generally increased compared to the control group (53.94 ± 8.98) on the post-test. There was a significant difference between the groups on the pretest and posttest. Additionally, a significant difference was observed between the pretest and post-test skills of the students in the intervention group ($p < 0.001$). No significant difference was observed in the control group (Table 1). Table 2 shows that changes in the dependent variable (students' skills) were caused by changes in the independent variable (simulated operating room training). This is shown by the eta-squared (η) value at the posttest stage.

The students' satisfaction increased in the intervention group (93.50 ± 14.50) compared to the control group (83.06 ± 9.69) in the post-test stage ($p < 0.001$), indicating that the students in the intervention group had a higher level of satisfaction compared to the control group (Table 3). Based on the eta-squared (η), it can be concluded that 0.08 of these changes in the dependent variable (students' satisfaction) are due to the changes in the independent variable (simulated operating room training) (Table 4).

Table 1. Comparison of student skill between Jiroft and Bam Universities

Variable		Group	n	Pretest		Posttest		p-value
				Mean	Standard deviation	Mean	Standard deviation	
Jiroft University students	Students' skill level	Intervention	20	80.28	9.10	87.82	11.21	p < 0.001
Bam University students		Control	20	56.72	7.99	58.94	8.98	p = 0.16
p-value				p = 0.07		p < 0.001		

Notes: The descriptive indicators of the research variables. The significance level was considered as p-value < 0.05.
Abbreviations: n, number of participants; p, probability-value.

Table 2. Results of covariance analysis for comparison of post-test scores in skill level between Jiroft and Bam Universities

Groups		Subscales	Sum of squares	Degree of freedom	Mean square	F	Significance level	η^2
Jiroft University students	post-test	Pretest	1367.56	1	1367.56	59.83	0.001	0.98
		Group	331.74	1	331.74	42.51	0.001	0.96
		Error	2217.01	17	22.85	-	-	-
Bam University students	Post-test	Pretest	811.15	1	811.15	23.55	0.001	0.99
		Group	785.61	1	785.61	22.81	0.001	0.99
		Error	3340.85	17	34.44	-	-	-

Note: Covariance analysis was conducted to compare the post-test scores in skill level between Jiroft and Bam University students. Cohen's f statistic was used to measure effect size. The significance level was considered as p-value < 0.05.
Abbreviations: F*, Fisher's F statistic; η^2, Eta-squared.

Table 3. Comparison of student satisfaction indicators between Jiroft and Bam Universities

Variable		Group	n	Pretest		Post-test		p-value
				Mean	Standard deviation	Mean	Standard deviation	
Jiroft University students	Students' skill level	Intervention	20	88.20	8.92	93.50	14.50	p < 0.001
Bam University students		Control	20	83.06	9.39	87.26	9.69	p = 0.46
p-value				p = 0.06		p < 0.001		

Notes: The significance level was considered as p-value < 0.05. Abbreviations: n, number of participants; p, probability-value.

Table 4. Results of covariance analysis for comparison of post-test scores in satisfaction level between Jiroft and Bam Universities

Groups		Subscales	Degree of freedom	Mean square	F	Significance level	η^2
Jiroft University students	post-test	Pretest	1	298.79	3.52	0.06	0.03
		Group	1	784.16	9.26	0.003	0.08
		Error	17	84.66		-	-
Bam University students	Post-test	Pretest	1	2060.60	22.90	0.001	0.19
		Group	1	813.65	9.24	0.003	0.08
		Error	17	89.95	-	-	-

Notes: Covariance analysis was conducted to compare the post-test scores in satisfaction level between Jiroft and Bam University students. Cohen's f statistic was used to measure effect size.
Abbreviations: F*, Fisher's F statistic; η^2, Eta-squared.

Discussion

This study demonstrated that simulated operating rooms in clinical skill centers can positively influence the skills of operating room students. The students in the intervention group, who received training in the operating room simulation environment, had a significantly higher mean skill score than the control group. These results are consistent with those of Shahbazian et al., who conducted a quasi-experimental study at Shahroud University of Medical Sciences in 2012 and 2013, reporting that the mean practical scores of the intervention group's operating room students using traditional education plus simulation software increased. This study on the effectiveness of educational software showed a significant difference between the students' practical skill levels (27). Similarly, Khatouni et al. reported that simulating the operating room significantly contributed to the practical skills of nursing students (28). The difference between these studies and ours is that they investigated the use of operating room simulation software, while our study designed, investigated, and analyzed the entire space and conditions of the operating room in a simulated environment.

