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Acquisition of Fire Safety Knowledge and Skills with Virtual Reality Simulation

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Abstract

Background—Prelicensure nursing students seeking to enter perioperative nursing need preparatory fire safety knowledge and skills training to participate as a member of an operating room (OR) team.

Purpose—This pilot study examined the effectiveness of the Virtual Electrosurgery Skill Trainer (VEST®) on OR fire safety skills among prelicensure nursing students.

Methods—An experimental pre-posttest design was used in this study. Twenty nursing were randomized to a control or an intervention group. Knowledge and skills acquisition of OR fire safety were assessed.

Results—There were no statistically significant findings in knowledge for either group. Fisher's Exact test demonstrated significant relationships between the skills performance criteria of following emergency procedures for a fire and demonstrating PASS (pull – aim – squeeze – sweep) technique ($p = .001$).

Conclusions—Academic and hospital educators may consider incorporating virtual reality simulation to teach fire safety education or reinforce general fire safety practices to nursing students and novice nurses.

Keywords

Fire Safety; Nursing Education; Operating Room Fire Safety; Perioperative Nursing; Virtual Electrosurgery Skill Trainer (VEST®); Virtual Reality Simulation

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A nationally-recognized nursing shortage has particularly impacted perioperative nursing. One major factor contributing to this decline is a diminished number of perioperative courses and clinical practice hours being offered in schools of nursing. As the workforce of

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registered nurses (RNs) in this specialty area has dwindled, hospital administrators have sought creative solutions to recruit newly-licensed registered nurses (NLRNs) into the practice setting, such as monetary bonuses, nurse internship programs, mentoring programs, and the development of collaborative practice partnerships with schools of nursing.¹ Additionally, it is desired for NLRNs to enter the perioperative nursing practice setting with core knowledge and skills related to patient safety competencies.^{2,3} One such patient safety competency is operating room (OR) fire safety. Identifying an innovative teaching strategy to provide essential training is a beneficial tool to introduce perioperative nursing to prelicensure nursing students.

Virtual reality simulation (VRS) provides an interactive means to teach OR fire safety skills to students and NLRNs. VRS exemplifies how the health care and engineering industries are uniting to positively impact patient safety with the development of innovative teaching strategies. VRS is emerging as a teaching methodology to promote the acquisition of basic psychomotor skills.⁴ However, limited research attesting to VRS as an educational modality for the acquisition and transfer of knowledge and psychomotor skills among prelicensure nursing students has been recognized in the literature.⁴ VRS presents a creative teaching method to deliver skill-based education, such as fire safety, in an experiential manner rather than through traditional didactic theory and competency checklist formats.⁵⁻⁶

Using 3-D animation and an interface with computer technology, VRS immerses the learner in a virtual realm that allows for active engagement and interaction within a realistic environment.⁵ The Virtual Electrosurgery Skill Trainer (VEST®) is a virtual reality platform developed with funding from the National Institute of Health that is equipped with an education module designed to actively engage a learner in recognizing critical risk factors of OR fires. In the realm of surgical medicine, Olasky and colleagues communicated both the state of the science of VRS in the education of behavioral, technical, and surgical procedure skills, along with latest VRS educational training products.⁷ While incorporated in recent research exploring fire safety among surgical residents, no utilization of VEST® in prelicensure nursing education is described in the literature.⁸

Nursing students or NLRNs seeking to begin perioperative nursing practice need preparatory fire safety knowledge and skills to participate as a member of an OR team. This pilot project examined the effectiveness of VEST® on OR fire safety skills among prelicensure nursing students in a perioperative nursing elective course. The following research question was addressed: Is there a difference in acquisition and transfer of knowledge of OR fire safety skills among nursing students who receive OR safety education with VRS compared to those who receive traditional programmatic education?

Literature Review

Registered nurses practicing in the OR are exposed to fire hazards, which can drastically impact personal and patient safety. Learning how to divert a potentially disastrous surgical fire is an Association of periOperative Registered Nurses (AORN) priority.⁹ A triad of ignition sources, oxidizers, and fuel sources are universally recognized and labeled as the “fire triangle.”¹⁰ In close proximity to both the surgical patient and the collaborative surgical

team are ignition sources (eg, electrical surgical devices, lasers); oxidizers (eg, oxygen, nitrous oxide), and fuel sources (eg, surgical drapes, alcohol-based skin solutions), which together create a perfect triad to trigger a catastrophic fire event.¹⁰ Replicating a combustible event for educational purposes in any nursing education program is hazardous. Thus, education of fire safety initiatives has been primarily provided through didactic theory courses.

