The Effect of Video-Assisted Training and Visual Feedback With UV Germ Technology on Nursing Students' Hand Hygiene Beliefs, Practices, and Compliance

A Randomized Controlled Study

Gülten Karahan Okuroğlu, PhD; Aynur Kaynar Şimşek, PhD; Nazlı Pazar, RN; Şule Ecevit Alpar, PhD

Downloaded from http://journals.lww.com/jncqjournal by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 08/23/2023

ABSTRACT

Background: Hand hygiene (HH) is the most effective way to prevent health care–associated infections; however, HH compliance rates continue to be suboptimal.

Purpose: To determine the effectiveness of video-assisted training and visual feedback with ultraviolet (UV) germ technology on nursing students' HH beliefs, practices, and compliance.

Methods: This study used a double-blind, posttest randomized controlled design. The experimental group received training, visual feedback with UV germ technology, and instructional videos.

Results: A total of 46 students were included in the study (experimental 21 and control 25). The mean score of the HH skills checklist of the experimental group was significantly higher than that of the control group ($P = .0001$). The HH compliance rate was also higher in the experimental group (52.62%) compared with the control group (39.1%).

Conclusions: The training, visual feedback with UV germ technology, and instructional videos increased HH compliance rates in nursing students.

Keywords: education, hand hygiene, health care–associated infections, nursing

Author Affiliations: *Department of Nursing, Faculty of Health Sciences, Marmara University, Istanbul, Turkey (Drs Karahan Okuroğlu, Kaynar Şimşek and Ecevit Alpar); and Marmara University Pendik Education and Research Hospital, Istanbul, Turkey (Ms Pazar).*

This research was supported by the Marmara University Scientific Research Projects Coordination Unit (Project No. SAG-A-110718-0428).

We thank all the nursing students who participated to the study.

Some of the study results were presented as an oral presentation at the 5th National 1st International Basic Nursing Care Congress (December 6-8, 2019, Antalya, Turkey).

The authors declare no conflict of interest.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.jncqjournal.com).

Correspondence: *Gülten Karahan Okuroğlu, PhD, Associate Professor, Department of Nursing, Faculty of Health Sciences, Marmara University, Istanbul, Turkey (gulten.karahan@marmara.edu.tr).*

Accepted for publication: March 1, 2023

Early Access: March 22, 2023

DOI: 10.1097/NCQ.0000000000000710

Health care–associated infections (HCAIs) occur in the hospital setting by microorganisms transmitted through the hands of health care professionals due to a lack of appropriate hand hygiene (HH) practices.[1-3] The importance of HH in protecting against infectious diseases was once again understood in the COVID-19 pandemic period. The World Health Organization (WHO) estimated that HCAIs affect hundreds of millions of people worldwide and are a major global issue for patient safety.[4] HCAIs can increase the patient's risk of morbidity and mortality, slow down the healing process, and increase health care costs.[5,6]

HH is the most effective and inexpensive method to prevent HCAIs.[8-12] Although the importance of HH is well understood, compliance rates continue to be suboptimal. Observational studies have examined HH rates of health care workers in hospitals and found that compliance scores vary between 40% and 78%.[13-17]

Copyright © 2023 Wolters Kluwer Health, Inc. Unauthorized reproduction of this article is prohibited.

Downloaded from http://journals.lww.com/jncqjournal by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 08/23/2023

Education constitutes the most critical step among strategies aiming to increase HH compliance. However, HH compliance is a complex issue, and is affected by the knowledge, attitude, beliefs, and perceptions of the individual.[1,2]