In 2020, Chang-Chiao Hong et al. conducted a single-group intervention study with the aim of determining the effect of simulation on the perceived competence, effectiveness, and satisfaction of nursing students in the nursing department at a non-profit university in southern Taiwan. The study included 79 final-year nursing students who participated in three 75-minute simulated sessions during the semester. The students completed questionnaires before the first session and after each session. The results showed that after repeated use of simulation, statistically significant improvements were observed in the competence score of the students (29).

The results of the present study showed that the operating room simulation had increased scores in the components of sterilization and infection control skills, as well as scrub nurse duties, in students. Similarly, Liu et al. found that operating room simulation and situational simulation teaching to improving students' abilities (30).

The data from this study revealed that simulated operating rooms at clinical skill centers increased students' satisfaction. Similarly, Hunter et al. found that operating room simulation, specifically in areas such as wearing appropriate clothing, collecting and preparing tools, and controlling the sterility integrity, seal, and expiration date of sterile packets, increased operating room students' satisfaction (31). Zhao et al. also reported a significant relationship between simulated operating rooms and students' satisfaction, particularly in terms of factors such as wearing the gown correctly and preparing the sterile environment. Simulated operating rooms contribute to improving medical science students' clinical skills at clinical skill centers (13).

Jenifer et al. highlighted that the most important factors in operating room simulation that influenced students' satisfaction were preparing the sterile environment, covering the Mayo table and operation table, placing surgical tools within the operating field, prepping the operation position, and draping the surgical field for various surgeries (32). Yule et al. also reported that simulating operating rooms has an impact on the satisfaction of operating room students, with the most important factors affecting students' satisfaction being placing tools on a sterile surface, opening packets, pouring solutions, scrubbing for surgery, scrubbing the hands and arms, and using the correct disinfectant to wash hands (33). Similarly, Roshanzadeh explained the consequences of exposure to clinical learning challenges in real environments among operating room students, revealing the existence of learning distress, anxiety, incomplete care, and incorrect modeling. Such findings indicate that operating room students need a safe learning environment that is not challenging or stimulating (34).

It is worth noting that students still learn some of the skills required for working in the operating room in the real environment, which increases the risk of functional errors for both patients and students (3). To prevent such

errors, it is recommended to prepare a laboratory environment with the necessary technical equipment and hardware before clinical programs to prepare students to face the real environment (7, 35, 36). Despite the benefits of using simulation in the clinical education of students in medical groups, simulation still faces support, technical, and human barriers. Success in simulation-based education for students requires the support of universities and professors in terms of education and equipment (7, 16, 32). Therefore, it is suggested that designing such learning environments should be given priority in educational programs.

One of the limitations of this study was the students' initial unwillingness to participate in the study, which required the researcher to make some promises in order to obtain their consent. Although the training sessions were held for the students, maintaining consistent participation throughout the sessions was challenging. Additionally, the limited number of participants and the specific conditions of the simulation were other limitations of the study. It should also be noted that since this study was conducted on operating room students at Bam and Jiroft University of Medical Sciences, the findings cannot be generalized to students at other universities.

Conclusion

The findings of this study suggest that the simulated operating room in the Clinical Skills Center had a positive impact on the students' skills and satisfaction in the operating room. Therefore, the simulated operating room intervention can be considered a safe and effective educational method to enhance the practical skills of operating room students.

Ethical considerations

The present study reports the results of a master's dissertation in medical education. The study was conducted in accordance with ethical principles detailed in the Helsinki Declaration, and all methods were carried out following associated guidelines and regulations upon confirmation from the Kerman University of Medical Sciences. The ethics code and license were obtained from the Research Deputy Ethics Committee of the Kerman University of Medical Sciences with the number 98000327 and code IR.KMU.REC.1398.391.

Artificial intelligence utilization for article writing

Artificial intelligence (AI) has not been used for writing this article.

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Conflict of interest statement

The authors reported no actual or potential conflicts of interest.

Author contributions

E.N. and M.A. designed and supervised the study procedure. E.N. analyzed and interpreted the data and participated in planning the study and revising the manuscript. The manuscript was read and approved by all authors.

Supporting resources

The author declares that they received no financial support for the research, authorship, and/or publication of this article.

Data availability statement

The data used in this study is available upon request from the corresponding author.

