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Improving Infection Control Competencies in Nursing Education: The Impact of Simulation-Based Learning

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ABSTRACT

Background: Through simulation, students can enhance their critical thinking and analytical abilities to the best possible extent. To reduce hospital-acquired infections, it is critical to evaluate their current level of knowledge and develop future plans to increase it. **Objectives:** The aim of this study was to evaluate the impact of simulation-based learning on undergraduate nursing students' infection control competencies. **Methods:** A quasi-experimental research design (one-group pre-post-test design) was used to achieve the aim of this study. The study was carried out in the Faculty of Nursing at Sohag University Hospital. A convenient sample of B. Sc. (700 undergraduate nursing students) in their third year was recruited in this study. Three tools were used to collect data: Tool (1): Structured Knowledge Questionnaire on Infection Control Practices and Tool (II): Undergraduate nursing students' observation checklist. **Results:** The study results revealed that there was a statistically significant difference in mean knowledge scores on infection control practices between pre- and post-tests with a '*t*' value of 12.55 at $p<0.001$, and also there was a high statistically significant difference in mean practice scores on infection control practices between pre- and post-tests with a '*t*' value of 15.99 at $p<0.001$. There was a significant correlation between pretest and post-test scores of knowledge and practice (p-value=0.001) on infection control practices among undergraduate nursing students regarding infection control practices among undergraduate nursing students. **Conclusion:** According to the current study's findings, undergraduate nursing students' knowledge and practices regarding infection control competencies improved when they participated in simulation-based learning.

Keywords: Infection Control Competencies; Quasi-Experimental Study; Simulation-Based Learning; Undergraduate Nursing Education

INTRODUCTION

Nursing education empowerment is the ability to motivate oneself and others to achieve positive outcomes in practice and the workplace (Al-Ahmari *et al*., 2021). The Centers for Disease Control and Prevention (CDC) emphasizes routine precautions as essential for preventing healthcare-associated infections among patients and healthcare workers (Beutlin & Philo, 2023). Simulation in nursing provides a safe environment for repeated

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practice to mastery, with feedback that strengthens skill acquisition, critical thinking, and reflective analysis (Shelar *et al*., 2020).

Simulation-based learning can be concisely defined as an educational approach that incorporates diverse activities such as patient simulators, virtual environments, and role-playing to replace or enhance real experiences with guided ones. It mimics clinical practice through scenarios, manikins, and computer-based simulations, offering immediate feedback, repetitive practice, and tailored learning experiences. However, limited opportunities for hands-on practice with actual patients during undergraduate studies can hinder competence development, potentially leading to errors and compromising patient safety (Malarvizhi *et al*., 2019).

Quality education is crucial for developing competent healthcare professionals. However, evidence suggests nurses may be underprepared to meet societal needs, particularly in developing countries. Simulation-based education offers a potential solution, providing a range of activities, including patient simulators, virtual environments, and role-playing. Simulation is a valuable tool for nursing educators, enabling future nurses to develop essential skills for real-world practice. Effective performance is measured by accuracy, completeness, cost, and speed. Inadequate preparation can lead to negative outcomes, especially in critical care (Sengupta &Tungoe, 2021).

Simulation-based learning incorporates diverse activities, including patient simulators, virtual environments, and role-playing. This approach replaces or enhances real experiences with guided ones, mimicking clinical practice through scenarios, manikins, and computer-based simulations. Simulation has become essential in nursing education, providing hands-on training and critical thinking opportunities (Malarvizhi *et al*., 2019). Effective nursing education should prioritize cognitive, psychomotor, and affective domains. Valid assessment tools are essential for evaluating competence in procedures like vein puncture (Lapkin & Levett-Jones, 2021). Simulation-based experiences require intentional planning and design to achieve desired outcomes (Xavier *et al.*, 2025).

While the international literature strongly supports simulation as a tool for competence development, there is a scarcity of local evidence from Egypt. Reports highlight that Egyptian nursing students often have limited opportunities for hands-on clinical practice, particularly in infection control procedures such as hand hygiene, PPE use, and biomedical waste management. This gap is concerning given the high prevalence of healthcare-associated infections in Egyptian hospitals and the urgent need to improve undergraduate preparedness in infection control (Elbaky *et al*., 2023).