Studies have shown the WHO 5 moments for HH strategy can significantly improve compliance and knowledge of health care workers regarding HH practices.[7,18,19] The WHO recommends a multimodal strategy to improve HH compliance, including training, education, monitoring, feedback, and visual reminders.[20,21] Including HH training during undergraduate nursing education affects student nurses' knowledge, attitudes, beliefs, and perceptions about HH and contributes to high HH compliance.[22-24] Health care workers and students need repeated support with various methods and techniques from training sessions on HH practices to improve knowledge and practices to reduce HCAIs.[7,25,26] Changes in information and communication technologies offer various opportunities in creating effective learning environments. Effective educational materials are created using information and communication technologies such as animation, simulation, video, multimedia, and hypermedia. There are many studies showing the effects of these technologies on teaching and learning in nursing.[27-30] Also, electronic devices have been used in learning HH practices, and they have been shown to be a practical option due its ease of use.[16,31,32] HH training kits containing ultraviolet (UV) technology are one such device. Studies show that using UV technology with a black light to show inadequate HH is an effective training method to improve HH compliance.[33] This study aimed to determine the effectiveness of video-assisted training and visual feedback with UV germ technology on nursing students' HH beliefs, practices, and compliance.

METHODS

Study design, setting, and sample

This study applied a double-blind, posttest randomized controlled design. The study was conducted with first-year nursing students who performed clinical practice for the first time in a public university in Istanbul between July 11, 2018, and July 1, 2020. Power analysis was performed using the G-Power 3.1 software program ($\alpha = .05$, effect size $d = 0.8$).[33] Accordingly, the minimum sample size for each group was calculated as 34 for 0.90 $(1 - \beta)$ power. Observational data were obtained in a public hospital in Istanbul. The results of the study could be affected by physical conditions and institutional differences in hospitals. For this reason, 54 students who performed clinical practice in the same hospital were invited to participate in the study; 4 students did not agree to participate in the study. Randomization was made by assigning numbers to the students and selecting them from a table of random numbers. Two students from the experimental group were excluded from the study because they did not continue the clinical practice. One student left the study due to health reasons, and 1 student without giving a reason. The study was completed with 21 students in the experimental group and 25 students in the control group. After the study was completed, the post hoc power analysis was calculated and found to be 0.79 $(1 - \beta)$ (significance level $\alpha = 0.05$, effect size $d = 0.8$).

Instruments

Demographic data were collected from a characteristics form, which included 5 questions about students' sociodemographic features. Students were also asked about their beliefs regarding the importance of HH, rated on a numerical scale from 1 (not at all important) to 10 (extremely important). Other data collection tools are presented next.

Hand Hygiene Belief Scale

The Hand Hygiene Belief Scale (HHBS) developed by van de Mortel[34] was translated into Turkish by Karadağ et al.[2] The scale consists of 22 items using a 5-point Likert-type rating (1 = strongly disagree to 5 = strongly agree). Higher scores indicate higher beliefs on the importance of HH. The Cronbach α value was 0.76. The minimum score obtained from the scale is 22, and the maximum score is 120.[2] The Cronbach α coefficient was 0.81 in this study.

Hand Hygiene Practice Inventory

The Hand Hygiene Practice Inventory (HHPI) was developed by van de Mortel[34] and was adapted into Turkish by Karadağ et al.[2] The scale includes statements regarding the frequency of HH practices using a 5-point Likert scale (1 = never to 5 = always). The minimum score that can be obtained from the scale is 14, and the maximum score is 70. The Cronbach α value of the scale was reported as 0.82.[2] The Cronbach α coefficient was 0.84 in this study.

Copyright © 2023 Wolters Kluwer Health, Inc. Unauthorized reproduction of this article is prohibited.

Downloaded from http://journals.lww.com/jncqjournal by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 08/23/2023

Hand Hygiene Skill Checklist

The Hand Hygiene Skill Checklist (HHSC) is a tool that was organized according to the WHO HH guide.[4] Hand hygiene skill was defined as "hand rubbing with antiseptic" and included 9 steps, with scores ranging from 0 to 18 (0 = not done, 1 = needs improvement, and 2 = done well). Interobserver consistency was calculated with the Pearson correlation test, and was found to be high ($r = 0.925$; $P = .000$).

Hand Hygiene Compliance Observation Tool

The Hand Hygiene Compliance Observation Tool (HHCOT) was prepared according to the WHO guide by the authors.[4] For assessing HH compliance, HH opportunities and actions were observed and recorded. The opportunities for HH are those defined by the WHO.[4] The HH compliance rate was calculated by dividing the number of actions by the number of opportunities.

