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Prevention of Ventilator-Associated Pneumonia in Intensive Care Units: The Effect of Scenario-Based Simulation on Nursing Students' Skill Development Process

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ABSTRACT

Background: Nursing students need to be equipped with effective clinical skills to prevent ventilator-associated pneumonia (VAP) in high-risk patients in intensive care units.

Aim: The study aimed to determine the effectiveness of scenario-based simulation training in developing knowledge and skills for the prevention of VAP in undergraduate nursing students.

Study Design: A single-group, pretest-posttest quasi-experimental study was conducted with undergraduate nursing students enrolled in an intensive care course. Scenario-based simulations and a VAP Prevention Performance Checklist were prepared for the study. The students' skill performance was assessed simultaneously by two independent observers before and after the simulation training. Pretest and posttest scores were compared with Wilcoxon, McNemar and McNemar-Bowker tests, and interrater agreement was assessed using intraclass correlation coefficients (ICC).

Results: In total, 36 students participated in the study. The content validity of the VAP Prevention Performance Checklist was assessed using the Delphi method, which resulted in expert consensus for all items in the second round (the scale-level content validity index was 1.00). There was excellent interrater agreement in the skill performance assessment (ICC = 0.982; $p < 0.001$). The students' VAP prevention performance scores were significantly higher in the posttest than in the pretest (38.38 ± 7.81 vs. 18.38 ± 5.06, $p = 0.002$, Cohen's $d = 1.25$).

Conclusions: Scenario-based simulation training was shown to be effective in increasing nursing students' awareness and implementation of skills that contribute to the prevention of VAP. Scenario-based simulations can be used as an effective method to improve VAP prevention knowledge and skills during undergraduate nursing education and in-service training.

Relevance to Clinical Practice: Scenario-based simulations can be used as an effective method to improve VAP prevention knowledge and skills during undergraduate nursing education and in-service training.

1 | Introduction

Ventilator-associated pneumonia (VAP) is a hospital-acquired infection that raises the risk of mortality and morbidity and results in increased treatment costs and longer hospital stays [1–3]. Although the incidence of VAP generally varies between 5% and 40%, this rate increased to 46% during the COVID-19 pandemic [1–3]. Given its high incidence and serious consequences,

Impact Statements

- What is known about the topic
  - Ventilator-associated pneumonia (VAP) is a common and serious healthcare-associated infection in intensive care units, increasing patient morbidity, mortality, length of stay and healthcare costs.
  - Nursing students and intensive care nurses, particularly in low- and middle-income countries, often have insufficient knowledge and skills for VAP prevention.
  - While simulation-based education enhances clinical competencies, its integration into intensive care nursing curricula for VAP prevention remains limited.
- What this paper adds
  - Scenario-based simulation significantly improves nursing students' performance in VAP prevention practices.
  - High-fidelity simulation is an effective method for developing routine intensive care nursing skills.
  - These findings support incorporating simulation-based training into undergraduate nursing curricula and clinical staff development programmes.

guidelines for VAP prevention are continuously being updated and show promise in reducing infection rates by shaping care practices [4–9].

Unfortunately, lack of information about prevention strategies remains a significant problem in low- and middle-income countries with high VAP rates [10]. These countries face the need for sufficient health personnel (e.g., a balanced nurse-to-patient ratio) as well as cost-effective continuing education programmes for health personnel [5, 11]. The literature data reveal a significant deficiency in the knowledge of intensive care unit (ICU) nurses, nursing students and resident physicians regarding approaches to VAP prevention [10, 12–19]. There is also evidence demonstrating moderate compliance with evidence-based VAP prevention strategies [14], nurses' generally poor reflection of guidelines in clinical care [20] or their partially reflection of this information in practice [21, 22], and the need for continuing education on VAP prevention [23].

1.1 | Background

Current approaches to preventing VAP require a combination of technical knowledge and skills ranging from performing airway suctioning safely and correctly, assessing the need for airway suctioning, measuring cuff pressure and changing the heat, moisture, and bacteria filters and ventilator circuits using appropriate techniques. In addition, communication and collaboration within the team also play a critical role in managing these processes effectively. In a study aiming to teach physicians and nurses correct cuff pressure measurement technique using the simulation method, Patel et al. [24] found that these healthcare professionals were not able to check cuff pressure using the correct technique and emphasised the importance of providing opportunities to build such critical skills in safe and controlled environments. Studies evaluating the effectiveness of VAP prevention training have indicated that these training increase participants' compliance with VAP preventive practices, resulting in statistically significant reductions in ventilator duration, length of hospital stay and VAP incidence [25, 26]. As ICUs handle patients with critical and complicated illnesses, the teams staffing these units should receive specially designed training [27]. Not acquiring these skills preclinically can lead to many problems in the hospital setting.

Health education can be delivered using a wide range of methods, from theoretical instruction to case studies, simulations to clinical applications. The use of simulation in health education supports learning in a safe environment and contributes to students' knowledge and skill building by providing realistic experiences, especially with scenario-based simulations. In this context, simulation is defined as a method in which guided experiences are provided by creating realistic environments that imitate real-world events and phenomena [27]. Studies show that scenario-based simulations are superior to other teaching methods in improving nursing students' knowledge, technical and non-technical skills, cooperation and performance, especially in the management of critical patients [27–29]. In a meta-analysis of studies with undergraduate nursing students, it was emphasised that simulations significantly increase students' knowledge, skill performance and self-confidence, thereby minimising the risk of error and enabling them to work safely by upon entering the profession [30]. Another meta-analysis study conducted in Chinese and English databases revealed that simulations performed with high-fidelity scenarios were effective in improving nursing students' professional skills such as critical thinking, communication, and clinical decision-making and facilitated their transition from the learning process to clinical environment [31]. These findings strongly indicate that integrating simulation techniques into the training curricula of healthcare professionals who will work in the ICU is beneficial both in terms of improving their professional skills and enhancing patient safety.

Although Intensive Care Nursing is a compulsory course in many countries, most undergraduate nursing programmes in Turkey offer it as an elective course. Based on a review of the national and international literature, scenario-based simulation training is not widely used in Intensive Care Nursing courses. Instead, most offer theoretical information about VAP prevention, while VAP preventive skills are often limited or not taught. Moreover, there are limited data on the knowledge and skill levels of nursing students regarding VAP prevention and the effect of simulation training on these skills. However, learning about the ICU environment and patient management during their undergraduate education will give nursing students an important advantage in coping with unexpected situations and avoiding undesirable events. As nurses have the most daily interaction with patients during care and treatment and therefore have the main role in VAP prevention, they must receive up-to-date VAP preventive training and improve their clinical skills starting from their nursing education. Therefore, including the skills in the ventilator care bundle in simulation-based VAP prevention training should be effective in preventing VAP and improving students' critical decision-making and clinical skills.

