

Feature Article

A Simulated Tracheostomy Tube Change Educational Intervention to Promote Competency Among Novice Healthcare Professionals: A Repeated Measures Study

Jessica Peter, DNP, MS, ACNP-BC^a, Chandler H Moser, PhD, BSN, RN, CNOR^b, Vidyadhari Karne, MBBS^c, Stanola Stanley, BS, MHA^d, Helen Wilson, DNP, MSN, APRN, FNP-C, CRRN, CNE^e, Carol S Maragos, MSN, ACNP-BC, CORLN^f, Jacqueline Stokes, MS, MEHP, RRT^g, Kathryn Mattare, BS, RRT^h, Laurie Turner, MSN, RNⁱ, Michael J Brenner, MD, FACS^j, Vinciya Pandian, PhD, MBA, MSN, RN, ACNP-BC, FCCM, FAANP, FAAN, FFMRCST^k

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Abstract

Objective

To evaluate an educational intervention to promote confidence, knowledge, and skills in tracheostomy tube change among nursing students.

Methods

The study, conducted at the Johns Hopkins Center for Immersive Learning and Digital Innovation, enrolled nursing students without prior experience in tracheostomy tube change. The intervention included a pre-recorded presentation, faculty demonstrations with a Tracheostomy Care Training Simulation Model, and participant practice demonstrating skills. Primary outcomes included confidence, knowledge, and competency with tracheostomy tube changes. Secondary outcomes included number of attempts required to achieve competency and time required per attempt. The study followed STROBE guidelines with repeated measure design.

Results

Participants in the study (n=50) had a mean age of 30 years, were predominantly female (83%) with a bachelor's degree (76%), most often in the third semester of nursing school (45%). Participants showed a mean improvement of 3.58 points out of five (SD: 0.56, P<0.001) across 11 pre- and post-test items. Every confidence assessment improved, with the largest increase in assessing tube placement. Knowledge assessments improved across all eight test items in the first test-retest interval, showing an improvement of 1.14 points out of five (SD: 0.89, P<0.001). Competency assessment improved in the first test-retest interval of 1.01 points out of five (SD: 0.65, P<0.001). On serial assessments, time to complete tracheostomy tube change decreased from 2.39 to 0.60 minutes. Faculty deemed 95% of participants competent after only one skill testing iteration.

Conclusion

An educational intervention, combining digital presentations with interactive faculty-led simulations and practical skill assessments, successfully elevated nursing students' confidence, knowledge, and competency in tracheostomy tube changes.

a Assistant Professor, Department of Nursing Faculty, Johns Hopkins University School of Nursing, Baltimore, Maryland, United States

b Nurse Scientist, Center for Nursing Science and Clinical Inquiry, Madigan Army Medical Center, Joint Base Lewis-McChord, WA, United States

c Resident, Department of Pathology and Laboratory Medicine, University of Southern California, Los Angeles, CA, United States

d Research Assistant, Center for Immersive Learning and Digital Innovation, Johns Hopkins University, Baltimore, Maryland, United States

e Professor, School of Nursing, Washington Adventist University, Takoma, MD, United States

f Nurse Practitioner, Department of Otolaryngology Head-Neck Surgery, The Johns Hopkins Hospital, Baltimore, MD, United States

g Respiratory Therapist, Adult Cystic Fibrosis Program, The Johns Hopkins Hospital, Baltimore, MD, United States

h Respiratory Therapist, Clinical Coordinator, Adult Respiratory Care, The Johns Hopkins Hospital, Baltimore, MD, United States

i Retired Nurse, Department of Otolaryngology Head-Neck Surgery, The Johns Hopkins Hospital, Baltimore, MD, United States

j Associate Professor, Department of Otolaryngology – Head & Neck Surgery, University of Michigan Medical School, Ann Arbor, Michigan, United States, and President, Global Tracheostomy Collaborative, Raleigh, North Carolina, United States

k Associate Professor and Assistant Dean of Immersive Learning and Digital Innovation, Johns Hopkins University School of Nursing; Outcomes After Critical Illness and Surgery (OACIS) Research Group, Johns Hopkins University School of Medicine, Baltimore, Maryland, United States

INTRODUCTION

Healthcare professionals in the critical care setting require proficiency in mechanical ventilation, tracheostomy airway management, and patient outcomes.^{1,2} The advent of novel modes of mechanical ventilation and standardized protocols, such as the ARDSnet protocol and Surviving Sepsis guidelines,³⁻⁵ has improved survival rates in patients suffering from acute respiratory distress syndrome. However, prolonged mechanical ventilation has increased the need for placement of tracheostomy to improve airway management.⁶⁻⁸ Tracheostomy is one of the most commonly performed surgical procedures following prolonged mechanical ventilation and acute respiratory distress syndrome.⁹⁻¹¹ An estimated 80,612 tracheostomies were performed in 2002, with a peak of 89,545 in 2008 and a nadir of 58,840 in 2017.^{9,12} However, during the COVID-19 pandemic, the prevalence of ARDS increased, and the tracheostomy rate increased to > 100,000 annually.^{11,13}