Interventions

Hand hygiene training kit

Using invisible UV germ technology, this handwashing education kit helps provide a visual demonstration of effective HH. The kit contains a UV light and germ lotion, and is used in a dim environment with reduced light. The lotion simulates germs on an individual's hands, and glows bright green under a black light. When an individual correctly performs HH, these areas do not glow, thus providing immediate visual feedback on whether or not they are appropriately performing HH (see Supplemental Digital Content Figure 1, available at: http://links.lww.com/JNCQ/B102).

Hand hygiene instructional videos

The researchers worked with a professional production team to develop HH instructional videos. A total of 6 instructional videos were made, 1 video for each of the WHO 5 moments of HH, and 1 video for appropriate HH techniques.

Study process

Students in the control group were given a 2 hour, face-to-face theoretical lecture about HH. Students demonstrated HH skills in the skills laboratory for 2 hours; their technique was evaluated with a checklist (posttest). Then, control group students were observed in clinical practice for 2 weeks to evaluate HH compliance. The observations were made double-blind by 2 observers, 1 researcher (infection control nurse) and 1 independent (was educated by infection control nurses). Each student was observed for 20 minutes using the HHCOT (posttest). The observers informed the students that they would be observed regarding their HH practices, but the observers were not introduced to them. Finally, students completed the HHBS and HHPI (posttest).

After data from the control group were collected, the intervention process of the experimental group was started. The experimental group was given 2 hours of theoretical and 2 hours of laboratory practice similar to the control group. Different from the control group, 2 additional interventions were implemented (*HH training kit* and *HH instructional videos*).

Students in the experimental group used the HH training kit with UV germ technology until they performed HH correctly. HH skill performance was evaluated with the HHSC (posttest). The HH instructional videos were continuously shown on LED screens placed in the school corridors for 2 weeks. Following this, students in the experimental group were observed in clinical practice for 2 weeks. Each student was observed for 20 minutes using the HHCOT (posttest). Finally, students completed the HHBS and HHPI. The study flow is shown in Supplemental Digital Content Figure 2 (available at: http://links.lww.com/JNCQ/B103).

Data analysis

The Statistical Package for the Social Sciences program (IBM Corporation, Armonk, New York) was used for data analysis. Data were assessed using the Mann-Whitney *U* test, Spearman test, and descriptive statistics, including percentage, frequency, median, mean, and standard deviation. All the results were considered significant at $P < .05$ and a confidence interval of 95%.

Ethical considerations

This study was approved by the authors' institutional ethical review boards (approval No. 09.2018.320). Consent was obtained from the students who participated in the study. Permission was obtained from the school and hospital administrations where the study was conducted. The necessary permission was

Copyright © 2023 Wolters Kluwer Health, Inc. Unauthorized reproduction of this article is prohibited.

obtained from the authors for the scales used in the study.

RESULTS

The mean age of students in the experimental group was 19.09 (SD = 1.51) years and 61.9% (n = 13) were female. The mean age of students in the control group was 19.28 (SD = 1.38) years and 72% (n = 18) were female. For the location of clinical practice, students practiced in the internal medicine clinics (48%, n = 12 control; 42.9%, n = 9 experimental group) or the surgical clinics (52%, n = 13 control; 57.1%, n = 12 experimental group).

There was no significant difference between the control group (mean = 9.2, SD = 1.35) and the experimental group (mean = 9.14, SD = 1.15) related to their beliefs on the importance of HH ($P = .591$). For the HHBS, there was no significant difference in mean scores between the control group (mean = 84, SD = 5.09) and the experimental group (mean = 85.42, SD = 6.29; $P = .365$) or the HHPI (experimental mean = 67, SD = 3.91; control mean = 66.16, SD = 4.16; $P = .324$). The HHSC's mean score was significantly higher for the experimental group (mean = 12.61, SD = 2.80) compared with the control group (mean = 6.64, SD = 2.37; $P = .0001$). During the 2-week observation period, HH compliance was 52.2% (59/112) for the experimental group and 39.1% (36/92) for the control group.

