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Brief Report

Evaluating the Effect of Hospital Information System Simulation-Based Training on Informatics Skills of Operating Room Students: A Semi-Experimental Study

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Abstract

Background: The use of technology-based learning methods, such as computer simulation-based learning, is increasing in medical education. Applying these methods can empower and improve the practical skills and readiness of this group of students.

Objectives: This study aimed to determine the effect of training based on a hospital information system (HIS) simulator on the informatics skills of operating room students.

Methods: This semi-experimental before-and-after study was conducted in the first semester of 2022 on 3rd-semester undergraduate operating room students at Ferdows University of Medical Sciences. The educational content in this study was the simulated operating room module in the HIS simulation training system. Students were tested before and after the intervention. Data were analyzed using SPSS 26 and the Wilcoxon test to compare students' scores before and after the intervention.

Results: A total of 12 students participated in this study, with 8 (67%) being female. Before starting the training with the educational simulator, the mean test score was 20.25±4.86 (out of 28). The mean score after the intervention was 24.67±3.45. Data analysis revealed a significant difference in mean test scores before and after the intervention ($P = 0.028$). Additionally, there was no significant relationship between gender, age, and student GPA and the pre- and post-test mean scores ($P > 0.05$).

Conclusion: The results of this study showed the effectiveness of simulation-based training in improving the informatics skills of operating room students. It is suggested that the application of this teaching method be investigated in other skill areas of medical students as well.

Keywords: E-Learning; Simulator System; Hospital Information System; Skill; Operating Room Students

Background

Due to the COVID-19 outbreak, many educational activities in educational institutions, universities, and medical centers faced limitations or stopped altogether. To reduce the spread of COVID-19 infection, in-person education activities were transitioned to online education methods in most developed and developing countries. On the other hand, in many cases and for some medical science educational groups, due to various limitations such as data and information security

concerns, patient safety issues, a lack of specialist instructors, and crowded hospital environments, there is no opportunity for training and working with health information systems. Thus, the students cannot acquire sufficient and correct practical skills to work with these information systems (1).

Considering all the mentioned issues and the limitations that exist in the field of education, especially traditional education (2), there are new, complementary, and technology-based methods that can help reduce the gap in scientific knowledge and practical skills of students. In various fields of medical sciences, including medicine, dentistry, pharmacy, nursing, and paramedical sciences, different types of clinical and non-clinical e-learning tools have been used. The results of most studies conducted indicate success in using this method and relative satisfaction among students in using it (3-10). The results of two systematic review studies (11, 12) showed that these methods can increase the skills, knowledge, and satisfaction of users and also serve as a complementary method to in-person education by providing multiple capabilities.

Various technologies, such as virtual education, virtual reality, augmented reality, educational simulator software, and applications, are among the complementary educational methods (1, 3, 4, 11, 12). Using these methods, students can learn in suitable conditions that closely resemble the real work environment, applying real data, practice each process several times, experiment, and gain experience in a real environment. Using these methods, without disrupting hospital processes or compromising information security or patient safety, education is carried out with appropriate quality (1, 13). Additionally, e-learning methods can increase students' motivation, participation, and satisfaction in the field of education (14).

Operating room students require various types of clinical training, including familiarity with different surgical methods and the acquisition of skills in performing them. Additionally, they need non-clinical training, such as acquiring basic knowledge in their theoretical courses based on their curriculum. The use of simulator systems is one of the new methods in e-learning. Several simulators have been created for the clinical education of operating room students (15). These simulators include McGill for teaching and evaluating laparoscopic skills (16), Sim Man 3G for teaching simulation-based surgical methods on computer mannequins (17), and the spinal fusion surgery training simulator (18). The results of these studies showed that the use of clinical education simulators has had a significant impact on the basic knowledge and practical skills of operating room students (15).

The surgical information system (SIS) is a key subsystem of the hospital information system (HIS), with surgeons and operating room specialists being the primary end-users of this system. The SIS has various capabilities, such as recording patient information and status, entering information on services/surgeries performed for patients, transferring patients from the waiting list to the clinical department, and requesting blood and other services from other departments (19). Based on our knowledge, operating room students do not receive training on the use of health information systems (HISs) during their studies, and their education is often limited to clinical training. Therefore, there is a need to learn how to use these systems before entering the real work environment and hospital. Thus, this study was conducted to evaluate the impact of HIS simulation-based training on the informatics skills of operating room students before entering the internship course in the hospital.