1.2 | Aim

The study aimed to determine the effectiveness of scenario-based simulation training in developing knowledge and skills for the prevention of VAP in undergraduate nursing students.

1.3 | Research Hypotheses

H0. *There will be no difference between the pretest and posttest VAP prevention skill performance scores of nursing students trained with scenario-based simulation.*

H1. *There will be an improvement between the pretest and posttest VAP prevention skill performance scores of nursing students trained with scenario-based simulation.*

2 | Desing and Methods

2.1 | Study Design

A pretest–posttest single-group quasi-experimental study was conducted.

2.2 | Setting and Sample

The population of the study consisted of 97 students enrolled in the Intensive Care Nursing course in the nursing department of a public university in the Black Sea region of Türkiye in the spring semester of the 2021–2022 academic year. Power analysis was performed to calculate the sample size. The minimum sample number for an effect size (d) of 0.615 [32] with 95% confidence (1-α) and 95% test power (1-β) was determined to be 37 participants. Considering possible losses, we decided to include 39 volunteer students in the sample. Microsoft Excel was used to assign the students to teams and determine the teams' training days in order to make an unbiased assignment. Exclusion criteria were (1) not participating in the theoretical and/or practical Caring for the Mechanically Ventilated Patient and VAP Prevention training, (2) not participating in the pretest, simulation and/or posttest and (3) wanting to withdraw from the study.

2.3 | Data Collection Tools and Methods

The study data were collected using three questions about the students' age, gender and type of high school (health vocational high school or other) and the VAP Prevention Performance Checklist. The VAP Prevention Performance Checklist was prepared by the researchers to evaluate the participants' performance of skills that contribute to the prevention of VAP based on the relevant literature [4, 24, 33–35].

2.3.1 | VAP Prevention Performance Checklist

2.3.1.1 | Content Validity. The content validity of the checklist was evaluated using a two-round Delphi method involving five experts that were highly experienced in their respective fields [36–39]. The panel consisted of an intensive care physician (15 years of intensive care experience, with dual specialisation in anaesthesiology and critical care medicine), an intensive care nurse (25 years of clinical and managerial intensive care experience, along with expertise in simulation-based orientation training), a medical education and informatics specialist (a pioneer in the widespread adoption of simulation research and the development of simulation-based postgraduate programmes in Turkey), an educational measurement and evaluation specialist (with academic expertise and postdoctoral experience in simulation and advanced learning technologies in the USA) and a health sciences specialist with extensive experience in the field of simulation.

During the first round of the Delphi process, the panel evaluated a total of 39 items using a 3-point rating scale (3 = relevant, 2 = somewhat relevant/requires minor revision, 1 = irrelevant/requires major revision). The item-level content validity index (I-CVI) for each item was calculated based on the proportion of experts who rated an item as relevant. Of the 39 items, 30 (77%) were rated as relevant by all experts (I-CVI = 1.00), 5 items (13%) were rated as relevant by four experts (I-CVI = 0.80), and 4 items (10%) yielded I-CVI values below 0.80. The scale-level CVI (S-CVI), calculated as the average of all I-CVI values, was 0.92 in the first round, indicating a high level of content validity for the instrument [38]. In addition to quantitative scoring, the experts provided written feedback on the items. For certain items, the experts noted they contained redundant skill steps (5 items), were absent from the relevant clinical protocols (2 items) or lacked universal applicability across all scenarios (9 items), ultimately recommending their removal. Consequently, these items were excluded from the checklist following a combined evaluation of the quantitative and qualitative data.

In the second Delphi round, conducted following these revisions, all 23 retained items were unanimously rated as relevant, resulting in I-CVI values of 1.00 and an S-CVI value of 1.00. These findings indicate excellent content validity [36–39].

After establishing content validity, the checklist and simulation scenarios were piloted with 11 students (organised into teams of 2–3). Based on the students' feedback, no further modifications were made to the checklist, thereby confirming the instrument's applicability. Data obtained from the pilot test were not included in the main analysis. Although the SHEA/IDSA/APIC guideline recommended oral care with chlorhexidine, this recommendation was removed from the 2022 version [40]. All students were informed about this update to the guidelines.

2.3.1.2 | Checklist Scoring. The final checklist includes a total of 23 items (Figure S1). Items 1, 3, 6–8 and 11–20 are scored as either 'performed' (2 points) or 'not performed' (0 points). The remaining items (2, 4, 5, 9, 10 and 21–23) are evaluated as 'fully performed' (2 points), 'partially performed' (1 point) or 'not performed' (0 points). The total score ranges from 0 to 46 points, with higher scores indicating better performance of VAP prevention skills.

2.3.1.3 | Checklist Reliability. The internal consistency of the instrument was evaluated using the Cronbach's alpha coefficient. The Cronbach's alpha value was calculated as 0.521 for the pretest and 0.876 for the posttest.

2.4 | Study Procedures

During the preparation phase of the study, scenarios were developed and piloted. The scenarios prepared by the researchers were evaluated for content and scope by a total of four experts with over 15 years of professional experience in their respective fields: one ICU physician, one ICU nurse and two experts in the field of simulation in the health sciences. These experts provided their input within the framework of the Delphi method to ensure the validity of the scenarios.

Minor alterations to the scenarios were made according to the experts' suggestions before pilot testing. The simulation scenarios included hypoxia secondary to pulmonary embolism with endotracheal ventilation, COPD (chronic obstructive pulmonary disease) with tracheostomy ventilation and anaphylactic shock with endotracheal ventilation (Figures S2–S4). The scenarios were first piloted with 11 students. No changes to scenario duration, content or debriefing session were made, but the prebriefed text in the scenario text was expanded as a result of the students' feedback. Data from the pilot test were not included in the study sample.