DISCUSSION

This study found no significant differences between the mean scores of the HHBS, HHPI, or the nursing students' beliefs on the importance of HH. The average HHSC score of the experimental group was significantly higher than that of the control group. These findings show that students in both groups had similar levels of knowledge and beliefs about HH; however, those in the experimental group had higher scores on the HHSC and HH compliance. Similarly, in the study where Konicki and Miller[35] examined the effect of video training on HH, there was no difference between the 2 groups in terms of HH knowledge scores. Believing in the importance and necessity of HH is known to affect HH behavior. In this study, the lack of difference between the experimental and control groups between the HH belief scores showed that traditional teaching methods effectively strengthened students' HH beliefs. Still, traditional teaching was insufficient in increasing HH skills and compliance. Fishbein et al[36] emphasized that traditional learning methods are insufficient in developing and maintaining HH behaviors in the long term.

Conversely, it was seen that the experimental group had a higher HH skills checklist score than the control group. Although there is a direct relationship between the level of knowledge and skill competence,[37,38] this finding shows that even though students had a high level of knowledge and beliefs about HH, they did not appropriately apply this skill. This study showed that use of HH training devices, such as UV germ technology, can improve HH technique and compliance of nursing students. The HH training device used in this study provided visual feedback by showing the noncompliant areas with UV rays after HH. Thus, the students improved their HH skills by repeating the process until they fully implemented HH. Other literature also shows the effectiveness of HH education devices and tools.[33,39-42]

In this study, the HH compliance rate was 52.2% in the experimental group and 39.1% in the control group. Observational studies have examined HH compliance rates of health care workers and found that compliance scores vary between 40% and 78%.[15,16,43] Conversely, the higher HH compliance rate in the experimental group supports the effectiveness of the interventions used in this study. Our findings are similar to previous research that found improvements in HH compliance rates of nurses after using educational videos, visual feedback, and electronic reminders.[44-46]

Results of this study showed that visual feedback through UV technology was not superior to traditional learning methods in increasing nursing students' HH beliefs and knowledge. However, it was successful in improving HH skills and compliance. This finding suggests that observational data might be more realistic than data obtained based on students' self-reports. Nematian et al[17] found a difference between nurses' self-reported HH compliance levels and observed HH compliance rates.

While the students gain theoretical knowledge in education, discrepancies between theory and practice may become apparent during clinical training. In this study, it was thought that the preparation of the educational videos for HH

Downloaded from http://journals.lww.com/jncqjournal by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 08/23/2023

Copyright © 2023 Wolters Kluwer Health, Inc. Unauthorized reproduction of this article is prohibited.

indications with realistic scenarios was effective in increasing the HH compliance of the students. Also, broadcasting the videos on the LED screens placed in the school corridors, and thus the continuous exposure of the students to these videos, may have strengthened their visual memory regarding HH.

Interventions used in this study, including the HH training kit containing UV germ technology and educational videos, could be extended to training practicing nurses. In addition, it is recommended that managers and nurse educators integrate these interventions into nursing orientation, and through ongoing education. This could help to improve HH compliance rates of nurses in the clinical setting.

Limitations

One of the limitations of this study is that the HH skill in handwashing with soap and water was not evaluated. The duration of clinical observation was limited due to the clinical practice time of the students. Therefore, this study did not examine whether the improvement in students' HH skills translates into long-term behavioral changes. This research was conducted with the students of a nursing school in Istanbul.

CONCLUSIONS

Appropriate HH can improve patient outcomes; however, compliance with this important practice is suboptimal. We found that using an HH training kit containing UV germ technology, along with educational videos, improved nursing students' HH skills and compliance rates. Other schools of nursing, along with hospitals, should consider implementing similar interventions to improve HH compliance rates.