Recent advancements in healthcare simulation technologies have expanded educational opportunities for medical students across specialties. The results of some studies have demonstrated that students who received simulation-based EHR training showed improvements in documentation quality and efficiency compared to those trained through traditional methods (12, 20). Similarly, other studies have found that perioperative nurses and surgical technologists who participated in HIS simulation training reported higher confidence levels and made fewer errors during their initial clinical rotations (21-23). Despite these promising findings, some studies (24, 25) identified a critical gap in specialized informatics training for operating room personnel, noting that most existing simulators focus on clinical skills rather than health information management competencies. This gap is particularly concerning as Abbasi et al. observed that the participants mentioned their need for training to use the surgical information system. Inadequate HIS training may be associated with increased documentation errors and workflow inefficiencies in surgical settings.

The pandemic-era shift to digital education has accelerated innovation in simulation-based training approaches. Some studies have found that virtual HIS simulators not only maintain educational continuity during clinical placement disruptions but also enhance students' digital literacy skills compared to pre-pandemic cohorts (26, 27). Building on this momentum, Kinnunen et al. (28) evaluated the informatics competencies among healthcare providers and

emphasized the need for specialization in HIS training. Our study addresses these identified gaps by implementing a tailored simulation system specifically designed for operating room students, focusing on the unique documentation and information management challenges they face in surgical settings. Unlike previous approaches that adapted general healthcare informatics curricula, our intervention targets the specialized needs of the operating room environment.

Objectives

This study aimed to determine the effect of training based on a hospital information system (HIS) simulator on the informatics skills of operating room students.

Methods

Study Setting and Population: This quasi-experimental study was conducted as a before-and-after design in the first semester of the academic year (2023-2024). A total of twelve third-semester undergraduate operating room students at Ferdows Faculty of Medical Sciences were eligible to participate in this study during the first semester of the 2022–2023 academic year. All twelve students were invited to participate through an announcement made during their regular curriculum activities. A census sampling method was used, and all eligible students were included in the study without any sampling. Our inclusion criteria required participants to be actively enrolled in the Operating Room program with no previous formal training or experience with hospital information systems. Students with prior HIS usage experience or those who were unable to attend the orientation session were excluded. All 12 students who met all criteria provided written informed consent and were enrolled in the study. No sampling method was applied as we included the entire eligible population of third-semester students.

In this regard, an orientation session was held for all students, introducing the scenario-based computer simulator and providing explanations about the training method, practice, and testing procedures, as well as the purpose and necessity of using the simulator. Sufficient time was also allocated to address ambiguities and answer questions about its implementation. After providing necessary explanations about the study procedure, their demographic characteristics (i.e., gender, age, grade point average, informatics skill, and HIS usage experience) were recorded in a checklist.

HIS Simulator System: The web-based simulator for teaching HISs offers important functional capabilities, including interactive training courses, multimedia content, practical exercises, tests, and user feedback. In addition, the administration, communication, and content management capabilities considered in this system can extend the learning process beyond other educational simulators. Other features, such as an information dashboard, reporting, question bank design, and messaging, have also been implemented to create an integrated educational system.

One of the simulated educational contents in this system is the training module for the operating room, available in the HIS, which was provided to the students. After students registered in the educational simulator system, they were given access to the "test" section related to the operating room module. After taking the test and obtaining and recording the score for this section (maximum 28), the educational content was made available to them for further review. Subsequently, the practice content for this module was provided to students so they could practice at any time, from anywhere, and on any device (mobile phone, tablet, laptop, or personal computer) for two weeks. Training and practice with the simulator system provided students with access to the test section of this module. Finally, the test scores were recorded in the post-training stage with the simulator system. The developed exam was based on the content of the educational process and completed practices, and was designed as a scenario.