Significance of the Study

The adoption of innovative learning tools, such as simulation, has grown in nursing education alongside the advancements in contemporary technology. Simulations create a learning environment that ensures patients receive safer care within healthcare services while minimizing environmental risks (Kudari, 2023). Furthermore, simulation provides researchers with the opportunity to improve the quality of nursing education, enhance nursing students' skills in infection control, reduce infection risks, implement effective infection control practices in healthcare settings, develop practical skills, use simulation-based learning to enhance nursing students' practical skills, enhance patient safety, improve the quality of healthcare, and reduce patient health risks. Therefore, the purpose of this study was to evaluate the impact of simulation-based learning on undergraduate nursing students' infection control competencies.

Operational Definitions

Effectiveness: It refers to the outcome of simulation-based learning on infection control practices for nursing students as evidenced by improvement in competency of nursing students after the intervention.

Simulation-based Learning: Simulation-based learning includes learning objectives, prerequisite knowledge for students, pre-simulation preparation, simulation design process, simulation scenario, role of participants, and debriefing sessions. A comprehensive learning by artificially creating real-life situation of a clinical unit, which includes hand hygiene, use of personal protective equipment, biomedical waste management, and isolation by making use of a low-fidelity simulator.

Competency: Competency refers to the level of knowledge and skills demonstrated by undergraduate nursing students in performing infection control practices. In this study, competency is considered the dependent variable and is expected to improve as a result of the independent variable, simulation-based learning. The research hypothesizes that simulation-based learning will have a positive effect on the infection control competencies of undergraduate nursing students.

METHODOLOGY

Design

This study employs a quasi-experimental design, specifically a one-group pretest–posttest design.

Setting

The study was carried out in the Faculty of Nursing at Sohag University Hospital. The present study was implemented at Sohag University Faculty of Nursing, one of the governmental universities in Upper Egypt affiliated with the Ministry of Higher Education and Scientific Research. It was constructed in 2006 and added to the faculties of nursing in Egypt. The nursing departments consisted of eight academic departments, namely, medical-surgical nursing, maternal and gynecological nursing, pediatric nursing, community health nursing, nursing administration, critical care nursing, geriatric nursing, and mental health and psychiatric nursing.

Subjects

A convenience sample of 700 third-year nursing students was recruited during the first semester of the 2024-2025 academic year. These students were in their third nursing level and had not received prior training on the specific procedures being studied.

Tools for Data Collection

Two tools were used to collect data for the current study as follows:

Tool (1): Structured Knowledge Questionnaire (MCQ) about Infection Control Practices: The tool was developed by the researcher following a review of relevant recent national and international literature and subsequently translated into simple Arabic. It consists of two components as follows:

Part 1: This section contained data regarding the demographic characteristics of undergraduate nursing students, including age, gender, place of residence, and academic performance (previous year).

Part 2: Knowledge of undergraduate nursing students concerning infection control (pre and post): The researcher developed this after reviewing relevant national and international literature (George, 2020; Beutlin & Philo, 2023). Undergraduate nursing students' comprehension of hospital-associated infection definitions, transmission routes, the chain of infection, and prevention strategies was covered in the questions about hospital-associated infections and infection control measures (Al-Ahmari *et al.*, 2021).

Scoring System for Knowledge of Undergraduate Nursing Students: Knowledge Assessment Scoring System: It included 30 multiple choice questions; the total score was 30 (correct response: 1-point, incorrect response: 0 points, maximum score: 30 points).

Knowledge Level Categorization: Satisfactory knowledge: ≥60% (≥18 points), Unsatisfactory knowledge: <60% (<18 points)

Tool (II): Observation Checklist for Undergraduate Nursing Students: The researchers developed this tool, which was developed based on current literature for accuracy (Haque *et al*., 2018, Koo *et al*., 2016), to evaluate nursing students' infection control skills, focusing on:

1. Hand hygiene

2. PPE use (donning/doffing)

3. Infection control during procedures like IV infusion, cannulation, blood transfusion, oxygen equipment handling, vital sign measurement, central line/umbilical venous catheter use, solution preparation, and artificial/gavage feeding

Scoring System

The scoring system utilized for the practice of undergraduate nursing students involved an observational checklist, where each item was assigned, a score ranging from 0 to 1. A score of (1) was given for tasks that were completed correctly and thoroughly, while a score of (0) was assigned for tasks that were either not completed or were done incompletely. It included 100 multiple choices, and the total score was 100. The classification by Alfar *et al.* (2020) led to the division of all nursing practices into two groups, namely adequate and inadequate practice. A practice was deemed inadequate if the score of the undergraduate nursing students was below 60%, whereas it was considered adequate if the score exceeded 60%.