REFERENCES

1. Labrague LJ, McEnroe-Petitte DM, Van de Mortel T, Nasirudeen AMA. A systematic review on hand hygiene knowledge and compliance in student nurses. *Int Nurs Rev*. 2018;65(3):336-348. doi:10.1111/inr.12410
2. Karadağ M, Yıldırım Y, İşeri ÖP. Validity and reliability of the Hand Hygiene Belief Scale and Hand Hygiene Practices Inventory. *Cukurova Med J*. 2016;41(2):271-284. doi:10.17826/cutf.237742
3. Giammanco A, Calà C, Fasciana T, Dowzicky MJ. Global assessment of the activity of tigecycline against multidrug-resistant gram-negative pathogens between 2004 and 2014 as part of the tigecycline evaluation and surveillance trial. *mSphere*. 2017;2(1):e00310-16. doi:10.1128/mSphere.00310-16
4. World Health Organization. Guidelines on Hand Hygiene in Health Care. Published 2009. Accessed June 12, 2021. https://apps.who.int/iris/bitstream/handle/10665/44102/9789241597906_eng.pdf?sequence=1
5. Yallew WW, Kumie A, Yehuala FM. Risk factors for hospital-acquired infections in teaching hospitals of Amhara regional state, Ethiopia: a matched-case control study. *PLoS One*. 2017;12(7):e0181145. doi:10.1371/journal.pone.0181145
6. Shobowale EO, Adegunle B, Onyedibe K. An assessment of hand hygiene practices of healthcare worker of a semi-urban teaching hospital using the five moments of hand hygiene. *Niger Med J*. 2016;57(3):150. doi: 10.4103/0300-1652.184058
7. Buković E, Kurtović B, Rotim C, Sviračević V, Friganović A, Važanić D. Compliance with hand hygiene among healthcare workers in preventing healthcare associated infections—a systematic review. *J Appl Health Sci*. 2021;7(1):57-69. doi:10.24141/1/7/1/6
8. Vermeil T, Peters A, Kilpatrick C, Pires D, Allegranzi B, Pittet D. Hand hygiene in hospitals: anatomy of a revolution. *J Hosp Infect*. 2019;101(4):383-392. doi:10.1016/j.jhin.2018.09.003
9. Ben Fredj S, Ben Cheikh A, Bhiri S, et al. Multimodal intervention program to improve hand hygiene compliance: effectiveness and challenges. *J Egypt Public Health Assoc*. 2020;95(1):11. doi:10.1186/s42506-020-00039-w
10. Pittet D, Allegranzi B, Boyce J. World Health Organization world alliance for patient safety first global patient safety challenge core group of experts. The World Health Organization guidelines on hand hygiene in health care and their consensus recommendations. *Infect Control Hosp Epidemiol*. 2009;30(7):611-622. doi:10.1086/600379
11. Cruz JP, Bashtawi MA. Predictors of hand hygiene practice among Saudi nursing students: a cross-sectional self-reported study. *J Infect Public Health*. 2016;9(4):485-493. doi:10.1016/j.jiph.2015.11.010
12. Rangappa P. Ignaz Semmelweis—hand washing pioneer. *J Assoc Physicians India*. 2015;63(3):56-57.
13. Jones D, Martello M, Biron A, Lavoie-Tremblay M. A systematic review on the effectiveness of interventions to improve hand hygiene compliance of nurses in the hospital setting. *J Nurs Scholarsh*. 2017;49(2):143-152. doi:10.1111/jnu.12274
14. Kolola T, Gezahegn T. A twenty-four-hour observational study of hand hygiene compliance among health-care workers in Debre Berhan referral hospital, Ethiopia. *Antimicrob Resist Infect Control*. 2017;6:109. doi: 10.1186/s13756-017-0268-y
15. Scheithauer S, Lemmen SW. How can compliance with hand hygiene be improved in specialized areas of a university hospital? *J Hosp Infect*. 2013;83:17-22. doi:10.1016/S0195-6701(13)60005-5
16. Sunkesula VC, Meranda D, Kundrapu S, et al. Comparison of hand hygiene monitoring using the 5 moments for hand hygiene method versus a wash in–wash out method. *Am J Infect Control*. 2015;43(1):16-19. doi:10.1016/j.ajic.2014.10.003
17. Nematian SSS, Palenik CJ, Mirmasoudi SK, Hatam N, Askarian M. Comparing knowledge and self-reported hand hygiene practices with direct observation among Iranian hospital nurses. *Am J Infect Control*. 2017;45(6):e65-e67. doi:10.1016/j.ajic.2017.03.007
18. Laskar AM, Deepashree R, Bhat P, et al. A multimodal intervention to improve hand hygiene compliance in a tertiary care center. *Am J Infect Control*. 2018;46(7):775-780. doi:10.1016/j.ajic.2017.12.017
19. Staines A, Vanderavero P, Duvillard B, Deriaz P, Erard P, Kundig F. Sustained improvement in hand hygiene compliance using a multi-modal improvement programme at a Swiss multi-site regional hospital. *J Hosp Infect*. 2018;100(2):176-182. doi:10.1016/j.jhin.2018.04.010

