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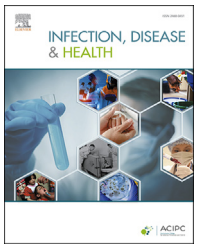

Research paper

The effectiveness of simulation-based training on KAU hospital housekeeping staff performance

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KEYWORDS
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Terminal cleaning;
Housekeeping staff

Abstract *Background:* Hospital Housekeeping staff play a key role in maintaining safe and clean environments to prevent infection and its spread in hospital. Innovative training approaches are necessary for this category; especially since their educational level is below average. Simulation based training can be a valuable tool for them in health care sector. However, no studies have explored the impact of simulation-based training on housekeeping staff performance, which is the focus of this study.
Objective: This research focuses on exploring the effectiveness of simulation-based training for Hospital Housekeeping Staff.
Methods: The study used pre-post training data from 124 housekeeping staff in different work areas at KAUH to measure the effectiveness of the program on their performance. The training includes five segments: General Knowledge training, Personal Protective Equipment, Hand Hygiene, Cleaning Biological Materials, and Terminal Cleaning. The study incorporated a two-sample paired T-test, One-Way ANOVA to detect differences in mean performance pre-and post-training and between groups in terms of gender and work area.
Results: Study results show a significant improvement in housekeeping staff performance after the training, where the performance measure of GK was improved by 33%, PPE 42%, HH 53%, Biological Spill Kit is 64%, and terminal cleaning 11% However, there is no significant difference in performance improvements in all stations in regards of gender and work area except for the Biological Spill Kit in terms of the work area.

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Conclusion: Results show the effectiveness of training as there are statistically significant differences in housekeeping staff mean performance pre-and post-training. The simulation-based training changed the behavior of the cleaners, as they became more confident and understanding in performing their work. Expanding the use of simulation as a basis for training this important group and further study is recommended.

Highlights

- Housekeeping staff play a major role in hospital Prevention Infection and Control.
- Experience using simulation as a basis for training housekeeping on their associated tasks in the hospital.
- Using simulation technology as a basis for training housekeeping staff is an addition to the health sector.

Introduction

Maintaining hospitals cleanliness is one of the most critical patient safety issues, as cleaning is an influential factor in controlling infection and its spread [1]. Several studies indicate that cleaning is vital in reducing hospital-acquired infections and related costs. The lack of proper hospital hygiene is usually associated with unpleasant outcomes and higher costs associated with longer length of stay and use of expensive medications. These avoidable costs deserve attention because they affect the quality of care delivered and the safety of patients and staff in healthcare facilities [1—3]. Also, one of the reasons for (methicillin-resistant *Staphylococcus aureus* (bacteria in hospitals is poor cleaning [4,5]. According to the Center for Disease Control and Prevention (CDC), nearly 100,000 people die each year from hospital-acquired diseases in America [6].One study indicates a significant reduction in hospital infections due to cleaning compliance at a rate of 10,000 patients per day [7]. The standard method of reducing and preventing these infections is decontamination of patient rooms through manual cleaning and disinfection [8]. Maintaining the safety of hospitals and health care workers should be a priority for any hospital [1]. The better the education in infection control, the lower the risk [3].

Role of hospital housekeeping staff

Hospital housekeeping staff play a key role in creating and maintaining a safe and clean environment to prevent infection and its spread. Therefore, it is necessary to train housekeeping staff on an ongoing basis and create programs dedicated to them and their training needs. Especially in the current circumstances of the spread of COVID-19, it is necessary to emphasize safe and correct practices [9]. In general, many hospitals are quick to spend money on new programs, specialized staff, and equipment, and they often try to reduce environmental hygiene maintenance costs as much as possible, whether in terms of cost reduction in products that they use or in training and continuing education programs for housekeeping staff [1]. However, when proper training is put in place by health institutions, the effectiveness of housekeeping staff will lead to reduced health risks and infection spread and better control [10]. Many studies have stressed the importance of housekeeping staff training [11,12]. Previous studies have provided that housekeeping staff are exposed to injuries and accidents due to their lack of knowledge and awareness of the correct practices associated with their tasks in hospitals [13,14]. As a result, dedicated training programs are needed to equip them with the knowledge, skills, and understanding required to perform their job efficiently and effectively [15].