Validity of Tools

A panel consisting of five experts from the Medical Surgical Nursing Department and two expert professors from Nursing Administration, each with over ten years of experience, evaluated the content of the tools for the assessment tools, which underwent validation and reliability testing:

Validation

Face validity and content validity was confirmed by expert panel. Ensured clarity, comprehensiveness, appropriateness, and relevance

Reliability

- Cronbach's alpha tests were done.
- Tool 1: $\alpha = 0.897$ (high reliability)
- Tool 2: $\alpha = 0.883$ (high reliability)

Pilot Study

The pilot study was conducted with 10% of the sample size. To test tool feasibility and effectiveness (70 undergraduate nursing students). This study aimed to ascertain the time required for data collection, identify any ambiguities in the tool, and ensure the clarity of the items. It served to clarify and assess the feasibility of the study. The undergraduate nursing students who participated in the pilot study were also included in the main study.

Fieldwork

Approval to conduct the study was obtained from the director of Sohag University Hospital, Egypt. Data collection was conducted from October to December 2024.

At the beginning of the study, nursing students were informed about the purpose and nature of the research, and informed consent was obtained. The study was executed in four phases:

1. Assessment Phase: Nursing students' demographic characteristics, knowledge of infection control (Tool I), and observed practices (Tool II) were assessed.

2. Planning Phase: Goals and priorities were established based on assessment findings, and a five-session simulation-based learning program was designed to improve knowledge and skills related to infection control competences.

3. Implementation Phase: The program was delivered in five sessions (30–45 minutes each, three days per week). The sessions incorporated a combination of lectures, group discussions, demonstrations, and simulation-based learning using manikins. Teaching materials included PowerPoint presentations, printed booklets, and practical demonstrations. Feedback and debriefing were provided throughout to enhance skill acquisition and reflective learning.

4. Evaluation Phase: The same pre-test tools and observational checklist were used post-intervention to evaluate changes in students' knowledge and infection control competences and practices.

Statistical Design

Coded data was imported into SPSS (version 22). Analysis of quantitative data using mean and standard

deviation (SD) and *t*-test (pretest-posttest comparison). Qualitative data was analyzed using numbers, percentages, and the $\chi 2$ test. Significance levels were $P > 0.05$: not significant, $P \leq 0.05$: statistically significant, and $P \leq 0.001$: highly statistically significant. Pearson correlation assessed relationships between quantitative variables.

Ethical Consideration

The research obtained ethical clearance from the Faculty of Nursing Ethical Committee, Sohag University, Egypt, with reference number 154 on 5th December, 2023.

RESULTS

Table 1: Demographic Data among Undergraduate Nursing Students

Demographic Data	No	%
Age in Years		
20 – 22	539	77
23 -25	161	23
19.98±9.38		
Gender		
Male	280	40
Female	420	60
Place of Residence		
Rural	280	40
Semi Urban	336	48
Urban	84	12
Academic Performance (Previous Year)		
Distinction and above	210	30
First Class	490	70

Table 1 shows that most students were between 20 and 22 years old, the majority were female, and nearly half lived in semi-urban areas. About two-thirds achieved first-class academic performance.

Table 2: Comparison between Pre-and Post-test Mean and Standard Deviation of Competency (Knowledge) on Infection Control Practices among Undergraduate Nursing Students

Competency	Knowledge			
	Mean	SD	Mean Diff	Independent "*t*" value
Pretest	9.44	4.22	9.23	*t*=11.76
Post Test	18.88	2.66		*p*<0.001*

Table 2 demonstrates a significant improvement in students' knowledge scores on infection control after the intervention.