The benefits of early tracheostomy include improved mechanical ventilation weaning, patient mobility, respiratory recovery, and decreased incidence of ventilator-associated pneumonia.^{14,15} However, the presence of tracheostomy can add complexity to disposition planning. Patients are frequently discharged from critical care environments to acute or subacute care environments with a tracheostomy tube in place, necessitating safe tracheostomy care practices and clinical competency across settings.^{8,16-19} Performing tracheostomy tube changes is a vital component of tracheostomy care,²⁰ yet minimal literature exists exploring best practices, and there is no universally accepted definition of independent procedural competence.^{20,21} The importance of both procedural competency and education and knowledge surrounding potential complications necessitates the development of an educational competency program and a robust system of tracheostomy care.²²

Procedures for tracheostomy tube change are not well standardized, and protocols for establishing competency do not exist currently within the literature. In addition, the first tube changes may require higher levels of expertise and support due to lack of a mature tract and risk of false passage. There is, therefore, a critical role for ensuring proficiency with tracheostomy tube change, to avoid potential airway complications. Research demonstrates that healthcare professionals often experience anxiety with tracheostomy tube changes and that maintaining overall competence remains a challenge.^{23,24} Pritchett et al. showed that only 46% of nurses self-reported feeling “totally comfortable” changing established tracheostomy tubes, and a mere 4% of respondents felt at ease managing accidental decannulation.²⁵ Lack of comfort during routine procedural tube change and accidental decannulation was consistently reported in nurses with less than five years of experience and those practicing outside the critical care unit.^{25, 26} Such findings underscore the need for establishing procedural competency in school curricula and annual practice competencies.

This study aims to evaluate the effectiveness of a tracheostomy tube change educational program in an adult simulation model with an objective structured clinical evaluation tool in establishing procedural competence, ultimately ensuring safe and effective tracheostomy airway management in the critical care environment.

METHODS

Design and setting

A repeated measure design was used to evaluate the effectiveness of a tracheostomy tube change educational program. The study was conducted at the Johns Hopkins Center for Immersive Learning Digital Innovation funded by the Agency for Healthcare Research and Quality (AHRQ). The findings follow the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.²⁷

Figure 1. Tracheostomy Tube Change



Ethical consideration

This study was considered exempt by the Johns Hopkins School of Medicine Institutional Review Board (IRB00045393).

Sample

Participants included students who were enrolled at the Johns Hopkins University School of Nursing who had never performed a tracheostomy tube change. A student was allowed to participate in the study only once. Students who had performed a tracheostomy tube change in the past were excluded from the study.

Recruitment

We recruited eligible participants through various channels, including flyers, website postings on the school intranet, and targeted email blasts. To maximize visibility and ensure broad participation, we placed flyers throughout the School of Nursing, where students frequently review school announcements. In addition, website postings were made within the school intranet to reach students who regularly use this platform. Finally, email blasts were drafted and sent to program directors to expand our reach, who then disseminated the information to all students. These recruitment strategies were designed to increase awareness and generate interest in the study, resulting in a diverse and representative sample of participants.

Consent

Eligible students who expressed interest in participating in the study via phone call or email were provided a comprehensive explanation of the study's purpose, procedures, potential risks, and benefits by the study coordinator. To allow sufficient time for participants to review the study procedures, they were allowed to take the consent form and review it at their own pace before agreeing to participate. The study coordinator was available to answer any questions and address participants' concerns before providing verbal consent.

Intervention

The tracheostomy tube change educational program consisted of a pre-recorded PowerPoint presentation, a faculty demonstration on an adult Tracheostomy Care Training Simulation Model (Figure 1), and a return demonstration, where participants demonstrated the newly learned skills.

Pre-recorded PowerPoint presentation: The pre-recorded PowerPoint presentation provided participants with a comprehensive overview of tracheostomy tube changes. The presentation included communicating with interprofessional team members before the procedure, deciding when to perform a tracheostomy tube

change, explaining the procedure, assessing the patient's clinical status and history, appropriate patient positioning, and what to do in case of airway loss. Additionally, a video demonstrating the necessary equipment and tracheostomy tube change procedures was embedded within the presentation. The study team developed this presentation and was refined by content experts until a consensus was reached among ten experts. The presentation lasted approximately 20 minutes, after which participants were encouraged to ask questions and seek clarification.