References

1. Ericsson KA. Acquisition and maintenance of medical expertise: a perspective from the expert-performance approach with deliberate practice. Academic Medicine. 2015;90(11):1471-86. [https://doi.org/10.097/ACM.0000000000000939]

2. Amiri M, Khademian Z, Nikandish R. The effect of nurse empowerment educational program on patient safety culture: a randomized controlled trial. BMC Medical Education. 2018;18(1):1-8. [https://doi.org/10.1186/s12909-018-1255-6]

3. Burton R, Hope A. Simulation based education and expansive learning in health professional education: a discussion. Journal of Applied Learning and Teaching. 2018;1(1):25-34. [https://doi.org/10.37074/jalt.2018.1.1.4]

4. Becker V, Jedlicska N, Scheide L, et al. Changes in medical students and anesthesia technician trainees attitudes towards interprofessionality–experience from

an interprofessional simulation-based course. BMC Medical Education. 2022;22(1):1-14. [https://doi.org/10.1186/s12909-022-03350-6]
5. Alfredsdottir H, Bjornsdottir K. Nursing and patient safety in the operating room. Journal of Advanced Nursing. 2008;61(1):29-37. [https://doi.org/10.1111/j.1365-2648.2007.04462.x]
6. Escudero E, Silva M, Corvetto M. Simulation: a training resource for quality care and improving patient safety. Nursing-New Perspectives. 2019. [http://dx.doi.org/10.5772/intechopen.88918]
7. Eyikara E, Baykara ZG. The Importance of simulation in nursing education. World Journal on Educational Technology. 2017;9(1):2-7. [PMC8116070]
8. Ostadhasanloo H, Mahmoodi F, Adib Y, Zamanzadeh V. Lived experiences of nursing students concerning education in simulated learning environments: a phenomenological study. Journal of Medical Education Development. 2022;15(45):44-53. [https://doi.org/10.52547/edcj.15.45.68]
9. Mohammadi G, Tourdeh M, Ebrahimian A. Effect of simulation-based training method on the psychological health promotion in operating room students during the educational internship. Journal of Education and Health Promotion. 2019;8:172. [http://doi.org/10.4103/jehp.jehp_106_19]
10. de Vries EN, Prins HA, Crolla RM, et al. Effect of a comprehensive surgical safety system on patient outcomes. New England Journal of Medicine. 2010;363(20):1928-37. [http://doi.org/10.10.1056/NEJMsa0911535]
11. Hammoud MM, Nuthalapaty FS, Goepfert AR, et al. To the point: medical education review of the role of simulators in surgical training. American Journal of Obstetrics and Gynecology. 2008;199(4):338-43 [https://doi.org/10.1016/j.ajog.2008.05.002]
12. Pupkiewicz J, Kitson A, Perry J. What factors within the peri-operative environment influence the training of scrub nurses? Nurse education in practice. 2015;15(5):373-80. [https://doi.org/10.1016/j.nepr.2015.03.004]
13.Zha o Y, McDonell V, Samuelsen S. Assessment of the combustion performance of a room furnace operating on pipeline natural gas mixed with simulated biogas or hydrogen. International Journal of Hydrogen Energy. 2020;45(19):11368-79. [https://doi.org/10.1016/j.ijhydene.2020.02.071]
14. Makary MA, Mukherjee A, Sexton JB, et al. Operating room briefings and wrong-site surgery. Journal of the American College of Surgeons. 2007;204(2):236-43. [https://doi.org/10.1016/j.jamcollsurg.2006.10.018]
15. Zadi O, Nasiri E, Bazari Z, Asadpour H. Factors affecting on quality of clinical education from perspectives of operating room and anesthesiology students at Mazandaran university of medical sciences in 2018. Education Strategies in Medical Sciences. 2020;13(4):335-41.
16. Paige JT, Arora S, Fernandez G, Seymour N. Debriefing 101: training faculty to promote learning in simulation-based training. The American Journal of Surgery. 2015;209(1):126-31. [https://doi.org/10.1016/j.amjsurg.2014.05.034]
17. Torabizadeh C, Darari F, Yektatalab S. Operating room nurses' perception of professional values. Nursing Ethics. 2019;26(6):1765-76. [https://doi.org/10.1177/0969733018772077]
18. Ugur E, Kara S, Yildirim S, Akbal E. Medical errors and patient safety in the operating room. Age. 2016;33(6.53):19-50. [PMID: 27183943]
19. Weaver SJ, Salas E, Lyons R, et al. Simulation-based team training at the sharp end: A qualitative study of simulation-based team training design, implementation, and evaluation in healthcare. Journal of Emergencies, Trauma and Shock. 2010;3(4):369-77. [https://doi.org/10.4103/0974-2700.70754]
20. Ebadi M, Sharififar ST, Baniyaghoobi F, Pishgoie A. Comparison of nursing students' Satisfaction about two methods of demonstration and simulation for training of mask making against chemical attacks. Education Strategies in Medical Sciences. 2016;9(1):63-70.
21. Sadeghnezhad H, Khazaei T, Nasiri A. Comparing the effect of concept mapping to clinical simulation on emergency medical studentsclinical decision making. Iranian Journal of Medical Education. 2014;14(3):241-51.
22. Erfanian F, Khadivzadeh T. The effects of simulation based and traditional education on students'skill in pelvic examination. Journal of Internal Medicine Today. 2008;14(2):61-9. [http://imtj.gmu.ac.ir/article-1-405-en.html]
23. Leighton K, Kardong-Edgren S, Gilbert GE. Are traditional and simulated clinical environments meeting nursing students' learning needs? Clinical Simulation in Nursing. 2021;59:85-93 [https://doi.org/10.1016/j.ecns.2021.06.003]
24. Khazaei J, Zarouj H, Abbasi A. Qualification of clinical education of operation room in Bachelor degree from the perspective of students and educators in this field at the university of medical sciences, in Semnan.