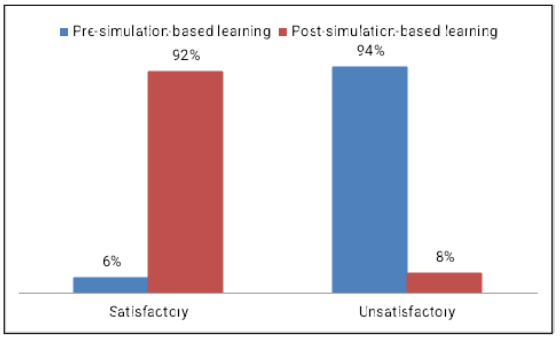

Figure 1: Total Knowledge Level among Studied Undergraduate Nursing Students Regarding Infection Control Competency Pre and One Month Post Simulation-Based Learning

Figure 1 highlights a marked shift in knowledge levels, with most students moving from unsatisfactory knowledge before training to satisfactory knowledge after the intervention.

Table 3: Comparison of Pre-and Post-test Mean Scores of Infection Control Practice Competency among Undergraduate Nursing Students

Competency (Practice)	Mean (Total=100)	SD	Mean Diff.	Paired "*t*" value	*P*-value
Pre-test	69.98	3.10	12.68	14.77	< 0.001*
Post-test	82.66	1.54			

**Highly statistically significant at p < 0.001*

Table 3 demonstrates a highly statistically significant improvement in nursing students' infection control practice competency following the intervention. The total mean practice score increased from 69.98 ± 3.10 (out of 100) in the pre-test to 82.66 ± 1.54 in the post-test. This clinical improvement is statistically supported by a *t*-value of 14.77 at $p < 0.001$, indicating that the educational intervention effectively enhanced the students' practical skills, Hence, the hypothesis was achieved with a significant difference in competency scores on infection control practices between pretest and post-test among nursing students.

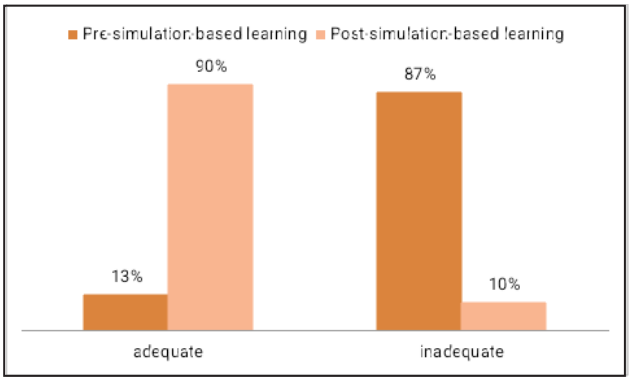

Figure 2: Total Practices Level among Studied Undergraduate Nursing Students Regarding Infection Control Competency Pre and One Month Post Simulation-Based Learning

As illustrated in Figure 2, students' practice levels improved considerably following the sessions, with the majority achieving adequate practice levels compared to predominantly inadequate levels pre-intervention.

Table 4: Correlation between Knowledge and Skill on Infection Control Practices among Undergraduate Nursing Students (n=700)

Variables	Pre test		Post test	
Knowledge / Practice	*r*	*p*	*r*	*p*
	0.7579	0.001	0.3998	0.001*

**highly statistically significant differences<0.005*

As presented in Table 4, there was a strong positive correlation between the total knowledge and practice scores at both pre-test ($r = 0.76$, $p = 0.001$) and in the post-test ($r = 0.3998$, $p = 0.001^{*}$).

DISCUSSION

A replicate teaching technique, simulation-based education uses a setting that is similar to real-world clinical situations. When necessary, this method makes repeated learning safe and efficient. Additionally, using standardized patients who have been carefully taught to portray their sickness and emotional states in a simulation that mimics real-life circumstances enable students to comprehend the thoughts and feelings of patients through interaction, thereby providing more realistic and tangible experiences (Cant & Cooper, 2020). So, the researchers did this study to evaluate the impact of simulation-based learning on undergraduate nursing students' infection control competencies.

Findings of the current study revealed that the majority of the undergraduate nursing students were aged between 20 and 22 years (77%) with a mean age of 19.98+9.38 and scored first class in previous year academic performance (70%), and nearly half of them (48%) were from semi-urban areas. The findings of the study were in line with a quasi-experimental investigation of the efficacy of clinical simulation on home visits that was carried out by Ruiz-Fernández *et al*. (2022) with 130 nursing students. According to the study's findings, the same average age was 22.2 years.