The implementation phase of the study comprised the pretest, simulation training and posttest (Figure 1) and was carried out in the simulation laboratory of the nursing department. This laboratory is equipped with fixtures and consumables similar to those in the ICU, as well as a high-fidelity simulator (Gaumard Susie S1001). During the training, the researcher (X.X.) prepared the laboratory according to the scenarios (Figure S5) After obtaining written consent, the students who volunteered to participate in the study were randomly assigned to teams. The pretest was conducted in the first week, the simulation training in the second week and the posttest in the third week (Figure S5). The simulation sessions included briefing (5 min), simulation (10 min) and debriefing (30 min). The debriefing was held immediately after the end of the simulation. In the debriefing, the students viewed performance videos and analysed them with the GAS (Gather/Analyse/Summarise) technique. The pretest and posttests were also conducted in the form of scenario-based

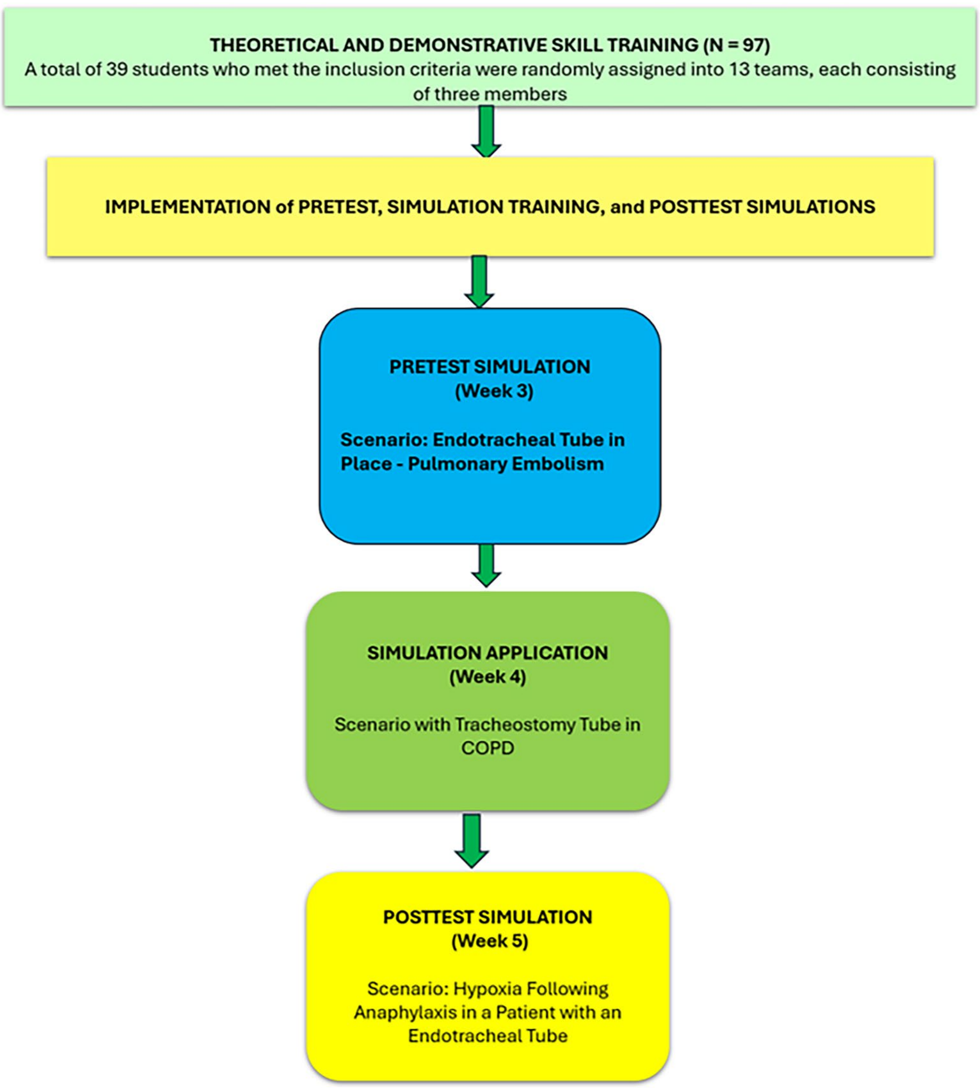

FIGURE 1 | Study flow diagram. Illustrates the research process from participant recruitment to final evaluation.

TABLE 1 | Comparison of pretest and posttest performance scores on the ventilator-associated pneumonia prevention performance checklist between the observers.

	Observer 1		Observer 2					
	Mean ± SD	**Median (range)**	**Mean ± SD**	**Median (range)**	***Z***	***p****	**ICC (95% CI)**	***p***
Pretest	17.54 ± 5.78	16 (12–33)	18.54 ± 4.63	17 (13–30)	9.715	0.198	0.935 (0.650–0.788)	< 0.001
Posttest	38.46 ± 8.26	42 (14–44)	38.15 ± 7.38	40 (18–44)	−0.483	0.629	0.982 (0.887–0.940)	< 0.001

Abbreviation: ICC, intraclass correlation coefficient.
*Wilcoxon test.

TABLE 2 | Comparison of nursing students' averaged pretest and posttest scores on the ventilator-associated pneumonia prevention performance checklist ($n = 36$).

	Pretest		Posttest				
	Mean ± SD	**Median (range)**	**Mean ± SD**	**Median (range)**	***Z***	***p****	**ES [%95 CI]**
Total score	18.38 ± 5.06	17 (13–32)	38.38 ± 7.81	41 (16–44)	3.112	**0.002**	0.610 [0.089–0.869]

Note: ES [95% CI] = effect size [95% confidence interval]: paired correlation coefficient (*r*). Bold values indicate statistical significance ($p < 0.05$).
*Wilcoxon test.

simulations in which the students' performance was evaluated independently by two observers (Figure S6).

2.5 | Data Analysis

The data were analysed using IBM SPSS version 23 (IBM Corp., Armonk, NY, USA). The data are presented as frequency and percentage for categorical variables and mean and standard deviation or median and range for quantitative data. The significance level was accepted as $p < 0.05$. The Shapiro–Wilk test was used to check the data for normal distribution. Wilcoxon test was used to compare non-normally distributed data between paired samples, and intraclass correlation coefficient (ICC) was used to examine interrater agreement [41]. Interrater agreement was interpreted as poor for ICC < 0.50, moderate for ICC = 0.50–0.75, good for ICC = 0.75–0.90 and excellent for ICC > 0.90 [41]. The McNemar and McNemar-Bowker tests were used to compare item ratings given in the pretest and posttest. In addition, the internal consistency of the instrument was assessed using Cronbach's alpha coefficient. Content validity was evaluated using the CVI based on expert ratings. Cohen's *d* effect sizes were interpreted as small (0.2), medium (0.5) and large (0.8), according to Cohen [42]. For Wilcoxon test results, effect sizes were calculated as rank-biserial correlation (*r*) with 95% confidence intervals.