To assign scores to each process, the weighted importance analysis (WIA) approach was employed. This scoring method is based on the principles of weighted importance analysis, a method applicable to evaluating the performance of complex processes. WIA is a scientific method for evaluation and decision-making in which the relative importance of each element or stage in a process is determined, and based on that, a weight or coefficient is assigned to each element. Then, the performance of each element is combined with its weight, and the overall impact is calculated. Accordingly, the key steps related to each scenario were determined by health information management (HIM) experts, medical informatics (MI) experts, and a hospital information system (HIS) analyst. The scoring was completed. The simulator system also automatically calculates students' scores for each scenario in the exam section based on their performance. Each scenario was designed based on a real case and, after scoring, underwent testing and evaluation. The validity and reliability of the exam were reviewed and confirmed by HIM and MI experts. As well, all students have provided informed consent to participate in the study.

Data Analysis: After completing the checklist and students' test scores through the simulator system, the

data were entered into SPSS.26 for analysis. First, using descriptive statistics indices such as central and dispersion indices (i.e. frequency, percentage, mean, and SD), the data were described. Then, using the Wilcoxon test, a comparison of students' scores was made in two stages before and after the intervention. Additionally, the Mann-Whitney test was employed to assess the relationship between gender and pre-test and post-test scores, while the Kruskal-Wallis test was used to examine the relationship between age and pre-test and post-test scores. Spearman's correlation coefficient test was also used to examine the correlation between GPA and pre-test and post-test scores. A p-value of less than 0.05 was considered significant.

Results

As shown in Table 1, 8 (67%) students out of 12 were female. Seven of them (58%) were 22 years old, and the mean of total GPA was 15.70 ± 1.13.

Before starting the training with the educational simulator, the highest and lowest scores obtained by students were 28 and 11, respectively, and their mean score was calculated as 20.25 ± 4.86. Following the intervention, the highest and lowest scores obtained by students were 28 and 16, respectively, with a mean score of 24.67 ± 3.45. Considering that the test score did not follow a normal distribution (p = 0.011), the non-parametric Wilcoxon test was used to compare the pre-test and post-test scores.

Table 1. Demographic information of participants

Demographic Information		Frequency (%)
Gender	Female	8 (67)
	Male	4 (33)
Age	22	3 (25)
	21	7 (58)
	20	2 (17)
Informatics Skill (self-declaration)	Low	8 (67)
	Medium	3(25)
	High	1 (8)
HIS Usage Experience	No	12 (100)
GPA	Mean ± SD	15.7±1.13

GPA: Grade Point Average; SD: Standard deviation

Data analysis revealed that the difference in test scores obtained before and after training was statistically significant (p = 0.028) (Table 2).

Table 2. Comparison of students' score before and after the intervention

Variable	Mean(SD)	Median	Min	Max	P-value
Pre-test score	20.25(6.86)	22	11	28	0.028
Post-test score	24.67(3.45)	26	16		

SD: Standard deviation

Additionally, no statistically significant relationship was found between any of the variables, including gender and age (Table 3). Furthermore, based on the Spearman correlation test, there was no statistically significant correlation between students' GPA and their pre-test scores (r = -0.51, P = 0.088). Similarly, no statistically significant correlation was found between their GPA and post-test scores (r = 0.51, P = 0.092). Figures 1-3 show the students' scores before and after the intervention, broken down by gender and age groups.

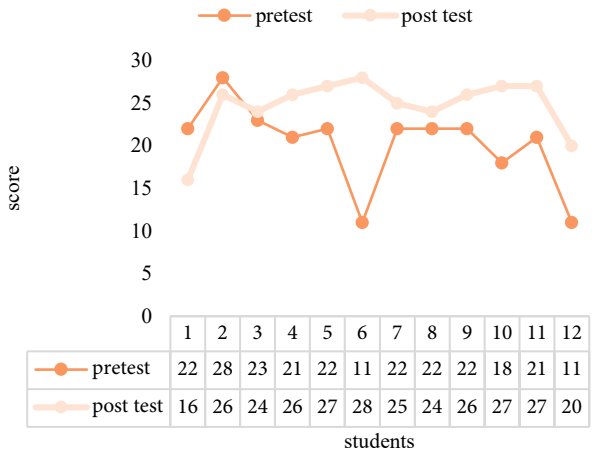

Figure 1. The students' score before and after the intervention

Table 3. Effect of gender and year of birth on pre-test and post-test scores

Variable		Pre test		Post test	
		Mean	SD	Mean	SD
Gender	Female	19.88	5.89	24.00	4.04
	Male	21.00	2.16	26.00	1.41
Test Result		U**=15.5, P=0.933		U**=11.5, P=0.461	
Year of Birth	2001	23.67	3.79	26.33	0.58
	2002	18.14	5.08	23.71	4.27
	2003	22.50	0.71	25.50	2.12
Test Result		H***=3.64, P=0.162		H***=0.83, P=0.66	