The literature clearly articulates the urgency of each health care professional in the OR setting to know what is required of his/her role as a member of a surgical team.^{11,12} Even more so is the obligation of nursing and medical professionals to remain competent on educational content related to surgical devices that have the potential to ignite a fire and how to respond to it.^{13–14} Of note are newly-developed educational resources prominently described in the AORN Fire Safety Tool Kit and continuing education modules designed and delivered in traditional paper format.^{10,14} This fire safety education resonates with patient safety protocols outlined by the American Association of Anesthesiology, The Joint Commission National Patient Safety Goals, and the US Food and Drug Administration.^{12, 15}

Historical use of virtual reality in medical education and the training of health care professionals in disaster management is well documented. However, despite the significant advances in technology over the past 20 years, VRS has not been fully used to its maximum potential in the education of both practicing and future nursing professionals.^{7,16}

High-fidelity simulation technology such as human patient and virtual reality simulators offer a transformative experiential teaching-learning process by which to educate nursing students. VRS offers faculty the next progressive step toward providing experiential learning for nursing students. This article presents findings from a pilot study which incorporated VEST® as an educational platform to train prelicensure nursing students on OR surgical fire safety.

Methods

Design and Sample

An experimental pre-posttest design was used. A non-probability convenience sample was used to recruit prelicensure baccalaureate nursing students enrolled a perioperative nursing elective course in a school in the southwestern United States. An exclusion criterion was knowledge of experiencing negative effects such as nausea or vomiting after prior use of a virtual reality device. Participants were informed of the potential to experience illness, nausea or vomiting while interacting with the virtual reality headset/system. Participants were recruited face-to-face during scheduled class time. The study was approved by the authors' University Institutional Review Board.

Twenty-six students (22 female) were enrolled in the perioperative nursing elective course. Participants were randomized into either a control group (traditional programmatic education only) or intervention group (addition of VRS with VEST® module to traditional programmatic education) for a total of 13 participants per group.

Procedures

Both groups received the didactic education on OR fire safety consisting of classroom lecture, presentation of the AORN protocols for fire safety, and interactive clinical scenario discussions focused on the fire triangle and OR team member roles.^{9,10,17} In addition, the intervention group completed a training session to orient to VEST® followed by 5 independent and monitored VEST® module education sessions. One week after completion of all didactic theory and VEST® education, both groups completed the posttest to measure knowledge gained on fire safety.

Next, each participant was randomly assigned to a perioperative team to complete a simulated OR fire drill scenario designed to assess the transfer of knowledge into the practice setting. The fire drill simulation scenario incorporated a: a) prebriefing to review learner objectives, b) replicated OR, c) human patient simulator realistically portraying a patient undergoing an OR procedure, and d) simulated fire source. Participants actively engaged in defined roles of circulator nurse, scrub nurse, nurse anesthetist, and surgeon to recognize the essential elements of the fire triangle and demonstrate fire safety education by using necessary action steps during a simulated fire. In accordance with the fire safety education provided during the course, the role performance actions included the following: a) the circulating and scrub nurse extinguishes burning material (fuel), b) nurse anesthetist stops the flow of gas (ignition), and c) surgeon removes burning material such as drapes (oxidizers). All roles included the responsibility of explaining fire triangle elements, assessing for the risk of a fire, and notifying team members of the presence of a fire.¹⁷ The Standards of Best Practice: Simulation^{SM} were consulted when developing, designing, and facilitating the fire drill.¹⁸

Data Collection Instruments

An investigator developed 10-item multiple response (7) and true/false (3) pencil and paper *Fire Safety Evaluation* test to assess existing and acquisition of knowledge of OR fire safety was administered in a pre- posttest format. Each test item was valued as 10 points with the possibility of scores to range from 0 to 100% with higher scores indicating greater acquisition of knowledge. Test items have been used previously in this course with test item analysis completed for each item for reliability. Content validity was completed to ensure alignment with the AORN fire safety guidelines.¹⁴