2.6 | Ethical and Institutional Approvals

Institutional permission and ethical approval from the Non-Interventional Clinical Research Ethics Committee of a university in Turkey (19 March 2020—E.7706) were obtained before the study. However, due to the postponement of research projects during the COVID-19 pandemic, a second institutional permission (30 December 2021—E.49722) and ethics committee approval from the same ethics committee (04 February 2022—E.55797) were obtained. Informed written consent was obtained from all students who agreed to participate in the study. The video recordings of the simulations obtained for analysis were deleted after being used in the debriefing session on the same day. To prevent bias, the pretest and posttest assessments were performed independently by two faculty members who were not part of the research team. The simulation scenarios were evaluated by educators who were trained in simulation and had experience in the simulation field. Students who did and did not participate in the study were informed that there would be no change to the routine course procedures and assessment, and that their participation or nonparticipation in the study would not be reflected in their course performance as a grade in any way.

3 | Results

Three students who could not continue the simulations were excluded from the study. Thus, the analysis included 36 participants divided into 13 teams of 2–3 students each. The mean age of the participating students was 21.11 ± 0.85 years and 88.9% were female. There was no statistically significant difference between the observers' scores in the pretest ($p = 0.198$) or posttest ($p = 0.629$). Interrater agreement was excellent for the pretest (ICC = 0.935; $p < 0.001$) and posttest (ICC = 0.982; $p < 0.001$) scores (Table 1). The students' median score for VAP prevention skill performance was 17 in the pretest and increased significantly to 41 in the posttest ($Z = 3.112$, $p = 0.002$) (Table 2). Cohen's d value was 1.259, indicating a large effect of the intervention. The number of teams who implemented the VAP prevention strategies was seen to increase after the simulation training (Table 3).

4 | Discussion

In this study, nursing students' performance scores doubled after training with scenario-based simulation for VAP prevention. This statistically significant improvement supports our alternative hypothesis.

TABLE 3 | Comparison of the students' pretest and posttest scores on the ventilator-associated prevention performance checklist.

	Pretest			Posttest				
Skill checklist	**Performed completely**	**Performed partially**	**Not performed**	**Performed completely**	**Performed partially**	**Not performed**	**Test stat.**	***p***
1. Inform patient about the intervention	6 (46.2)	—	7 (53.8)	6 (46.2)	—	7 (53.8)	—	1.000*
2. Verify patient's identity with two identifiers (patient file and wristband)	3 (23.1)	5 (38.5)	5 (38.5)	12 (92.3)	—	1 (7.7)	—	—
3. Check physician's order	4 (30.8)	—	9 (69.2)	11 (84.6)	—	2 (15.4)	—	**0.016***
4. Check patient's units/doses of fluids and medications	4 (30.8)	—	9 (69.2)	13 (100)	—	—	—	—
5. Check patient's vital signs	6 (46.2)	2 (15.4)	5 (38.5)	11 (84.6)	1 (7.7)	1 (7.7)	6.000	0.050**
6. Check whether the head of the patient's bed is at the appropriate elevation (30°–45°)	5 (38.5)	—	8 (61.5)	7 (53.8)	—	6 (46.2)	—	0.727*
7. Change patient's position	5 (38.5)	—	8 (61.5)	7 (53.8)	—	6 (46.2)	—	0.727*
8. Perform hand hygiene	5 (38.5)	—	8 (61.5)	9 (69.2)	—	4 (30.8)	—	0.219*
9. Assess need for airway suctioning and perform suctioning	7 (53.8)	3 (23.1)	3 (23.1)	11 (84.6)	—	2 (15.4)	—	—
10. Wash suction catheter with saline and replace	8 (61.5)	1 (7.7)	4 (30.8)	11 (84.6)	—	2 (15.4)	—	—
11. Check patient's mouth for secretions	6 (46.2)	—	7 (53.8)	9 (69.2)	—	4 (30.8)	—	0.375*
12. Perform oral care with 0.12% chlorhexidine solution	1 (7.7)	—	12 (92.3)	9 (69.2)	—	4 (30.8)	—	**0.008***
13. Check cuff pressure of endotracheal tube/tracheostomy cannula	9 (69.2)	—	4 (30.8)	12 (92.3)	—	1 (7.7)	—	0.375*
14. Check whether the endotracheal tube/tracheostomy cannula securements are soiled	4 (30.8)	—	9 (69.2)	10 (76.9)	—	3 (23.1)	—	**0.031***
15. Check mechanical ventilator connections are in place	5 (38.5)	—	8 (61.5)	11 (84.6)	—	2 (15.4)	—	**0.031***
16. Check mechanical ventilator circuit for fluid/secretions	2 (15.4)	—	11 (84.6)	11 (84.6)	—	2 (15.4)	—	**0.004***
17. Check bacterial filter of the mechanical ventilator circuit for contamination	2 (15.4)	—	11 (84.6)	10 (76.9)	—	3 (23.1)	—	**0.021***

(Continues)

TABLE 3 | (Continued)

Skill checklist	Pretest			Posttest			Test stat.	*p*
	Performed completely	Performed partially	Not performed	Performed completely	Performed partially	Not performed		
18. Check heat/moisture filter of the mechanical ventilator circuit for contamination	2 (15.4)	—	11 (84.6)	11 (84.6)	—	2 (15.4)	—	**0.004***
19. Perform peptic ulcer prophylaxis upon physician's order	—	—	13 (100)	12 (92.3)	—	1 (7.7)	—	—
20. Perform deep vein thrombosis prophylaxis upon physician's order	—	—	13 (100)	12 (92.3)	—	1 (7.7)	—	—
21. Check condition of antiembolism stockings and apply smoothly up to the kneecap	2 (15.4)	—	11 (84.6)	13 (100)	—	—	—	—
22. Record interventions on the nurse follow-up form	6 (46.2)	—	7 (53.8)	11 (84.6)	—	2 (15.4)	—	0.063*
23. Work in cooperation with team	4 (30.8)	7 (53.8)	2 (15.4)	9 (69.2)	3 (23.1)	1 (7.7)	3.667	0.160**

Note: —, not applicable (scoring was binary for items 1, 3, 6–8 and 11–20; statistical analysis was not possible for some items due to small cell sizes). Bold values indicate statistical significance ($p < 0.05$).
*McNemar test.
**McNemar-Bowker test.

To the best of our knowledge, no previous studies have utilised simulation techniques specifically to enhance VAP prevention skills. However, the literature does include a study from Spain detailing the design and content validation of a checklist to evaluate the infection prevention performance of ICU nurses during simulation-based scenarios [43]. The authors of the study posited that utilising a clinically tested and validated checklist can facilitate the translation of ICU nurses' knowledge and skills regarding the prevention of VAP and central line-associated bloodstream infections into the clinical care of critically ill patients [43].