Faculty Demonstration on a Tracheostomy Care Training Simulation Model: Following the PowerPoint presentation, participants received a demonstration on an adult tracheostomy manikin on how to perform a tracheostomy tube change. A tracheostomy expert from the study team conducted the demonstration. It covered standard precautions, hand hygiene, equipment collection, respiratory and airway assessment, "time out," self-introduction to the interprofessional team, tracheostomy tube change, stoma assessment, airway management in case of loss, respiratory status assessment post-procedure, and tube placement verification (Feeling presence of exhaled air, auscultation for breath sounds, and end-tidal CO₂). The demonstration lasted approximately 20 minutes.

Return demonstration: Participants were then asked to provide return demonstrations, during which they were allowed to repeat the demonstration until they felt confident and the supervising faculty deemed their demonstration successful. In addition to demonstrating tactile skills on the manikin, participants were asked to describe the procedure's rationale verbally, discuss the steps, potential risks, and complications, and explain how they would manage if they lost the airway.

Overall, the intervention was designed to provide participants with a comprehensive educational experience on tracheostomy tube changes and to ensure they felt confident and competent in performing the procedure.

Outcome Measures

The study's primary outcome variables included the assessment of confidence, knowledge, and competency related to tracheostomy tube changes. We defined confidence as the participants' self-reported comfort level to perform a tracheostomy tube change independently. The knowledge referred to understanding the various factors contributing to a successful tracheostomy tube change, as correlated with the PowerPoint presentation's content. Competency was measured based on the ability to confidently demonstrate a tracheostomy tube change, as assessed by the participant and deemed successful by the supervising faculty. A successful return demonstration of a tracheostomy tube change was defined as one in which the participant correctly demonstrated 90% or more of the steps and correctly answered 90% or more of the knowledge assessment questionnaire.

The secondary outcome variables included the number of attempts required by the participants to attain competency in performing a tracheostomy tube change and the time taken for each attempt in minutes. These variables aimed to provide further insight into the effectiveness of the educational intervention in improving participants' competency and the time taken to achieve competency.

Instruments

The instruments used in the study consisted of a demographic questionnaire, a confidence questionnaire, a knowledge assessment questionnaire, and an objective structured clinical evaluation questionnaire.

Demographic Questionnaire: The demographic questionnaire included six items to collect data on the participants' ages, genders, ethnicities, education, current semester of school, and previous healthcare experiences.

Confidence Questionnaire: The confidence questionnaire, developed by the study team, included 11 items that assessed the

participants' confidence level in performing various tracheostomy tube change steps. Participants rated their confidence level on a five-point Likert scale, ranging from 0 (will not attempt skill) to 4 (will attempt while teaching to another nursing student).

Knowledge Assessment Questionnaire: The knowledge assessment questionnaire, also developed by the study team, consisted of 8 items that assessed participants' knowledge of various aspects of tracheostomy tube change care. Participants rated their knowledge level on a five-point Likert scale, ranging from 0 (Does not know) to 4 (Very Knowledgeable).

Objective Structure Clinical Examination (OSCE) Tool: The OSCE, also developed by the study team, included 12 items that assessed participants' competency on various steps of tracheostomy tube change. Participants rated their competency level on a five-point Likert scale, ranging from 0 (unable to perform) to 4 (performs quickly with proper technique).

Data Collection

Upon obtaining verbal consent, participants completed a demographic questionnaire. A confidence questionnaire was administered before and after a PowerPoint presentation on tracheostomy tube change. Supervising faculty completed questionnaires after each participant's return demonstration to assess participants' knowledge and competency. The supervising faculty also documented the number of attempts and the time taken for each attempt during the return demonstrations.

Data Management

Participants and supervising faculty completed questionnaires in paper format, and responses were entered into Research Electronic Data Capture (REDCap) for storage.²⁸ The original paper responses were securely stored in a locked cabinet that only the principal investigator could access. Only de-identified data were exported into a statistical software for analysis to ensure participant confidentiality.

Statistical Analysis

We conducted descriptive statistics using appropriate central tendency and variance measures for all study variables. As the data from each participant is expected to be highly correlated, we conducted serial t-tests paired by participants to compare each test to the previous one. Specifically, we investigated three areas: (1) changes in student confidence levels before and after the educational video, (2) changes in tracheostomy knowledge assessment at each testing event, and (3) changes in competency assessment at each testing event. All statistical tests were two-tailed, with an alpha level of 0.05 for significance. We performed the analyses using STATA 17.²⁹

RESULTS

Participant characteristics

Of the 50 participants, only 42 provided demographic data. The data of 42 participants showed a mean age of 30 years (SD = 7). The majority of the participants were female (83%), had a bachelor's degree (76%), and were in their third semester of school (45%). The ethnic distribution was primarily Caucasian (76%), with smaller percentages of Asian American (10%), African American (5%), Hispanic (2%), and other (7%). In terms of previous healthcare experience, most participants had experience as a Certified Nursing Assistant (38%) or other volunteer roles (45%), while a smaller percentage had experience as an EMT/Paramedic (7%) or Hospital Technician (10%) (**Table 1**).