Among the most important practices that hospital housekeeping staff perform is a daily task include the following:first: donning and doffing)PPE(: cleaners in the health sector are exposed to infections and diseases such as (Covid) and others, as they are in direct contact with the patient's environment; the proper use of personal protective equipment (PPE) is vital in preventing the spread of infection [16]. Second: Hand hygiene: housekeeping staff frequently contact patients environment, making it easy for microorganisms to be transmitted through their hand; Alcohol-based hand sanitizers effectively reduce the number of germs, wash and sanitize hands is one of the best ways to avoid getting sick and prevent spreading germs to others [17]. Third: Cleaning Biological Materials (blood) & Waste Management: exposure to blood and body fluids is a major risk of infections and constitutes a risk of transmission of bloodborne viruses including HIV, hepatitis B and C virus [18]. Professional bio cleaning is a process intended to reduce the biological contamination of surfaces [19]. On the other hand, infectious waste may be associated with diseases like viral hepatitis and other life-threatening viral infections, as well as pyogenic and enteric infections [20]. It has been documented in the literature that hospital housekeeping staff are the most vulnerable to accidents with biological materials and needle stick injury (NSI), which have led to an increase in the rate of morbidity and mortality among them due to improper disposal of waste, including needles/sharps; However, these life-threatening risks can be prevented with continuous and appropriate training and education [21,12,13].Fourth: Terminal cleaning: It is known as the comprehensive cleaning of the patient's room, which includes every part of the room, and it must be done in the

following circumstances: Following discharge, transfer or death of a patient who has had a known infection, Following isolation/contact precaution nursing of a patient.

Where non-compliance with the terminal procedures leads to infection, various diseases, and danger, especially when receiving the next patient. Terminal cleaning is a critical step in preventing the transmission of healthcare-associated pathogens [22].

Clearly, the practices of the housekeeping staff contribute to spreading or reducing infection in hospitals. The focus of this study will be on the practices that the housekeeper performs during his daily work. Through the simulation-based training for training this category on the topics above.

Simulation-based training in healthcare

Generally, simulation is defined as a process of imitation of something or a real circumstance, a realistic process to clarify information to the recipient by simulating the actual reality and has different levels and types that are determined based on trainees' needs or capabilities; healthcare simulations can be said to have four main purposes — education, assessment, research, and health system integration in facilitating patient safety [23].

Simulation in medical education is defined as an artificial representation of a real-world process to achieve educational goals through experiential learning to replicate clinical scenarios [24]. Simulation in healthcare is now used to facilitate patient safety and improve the safety, effectiveness, and efficiency of healthcare services: represented in education, evaluation, research, and health system integration [25]. As a result, the use of simulation in training has wide and great acceptance in the field of healthcare [26] as it has proven its effectiveness for medical students [27,28], physicians [29,30], nurses [31,32], and pharmacy students [33,34]. However, no studies are exploring the use of simulation in training housekeeping staff, which is the focus of this study.

Simulation-based education encompasses a wide variety of training methods for healthcare including High-fidelity mannequins: A term often used to refer to the broad range of full-body manikins that have the ability to mimic, at a very high level, human body functions [35]. Partial-task simulators: Task trainers are used to teach and assess the individual performance of a particular task or procedure around a set of metrics [36]. Standardized patient simulation involves the use of individuals trained to portray the roles of patients, family members or others to allow students to practice physical exam skills, history taking skills, communication skills and other exercises [37]. Virtual reality (VR): is an advanced, human—computer interface that simulates a realistic environment [38]. Simulation scenario: is an artificial representation of a real-world event to achieve educational goals through experiential learning [39]. Role-playing: asking students to act out a situation. E-learning includes all the simulations on the computer. combination of simulations: uses two or more of the previous types of simulations to create a more realistic simulation. It can also help students practice more than one skill at a time [40].

Several levels of simulation technology can be used and implemented in training fidelity: can be defined as the degree of exactness with which a manikin or simulator represents a live patient or scenario, levels of fidelity vary depending on usage [41]. Including high-fidelity and low-fidelity simulations; the selection of the appropriate tier depends on the intended learning objectives and allocated budget. High-fidelity (HF) simulators operate on highly realistic devices to immerse the users in complex scenarios and practical feedback [42,43]. On the other hand, low-fidelity simulators are those that feel the least real to the learner [43]. For various purposes, learners may require different levels of simulation at the same time. High fidelity is not always better than low fidelity, as this depends on the type of task and the level of learners [42,44,45].

This research will focus on low-Fidelity simulations, as they are relatively easy and less expensive to implement and transfer, which is suitable for the target group [43]. Some types of simulations used in this research are Partial Task Trainers, Role-playing, E-learning, simulation scenarios.

Simulation is used in many fields and categories, It can be employed based on the need. This research focuses on training housekeeping staff using real experiences that they face in their daily work routine, i.e., transferring objective reality to training using simulation through different stations.

This research study took the initiative to create a customized simulation-based training program in King Abdulaziz University Hospital (KAUH) targeting hospital housekeeping staff. The study focuses on the practices and roles of hospital housekeeping staff related to infection control environmental health. This paper aims to explore the effectiveness of using simulation-based training on improving the performance of housekeeping staff of KAUH in Jeddah, Saudi Arabia. Specifically, this paper investigated the following research questions.

1) How effective is simulation-based training in improving the performance of Housekeeping Staff in hospitals?
2) Will there be differences in the simulation-based training effectiveness across housekeeping staff based on their designated work area and gender?