SD: Standard Deviation

Mann-Whitney U test, * Kruskal-Wallis H test

Discussion

This study was conducted to evaluate the impact of a web-based HIS simulation system on the informatics skills of undergraduate operating room students. The results indicated a significant effect of training using the simulator system on the skill level of students in this field in using the HIS. Based on the results of this study, students' demographic information, including age and gender, as well as their GPA, did not significantly affect the scores obtained in the test.

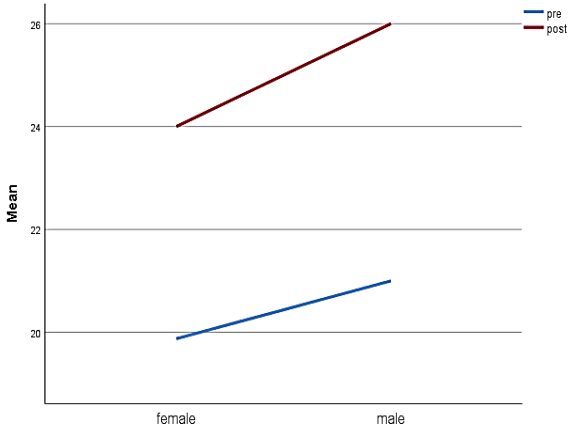

Figure 2. The students' score by gender before and after the intervention

To our knowledge, all studies conducted in this field on operating room students have focused on the clinical education using simulators. In this study, non-clinical education for students was implemented to improve their informatics skills, which demonstrated a positive impact of this type of education. In line with these findings, the results of Ghaffari et al.'s study showed that applying an interactive software to teach the HIS to undergraduate students of health information technology (HIT) could increase students' scores after training with the software compared to before the intervention. The results of the present study indicated an increase in students' informatics skills in using the HIS, which is confirmed by Ghaffari et al.'s study (1).

In line with the findings of the present study, two studies also used an electronic health record (EHR) simulator to train pharmacy students. The results of their study indicated that these students were appropriately prepared to use the EHR and had increased their skills. Vuk et al. (10) also examined the impact of EHR training through simulation on physicians and nurses in their study. Their study also demonstrated that training through simulation can enhance the efficiency of physicians and nurses in delivering healthcare services. They also suggested that the use of simulators should be an important educational method before implementing and using health information systems.

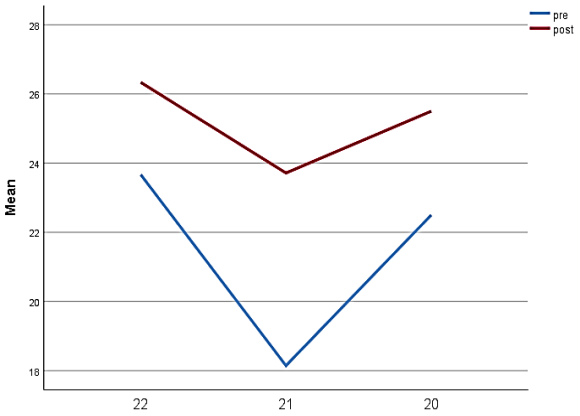

Figure 3. The students' score by age before and after the intervention

Insufficient user training is a major barrier to the successful use of HITs (29, 30). Upgrading the skills of the healthcare workforce requires creating opportunities for extensive, accessible, and cost-effective learning (31). As healthcare institutions increasingly rely on the use of health information systems, the demand for personnel with strong informatics competencies increases (32). The results of this study and, as well a those of Shachak et al. (9) showed that simulator systems are useful tools for education. Positive evaluations of the hospital information system education through using a simulator system showed that simulator-based learning can effectively complement the traditional learning approach for teaching students' practical skills. Therefore, it is suggested that the use of simulator-based tools be included in the syllabi and curriculum of other medical science groups as well. Future research should address these limitations through multi-center randomized controlled trials with longer follow-up periods and performance assessment in actual clinical settings.