VAP prevention remains an important issue in ICUs in both developing and developed countries and requires adequate theoretical knowledge and clinical skills not only among current health professionals but also nursing students. Unfortunately, simulation-based training for VAP prevention are not offered in our country, but a few have been documented elsewhere in the world. As VAP can prolong hospital stays and even result in mortality in ventilator-dependent individuals, health teams should provide care that is consistent and meets the care quality standards. It has been reported that nurses who received training about VAP prevention showed an increase in knowledge after the training [13]. Increased knowledge also contributes to skill development. Alvina et al. examined the effect of a 10-week training (3 sessions per week, 15 sessions total) using PowerPoint narrative audio–visual demonstrations and videos. The nurses were given 2 weeks to apply their knowledge and 4 weeks to develop the practices in the study to reduce VAP. A positive impact on the nurses' knowledge and practices was observed after the VAP prevention training [13]. Although the training in that study was not simulation-based, it may have been effective because it provided nurses with the opportunity to simultaneously practice what they learned in the real environment. As our study utilised simulation scenarios and realistic environments, it can be said that simulation training may promote the learning of VAP preventive approaches and their transfer to clinical skills; however, this effect may vary depending on the educational setting and context. Students do not receive adequate training to prevent VAP in nursing school [12].

In the present study, we observed that in the posttest, the students more frequently checked whether the endotracheal and tracheostomy tube securements were clean, whether the mechanical ventilator connections were in place, whether fluid or secretion in the connections and whether the bacterial and heat/moisture filters needed to be changed. These findings show that the training was effective. Consistent with our findings, it has been emphasised in the literature that training provided to nurses results in better compliance with and knowledge of the specified procedures [33, 44–48].

Other practices that showed highly significant improvement in the study were recording the procedures performed and ensuring team cooperation. Simulation work is an effective method for increasing teamwork [49]. Similarly, the literature shows that team cooperation and record-keeping are effective in preventing VAP and determining surveillance outcomes [9, 33, 47, 48, 50, 51]. In one study, it was emphasised that even if physicians had sufficient knowledge about VAP prevention guidelines, they were not aware of the practices only performed by nurses (e.g., disinfecting hands and wearing gloves before tracheal suctioning), and therefore close cooperation between these two groups is imperative [23]. In addition, it is vital that not only nurses but also the whole teamwork in harmony with each other and that VAP is managed with a team mentality in order to reduce the incidence of VAP. Simulation interventions that will strengthen interprofessional cooperation and team awareness in VAP management are also needed.

Although not statistically significant, we observed an increase in the performance of cuff pressure measurement in the posttest. Checking cuff pressure has been included since the first VAP care bundle interventions were determined. However, it is reported that digital measuring devices are needed rather than the manual devices currently used in clinics [24]. In their study aiming to teach the cuff pressure measurement technique to physicians and nurses using simulation training, Patel et al. [24] reported that healthcare professionals were unable to correctly check cuff pressure, pointing out that clinical skills should first be developed in safe environments. Although not included in the aims of this study, we similarly observed that the nursing students would suddenly increase and/or decrease cuff pressure when measuring for the first time before starting the simulation. The students were asked to repeat cuff pressure measurements until they could do so safely. This shows that it is important for students to develop skills that are commonly used in the ICU in safe environments before proceeding to simulation scenarios and/or clinical practice in order to provide safe patient care in a stressful, dynamic and high-risk environment such as the ICU.

The literature data suggest that nursing students have a moderate level of knowledge about endotracheal suctioning [52]. The main strengths of our study are that after providing theoretical education on VAP prevention, the students had one-to-one skill practice for open and closed endotracheal suctioning, cuff pressure measurement, tracheostomy care and tracheal suctioning, and changes in their skills were tested in scenario-based simulations. Performing airway suctioning using proper techniques and under appropriate conditions is essential for VAP prevention. In addition, as the study coincided with the COVID-19 pandemic, there was a greater number of patients in need of mechanical ventilation, especially in the ICU, increased media attention to the need for mechanical ventilation, and high mortality and morbidity rates, which we believe increased students' attention, awareness and interest in learning about this subject.

5 | Limitations

Because the performance assessment guide and scenarios were prepared in accordance with guidelines published before 2022 [53–56], oral care with chlorhexidine was included in the training. However, this recommendation was removed from the SHEA/IDSA/APIC guideline updated in 2022 [42]. As this up-to-date information was published after the assessment tool and scenarios used in the research were developed, it could not be reflected in the study. Additionally, the study was planned to have the same two observers conduct both the pretest and posttest assessments for consistency. However, some faculty who participated in the pretest could not perform the posttest because the simulation practice sessions of some groups conflicted with their teaching schedule. Moreover, a longer term follow-up of students was not conducted, which limited our ability to assess whether the knowledge and skills acquired through simulation were retained over time. For future research, it would be valuable to investigate whether these skills are transferred to clinical practice during practical training in healthcare settings.

6 | Implications for Practice

The results of this study demonstrated that simulation training significantly improved nursing students' performance in implementing VAP prevention strategies. Based on these findings, we recommend incorporating scenario-based simulation training focusing on VAP prevention into undergraduate nursing curricula. However, further research is warranted before implementing this training in other settings and populations. Specifically, additional studies are needed to evaluate the applicability and effectiveness of these simulation scenarios in postgraduate nursing education programmes, in-service training programmes, and educational initiatives targeting nurses and other healthcare professionals at different levels.

Another practical implication of this study concerns the VAP prevention checklist developed and used in this research. Psychometric analyses indicated that the checklist is valid, reliable and practical for educational and research purposes within a sample of undergraduate nursing students. However, before its use in postgraduate and in-service nursing education programmes, it is recommended that the existing checklist be revised to incorporate more advanced clinical decision-making steps and better address the needs of the target population [43].

7 | Conclusion

Scenario-based simulation training was shown to be effective in increasing nursing students' awareness and implementation of skills that contribute to the prevention of VAP. Scenario-based simulations represent a valuable tool for undergraduate nurses.

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The authors have nothing to report.

Ethics Statement

Institutional permission and ethical approval from the Amasya University Non-Interventional Clinical Research Ethics Committee (19 March 2020—E.7706) were obtained before the study. However, due to postponement of research projects during the COVID-19 pandemic, a second institutional permission (30 December 2021—E.49722) and ethics committee approval from the Amasya University Non-Interventional Clinical Research Ethics Committee (04 February 2022—E.55797) were obtained.