Methods

Study protocol, training program, and participants

The experimental research design was conducted at King Abdulaziz University Hospital (KAUH) in Jeddah and led to establishing a simulation-based training program dedicated to hospital housekeeping staff under the name of (Simulation-based Training for the Hospital Housekeeping Staff).

This program was built with calibration with (Department of Infection Control and Environmental Health, Department of Housekeeping, Department of Nursing and simulation center) Where frequent meetings were held before the start of the training program to work on: the training plan, the methodology, the training content, building an integrated team that includes trainers specialized in the field, the distribution of tasks and the preparation for that was about 3 months before the start of the training program.

The training program was divided into two days for each group of participants. The program includes Five different

main training stations: Introduction and General Knowledge Assessment, Personal Protective Equipment (PPE), Hand Hygiene (HH), Biological Materials Spills (Biological Spill Kit), and Terminal Cleaning.

Training stations that include different simulation scenarios, role-playing, and training videos in the language of housekeeping staff. Also, partial task trainers are used to assisting them in practicing learned procedures and protocols.

First station: Introduction and General Knowledge Assessment

The main objective of this station was to prepare participants for the training program. Participants were given a pre-test to measure their initial knowledge regarding infection control cleaning practices and protocols, which contains illustrations that make it easier for the participants to understand and answer the test questions themselves.

After which, they were given an introductory lecture on hospital-related infection and its implications. Then, participants were divided into two separate groups and were alternating the remaining training stations (i.e., PPE, HH, BSK). Each station's trainees' performance was evaluated before and after the training using checklists. The knowledge assessment post-test was measured at the end of the training program.

Second station: personal protective equipment

In this station, participants were observed and evaluated on the correct procedure of wearing and removing PPE either on themselves or on a half-body simulator (Partial-task simulators). After completing the pre-training evaluation, an educational video(E-learning) in the housekeepers' language- and a demonstrated (scenario) explained the correct protocol in wearing and removing PPE and displaying different signs for different types of isolation rooms. One of the scenarios was about the (Contact isolation).

Where one of the team members inside the isolation room plays the role of a patient who suffers from an infectious allergy in the skin, then another one plays the role of the cleaner who wants to clean this room and is shown the correct way to put on and take off the PPE. The trainers make sure that the trainees understand the correct procedures, and then reassess the trainees to measure their competencies.

Trainers ensure that the trainees understand the proper procedures, then re-evaluate the trainees to measure their competencies.

Third station: hand hygiene

The housekeeper's knowledge of the Five Moments of hand hygiene approved by the World Health Organization is measured and evaluated in this station. Trainers evaluate each participant individually before starting the training process by filling out the trainee's relevant checklist. After completing the pre-training evaluation, two educational videos (E-learning) were played on the correct method of sterilizing and washing hands, including the five moments of hand hygiene. Trainees are re-evaluated to measure their competence in applying the knowledge gained.

Fourth station: cleaning biological materials & waste management

In this station, participants were trained to build knowledge on the different types of waste and the common mistakes in waste management and PPE to be worn when transporting waste. Specifically, participants were trained on handling needlestick/sharps and biological spills such as bloodstains.

Trainers evaluate each participant individually before starting the training process by filling out the trainee's relevant checklist. After completing the pre-training evaluation, an educational video (E-learning) is followed by a demonstration (scenario) related to biological material spills, blood. A red substance was spilled that appeared in the form of a blood stain, and the trainer played a role in cleaning this stain. Afterward, trainees' reactions were observed, and performance was measured using the relevant checklist.

Fifth station: terminal cleaning

This station focusses on the correct way to clean a patient's room, terminal cleaning.

This station was equipped as a real patient room with all the tools of the room, including equipment, furniture, and a toilet. The terminal cleaning method was used here because it differs from routine cleaning in that it is deeper and more comprehensive. Rooms must be cleaned in this way at the time of the patient's discharge. Trainees are evaluated to measure their performance by the supervisor after attending the training program while they are doing terminal cleaning.

Participants and sample size

The total number of participants who underwent the training program is 124 Housekeeping Staff from different work areas in the hospital (Basement, Emergency Room (ER), Operation Room (OR), Outpatient Department (OPD), Patient Area (PA), and Ground Floor (GF). Their experience ranges from (2—5 years) and their educational level is below average. However, since the process of development, review, and approval of all tools and checklists used in this research have not been completed simultaneously, the number of participants in each station varies. Table (1)

Table 1 Number of participants for each station.

Training Station	Participant #	Male	Female
General Knowledge Assessment	124	96	28
Hand Hygiene (HH)	124	96	28
Biological Spills	114	90	24
Personal Protective Equipment (PPE)	104	81	23
Terminal Cleaning	104	81	23

shows the numbers of Housekeeping Staff who were trained in each of the program's main stations.

