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ORIGINAL RESEARCH

# Nurses' Knowledge on the Prevention of Ventilator-Associated Pneumonia (VAP) among Critically Ill Patients

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**Abstract**

**Background:** Ventilator-associated pneumonia (VAP) is a significant concern in healthcare settings, particularly among critically ill patients who require mechanical ventilation. Nurses play a vital role in preventing VAP through their knowledge and implementation of evidence-based practices. However, there exists a notable gap in the research regarding nurses' knowledge of preventing VAP to improve patient outcomes and reduce healthcare costs.
**Purpose**: This study aimed to assess nurses' knowledge of preventing VAP among critically ill patients using the ventilator bundle checklist.
**Methods**: This study used a one-group pretest-posttest design to test the change in the nurses' knowledge scores on VAP working in two government hospitals in Buraidah, Al Qassim Region, Saudi Arabia. The study covered 250 purposively and conveniently sampled nurses from intensive care units. Data collection was performed in three phases: pre-test, VAP educational program, and post-test. Data were collected using self-administered questionnaires on nurses' socio-demographics, a 20-item self-made survey about the knowledge of VAP and its prevention and the adapted ventilator bundle checklist. The collected data were entered, prepared, and analyzed using SPSS version 25.0. Relevant ethical issues were strictly considered.
**Results**: The results showed that during the pre-test, correct responses were accounted for but showed low scores in the following areas: general knowledge of VAP (27.6%), factors associated with VAP (36%), international guidelines for prevention (20.8%), and nurses' roles in prevention (16.4%). However, in the post-test, there was a remarkable increase in the knowledge scores in the same categories (95.2%) on general knowledge, on factors associated with VAP (74.8%), on international guidelines (73.6%) and on nurses' roles in prevention (61.6%). The program significantly improved overall VAP knowledge and knowledge in specific areas like general VAP, associated factors, international guidelines, and nurses' roles in prevention ($p$<0.000).
**Conclusion**: A pre-test revealed low baseline knowledge across all four areas assessed: general VAP knowledge, factors associated with VAP, international VAP prevention guidelines, and nurses' roles in VAP prevention. However, post-test scores markedly increased in all areas, indicating the educational program's effectiveness. Hence, the findings suggest that educational intervention focused on VAP screening and bundle protocols could be beneficial to address the gap in knowledge on VAP.

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## 1. Introduction

Ventilator-associated pneumonia (VAP) is a lung infection that develops in a patient hooked to a ventilator machine after 48 hours (Centers for Disease Control and Prevention, 2021). VAP is one of the most notable intensive care unit (ICU)-acquired infections and the leading cause of death among patients admitted to intensive care units (Kharel et al., 2021). A ventilator machine that helps a patient breathe by providing oxygen can be a portal of infection if germs enter the tube and

reach the patient's lungs. The primary risk factor for VAP among critically ill patients is endotracheal (ET) intubation. The ET tube breaks the airway defenses, and mucociliary clearance impairs cough and facilitates the microaspiration of bacteria-laden secretions that pool above the endotracheal tube cuff. Thus, the highest risks of VAP occur during the first 10 days after intubation. Traditional signs and symptoms of VAP among ventilated patients are typically fever, leukocytosis, changes in a respiratory parameter such as worsening hypoxemia and purulent secretions, and chest X-ray showing new or progressive diffuse infiltrate (Papazian et al., 2020; World Health Organization, 2021).

The diagnostic triad for the presence of VAP is a pulmonary infection accompanied by fever, purulent secretions, leukocytosis, bacteriologic evidence of pulmonary disease, and radiologic suggestions of pulmonary infection. There was 69% sensitivity in diagnosing and 75% specificity of VAP when the combination of radiologic infiltrates and 2 clinical criteria were observed in patients hooked in mechanical ventilators (Abad et al., 2021; Al Aswad & Bayoumi, 2022; Dipanjali et al., 2020; Getahun et al., 2022; Jakhar et al., 2023). Concomitantly, diagnosing VAP requires high clinical precision through microbiologic analysis of respiratory secretions, radiologic examination, and focused physical examination. In addition, performing semi-quantitative cultures of endotracheal aspirates and gram stains is recommended for guiding treatment among patients who develop VAP (Centers for Disease Control and Prevention, 2021).

According to the World Health Organization (2021), VAP is the most common hospital-acquired infection among mechanically ventilated patients. Similarly, approximately 28% of patients who receive mechanical ventilation develop VAP. The incidences vary extensively from 5% to 40%, depending on the diagnostic criteria and setting. Thus, prolonged hospital stays and duration of mechanical ventilation are associated with VAP (Papazian et al., 2020). Additionally, there was an estimated 10% mortality of VAP, which is higher death rates from patients in surgical ICU and with mid-range severity scores among patients at admission.

Undeniably, preventing VAP among ventilated patients remains a major clinical challenge associated with high morbidity, mortality, high hospital cost, and increased length of hospital stay (Subramanian et al., 2013). VAP prevention begins during intubation and must be continued until the extubation of critical patients. Thus, nurses need an extensive understanding of the strategies to develop VAP among ventilated patients. For this reason, critical care nurses play an essential role in VAP prevention. Nurses need to recognize the earliest signs and symptoms, reduce the risk factors, and assist in diagnosing VAP in patients hooked to a mechanical ventilator. Also, critical care nurses must adhere to evidence-based guidelines to prevent VAP and consistently translate evidence-based findings care to ventilated patients. The Centers for Disease Control and Prevention (2021) provides the healthcare community with guidelines and tools, such as the bundle checklist for nurses to help eradicate VAP cases. The Institute for Healthcare Improvement (IHI, 2021) introduced a bundle checklist as a straightforward set of evidence-based practices that are proven effective. There are five components of the VAP bundle from IHI, namely (1) head-of-bed elevation between 30 and 45 degrees; (2) a daily "sedation vacation" and a readiness-to-wean assessment; (3) peptic ulcer disease prophylaxis; (4) deep vein thrombosis prophylaxis; and (5) daily oral care with chlorhexidine (a new intervention added since 2010) (Al-Tawfiq & Abed, 2010; Benson et al., 2013; Papazian et al., 2020).