Table 1. Demographics of participants

Characteristic	N = 42
Age, mean years (SD)	30 (7)
Gender, female	35 (83%)
Education	
Bachelor's degree	32 (76%)
Master's degree	8 (19%)
Doctoral or another advanced degree	2 (5%)
Current semester of school	
First	8 (19%)
Second	12 (29%)
Third	19 (45%)
Fourth	2 (5%)
Fifth	1 (2%)
Ethnicity	
African American	2 (5%)
Asian American	4 (10%)
Caucasian	32 (76%)
Hispanic	1 (2%)
Middle Eastern	0
Other	3 (7%)
Previous healthcare experience	
EMT / Paramedic	2 (7%)
Certified Nursing Assistant (CAN)	11 (38%)
Hospital Technician	3 (10%)
Other	13 (45%)

Confidence assessments

Forty-two participants completed both pre and post-tests, while eight completed a pre-test only and were excluded from this analysis portion. Pre-test self-assessment of student confidence across 11 items ranged from 1.75 (SD: 0.63, "assessing tube placement") to 4.74 (SD: 0.45, "washing hands"), with an overall mean of 3.24 points (SD: 0.63). Post-test scores ranged from 2.80 (SD: 0.81, "inflate cuff") to 4.93 (SD: 0.26, "washing hands"), with an overall mean across all items of 3.58 points (SD: 0.56). While every item saw a statistically significant improvement in scores, the largest percent increase in confidence was seen in "assessing tube placement," which increased by 1.78 points between tests (SD: 1.05, $p < 0.001$), a two-fold increase. Conversely, the smallest increase in scores, 0.19 points (SD: 0.40, $p < 0.003$), was seen in "washing hands," a rudimentary skill that participants felt confident doing in the pre and post-test periods. Overall, the data show significant improvements in all 11 skills between the pre-test and post-test, with P-values ranging from 0.003 to < 0.001 . The overall score also showed a significant improvement by 49.2% from the pre-test mean score of 2.40 (SD=0.63) to the post-test mean score of 3.58 (SD=0.56), with a change in scores of +1.18 (SD=0.69) and a P-value of < 0.001 (Table 2).

Knowledge assessments

In the initial testing event, 28 students participated, whereas 24 participants attended the second test. Eight and three individuals took the third and fourth tests, respectively. Of the four participants for whom one knowledge assessment was completed, the

mean score was 3.33 points (SD: 0.82), 1.32 points higher than the remaining 24 participants ($p = 0.013$).

Table 3 summarizes the changes in scores for each of the eight test items for the knowledge assessment portion. The results show significant improvement in scores between Test 1 and Test 2 for all items. However, the changes in scores between Test 2 and Test 3 were significant for only half of the items, and there were no significant changes in scores between Test 3 and Test 4. For the first six Likert-response items, the most significant incremental change occurred between the first and second tests (+1.14 points, SD: 0.69, $p < 0.001$), a 56.4% increase. Furthermore, the weakest area of knowledge at test one, "tube change contraindications," saw the most significant increase between the first and second tests at 1.52 points (SD: 1.04, $p < 0.001$), or a two-fold increase. Management of airway loss saw the greatest improvement from test 2 to test 3. Management of airway loss often requires a higher skill level that develops with repeated exposure to this patient complication. There were no scores recorded at test 3 and test 4 to make a comparison if more than 3 attempts are needed to master competency. Notably, all participants conveyed sufficient knowledge of the equipment and instrument usage by the third test. Overall, the data suggest that learners made significant gains in knowledge between the first and second tests, but their gains were limited after that. It is also worth noting that the p-values for the changes in scores were generally lower for the first six items than for the last two items, which suggests that the first six items were more sensitive to changes in knowledge over time.

Table 2. Confidence questionnaire pre- and post-test paired t-tests

Skill	Pre-test, mean score (SD)	Post-test, mean score (SD)	Change in scores (SD)	df	P
Wash hands	4.74 (0.45)	4.93 (0.26)	+0.19 (0.40)	41	0.003
Collect proper equipment	2.19 (0.78)	3.51 (0.78)	+1.32 (1.11)	41	<0.001
Deflate tracheostomy cuff	1.88 (0.78)	2.85 (0.79)	+0.97 (1.15)	40	<0.001
Remove existing tube	1.68 (0.62)	3.13 (0.79)	+1.45 (0.99)	39	<0.001
Insert new tube into stoma	1.63 (0.54)	2.98 (0.79)	+1.35 (0.96)	40	<0.001
Insert cannula and secure	1.63 (0.54)	3.10 (0.70)	+1.47 (0.90)	40	<0.001
Inflate cuff	1.83 (0.77)	2.80 (0.81)	+0.97 (1.04)	40	<0.001
Secure tracheostomy ties	1.98 (0.76)	3.66 (0.73)	+1.68 (1.23)	40	<0.001
Assess tube placement	1.75 (0.63)	3.53 (0.93)	+1.78 (1.05)	39	<0.001
Use universal precautions	3.15 (1.05)	4.25 (1.01)	+1.10 (0.96)	39	<0.001
Maintain clean technique	3.24 (0.92)	4.24 (0.99)	+1.00 (0.87)	40	<0.001
Overall	2.40 (0.63)	3.58 (0.56)	+1.18 (0.69)	41	<0.001