Consent

Informed written consent was obtained from all students who agreed to participate in the study. The video recordings of the simulations obtained for analysis were deleted after being used in the debriefing session on the same day. To prevent bias, the pretest and posttest assessments were performed independently by two faculty members who were not part of the research team. The simulation scenarios were evaluated by educators who were trained in simulation and had experience in the simulation field. Students who did and did not participate in the study were informed that there would be no change to the routine course procedures and assessment, and that their participation or nonparticipation in the study would not be reflected in their course performance as a grade in any way. Although the SHEA/IDSA/APIC guideline recommended oral care with chlorhexidine, this recommendation was removed from the 2022 version [51]. All students were informed about this update to the guidelines.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. R. Raycheva, V. Rangelova, and A. Kevorkyan, “Cost Analysis for Patients With Ventilator-Associated Pneumonia in the Neonatal Intensive Care Unit,” *Healthcare* 10, no. 6 (2022): 980, https://doi.org/10.3390/healthcare10060980.

2. L. Papazian, M. Klompas, and C. E. Luyt, “Ventilator-Associated Pneumonia in Adults: A Narrative Review,” *Intensive Care Medicine* 46, no. 5 (2020): 888–906, https://doi.org/10.1007/s00134-020-05980-0.

3. D. R. Giacobbe, D. Battaglini, E. M. Enrile, et al., “Incidence and Prognosis of Ventilator-Associated Pneumonia in Critically Ill Patients With COVID-19: A Multicenter Study,” *Journal of Clinical Medicine* 10, no. 4 (2021): 555, https://doi.org/10.3390/jcm10040555.

4. F. Álvarez Lerma, M. Sánchez García, L. Lorente, et al., “Guidelines for the Prevention of Ventilator-Associated Pneumonia and Their Implementation. The Spanish “Zero-VAP” Bundle,” *Medicina Intensiva* 38, no. 4 (2014): 226–236, https://doi.org/10.1016/j.medin.2013.12.007.

5. V. D. Rosenthal, W. Duszynska, B. E. Ider, et al., “International Nosocomial Infection Control Consortium (INICC) Report, Data Summary of 45 Countries for 2013–2018, Adult and Pediatric Units, Device-Associated Module,” *American Journal of Infection Control* 49, no. 10 (2021): 1267–1274, https://doi.org/10.1016/j.ajic.2021.04.077.

6. M. G. Gozel, C. H. Hekimoglu, E. Y. Gozel, E. Batir, M. L. ML, and E. A. Mese, “National Infection Control Program in Turkey: The Healthcare Associated Infection Rate Experiences Over 10 Years,” *American Journal of Infection Control* 49, no. 7 (2021): 885–892, https://doi.org/10.1016/j.ajic.2020.12.013.

7. S. Keske, “The Significance of Multidirectional Studies in Control of Health Care-Associated Infections,” *Klimik Dergisi/Klimik Journal* 32, no. 2 (2019): 190–194, https://doi.org/10.5152/kd.2019.41.

8. N. J. Mavinga, M. J. Nsiala, M. E. Mafuta, M. Y. Yanga, B. E. Amisi, and J. P. Ilunga, “Implementation and Evaluation of the Impact of a “Ventilator-Bundle” at Kinshasa University Clinics: Before and After Study,” *Journal of Infectious Diseases and Medical Microbiology* 3, no. 2 (2018): 21–25, http://www.alliedacademies.org/journal-infectious-diseases-medical-microbiology/.

9. F. Álvarez-Lerma, M. Palomar-Martínez, M. Sánchez-García, et al., “Prevention of Ventilator-Associated Pneumonia: The Multimodal Approach of the Spanish ICU “Pneumonia Zero” Program*,” *Critical Care Medicine* 46, no. 2 (2018): 181–188, https://doi.org/10.1097/CCM.0000000000002736.

10. A. B. Getahun, Y. Belsti, M. Getnet, et al., “Knowledge of Intensive Care Nurses' Towards Prevention of Ventilator-Associated Pneumonia in North West Ethiopia Referral Hospitals, 2021: A Multicenter, Cross-Sectional Study,” *Annals of Medicine and Surgery* 78 (2022): 1–6, https://doi.org/10.1016/j.amsu.2022.103895.

11. S. Kharel, A. Bist, and S. K. Mishra, “Ventilator-Associated Pneumonia Among ICU Patients in WHO Southeast Asian Region: A Systematic Review,” *PLoS One* 16, no. 3 (2021): e0247832, https://doi.org/10.1371/journal.pone.0247832.

12. S. M. Aloush, “Nursing Students' Knowledge About Ventilator-Associated Pneumonia Prevention Guidelines: Effectiveness of a Teaching Program,” *American Journal of Infection Control* 45, no. 5 (2017): 544–546, https://doi.org/10.1016/j.ajic.2017.01.025.

13. B. Alvina, M. Afzal, and A. Ali, “Effect of Educational Guidelines on Nurses' Knowledge and Practices Regarding Ventilator Associated Pneumonia at Tertiary Care Hospital Lahore,” *Pakistan Journal of Health Sciences* 4, no. 01 (2023): 104–107, https://doi.org/10.54393/pjhs.v4i01.506.

14. V. Bankanie, A. H. Outwater, L. Wan, and L. Yinglan, “Assessment of Knowledge and Compliance to Evidence-Based Guidelines for VAP Prevention Among ICU Nurses in Tanzania,” *BMC Nursing* 20, no. 1 (2021): 209, https://doi.org/10.1186/s12912-021-00735-8.

15. N. F. Donmez, D. Kanyilmaz, C. Tiryaki, S. Yilmaz, and B. Dikmen, “Evidence-Based Guidelines for the Prevention of Ventilator Associated Pneumonia: Results of Knowledge Test Among Anesthesia Residents Employed in ICU,” *Journal of the Turkish Anaesthesiology and Intensive Care Society* 40, no. 4 (2012): 202–211, https://doi.org/10.5222/JTAICS.2012.202.

16. G. Kalyan, R. Bibi, R. Kaur, et al., “Knowledge and Practices of Intensive Care Unit Nurses Related to Prevention of Ventilator Associated Pneumonia in Selected Intensive Care Units of a Tertiary Care Centre, India,” *Iranian Journal of Nursing and Midwifery Research* 25, no. 5 (2020): 369–375, https://doi.org/10.4103/ijnmr.IJNMR_128_18.

17. A. Madhuvu, R. Endacott, V. Plummer, and J. Morphet, “Nurses' Knowledge, Experience and Self-Reported Adherence to Evidence-Based Guidelines for Prevention of Ventilator-Associated Events: A National Online Survey,” *Intensive & Critical Care Nursing* 59, no. 1 (2020): 102827, https://doi.org/10.1016/j.iccn.2020.102827.