Journal of Education and Ethics in Nursing. 2014;3(3):39–46.
25. Mahdavi R, Pooladi S, Bahreini M, Motamed N. Designing and determining the psychometric properties of the clinical skills questionnaire for operating room nursing students. Strides in Development of Medical Education. 2017;14(3):1-7.
26. Borim Nejad L, Sajadi Hezaveh M, Khosravi S. The effect of learning contract on self-directed learning and satisfaction of nursing students in clinical education. Iranian Journal of Medical Education. 2015;14(12):1084-92.
[https://doi.org/10.14196/mjiri.31.72. eCollection 2017]
27. Shahbazian B, Montazeri A, Abbasi A. The impact of educational software designed on operating room students' learning of practical skills. Research in Medical Education. 2015;7(4):13-9. [https://doi.org/10.18869/acadpub.rme.7.4.13]
28. Khatooni M, Alimoradi Z, Samiei-Seiboni F, Shafiei Z, Atashi V. The impact of an educational software designed about fundamental of nursing skills on nursing students' learning of practical skills. Journal of Clinical Nursing and Midwifery. 2014;3(1):9-16. [http://78.39.5.47/article-1-56-en.html]
29. Hung CC, Kao HF, Liu HC, Liang HF, Chu TP, Lee BO. Effects of simulation-based learning on nursing students' perceived competence, self-efficacy, and learning satisfaction: a repeat measurement method. Nurse Education Today. 2021 Feb 1;97:104725. [https://doi.org/ 10.1016/j.nedt.2020.104725]
30. Liu F, Wang L, Zhao J, et al. Research on the application of cross-specialty education and situational simulation teaching in operation nursing practice teaching. Journal of Education and Training Studies. 2021Jun;9(6):68-73.
[https://doi.org/10.11114/jets.v9i6.5274]
31. Hunter S, Katz D, Goldberg A, et al. Use of an anaesthesia workstation barrier device to decrease contamination in a simulated operating room. BJA: British Journal of Anaesthesia. 2017;118(6):870-5. [https://doi.org/ 10.1093/bja/aex097]
32. Jeffries PR. A framework for designing, implementing, and evaluating: simulations used as teaching strategies in nursing. Nursing Education Perspectives. 2005;26(2):96-103. [PMID: 15921126]
33. Yule S, Parker SH, Wilkinson J, et al. Coaching non-technical skills improves surgical residents' performance in a simulated operating room. Journal of Surgical Education. 2015;72(6):1124-30. [https://doi.org/10.1016/j.jsurg.2015.06.012]
34. Tajabadi A, Davoodvand S, Mohammadi S. Consequences of exposure to clinical learning challenges among operating room students. Journal of Medical Education Development. 2024;16(52):37-44. [https://doi.org/10.32592/jmed.2023.16.52.37]
35. Rajaguru V, Park J. Contemporary integrative review in simulation-based learning in nursing. International Journal of Environmental Research and Public Health. 2021;18(2):1-12.
[https://doi.org/10.3390/ijerph18020726]
36. Azarabad S, Zaman SS, Nouri B, Valiee S. Frequency, causes and reporting barriers of nursing errors in the operating room students. Research in Medical Education. 2018;10(2):18-27. [https://doi.org/10.29252/rme.10.2.18]