Competency assessments

The initial testing event enrolled a cohort of 45 students while 43 participants completed test two, test three was completed by 34, and test four by 13. Test five suffered from low enrollment, with only one participant, which led to its exclusion from the present analysis. Across the first 12 Likert-response items, the most remarkable increase in competency occurred between the first and second tests, exhibiting an improvement of 1.01 points (SD: 0.65, $p < 0.001$). Intriguingly, the two students who completed only one test iteration recorded a mean score of 3.00 points (SD: 0) across the same items, compared to a 2.00-point mean for the remaining 43 students ($p = 0.023$). These findings are summarized in **Table 4**.

Number of attempts

Participants took up to five competency assessments, with a median of three iterations. Notably, following the initial testing iteration, nearly all students, including the two who only participated once, were deemed competent by the faculty scorers (**Table 4**).

Time to completion

Concerning the time required to complete the competency assessments, a significant reduction was observed between the first and second tests, reflecting an improvement in proficiency (-1.15 minutes, SD: 2.06, $p = 0.005$). A subsequent enhancement in the speed of execution was noted at the following interval. However, an increase in the time required to complete the assessment was observed between the third and fourth iterations, though this difference was not statistically significant. Retaking the test was voluntary; although students who chose to retake the test recorded a shorter mean time than those who did not, these differences were not statistically significant.

DISCUSSION

The results of this study suggest that the educational program comprising a pre-recorded PowerPoint presentation, a demonstration on a Tracheostomy Care Training Simulation Model, and a return demonstration improved the knowledge and competency of

the participants in all aspects of tracheostomy tube change. This improvement was evidenced by the significant improvements in the participants' confidence, knowledge, and competency in performing the different aspects of tracheostomy tube change.

Studies on simulation-based training have consistently shown improvements in various aspects of healthcare provider performance in tracheostomy care. One study focused on tracheostomy care demonstrated increased knowledge by 15% and significant gains in comfort among inpatient providers, particularly benefiting less-experienced learners.³⁰ Another study highlighted the effectiveness of simulation-based training in improving knowledge and teamwork dynamics in managing COVID-19 airways, with sustained benefits observed up to one week post-training, especially notable in specific subgroups (non-anesthesia and resident).³¹ Additionally, simulation-based hybrid training significantly enhanced cognitive performance and confidence in managing otolaryngology skills and emergencies, with hands-on simulation training yielding superior objective assessment scores compared to lecture-based teaching alone.³² Finally, rapid implementation of simulation training for anticipated COVID-19 tracheostomy procedures led to increased physician confidence in procedure competency and the use of enhanced personal protective equipment, indicating the potential for enhanced safety and confidence in real-life scenarios.³³

While numerous studies highlight the advantages of simulation training, limited research delves into tracheostomy tube change training. Notably, one study discovered that operant conditioning methodology, despite necessitating longer instruction time, enhances accuracy in tracheostomy tube changes compared to conventional methods, with the operant learning group (OLG) exhibiting significantly higher accuracy rates than the traditional group ($P = 0.002$), indicating its potential for augmenting skill acquisition in medical education.³⁴ Additionally, the implementation of a quality improvement intervention, encompassing a tracheostomy tube change strategy bundle and staff training, resulted in a substantial reduction in the incidence of aspiration pneumonia in patients with tracheostomy ($p = .013$). This intervention also led to a notable increase in staff knowledge scores, rising from 46.6 ± 11.1 to 88.1 ± 6.8 , and enhanced staff adherence to documentation, increasing from 67.32% to 100%, underscoring the efficacy of standardized protocols, education, and interprofessional collaboration in optimizing the safety and efficiency of tracheostomy