18. N. Ozen and B. Armutcu, “Knowledge Levels of Critical Care Nurses on Evidence-Based Practices for the Prevention of Ventilator-Associated Pneumonia,” *Turkish Journal of Medical and Surgical Intensive Care* 9, no. 3 (2018): 78–83, https://doi.org/10.5152/dcbybd.2018.1880.

19. H. Rafiei, S. Rahimi, M. Shafaei, and M. Ommatmohammadi, “Emergency Nurses' Knowledge About Ventilator-Associated Pneumonia,” *International Emergency Nursing* 48 (2020): 1–4, https://doi.org/10.1016/j.ienj.2019.06.006.

20. S. M. Aloush, “Nurses' Implementation of Ventilator-Associated Pneumonia Prevention Guidelines: An Observational Study in Jordan,” *Nursing in Critical Care* 23, no. 3 (2018): 147–151, https://doi.org/10.1111/nicc.12323.

21. M. Jansson, T. Ala-Kokko, P. Ylipalosaari, H. Syrjälä, and H. Kyngäs, “Critical Care Nurses' Knowledge of, Adherence to and Barriers

Towards Evidence-Based Guidelines for the Prevention of Ventilator-Associated Pneumonia – A Survey Study," *Intensive & Critical Care Nursing* 29, no. 4 (2013): 216–227, https://doi.org/10.1016/j.iccn.2013.02.006.

22. S. M. Tabaeian, A. Yazdannik, and S. Abbasi, "Compliance With the Standards for Prevention of Ventilator-Associated Pneumonia by Nurses in the Intensive Care Units," *Iranian Journal of Nursing and Midwifery Research* 22, no. 1 (2017): 31–36, https://doi.org/10.4103/1735-9066.202073.

23. M. J. Pérez-Granda, P. Muñoz, C. Heras, G. Sánchez, J. Rello, and E. Bouza, "Prevention of Ventilator-Associated Pneumonia: Can Knowledge and Clinical Practice be Simply Assessed in a Large Institution?," *Respiratory Care* 58, no. 7 (2013): 1213–1219, https://doi.org/10.4187/respcare.01854.

24. V. Patel, E. J. Hodges, M. Z. Mariyaselvam, C. Peutherer, and P. J. Young, "Unintentional Endotracheal Tube Cuff Deflation During Routine Checks: A Simulation Study," *Nursing in Critical Care* 24, no. 2 (2019): 83–88, https://doi.org/10.1111/nicc.12397.

25. A. Branco, E. M. S. Lourençone, A. B. Monteiro, J. P. Fonseca, C. R. Blatt, and R. C. A. Caregnato, "Education to Prevent Ventilator-Associated Pneumonia in Intensive Care Unit," *Revista Brasileira de Enfermagem* (2020): 1–7, https://doi.org/10.1590/0034-7167-2019-0477.

26. İ. Esen Yıldız, *Anestezi ve Nöroloji Yoğun Bakım Ünitelerinde Ventilatör İlişkili Pnömoni Önlem Paketi Uygulaması ve Eğitimin Katkısının Değerlendirilmesi Uzmanlık Tezi* (Ndokuz Mayıs Üniversitesi Tıp Fakültesi, 2013), https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=3UtWcZwBGb8v6gjNb9zhlw&no=RETfrxvhfMvWkEx6SxqJOQ.

27. N. Seam, A. J. Lee, M. Vennero, and L. Emlet, "Simulation Training in the ICU," *Chest* 156, no. 6 (2019): 1223–1233, https://doi.org/10.1016/j.chest.2019.07.011.

28. C. La Cerra, A. Dante, V. Caponnetto, et al., "Effects of High-Fidelity Simulation Based on Life-Threatening Clinical Condition Scenarios on Learning Outcomes of Undergraduate and Postgraduate Nursing Students: A Systematic Review and Meta-Analysis," *BMJ Open* 9, no. 2 (2019): e025306, https://doi.org/10.1136/bmjopen-2018-025306.

29. Y. Y. Li, M. L. Au, L. K. Tong, W. I. Ng, and S. C. Wang, "High-Fidelity Simulation in Undergraduate Nursing Education: A Meta-Analysis," *Nurse Education Today* 111 (2022): 105291, https://doi.org/10.1016/j.nedt.2022.105291.

30. S. I. Tonapa, M. Mulyadi, K. H. M. Ho, and F. Efendi, "Effectiveness of Using High-Fidelity Simulation on Learning Outcomes in Undergraduate Nursing Education: Systematic Review and Meta-Analysis," *European Review for Medical and Pharmacological Sciences* 27 (2023): 444–458.

31. Y. Y. Lei, L. Zhu, Y. T. R. Sa, and X. S. Cui, "Effects of High-Fidelity Simulation Teaching on Nursing Students' Knowledge, Professional Skills and Clinical Ability: A Meta-Analysis and Systematic Review," *Nurse Education in Practice* 60 (2022): 103306, https://doi.org/10.1016/j.nepr.2022.103306.

32. B. Satria, A. Putra, J. Yuswardi, and K. H. Darmawati, "Effects of Using High Fidelity Mannequins on Skill and Knowledge of Nursing Students When Practicing Nebulizer Use," in *Challenges in Nursing Education and Research [Internet]* (CRC Press, 2020), 31–37, https://doi.org/10.1201/9781003043973-4.

33. R. Ambaras Khan and Z. Aziz, "The Methodological Quality of Guidelines for Hospital-Acquired Pneumonia and Ventilator-Associated Pneumonia: A Systematic Review," *Journal of Clinical Pharmacy and Therapeutics* 43, no. 4 (2018): 450–459, https://doi.org/10.1111/jcpt.12696.

34. C. Osti, D. Wosti, B. Pandey, and Q. Zhao, "Ventilator-Associated Pneumonia and Role of Nurses in Its Prevention," *JNMA; Journal of the Nepal Medical Association* 56, no. 208 (2017): 461–468.

35. A. Torres, M. S. Niederman, J. Chastre, et al., "International ERS/ESICM/ESCMID/ALAT Guidelines for the Management of Hospital-Acquired Pneumonia and Ventilator-Associated Pneumonia," *European Respiratory Journal* 50, no. 3 (2017): 1700582, https://doi.org/10.1183/13993003.00582-2017.

36. L. Furtado, F. Coelho, S. Pina, C. Ganito, B. Araújo, and C. Ferrito, "Delphi Technique on Nursing Competence Studies: A Scoping Review," *Healthcare* 12, no. 17 (2024): 1757, https://doi.org/10.3390/healthcare12171757.

37. A. Jorm, "Steps in Carrying Out a Delphi Study," in *Using the Delphi Method to Establish Expert Consensus [Internet]* (Springer Nature Singapore, 2025), 41–95, https://doi.org/10.1007/978-981-96-8357-4.