Transfer of knowledge of OR fire safety skills was examined with the *Perioperative Performance Evaluation Tool for Nursing* adapted from the AORN First Safety Toolkit Competency Assessment.¹⁴ Performance criteria items on the tool related to a) explaining the elements of the fire triangle, b) communicating a fire risk assessment, c) following emergency procedures for a fire, d) demonstrating PASS (pull – aim – squeeze – sweep) technique, and e) describing RACE (rescue – alarm – confine – extinguish/evacuate) were validated during the OR fire drill simulation scenario. Prior to data collection, the investigators reviewed the tool and discussed scoring for interrater reliability. In addition, the OR fire drill simulation scenario was video recorded for review and evaluation. During the scenario, the principal investigator and nurse co-investigator simultaneously coded each member of the perioperative team with “met” or “unmet” based on assigned roles and coded

“met” or “unmet” for overall team performance in respect to the criteria of each performance category. Post initial coding, the recorded video sessions were reviewed for accuracy and confirmation of the assigned code.

Data Analysis

Acquisition of knowledge was measured by the *Fire Safety Evaluation* pre- and posttest. Prior to analysis, data were examined for missing values, and normality testing was conducted. Due to sample size, non-parametric statistical analyses were conducted to address the study question. A Wilcoxon signed rank test was used to examine a change in test scores over time.

Transfer of knowledge was measured by the *Perioperative Performance Evaluation Tool for Nursing*.¹⁴ The OR fire drill perioperative roles and teams were identified as nominal data. Secondary to sample size, a Fisher’s exact test was performed to explore relationships between the perioperative teams and performance criteria of a) elements of the fire triangle, b) communicating a fire risk assessment, c) following emergency procedures for a fire, d) demonstrating PASS technique, and e) describing RACE. All data were analyzed using SPSS® version 24 (IBM, Armonk, NY). For all data, the alpha value was set at .05 for significance.

Results

Sample

A total of 20 participants completed all study procedures, with $n = 15$ for the control group and $n = 5$ for intervention group. Six participants (3 from each study group) opted out. Also, participants initially randomized to the intervention group who did not complete the VEST® education ($n = 5$) were transferred to the control group for data analysis purposes. A total of 7 perioperative teams completed the OR fire drill simulation scenario for a total of 3 to 4 participants per team.

Fire Safety Evaluation Pre-Posttest

Regarding acquisition of knowledge, no significant findings were evident with the Wilcoxon Signed Rank test for both groups with $Z = -1.36$, $p = .18$, with a small effect size of ($r = .25$) for the control group, and $Z = -1.51$, $p = .13$, with a large effect size of ($r = .45$) for the intervention group. Median values on the *Fire Safety Evaluation* exam scores demonstrated both the control and intervention groups were similar with existing knowledge of fire safety. However, the intervention group demonstrated a significant increase (20 points) in gained knowledge compared to the control group (10 points). In addition, mean and standard deviation scores were noted for each group with the intervention group mirroring the increase (12 points) in posttest scores compared to the control group (6 points), suggesting a greater increase in knowledge as compared to the control group (Table).

Perioperative Performance Evaluation Tool for Nursing

Fisher’s Exact test demonstrated significant relationships between the performance criteria of following emergency procedures for a fire for OR fire drill perioperative team 4 and

demonstrating PASS technique for perioperative teams 1 and 3 where $p = .001$.¹⁹ Further exploration of data revealed how an intervention group participant in the role of nurse anesthetist in team 4 performed the appropriate skill function (Supplemental Digital Content, Figure). However, as a whole, this perioperative team failed to meet criteria for following procedures as burning drapes covering the simulated patient were not removed. Two control group participants in the role of circulating nurse in perioperative teams 1 and 3 did not meet the criteria for demonstrating the PASS technique. All intervention group participants were noted to meet performance criteria for their assigned role in their perioperative team.