Table 3. Knowledge assessment score changes between re-tests

Knowledge test item	Previous test, mean score (SD)	Re-test, mean score (SD)	Change in scores (SD)	df	P
Communication with team members					
Test 1 to Test 2	2.04 (1.20)	3.33 (0.48)	+1.29 (1.20)	23	<0.001***
Test 2 to Test 3	3.13 (0.35)	3.63 (0.52)	+0.50 (0.53)	7	0.033*
Test 3 to Test 4	3.33 (0.58)	3.67 (0.58)	+0.34 (0.58)	2	0.423
List tube change contraindications					
Test 1 to Test 2	1.39 (1.03)	2.91 (0.29)	+1.52 (1.04)	22	<0.001***
Test 2 to Test 3	3.00 (0.53)	3.50 (0.53)	+0.50 (0.53)	7	0.033*
Test 3 to Test 4	3.33 (0.58)	3.67 (0.58)	+0.34 (0.58)	2	0.423
Explain the procedure to the patient					
Test 1 to Test 2	2.79 (1.18)	3.50 (0.59)	+0.71 (1.12)	23	0.005**
Test 2 to Test 3	3.13 (0.64)	3.63 (0.52)	+0.50 (0.53)	7	0.033*
Test 3 to Test 4	3.33 (0.58)	3.67 (0.58)	+0.34 (0.58)	2	0.423
Assess patient history and status					
Test 1 to Test 2	2.13 (1.33)	3.25 (0.79)	+1.12 (1.19)	23	<0.001***
Test 2 to Test 3	2.75 (0.89)	3.50 (0.53)	+0.75 (0.89)	7	0.048*
Test 3 to Test 4	3.33 (0.58)	3.67 (0.58)	+0.34 (0.58)	2	0.423
Management of airway loss					
Test 1 to Test 2	2.39 (1.33)	2.89 (1.02)	+0.50 (0.86)	17	0.024*
Test 2 to Test 3	2.00 (1.26)	3.17 (0.75)	+1.17 (1.60)	5	0.135
Test 3 to Test 4	-	-	-	-	-
List conditions to notify the provider					
Test 1 to Test 2	1.71 (1.16)	2.96 (0.46)	+1.25 (1.11)	23	<0.001***
Test 2 to Test 3	3.00 (0.54)	3.38 (0.74)	+0.38 (0.74)	7	0.197
Test 3 to Test 4	3.00 (1.00)	3.67 (0.58)	+0.67 (0.58)	2	0.184
Learner equipment knowledge (Y/N)					
Test 1 to Test 2 (proportion yes)	0.45 (0.51)	0.86 (0.35)	+0.41 (0.50)	21	0.001**
Test 2 to Test 3 (proportion yes)	0.63 (0.52)	1.00 (0)	+0.37 (0.52)	7	0.080
Test 3 to Test 4 (proportion yes)	-	-	-	-	-
Uses instruments properly (Y/N)					
Test 1 to Test 2 (proportion yes)	0.64 (0.49)	0.86 (0.35)	+0.28 (0.43)	21	0.022*
Test 2 to Test 3 (proportion yes)	0.63 (0.52)	1.00 (0)	+0.37 (0.52)	7	0.080
Test 3 to Test 4 (proportion yes)	-	-	-	-	-
Overall, first 6 items					
Test 1 to Test 2	2.02 (0.93)	3.16 (0.35)	+1.14 (0.89)	23	<0.001***
Test 2 to Test 3	2.87 (0.36)	3.49 (0.54)	+0.62 (0.54)	7	0.014*
Test 3 to Test 4	3.17 (0.60)	3.67 (0.58)	+0.50 (0.44)	3	0.189