38. D. F. Polit and C. T. Beck, "The Content Validity Index: Are You Sure You Know What's Being Reported? Critique and Recommendations," *Research in Nursing & Health* 29, no. 5 (2006): 489–497, https://doi.org/10.1002/nur.20147.

39. A. Romero-Collado, "Elementos esenciales para elaborar un estudio con el método (e)Delphi," *Enfermería Intensiva* 32, no. 2 (2021): 100–104, https://doi.org/10.1016/j.enfi.2020.09.001.

40. M. Klompas, R. Branson, K. Cawcutt, et al., "Strategies to Prevent Ventilator-Associated Pneumonia, Ventilator-Associated Events, and Nonventilator Hospital-Acquired Pneumonia in Acute-Care Hospitals: 2022 Update," *Infection Control and Hospital Epidemiology* 43, no. 6 (2022): 687–713, https://doi.org/10.1017/ice.2022.88Koo.

41. M. Y. Li, "A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research," *Journal of Chiropractic Medicine* 15, no. 2 (2016): 155–163, https://doi.org/10.1016/j.jcm.2016.02.012.

42. J. Cohen, *Statistical Power Analysis for the Behavioral Sciences*, Second ed. (Lawrence Erlbaum Associates, 1988), https://utstat.toronto.edu/~brunner/oldclass/378f16/readings/CohenPower.pdf.

43. M. Raurell-Torredà, O. Arrogante, A. M. Aliberch-Raurell, et al., "Design and Content Validation of a Checklist About Infection-Prevention Performance of Intensive Care Nurses in Simulation-Based Scenarios," *Journal of Clinical Nursing* 33, no. 8 (2024): 3188–3198, https://doi.org/10.1111/jocn.17010.

44. L. Acun Delen, S. Derya, and B. Kayhan Tetik, "Determination of Knowledge Levels of Nurses Working in the Emergency Department and Intensive Care Units About Evidence-Based Practices in the Prevention of Ventilator-Associated Pneumonia," *Journal of Cognitive Systems* 6, no. 2 (2021): 55–58, https://doi.org/10.52876/jcs.1004163.

45. K. Gönderen and L. Parlak, "Evaluation of the Awareness Levels of Nurses Working in the İntensive Care Unit About Ventilator-Related Pneumonia Prevention Bundle," *Aksaray Üniversitesi Tıp Bilimleri Dergisi* 3, no. 1 (2022): 6–10.

46. S. M. Jalal, A. M. Alrajeh, and J. A. A. Al-Abdulwahed, "Performance Assessment of Medical Professionals in Prevention of Ventilator Associated Pneumonia in Intensive Care Units," *International Journal of General Medicine* 15 (2022): 3829–3838, https://doi.org/10.2147/IJGM.S363449.

47. I. Martin-Loeches, A. H. Rodriguez, and A. Torres, "New Guidelines for Hospital-Acquired Pneumonia/Ventilator-Associated Pneumonia: USA vs. Europe," *Current Opinion in Critical Care* 24, no. 5 (2018): 347–352, https://doi.org/10.1097/MCC.0000000000000535.

48. M. Mastrogianni, T. Katsoulas, P. Galanis, A. Korompeli, and P. Myrianthefs, "The Impact of Care Bundles on Ventilator-Associated Pneumonia (VAP) Prevention in Adult ICUs: A Systematic Review," *Antibiotics* 12, no. 2 (2023): 227, https://doi.org/10.3390/antibiotics12020227.

49. R. B. Laco and W. P. Stuart, "Simulation-Based Training Program to Improve Cardiopulmonary Resuscitation and Teamwork Skills for the Urgent Care Clinic Staff," *Military Medicine* 187, no. 5–6 (2022): e764–e769, https://doi.org/10.1093/milmed/usab198.

50. E. Boltey, O. Yakusheva, and D. K. Costa, "5 Nursing Strategies to Prevent Ventilator-Associated Pneumonia," *American Nurse Today* 12, no. 6 (2017): 42–43.

51. V. D. Rosenthal, Z. Jin, Z. A. Memish, et al., "Multinational Prospective Cohort Study of Rates and Risk Factors for Ventilator-Associated Pneumonia Over 24 Years in 42 Countries of Asia, Africa, Eastern Europe, Latin America, and the Middle East: Findings of the International Nosocomial Infection Control Consortium (INICC)," *Antimicrobial Stewardship and Healthcare Epidemiology* 3, no. 1 (2023): e6, https://doi.org/10.1017/ash.2022.339.

52. Y. Ciğerci, C. Çevik, Ş. Çelebi, H. Kurt, and A. Arslan, "The Information Level Concerning of Endotracheal Aspiration Among Student Nurses," *International Refereed Journal of Nursing Researches* 6 (2016): 128, https://doi.org/10.17371/UHD.2016616572.

53. A. C. Kalil, M. L. Metersky, M. Klompas, et al., "Management of Adults With Hospital-Acquired and Ventilator-Associated Pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of America and the American Thoracic Society," *Clinical Infectious Diseases* 63, no. 5 (2016): e61–e111, https://doi.org/10.1093/cid/ciw353.

54. M. Klompas, R. Branson, E. C. Eichenwald, et al., "Strategies to Prevent Ventilator-Associated Pneumonia in Acute Care Hospitals: 2014 Update," *Infection Control and Hospital Epidemiology* 35, no. 8 (2014): 915–936, https://doi.org/10.1086/677144.

55. Y. Shi, Y. Huang, T. T. Zhang, et al., "Chinese Guidelines for the Diagnosis and Treatment of Hospital-Acquired Pneumonia and Ventilator-Associated Pneumonia in Adults (2018 Edition)," *Journal of Thoracic Disease* 11, no. 6 (2019): 2581–2616, https://doi.org/10.21037/jtd.2019.06.09.

56. SARI Working Group, *Guidelines for the Prevention of Ventilator-Associated Pneumonia in Adults in Ireland* (Health Protection Surveillance Centre, 2011), 26.

Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Figure S1:** VAP prevention performance checklist—checklist used to evaluate nursing students' skills in preventing VAP. **Figure S2:** Pretest scenario—simulation scenario applied before the intervention to assess baseline performance. **Figure S3:** Simulation scenario—core scenario used during the simulation-based training session. **Figure S4:** Posttest simulation scenario—*Scenario used after training to measure learning outcomes.* **Figure S5:** Nursing simulation laboratory intensive care unit preparations—depicts the setup and equipment of the ICU simulation environment. **Figure S6:** Nursing simulation laboratory and pre-application preparations—shows the materials and environment before the simulation sessions.