Measurement instruments

The pre-training and post-training activities measures were from the instruments designed, approved, and validated by the Infection Control Unit at KAUH and have been established based on the work policies and procedures approved by the hospital that has the accreditation of the joint committees (Canadian, American). Each station, General Assessment, PPE, HH, Biological Spills, terminal cleaning, has (10, 13, 10, 7, and 13) items, respectively.

The instruments mentioned above are used twice to measure participants' performance in each station before and after the training program. For each checklist, every correct answer or performance is given one point, and the total score is calculated as the measure of each participant's performance in that specific station.

Data analysis

The study uses a paired sample approach to assess participants' mean performance pre-and post-training and detect the significance of improvements, if any. To achieve this, Paired Two Sample T-tests were used to measure the progress of mean performance of the housekeeping hospital staff. Furthermore, One-Way analysis of variance (ANOVA) was used to investigate the differences of performance improvements among groups based on work area and gender. All the analyses were performed using IBM SPSS statistics version 27 Software.

Result

The results of the training effectiveness are presented by measuring the mean test score before and after the training program. The two means are compared to find statistical differences in participants' performance in the five training stations. One-way ANOVA follows the paired sample t-test to measure the differences in performance improvements based on participants' work area and gender.

Paired sample T-test: training effectiveness

The mean test scores before and after the participants completed the simulation-based training program are compared to find the difference or correlation. Table (2) shows scores of pre-and post-training in all stations. As shown, the results showed a significant improvement in housekeeping staff' performance in all stations; for the program in general, the station for personal protective equipment (PPE), the station for hand hygiene (HH), the station for cleaning biological materials (Biological spill kit) and the station terminal cleaning. All results show a statistically significant increase in mean performance with p -value $= .000 < .05$ for the first four stations and the fifth station p-value $= .05$. Moreover, Cohen's d test was calculated to determine the effect size of the detected differences. Values of Cohen's D test were 1.78, 1.77, 1.60, 1.89 and 1.56, respectively, which are all above the threshold of significant effect, indicating practical significance along with statistical significance.

Table 2 T-Test- Paired Two Sample for Means Program results before and after the training session.

Stations	# Obs.	Pre-Test Mean	Post Test Mean	P(T ≤ t) two-tail
General Knowledge	116	7.30	9.72	.000
PPE	96	9.16	13	.000
HH	116	6.30	9.76	.000
Biological Spill Kit	106	4.25	7	.000
Terminal cleaning	104	11.5	13	.05

One-Way ANOVA: differences in training effectiveness

To verify the homogeneity/difference in the level of improvement in the mean performance of housekeeping staff based on their designated work area; Basement, Emergency Room (ER), Outpatient Department (OPD), Patient Area (PA), and Ground Floor (GF), One-Way ANOVA test was used to analyze the variation in one direction. The results of the pre/post-test showed that there is no significant difference in performance improvements and equal averages for all work areas except for the biological materials cleaning station. It was shown that there are significant statistical differences in the advancement of mean performance of training in Biological Blood Spills station between participants with P-Value $= .013$, as shown in Table (3).

To compare group means, a post hoc analysis was performed to identify the differences between work areas. The results show that the main difference in performance improvements was between participants working in the Basement and Patient Area with mean performance improvement of 3.88 and 3.21, receptively and statistically significant difference between the basement and GF and PA See Table (4).

The study also investigates the improvement of performance based on gender; Male: (96), Female: (28) to verify the homogeneity/difference in the level of improvement in the mean performance of housekeeping staff based on their gender. The ANOVA test was used to transmit variation in one direction to all stations, where the results showed no statistically significant differences in all stations and equal gender averages Table (5).

Table 3 One Way ANOVA test for Biological Blood Spill Station.

ANOVA					
DIFF	Sum of squares	DF	Mean square	F	Sig.
Between Groups	62.030	5	12.406	3.034	.013
Within Groups	441.593	108	4.089		
Total	503.623	133			

Table 4 Mean Performance Improvement based on Work Area / Tukey's HSD test for detecting significant differences between performance improvements based on Work Area.

					95% Confidence Interval for Mean		
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Basement	25	3.88	1.965	.393	3.07	4.69	0	7
ER	9	2.44	2.186	.729	.76	4.12	0	7
GF	9	1.78	2.279	.760	.03	3.53	0	7
OPD	12	2.33	1.723	.497	1.24	3.43	0	5
OR	10	3.70	2.541	.803	1.88	5.52	0	7
PA	49	2.31	1.928	.275	1.75	2.86	0	7
Total	114	2.75	2.111	.198	2.35	3.14	0	7

Tukey's HSD test for detecting significant differences between performance improvements based on Work Area

					95% Confidence Interval	
(I)Work Area	(J) Work Area	Mean Difference (I-J)	Std. Error	Sig	Lower Bound	Upper Bound
Basement	1.436	.786	.453	-.85	3.72	
	GF	2.102	.786	.089	-.18	4.38
	OPD	1.547	.710	.257	-.51	3.61
	OR	.180	.757	1.000	-2.02	2.38
	PA	1.574	.497	.024	.13	3.02

Table 5 One Way ANOVA test for gender differences.