* P<0.05; ** P<0.01; *** P<0.001

Table 4. Skills assessment score changes between re-tests

Skill test item	Previous test, mean score (SD)	Re-test, mean score (SD)	Change in mean scores (SD)	df	P
Washes hands					
Test 1 to Test 2	3.16 (1.29)	3.74 (0.73)	+0.58 (1.05)	42	<0.001***
Test 2 to Test 3	3.71 (0.76)	4.00 (0)	+0.29 (0.76)	33	0.031*
Test 3 to Test 4	4.00 (0)	4.00 (0)	-	12	-
Collects appropriate equipment					
Test 1 to Test 2	1.95 (1.03)	3.00 (0.73)	+1.05 (1.21)	41	<0.001***
Test 2 to Test 3	2.88 (0.70)	3.91 (0.38)	+1.03 (0.68)	32	<0.001***
Test 3 to Test 4	3.84 (0.55)	3.92 (0.28)	+0.08 (0.28)	12	0.337
Assesses respiratory complaints					
Test 1 to Test 2	1.44 (0.96)	2.91 (0.84)	+1.47 (1.14)	42	<0.001***
Test 2 to Test 3	2.88 (0.88)	3.47 (0.71)	+0.59 (0.92)	33	<0.001***
Test 3 to Test 4	3.31 (0.95)	3.92 (0.28)	+0.61 (0.87)	12	0.025*
Performs "Time Out"					
Test 1 to Test 2	0.88 (0.94)	2.86 (1.00)	+1.98 (1.26)	41	<0.001***
Test 2 to Test 3	2.79 (1.07)	3.38 (0.78)	+0.59 (1.23)	33	0.009**
Test 3 to Test 4	3.23 (1.01)	4.00 (0)	+0.77 (1.01)	12	0.018*
Encourages introductions in the room					
Test 1 to Test 2	0.95 (1.06)	2.52 (1.17)	+1.57 (1.54)	41	<0.001***
Test 2 to Test 3	2.38 (1.21)	3.32 (0.91)	+0.94 (1.04)	33	<0.001***
Test 3 to Test 4	3.08 (1.26)	3.92 (0.28)	+0.84 (1.14)	12	0.021*
Performs tracheostomy tube change					
Test 1 to Test 2	1.79 (0.89)	2.63 (0.76)	+0.84 (0.95)	42	<0.001***
Test 2 to Test 3	2.41 (0.61)	3.41 (0.89)	+1.00 (0.89)	33	<0.001***
Test 3 to Test 4	2.85 (1.14)	3.77 (0.44)	+0.92 (0.86)	12	0.002**
Assesses stoma					
Test 1 to Test 2	1.69 (1.29)	2.88 (0.94)	+1.19 (1.47)	41	<0.001***
Test 2 to Test 3	2.79 (0.95)	3.26 (1.16)	+0.47 (1.08)	33	0.016*
Test 3 to Test 4	2.54 (1.56)	3.85 (0.55)	+1.31 (1.80)	12	0.022*
Manages loss of airway					
Test 1 to Test 2	2.47 (1.67)	3.21 (1.23)	+0.74 (1.50)	37	0.005**
Test 2 to Test 3	2.90 (1.11)	3.32 (1.14)	+0.42 (1.29)	30	0.079*
Test 3 to Test 4	2.77 (1.36)	3.62 (0.65)	+0.85 (1.52)	12	0.068*
Reassesses respiratory status					
Test 1 to Test 2	1.93 (1.30)	2.88 (0.94)	+0.95 (1.19)	41	<0.001***
Test 2 to Test 3	2.81 (1.00)	3.38 (1.07)	+0.57 (1.44)	31	0.034*
Test 3 to Test 4	2.85 (1.41)	4.00 (0)	+1.15 (1.41)	12	0.012*
Verifies tube placement					
Test 1 to Test 2	2.07 (1.08)	3.05 (0.92)	+0.98 (0.96)	42	<0.001***
Test 2 to Test 3	3.03 (0.98)	3.40 (1.03)	+0.37 (1.25)	32	0.103
Test 3 to Test 4	2.76 (1.36)	4.00 (0)	+1.24 (1.36)	12	0.007**
Uses universal precautions					
Test 1 to Test 2	2.81 (0.98)	3.28 (0.85)	+0.47 (0.83)	42	0.003**

Skill test item	Previous test, mean score (SD)	Re-test, mean score (SD)	Change in mean scores (SD)	df	P
Test 2 to Test 3	3.24 (0.92)	3.79 (0.41)	+0.55 (1.02)	33	0.003**
Test 3 to Test 4	3.69 (0.48)	4.00 (0)	+0.31 (0.48)	12	0.040*
Maintains clean technique					
Test 1 to Test 2	2.77 (1.02)	3.21 (0.91)	+0.44 (0.96)	42	0.004**
Test 2 to Test 3	3.09 (0.97)	3.74 (0.45)	+0.65 (1.04)	33	0.001**
Test 3 to Test 4	3.46 (0.52)	4.00 (0)	+0.54 (0.52)	12	0.003**
Time to complete procedure (mins)					
Test 1 to Test 2	2.39 (2.55)	1.24 (1.13)	-1.15 (2.06)	29	0.005**
Test 2 to Test 3	1.17 (0.96)	0.60 (0.23)	-0.58 (0.99)	20	0.014*
Test 3 to Test 4	0.57 (0.15)	2.23 (2.37)	+1.67 (2.49)	7	0.101
Deemed “competent” by faculty					
Test 1 to Test 2 (proportion yes)	0.95 (0.22)	0.98 (0.16)	+0.02 (0.16)	40	0.323
Test 2 to Test 3 (proportion yes)	1.00 (0)	1.00 (0)	-	29	-
Test 3 to Test 4 (proportion yes)	1.00 (0)	1.00 (0)	-	11	-
Overall, first 12 items					
Test 1 to Test 2	2.00 (0.60)	3.01 (0.53)	+1.01 (0.65)	42	<0.001***
Test 2 to Test 3	2.91 (0.52)	3.54 (0.46)	+0.63 (0.50)	33	<0.001***
Test 3 to Test 4	3.20 (0.53)	3.92 (0.14)	+0.72 (0.48)	12	<0.001***

* P<0.05; ** P<0.01; *** P<0.001

tube changes.³⁵ Similarly, our study aligns with existing literature on the effectiveness of simulation based educational interventions for procedural competence. However, the distinctive emphasis on tracheostomy tube change and the utilization of both knowledge and competency assessments render this study a novel contribution to the literature. Our findings further highlight the efficacy of incorporating simulated skills return demonstration into tracheostomy education, ultimately enhancing procedural competency and complication identification.