Downloaded from http://journals.lww.com/jncqjournal by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 08/23/2023

Copyright © 2023 Wolters Kluwer Health, Inc. Unauthorized reproduction of this article is prohibited.

Downloaded from http://journals.lww.com/jncqjournal by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 08/23/2023

20. Allegranzi B, Gayet-Ageron A, Damani N, et al. Global implementation of WHO's multimodal strategy for improvement of hand hygiene: a quasi-experimental study. *Lancet Infect Dis*. 2013;13(10):843-851. doi:10.1016/S1473-3099(13)70163-4
21. Lambe KA, Lydon S, Madden C, et al. Hand hygiene compliance in the ICU: a systematic review. *Crit Care Med*. 2019;47(9):1251-1257. doi:10.1097/CCM.0000000000003868
22. Valim MD, Rocha ILDS, Souza TPM, et al. Efficacy of the multimodal strategy for hand hygiene compliance: an integrative review. *Rev Bras Enferm*. 2019;72(2):552-565. doi:10.1590/0034-7167-2018-0584
23. Sundal JS, Aune AG, Storvig E, Aasland JK, Fjeldsæter KL, Torjuul K. The hand hygiene compliance of student nurses during clinical placements. *J Clin Nurs*. 2017;26(23-24):4646-4653. doi:10.1111/jocn.13811
24. Cambil Martin J, Fernández Prada M, González Cabrera J, et al. Comparison of knowledge, attitudes and hand hygiene behavioral intention in medical and nursing students. *J Prev Med Hyg*. 2020;61(1):E9-E14. doi:10.15167/2421-4248/jpmh2020.61.1.741
25. Maheshwari V. A study to assess knowledge and attitude regarding hand hygiene amongst residents and nursing staff in a tertiary health care setting of Bhopal City. *J Clin Diagn Res*. 2014;8(8):DC04-7. doi:10.7860/JCDR/2014/8510.4696
26. Alshehari AA, Park S, Rashid H. Strategies to improve hand hygiene compliance among healthcare workers in adult intensive care units: a mini systematic review. *J Hosp Infect*. 2018;100(2):152-158. doi:10.1016/j.jhin.2018.03.013
27. Horiuchi S, Yaju Y, Koyo M, Sakyo Y, Nakayama K. Evaluation of a web-based graduate continuing nursing education program in Japan: a randomized controlled trial. *Nurse Educ Today*. 2009;29(2):140-149. doi:10.1016/j.nedt.2008.08.009
28. Kaveevivitchai C, Chuengkriankrai B, Luecha Y, Thanooruk R, Panijpan B, Ruenwongsa P. Enhancing nursing students' skills in vital signs assessment by using multimedia computer-assisted learning with integrated content of anatomy and physiology. *Nurse Educ Today*. 2009;29(1):65-72. doi:10.1016/j.nedt.2008.06.010
29. Ward R, Sales R. Online multimedia delivery of the European Union directive within adult nursing education. *Nurse Educ Today*. 2009;29(3):301-309. doi:10.1016/j.nedt.2008.11.017
30. Karadag A, Caliskan N, Korkut H, Baykara ZG, Ozturk D. The effect of simulation training on the learning of some psychomotor skills by first year nursing students: the case of Turkey. *Procedia Soc Behav Sci*. 2012;47:781-785. doi:10.1016/j.sbspro.2012.06.734
31. Kwok YLA, Callard M, McLaws ML. An automated hand hygiene training system improves hand hygiene technique but not compliance. *Am J Infect Control*. 2015;43(8):821-825. doi: 10.1016/j.ajic.2015.04.201
32. Pellowe C, Adams J, Elliott S, Murrell K, Cox D. The use of an e-learning infection prevention programme in the preregistration nursing curriculum. *J Infect Prev*. 2010;11:55-57. doi:10.1177/1757177410362498