ANOVA

Source of Variation	SS	DF	MS	F	P-Value	F crit
Between Groups	2.037	1	2.037	0.849	0.358	3.918
Within Groups	292.672	122	2.398			
Total	294.709	123				

SUMMARY

Groups	Count	Sum	Average	Variance
Female	28	62	2.214	2.470
Male	96	242	2.520	2.378

Discussion

Previous studies report that learning using simulation technology has been effective over the years in different advanced fields, including healthcare [27—34]. In line with previous studies, this study confirms the effectiveness of hospital housekeeping staff simulation-based training as the target participants answering our first research question. As demonstrated, results show improvement in the performance of housekeeping staff at King Abdulaziz University Hospital in Jeddah after training them on a specialized simulation-based program, which was established for the purpose of this research providing a new addition to the healthcare field.

Participants were also re-evaluated after 6 months to ascertain the impact of simulation-based training; The results showed that they continued to maintain their performance after a period of time.

In terms of knowledge and practices, housekeeping staff performance averages in all program stations, namely general knowledge, PPE, HH, and biological spill, terminal cleaning, increased significantly after the simulation-based training. The results, in general, are consistent with several studies. For example, in one study, simulation training improved the performance of healthcare workers on (PPE) based on a scenario of contacting COVID-19 patients [46]. Other studies demonstrated that simulation-based training improved the duration and quality of hand hygiene [47,48]. Moreover, another study demonstrated the effectiveness of simulation-based training of medical students in dealing with bleeding cases; the study results showed improvement in knowledge and skills for bleeding management, and consequently, an improvement in physicians' performance [49].

As mentioned before, the result of this research is consistent with previous findings for other healthcare workers; We add to the existing body of knowledge by finding that simulation has proven effective in significantly improving performance before and after training for the hospital housekeeping staff. This is a valuable addition in the field of health, infection control, and safety.

Another critical point of the current study, directed to answering the second research question, indicates that there is no statistically significant difference in performance improvements among staff in different work areas except for the biological spill kit station; the difference in performance improvement was substantial between housekeeping staff working in the Basement Area and those working in the Patient Area. The mean performance improvement for the basement staff is more significant than those in the patient area. This might be logical as most staff working in the basement do not get the training attention as those working in the patient area; thus, the improvement of their performance was evident. However, not having a significant difference in other stations regarding work areas is inconsistent with previous literature [50].

Similarly, in terms of gender difference in performance improvement for all stations, results indicate no significant

differences, and the averages are equal for both sexes. Although this result was not expected, it is consistent with another study that aimed to assess gender bias in simulation exercises for emergency resident physicians; the study looked at potential gender differences in performance scores and assessments of participants in both gender, and there were no differences in scores due to gender, the results indicated point out that simulation evaluation may represent a less biased method for assessing the evaluators' competency in their performance [51].

However, most studies have shown statistical gender differences in performance and/or performance improvement [52,53].

On the other hand, patients' satisfaction with the hospital's housekeeping staff was measured before and after the simulation-based training program, their satisfaction rate with the housekeeping staff (cleaners) before training was 86.8%, and after training it became 97.13%; so this is excellent result because Patients' satisfaction with the services provided is a priority for any hospital as it is one of the basic elements of quality care that is reflected through the good training of health sector workers. We also did not receive cases of needle stick injury and blood fluids for housekeeping staff after attending the training program. This reflects the positive impact of the training stations.

Overall, the results showed the positive impact and the effectiveness and efficiency of the simulation-based training program for the housekeeping staff at King Abdulaziz University Hospital in Jeddah. These results show practical implications for highlighting the importance of establishing training programs for the target group. It also has theoretical consequences in terms of extending the body of testing the effectiveness of simulation training to this group.

Conclusion and recommendation

Training using simulation technology has been effective over the years in different and advanced fields including the healthcare field and as demonstrated in this research, is effective for a different and essential category in the healthcare field namely hospital housekeeping staff. Strong attention should be placed in highlighting the importance of hospital housekeeping staff, considering that they are the most vulnerable group of the healthcare system due to a lack of awareness of correct practices associated with their tasks in hospitals. This is a global dilemma that must be considered to maintain safety. Further investigation is needed to address the effect of housekeeping staff on the rate of nosocomial infection and the relation between housekeepers' morbidity and mortality rate after raising their level of performance.

Moreover, it is necessary to reconsider the training methods used for this category to ensure that infection control protocols are practiced correctly.

Future work and recommendations from the research will concentrate on expanding the use of simulation-based training by including augmented reality, virtual reality, and gamification in educating Hospital housekeeping staff. Furthermore, it is strongly advised to establish certified training programs for housekeeping staff by a specialized accredited institution granting work license that is periodically renewed.