The significant improvement in students' informatics skills following simulation-based training has substantial implications for curriculum development in medical informatics education, particularly for operating room professionals (33). Our findings suggest that formally integrating HIS simulation modules into operating room technology curricula could address a critical educational gap that currently exists between theoretical classroom instruction and practical clinical applications. Curriculum developers should consider creating a

progressive informatics competency framework that spans the entire program, beginning with foundational digital literacy in early semesters and culminating in advanced, system-specific training using simulators prior to clinical rotations. This approach would enable students to develop familiarity with healthcare information systems concurrently with their clinical skill development, rather than treating informatics as an isolated or ancillary competency. Additionally, our results support the development of interprofessional informatics education modules, where operating room students can interact with nursing, medical, and health information management students in simulated documentation scenarios, thereby better reflecting the collaborative nature of healthcare information management. As healthcare delivery becomes increasingly technology-dependent, curriculum committees should consider establishing dedicated informatics competency assessments as graduation requirements, potentially through objective structured clinical examinations (OSCEs) that incorporate HIS simulation scenarios alongside traditional clinical skills evaluation.

Strengths and Limitations: This study is the first study in the field of non-clinical education of operating room students to enhance their informatics skills in using the HIS with a simulator system. One limitation of this study is the small number of participating students. Furthermore, there are several additional limitations that warrant consideration. First, the single-institution design at Ferdows Faculty of Medical Sciences limits the generalizability of the findings to other educational settings with different curricula, technological infrastructure, or student demographics. Second, the absence of a control group introduces potential confounding factors, as improvements might partially reflect the natural learning progression of students or exposure to related content in other courses. Third, our assessment focused on immediate post-intervention skills, without follow-up evaluation to determine long-term retention or transfer of these skills to authentic clinical environments. Fourth, potential self-selection bias may exist, as students with a higher affinity for technology might have engaged more thoroughly with the simulator. Fifth, the simulator itself, while designed to replicate real HIS functionality, cannot fully reproduce the complexity and contextual challenges of actual hospital environments, including time pressures, interruptions, and system integration issues commonly encountered in practice. Finally, the Hawthorne effect may have influenced the outcomes, as participants were aware of being evaluated, which could have potentially altered their performance. Future research should address these limitations through multi-center randomized controlled trials with longer follow-up periods and performance assessment in actual clinical settings.

Implication of the Study: For educators in operating room and surgical technology programs, our results suggest that integrating HIS simulation-based training into standard curricula offers a viable strategy to develop essential informatics competencies before clinical placements. This approach may reduce the technical onboarding burden for clinical sites while potentially decreasing documentation errors during students' initial clinical experiences. For department chairs and curriculum developers, our findings support allocating resources to develop and maintain simulation environments that mirror contemporary hospital information systems, potentially through partnerships with HIT vendors or teaching hospitals. Medical education policymakers should consider updating accreditation standards to explicitly include informatics competencies for operating room professionals, recognizing these skills as core requirements rather than ancillary knowledge. Furthermore, healthcare administrators may benefit from incorporating similar simulation-based approaches into their onboarding processes for new surgical staff. Given the continuous evolution of health information systems, our study demonstrates the value of establishing educational frameworks that can adapt to technological advancements while providing consistent skills development, thereby creating a more prepared and technologically adept surgical workforce.

Conclusion

The results of this study showed the effectiveness of simulation-based education in improving the informatics skills of operating room students. These positive evaluations showed that the HIS education by the simulator system could be useful in enriching traditional HITs education. It is suggested that the application of this educational method in other areas of medical science, such as skills, should also be investigated. Additionally, the use of these platforms during crises, such as the COVID-19 pandemic, can help maintain learning continuity during the stoppage and disruption of in-person educational activities.

Additionally, we recommend future research involving multiple institutions and cohorts across different medical universities to increase the sample size

and enhance the generalizability of the findings. A multi-center approach would not only strengthen statistical power but also allow for comparative analyses across different educational contexts and student populations. Additionally, a longitudinal study design that tracks students' performance throughout their clinical rotations could provide valuable insights into the long-term retention of acquired informatics skills and their practical application in real clinical settings.

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Conflict of interests: There is no conflict of interest.

Ethical approval: This study was approved by the ethics committee of Birjand University of Medical Sciences (IR.BUMS.REC.1402.445).

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