According to the current study's findings, the mean knowledge scores regarding infection management varied significantly between the pre-test and post-test, with a "*t*" value of $p<0.001$. From the researchers' point of view, it confirmed the benefits of simulation-based learning. The results of the current study were supported by Sasikala and Sasikala (2022), who studied the effectiveness of educational games as a teaching tool on the learning outcome of critical care drugs and investigations among nursing students at selected colleges and found that less than one-fifth of the nursing students under investigation knew too little about infection control measures on the pretest. All participants, however, showed a good level of knowledge after the intervention. This result was suggestive of an effective trend, according to the experts.

Findings of the current study illustrated that there was a higher statistically significant difference in mean practice scores on infection control practices between pretest and post-test with a '*t*' value at $p < 0.001$. Hence, the hypothesis was achieved with a significant difference in competency scores on infection control practices between pretest and post-test among nursing students. From the perspective of the researchers, it reflected the success of the simulation-based learning.

The study results were supported by a quasi-experimental study conducted by Ruiz-Fernández *et al*. (2022), who studied the effectiveness of clinical simulation on home visits. The study findings found that when comparing the data before and after the simulation, a statistically significant increase was observed in the scores of self-efficacies ($p < 0.001$) and empowerment ($p < 0.001$).

Additionally, a previous study by Lee *et al*. (2019) has shown a lack of performance in the use of protective equipment with relation to adherence to required precautions. The ability to integrate infection control knowledge and abilities may therefore be enhanced by strengthening these competencies. Nonetheless, the study's participants' understanding of common precautions was lower than that of other research, including third- and fourth-year nursing students (Hong *et al*., 2024).

The data presented revealed that there was a significant correlation between pretest scores of knowledge and skill on infection control practices among undergraduate nursing students. From the perspective of the researchers, it confirmed that the simulation-based learning achieved the aim of the study. Greater knowledge improvements were shown by the simulation schooling (Byun *et al*., 2014). These findings are consistent with other research showing that simulation-based learning improves understanding of common safety measures (Desnita & Surya, 2020).

Furthermore, compared to those who received traditional lecture-based training, participants in simulation-based infection control education showed a more significant improvement in knowledge of standard precautions (Cho *et al*., 2022). Prior studies show that performance is improved when one is aware of standard precautions (Park & Byun, 2020). Considering the costs of simulation-based learning (Luctkar-Flude *et al*., 2024).

Additionally, Cha *et al*. (2022) found that environmental safety has an impact on both awareness and the implementation of common safety measures. Simulation programs that teach nurses and nursing students about healthcare-related infection control were demonstrated to improve participant skills more than other teaching methods like lecture-centered education or problem-based learning (Nakamura *et al*., 2023).

Simulation is an active learning strategy that integrates theoretical knowledge with practical application by modelling real-life clinical scenarios and enabling the direct execution of interventions. This approach enhances student engagement and facilitates deeper and more sustained learning outcomes. This study contributes more evidence to the existing literature supporting the effectiveness of simulation as a teaching technique. Furthermore, nursing skills and knowledge are significantly enhanced by debriefing during simulation (Kim & De Gagne, 2018).

Limitations

Limited generalization due to convenience sampling, single scenario used, and cost-effectiveness not evaluated. Future research should use larger, randomized samples, include multiple scenarios, explore various learning methods, and assess cost-effectiveness.

CONCLUSION

According to the current study's findings, undergraduate nursing students' knowledge and practices regarding infection control competencies improved when they participated in simulation-based learning. Hence, this expanded scope will help refine simulation-based learning, improving nursing students' knowledge and practices regarding infection control competencies. In light of the study's findings, the following suggestions are made given the present results, integrating simulation into nursing curricula could address gaps in infection control training, particularly in resource-limited settings. The same study can be conducted on a large sample size and in different settings to generalize the results. A comparative study can be conducted between traditional teaching and simulation-based teaching to discover simulation effectiveness.

Conflict of Interest

The authors declare that they have no competing interests.

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