Authorship statement

RMB: Conceptualization, Methodology, Investigation, Data Curation, Validation, Writing - Review & Editing, Visualization, Project administration, WMQ: Writing - Original Draft, Writing - Review & Editing, Supervision, RRS: Methodology, Software, Formal analysis, Validation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Supervision, MMA: Methodology, Investigation, Approval Tools of research and approval project designed. All authors contributed to the final analysis and interpretation of the results. All authors contributed to the drafting of this manuscript and approved it for submission.

Conflict of interest

The authors declare that there is no conflict of interest.

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Provenance and peer review

Not commissioned, externally peer reviewed.

Ethical approval

This study was approved by the Unit of Biomedical Ethics Research Committee, Ethical approval No. (20—651) on 12-August 2020 issued by King Abdulaziz University Research Center in Jeddah (Institutional Review Board). The IRB approved adherence to KAU guidelines, such as keeping and using data for research purposes only.

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References

[1] Peters A, Otter J, Moldovan A, Parneix P, Voss A, Pittet D. Keeping hospitals clean and safe without breaking the bank; summary of the Healthcare Cleaning Forum 2018. Antimicrob

Resist Infect Control 2018;132:7. https://doi.org/10.1186/s13756-018-0420-3.
[2] Hall L, White NM, Allen M, Farrington A, Mitchell BG, Page K, et al. Effectiveness of a structured, framework-based approach to implementation: the researching effective approaches to cleaning in hospitals (REACH) Trial. Antimicrob Resist Infect Control 2020;35:9. https://doi.org/10.1186/s13756-020-0694-0.
[3] Pittet D, Donaldson L. Clean care is safer care: a worldwide priority. Lancet 2005;366:1246–7. https://doi.org/10.1016/S0140-6736(05)67506-X.
[4] Han JH, Sullivan N, Leas BF, Pegues DA, Kaczmarek JL, Umscheid CA. Cleaning hospital room surfaces to prevent health care–associated infections. Ann Intern Med 2015;163(8):598–607. https://doi.org/10.7326/m15-1192.
[5] Washer P, Joffe H. The "hospital superbug": social representations of MRSA. Soc Sci Med 2006;63(8):2141–52. https://doi.org/10.1016/j.socscimed.2006.05.018.
[6] Reed D, Kemmerly SA. Infection control and prevention: a review of hospital-acquired infections and the economic implications. Ochsner Journal 2009 March 20. Retrieved February 23, 2023, from https://www.ochsnerjournal.org/content/9/1/27.abstract.
[7] Alfa MJ, Lo E, Olson N, MacRae M, Buelow-Smith L. Use of a daily disinfectant cleaner instead of a daily cleaner reduced hospital-acquired infection rates. Am J Infect Control 2015;43(2):141–6. https://doi.org/10.1016/j.ajic.2014.10.016.
[8] Health Quality Ontario. Portable ultraviolet light surface-disinfecting devices for prevention of hospital-acquired infections: a health technology assessment. Ont Health Technol Assess Ser 2018 Feb 7;18(1):1–73. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5824029/. PMID: 29487629; PMCID: PMC5824029.
[9] Alamgir H, Yu S. Epidemiology of occupational injury among cleaners in the healthcare sector. Occup Med 2008;58:393–9. https://doi.org/10.1093/occmed/kqn028.
[10] Demirturk N, Demirdal T. Effect of a training program for hospital cleaning staff on prevention of hospital-acquired infection. Infect Control Hosp Epidemiol 2006;27(12):1410–2. https://doi.org/10.1086/509859.
[11] Singh V, Narula H, Supehia S, Sharma M, Gupta PK, Sharma A, Rao S. Impact of video modules-based training on knowledge, attitude, and practices of cleaning and disinfection among housekeeping staff at a tertiary care center during the COVID-19 pandemic. Cureus 2021. https://doi.org/10.7759/cureus.19125.
[12] Meyer J, Nippak P, Cumming A. An evaluation of cleaning practices at a teaching hospital. Am J Infect Control 2021;49(1):40–3. https://doi.org/10.1016/j.ajic.2020.06.187.
[13] Gomes SC, Mendonça IV, Oliveira LP, Caldas, A. de. Acidentes de Trabalho Entre Profissionais da Limpeza Hospitalar em Uma capital do Nordeste, Brasil. Ciência & Saúde Coletiva 2019;24(11):4123–32. https://doi.org/10.1590/1413-812320182411.26752017.
[14] Saadeh R, Khairallah K, Abozeid H, Al Rashdan L, Alfaqih M, Alkhatatbeh O. Needle stick and sharp injuries among healthcare workers: a retrospective Six-year study. Sultan Qaboos Univ Med J [SQUMJ] 2020;20(1):54. https://doi.org/10.18295/squmj.2020.20.01.008.