33. Kısacık ÖG, Ciğerci Y, Güneş Ü. Impact of the fluorescent concretization intervention on effectiveness of hand hygiene in nursing students: a randomized controlled study. *Nurse Educ Today*. 2021;97:104719. doi:10.1016/j.nedt.2020.104719
34. Van de Mortel TF. Development of a questionnaire to assess health care students? hand hygiene knowledge, beliefs and practices. *Aust J Adv Nurs*. 2009;26(3):9-16.
35. Konicki T, Miller E. Use of a simulation intervention to examine differences in nursing students' hand hygiene knowledge, beliefs, and behaviors. *Nurse Educ Today*. 2016;45:96-101. doi:10.1016/j.nedt.2016.06.022
36. Fishbein AB, Tellez I, Lin H, Sullivan C, Groll ME. Glow gel hand washing in the waiting room: a novel approach to improving hand hygiene education. *Infect Control Hosp Epidemiol*. 2017;32(7):661-666. doi:10.1086/660359
37. Arias AV, Garcell HG, Ochoa YR, Arias KF, Miranda FR. Assessment of hand hygiene techniques using the World Health Organization's six steps. *J Infect Public Health*. 2016;9(3):366-369. doi:10.1016/j.jiph.2015.11.006
38. Škodová M, Gimeno-Benítex A, Martínez-Redondo E, et al. Hand hygiene technique quality evaluation in nursing and medicine students of two academic courses [In English, Portuguese, Spanish]. *Rev Lat Am Enfermagem*. 2015;23(4):708-717. doi:10.1590/0104-1169.0459.2607
39. Öncü E, Vayısoğlu SK, Lafcı D, Yıldız E. An evaluation of the effectiveness of nursing students' hand hygiene compliance: a cross-sectional study. *Nurse Educ Today*. 2018;65:218-224. doi:10.1016/j.nedt.2018.02.027
40. Higgins A, Hannan MM. Improved hand hygiene technique and compliance in healthcare workers using gaming technology. *J Hosp Infect*. 2013;84(1):32-37. doi:10.1016/j.jhin.2013.02.004
41. Suen LK, Wong JW, Lo KY, Lai TK. The use of hand scanner to enhance hand hygiene practice among nursing students: a single-blinded feasibility study. *Nurse Educ Today*. 2019;76:137-147. doi:10.1016/j.nedt.2019.01.013
42. Price L, Melone L, Cutajar E, et al. Investigating the effect of preparation for and participation in a hand-sanitizing relay on nursing students' ability to recall the WHO 6-step hand hygiene technique. *Am J Infect Control*. 2018;46(11):1304-1306. doi:10.1016/j.ajic.2018.04.222
43. Randle J, Firth J, Vaughan N. An observational study of hand hygiene compliance in paediatric wards. *J Clin Nurs*. 2013;22(17-18):2586-2592. doi:10.1111/j.1365-2702.2012.04103.x
44. Salmon S, Wang XB, Seetoh T, Lee SY, Fisher DA. A novel approach to improve hand hygiene compliance of student nurses. *Antimicrob Resist Infect Control*. 2013;2(1):16. doi:10.1186/2047-2994-2-16
45. Radhakrishna K, Waghmare A, Ekstrand M, et al. Real-time feedback for improving compliance to hand sanitization among healthcare workers in an open layout ICU using radiofrequency identification. *J Med Sys*. 2015;39(6):68. doi:10.1007/s10916-015-0251-1
46. Rees S, Houlahan B, Safdar N, Sanford-Ring S, Shore T, Schmitz M. Success of a multimodal program to improve hand hygiene compliance. *J Nurs Care Qual*. 2013;28(4):312-318. doi:10.1097/NCQ.0b013e3182902404

Copyright © 2023 Wolters Kluwer Health, Inc. Unauthorized reproduction of this article is prohibited.