Zhu et al.²⁶ surveyed practitioners who routinely provide tracheostomy surveillance as part of their practice and found that although practitioners were “very comfortable” with their tracheostomy management strategies, 80% of them felt that developing clinical practice guidelines would help them facilitate care and assist other specialties in the care and surveillance of tracheostomy patients. Our study represents a foundation for an intervention to improve competency in tracheostomy tube changes that combines education and return demonstration in the simulated environment back-to-back.

As noted, there was a significant increase in knowledge test scores between the first and second test administrations, likely due to proficiency increasing consistently among all our participants. Importantly, we felt this can partially be attributed to the model of education delivery coupling education and return demonstration. Furthermore, the most significant increase in competency occurred between the first and second tests, demonstrating that our intervention required minimal repetition to perform the return demonstration successfully.

Implications for Healthcare Professional Education

The study highlights the importance of providing adequate training and education to healthcare professional students to ensure

safe and effective tracheostomy airway management beyond the critical care environment. The study showed that the educational program improved students’ confidence and knowledge of tracheostomy tube change procedures. Therefore, education programs should consider incorporating such educational programs with timely coupling of theory and practice to enhance students’ procedural competence and ensure safe patient care.

Additionally, this study showed that a single demonstration of competency was typically adequate for the faculty scorers to deem students competent. However, most students voluntarily engaged in three iterations of the assessment, indicating that students’ confidence in performing tracheostomy skills may require more practice beyond what is required for competence.

Implications for Clinical Practice

The increasing number of patients requiring tracheostomy highlights the necessity for healthcare providers to have adequate knowledge and competencies in dealing with routine care, including tracheostomy tube change. Complications with tube change may occur more frequently without competence and standardized education for tracheostomy care. In 2013, the American Academy of Otolaryngology–Head and Neck Surgery released a clinical consensus statement³⁶ emphasizing the importance of consistency in tracheostomy tube change practices. However, the comfort level of nurses in handling potential emergencies varies with their experience level in the acute care setting.³⁷ In light of these findings, this study underscores the importance of educational programs to enhance nurses’ procedural competence and confidence in tracheostomy tube change procedures in clinical settings. Such programs could significantly improve patient safety and outcomes, especially as expert consensus consistently urges the need for standardized competency. Practice variations and management

of tracheostomy patients exist between high-acuity and community care. Efforts should consider incorporating these educational programs into their training curriculum to reduce adverse events associated with tracheostomy tube changes. This study represents a significant step in developing standardized practice competency and ensuring that all healthcare providers have the necessary skills to provide optimal care for variations in practice, which can help minimize complications and hospital stays.

Implications for Research

Providing a secure and regulated environment for tracheostomy simulation can boost healthcare professionals' self-efficacy in tracheostomy care, according to the findings of our study. Future research could investigate the long-term effects of such simulation-based educational programs on patient outcomes. While our findings offer encouraging proof for using simulation in nurse education and training, more study is required to assess the efficacy of tracheostomy simulation in real-world situations and with larger samples. Further investigations into the sustenance of knowledge and competency over time after such tracheostomy simulation training are advised. Our study, we believe, will promote the use of simulation-based training programs for tracheostomy care, ultimately resulting in better patient outcomes, such as reducing the incidence of tracheostomy-related complications, length of hospital stay, and overall healthcare costs.

Limitations

Some limitations of this study include the small sample size, limited generalizability to other healthcare disciplines and settings, and reliance on self-reported measures of confidence and knowledge. The study only included nursing students who had never performed a tracheostomy tube change and may not represent more experienced healthcare professionals. However, as other studies surveying practicing nurses demonstrated discomfort with tracheostomy tube change practice, practicing nurses would potentially benefit from our intervention. The study was conducted in a controlled environment and did not measure participants' ability to perform the procedure in real-world settings. The study also did not assess the long-term retention of knowledge and competency gained from the educational program. Finally, using a single tracheostomy manikin may limit the transferability of the results to different types of manikins or actual patients.

CONCLUSION

The results of this study suggest that an educational program including a pre-recorded PowerPoint presentation, a faculty demon-

stration of a Tracheostomy Care Training Simulation Model, and a return demonstration is effective in improving self-reported confidence in addition to tracheostomy tube change knowledge and competency. The study findings are consistent with existing literature on the effectiveness of related educational interventions for procedural competence. Further research is needed to investigate the long-term effects of such educational programs on patient outcomes.

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Corresponding author

Vinciya Pandian, PhD, MBA, MSN, RN, ACNP-BC, FAANP, FAAN
Johns Hopkins School of Nursing
525 North Wolfe Street
Baltimore, MD 21205
Email Address: vpandian1@jhu.edu
Telephone: 443-655-3482

Institution at which work was performed

Johns Hopkins University

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