[15] Ramphal L, Suzuki S, Mccracken IM, Addai A. Improving hospital staff compliance with environmental cleaning behavior. Baylor University Medical Center Proceedings 2014;27(2):88–91. https://doi.org/10.1080/08998280.2014.11929065.
[16] Mitchell R, Roth V, Gravel D, Astrakianakis G, Bryce E, Forgie S, et al. Are health care workers protected? An observational study of selection and removal of personal protective equipment in Canadian acute care hospitals. Am J Infect Control 2013;41(3):240–4. https://doi.org/10.1016/j.ajic.2012.04.332.
[17] Sendall M, McCosker L, Halton K. Cleaning staff's attitudes about hand hygiene in a Metropolitan Hospital in Australia: a qualitative study. Int J Environ Res Publ Health 2019;16(6):1067. https://doi.org/10.3390/ijerph16061067.
[18] Nouetchognou JS, Ateudjieu J, Jemea B, Mbanya D. Accidental exposures to blood and body fluids among health care workers in a Referral Hospital of Cameroon. BMC Res Notes 2016;9(1). https://doi.org/10.1186/s13104-016-1923-8.
[19] Meunier O, Fersing T, Burger S, Santasouk J. Biocleaning in operating theatres: Validation of cleaning techniques by revealing residual traces of blood. J Hosp Infect 2022;121:32–8. https://doi.org/10.1016/j.jhin.2021.11.023.
[20] Lateef A. Exposure to sharp injuries among hospital medical waste handlers. Toxicology Communications 2022;4(3):12. https://doi.org/10.53388/20220202012.
[21] Kandeel A, El-Gilany A-H. Needlestick and sharp injuries (NSSIs) among housekeepers in a Saudi hospital: an intervention study. Int J Infect Control 2017;13(i1). https://www.ijic.info/article/view/17329.
[22] Cleaning & disinfection. Cleaning & disinfection | PHA infection control. Retrieved January 28, 2023, from, https://www.niinfectioncontrolmanual.net/cleaning-disinfection#:~:text=Terminal%20cleaning%20is%20the%20thorough,or%20increased%20incidence%20of%20infection.
[23] The society for simulation in healthcare. 2019. https://www.ssih.org/About-SSH/About-Simulation.
[24] Al-Elq AH. Simulation-based medical teaching and learning. J Fam Community Med 2010 Jan;17(1):35–40. https://doi.org/10.4103/1319-1683.68787. https://pubmed.ncbi.nlm.nih.gov/22022669/. PMID: 22022669; PMCID: PMC3195067.
[25] Alanazi A, Nicholson N, Thomas S. The use of simulation training to improve knowledge, skills, and confidence among healthcare students: a systematic review. IJAHSP 2017. https://doi.org/10.46743/1540-580X/2017.1666.
[26] Harder BN. Use of simulation in teaching and learning in Health Sciences: a Systematic Review. J Nurs Educ 2010;49(1):23–8. https://doi.org/10.3928/01484834-20090828-08.
[27] Beal MD, Kinnear J, Anderson CR, Martin TD, Wamboldt R, Hooper L. The effectiveness of medical simulation in teaching medical students critical care medicine. Simulation in healthcare: J Soc Simu Healthc 2017;12(2):104–16. https://doi.org/10.1097/sih.0000000000000189.
[28] Paskins Z, Peile E. Final year medical students' views on simulation-based teaching: a comparison with the Best Evidence Medical Education Systematic Review. Med Teach 2010;32(7):569–77. https://doi.org/10.3109/01421590903544710.
[29] Green R, Curry N. Simulation training improves clinical knowledge of major hemorrhage management in foundation year doctors: simulation improves major hemorrhage knowledge. Transfusion Med 2014;24:379–84. https://doi.org/10.1111/tme.12161.
[30] Marker S, Mohr M, Østergaard D. Simulation-based training of junior doctors in handling critically ill patients facilitates the transition to clinical practice: an interview study. BMC Med Educ 2019;19:11. https://doi.org/10.1186/s12909-018-1447-0.
[31] Awad MS, Abdullah MK, Ibrahim RH, Abdulla RK. Nursing students' attitudes toward simulation technology in nursing education. J Emerg Technol Learn 2019;14:31. https://doi.org/10.3991/ijet.v14i14.10571.
[32] Cant Robyn P, Cooper Simon J. Simulation-based learning in nurse education: systematic review. J Adv Nurs 2009;66(1):3–15. https://doi.org/10.1111/j.1365-2648.2009.05240.x.
[33] Lin K, Travlos DV, Wadelin JW, Vlasses PH. Simulation and introductory pharmacy practice experiences. Am J Pharmaceut Educ 2011;75(10):209. https://doi.org/10.5688/ajpe7510209.
[34] Shaikh H, Crowl AN, Shrader S, Burkhardt CDO. Assessing self-perceived interprofessional collaborative competency on advanced pharmacy practice experiences through