Discussion

The purpose of this research was to examine the effectiveness of VEST® on OR fire safety skills among prelicensure nursing students in a perioperative nursing elective course. Findings demonstrated a greater increase in knowledge from pre to posttest in the intervention group (addition of VRS with VEST® module to traditional programmatic education) as compared to the control group (traditional programmatic education only). Transfer of knowledge evaluated after the fire drill simulation with the *Perioperative Performance Evaluation Tool for Nursing* demonstrated significance regarding the necessity for every member of a perioperative team to perform in a cohesive and routine manner by following established procedures when encountering a fire in the OR environment. Individually, intervention group members performed better than the control in their assigned roles, indicating the usefulness of the VEST® module in teaching OR fire safety.¹⁴

Prior to entering the health care setting for clinical practice hours as a prelicensure nursing student or transitioning into practice as a novice nurse, it is common for hospitals to require the completion of environmental awareness and fire safety modules. Findings demonstrated how 2 participants in the role of circulating nurse were unsuccessful with meeting role expectations particular to the PASS technique. Each intervention group participant who completed the VEST® education transferred knowledge into the simulated practice setting. Perioperative nurse mentoring programs have demonstrated the capacity to recruit and retain nurses, develop collegiality, and enhance perioperative competency skills among prelicensure students and novices nurses who did not receive formal clinical OR training.¹⁶ Education specific to OR fire safety with virtual platforms such as VEST® along with reinforcement through a mentoring program could enhance student learning and impact capacity to act during the presence of a fire.⁸ Perioperative nurses who are well informed of role expectations and capable of responding to a fire emergency in the OR are considered vital members of a collaborative team.²⁰ Practicing perioperative nurses are also a strong asset and provide critical mentoring to prelicensure nursing students. Additionally, collaborative perioperative nurse extern programs for prelicensure nursing students demonstrate the capacity to grow the perioperative nursing workforce.¹ Such exposures to these resources and programs can benefit not only the profession, but also patient outcomes.

Simulation-based educational strategies with human patient simulators and virtual reality platforms (such as VEST®) permit single and multiple learners to gain insight as to unique cognitive and performance aspects of team dynamics.²¹ VEST® delivers an immersive

educational experience to actively engage learners of diverse learning styles to promote the transfer of gained knowledge into the practice environment. Additionally, the interactive training received with virtual reality platforms provides avenues for advantageous educational exchanges in communication among diverse health care professionals and prelicensure health professions students related to best practice behaviors.²¹

This project addresses a gap in nursing education specific to the integration of effective and optimal technology into curricula to meet the learning needs of students. Virtual reality environments focused on medical training are becoming more prevalent along with computer-generated gaming and training simulators.²² Nurse educators can benefit from pursuing knowledge of and testing of alternate educational modalities for use in prelicensure nursing education.

Limitations

While a power analysis calculated with G*Power with effect size of 0.5 identified a necessary sample size of 34 for this study, the sample size was limited to enrollment numbers for this elective course. Conflicting schedules of job interviews, mid-semester activities, and outside employment impacted the participation in completion of the VEST® training by students in the intervention group. This research was conducted at 1 study site during a single academic semester. A portable hospital compressed nebulizer machine commonly used to deliver liquid medication to patients in an aerosol or humidified inhalation route was used to create a simulated fire in the scenario. Once placed under the surgical drapes of the patient experiencing the OR procedure, the aerosol would not consistently produce enough aerosol to simulate smoke from a “fire.” Two student OR teams needed an overhead cue from the control booth directing their attention to the presence of a small fire. Additional safe fire source options would need to be considered when replicating this study. Another limitation was noted in the reliability and validity with the study instruments. Additional research using existing tests and/or the AORN *Perioperative Performance Evaluation Tool for Nursing* is recommended.

Conclusion

This pilot study provided information to not only inform best practices in prelicensure nursing OR fire safety education, but also examined the potential feasibility of using the VEST® simulator for necessary fire safety skills for nursing students seeking to practice in perioperative nursing. Nurse educators may consider incorporating VRS into an existing curriculum to teach OR fire safety education or reinforce general fire safety practices prior to students entering the clinical setting. For hospital administrators and educators seeking to train novice nurses entering perioperative practice or evaluate practice competency of experienced RNs, this immersive virtual reality platform offers a mechanism to consistently and effectively deliver necessary OR fire safety education. Future recommendations would include extending the incorporation of VEST® to address research that can impact both RNs and interprofessional perioperative health care professionals presently working in the OR setting of both hospitals and surgical centers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table

Pre and Post Scores on Fire Safety Evaluation Test

	Pretest		Posttest	
	Control	Intervention	Control	Intervention
Median	70	70	80	90
Mean (SD)	76(13.5)	74(15.2)	82(15.6)	86(5.5)

Test items valued 10 points each, with possibility of scores range from 0 to 100%. Control (n=15). Intervention (n=5).