interprofessional simulations. AJPE 2020;84:7530. https://doi.org/10.5688/ajpe7530.
[35] High fidelity manikins. Renaissance School of Medicine at Stony Brook University. (n.d.). Retrieved December 24, 2022, from https://renaissance.stonybrookmedicine.edu/csc/services/manikinsim.
[36] Partial Task Trainers. Partial Task Trainers - Eastern Virginia Medical School (EVMS), Norfolk, Hampton Roads. (n.d.). Retrieved December 24, 2022, from, https://www.evms.edu/community/community_training/sentara_center_for_simulation_immersive_learning_a/capabilities/partial_task_trainers/.
[37] McMacken M. Standardized patient program. Maryland: Johns Hopkins Medicine, based in Baltimore; 2018, October 17. Retrieved December 24, 2022, from, https://www.hopkinsmedicine.org/simulation-center/training/.
[38] Virtual reality | IEEE Journals & Magazine | IEEE Xplore. Retrieved December 24, 2022, from, https://ieeexplore.ieee.org/abstract/document/666641.
[39] Simulation scenarios. Simulation Scenarios | The Faculty of Intensive Care Medicine. Retrieved December 24, 2022, from, https://www.ficm.ac.uk/simulation-scenarios.
[40] Types of simulation in nursing education. NurseJournal 2022, November 15. Retrieved December 17, 2022, from, https://nursejournal.org/resources/types-of-simulation-in-nursing-education/.
[41] Nathan Costiuc - Nathan Costiuc. What is Fidelity in clinical simulation? HealthySimulation.com. 2021, March 2. Retrieved September 30, 2022, from, https://www.healthysimulation.com/30181/what-is-fidelity-in-simulation/.
[42] Munshi F, Lababidi H, Alyousef S. Low- versus high-fidelity simulations in teaching and assessing clinical skills. J Taibah Univ Med Sci 2015;10(1):12—5. https://doi.org/10.1016/j.jtumed.2015.01.008.
[43] HealthLeaders. The many forms of simulation training. HealthLeaders Media; 2009. https://www.healthleadersmedia.com/nursing/many-forms-simulation-training.
[44] Lefor AK, Harada K, Kawahira H, Mitsuishi M. The effect of simulator fidelity on procedure skill training: a literature review. Int J Med Educ 2020;11:97—106. https://doi.org/10.5116/ijme.5ea6.ae73.
[45] Motola I, Devine LA, Chung HS, Sullivan JE, Issenberg SB. Simulation in healthcare education: a best evidence practical guide. Amee Guide no. 82. Med Teach 2013;35(10). https://doi.org/10.3109/0142159x.2013.818632.
[46] Maheu-Cadotte M-A, Lapierre A, Fontaine G. Effect of Simulation-Based Education on the Preparedness of Healthcare Professionals for the COVID-19 Pandemic: a systematic review and meta-analysis n.d.:23. https://www.erudit.org/en/journals/snahp/2021-v4-n1-snahp06099/1077986ar/.
[47] Ghazali AD, Deilhes E, Thomas J, Laland C, Thévenot S, Richer JP, et al. Impact of simulation-based training in hand hygiene with alcohol-based hand rub in emergency departments. Infect Control Hosp Epidemiol 2018;39:1347—52. https://doi.org/10.1017/ice.2018.229.
[48] Martos-Cabrera MB, Mota-Romero E, Martos-García R, Gómez-Urquiza JL, Suleiman-Martos N, Albendín-García L, Cañadas-De la Fuente GA. Hand hygiene teaching strategies among nursing staff: a systematic review. Int J Environ Res Publ Health 2019;16(17):3039. https://doi.org/10.3390/ijerph16173039.
[49] Green R, Curry N. Simulation training improves clinical knowledge of major haemorrhage management in Foundation Year Doctors. Transfus Med 2014;24(6):379—84. https://doi.org/10.1111/tme.12161.
[50] Singer SJ, Gaba DM, Falwell A, Lin S, Hayes J, Baker L, et al. Patient safety climate in 92 US hospitals. Med Care 2009;47(1):23—31. https://doi.org/10.1097/mlr.0b013e31817e189d.
[51] Siegelman JN, Lall M, Lee L, Moran TP, Wallenstein J, Shah B. Gender bias in simulation-based assessments of emergency medicine residents. J Grad Med Educ 2018;10:411—5. https://doi.org/10.4300/JGME-D-18-00059.1.
[52] Ritter EM, Lineberry M, Hashimoto DA, Gee D, Guzzetta AA, Scott DJ, Gardner AK. Simulation-based mastery learning significantly reduces gender differences on the fundamentals of Endoscopic Surgery Performance Exam. Surg Endosc 2018;32(12):5006—11. https://doi.org/10.1007/s00464-018-6313-y.
[53] Thorson CM, Kelly JP, Forse RA, Turaga KK. Can We continue to Ignore gender differences in performance on simulation trainers? J Laparoendosc Adv Surg Tech 2011;21:329—33. https://doi.org/10.1089/lap.2010.0368.