Nurses play a vital role in preventing VAP. However, a research gap exists in the study of nurses' knowledge of preventing VAP, which must be addressed to improve patient outcomes and reduce healthcare costs. While studies have examined nurses' overall understanding of infection control practices, few studies have specifically explored their knowledge of VAP prevention (Abad et al., 2021), which limits the understanding of the specific areas where nurses may be lacking in knowledge and the potential interventions that can be implemented to address these gaps. Another research gap is the lack of studies utilizing a one-group pretest-posttest design to evaluate changes in nurses' knowledge after educational interventions. This design allows for the assessment of knowledge improvement within the same group of nurses before and after an intervention, providing valuable insights into the effectiveness of educational programs. Using this design, researchers can determine if educational interventions significantly impact nurses' knowledge and identify areas where further improvement is needed.

Additionally, studies are needed to explore the factors influencing nurses' knowledge of VAP prevention. Understanding these factors can help identify barriers and facilitators to implementing evidence-based practices and inform strategies to improve nurses' knowledge in this area (Sanketh

et al., 2023). Factors such as educational background, years of experience, and access to resources may all play a role in nurses' knowledge of VAP prevention (Getahun et al., 2022; Yin et al., 2022). Studying these variables can provide valuable insights for nurse educators and policymakers. Lastly, there is a gap in research on the long-term sustainability of knowledge gained through educational interventions. While many studies focus on immediate improvements in knowledge after an intervention, there is limited evidence on whether this knowledge is retained over time. Longitudinal studies that follow nurses after an educational intervention can provide insights into the long-term impact of education on nurses' knowledge and inform strategies for ongoing education and support (Jakhar et al., 2023).

Undeniably, it is essential to improve clinical outcomes among mechanically ventilated patients to reduce the development of VAP. A bundle was formulated to reduce morbidity and mortality among patients hooked to a mechanical ventilator. Existing studies have proven the efficacy of VAP bundles globally (Al-Tawfiq & Abed, 2010) but not in the Kingdom of Saudi Arabia. For this reason, this study hopes to offer a novel approach to assimilating knowledge, contributing to a more scientific and evidence-based practice that yields safe, efficient, and quality patient care and healthcare outcomes. Therefore, this study aimed to assess nurses' knowledge of preventing VAP among critically ill patients using the ventilator bundle checklist.

## 2. Methods

### *2.1. Research design*

The study utilized a one-group pretest-posttest design, a quasi-experiment in which the outcome of interest is measured two times: once before and once after exposing a non-random group of participants to a specific intervention/treatment (Reichardt, 2019). This study design offers several advantages. Firstly, it can be conducted with a relatively small sample size, making it more feasible and cost-effective. Secondly, it establishes a temporal relationship between the intervention and the observed effects because the outcome is measured after the intervention. This temporal relationship is crucial for inferring causality (Hyman, 1982; Reichardt, 2019).

### *2.2. Setting and samples*

The study was conducted at two (2) government hospitals in Buraidah, Al Qassim Region, Saudi Arabia. These government hospitals have a 500-bed capacity supervised by the Ministry of Health. Due to their size and location, they serve a significant portion of the population, potentially leading to a more representative sample. The sample size was calculated using Raosoft software based on a 2,000 random samples with a 5% margin of error, 95% confidence interval (CI) , which yielded a required sample size of 357 (Raosoft, 2004). Two hundred fifty (250) nurses working in critical care units who provide direct care to mechanically ventilated patients participated in the study. Meanwhile, 107 nurses whose years of experience were less than six months and who refused to participate were excluded.

### *2.3. Intervention*

In this study, the researchers developed a structured educational program for registered nurses caring for mechanically ventilated patients in the ICU with an end view to improve nurses' knowledge and confidence in applying evidence-based practices to prevent VAP in critically ill patients. The two-tiered interventions consisted of the following: Part 1 offered a didactic lecture delivered by an ICU physician and experienced nurse educator who covered VAP definition, risk factors, prevention bundle elements, and recommended practices for hand hygiene, oral care, ventilator circuit care, and suctioning. Interactive elements, including polls and case studies, were incorporated to enhance engagement. Part 2 provided a hands-on skills demonstration focusing on proper preventive measures, including hand hygiene techniques, and simulated ventilator circuit care and suctioning procedures using mannequins or training models, which lasted two to three hours. Lastly, handouts summarized critical points from the lecture with visuals (i.e., diagrams, flowcharts), demonstration checklists for VAP prevention practices, and links to relevant articles and resources on VAP prevention from credible sources (e.g., the Centers for Disease Control and Prevention (CDC) guidelines).

*2.4. Measurement and data collection*

A self-made socio-demographic questionnaire was used to obtain descriptive variables of critical care nurses under study. A self-constructed 20-item tool about understanding VAP and its prevention was also used. Three subject matter experts evaluated and verified the content of the test questions (CVI=0.98; S-CVI=0.98 and I-CVI=0.98). Items in the questionnaire were subjected to content analysis and pre-testing to ensure validity, resulting in a 0.89 acceptable kappa value. Five (5) items were excluded from the study due to their inconsistency and inapplicability. When corrections were integrated, the final questionnaire was prepared and disseminated. The total knowledge score was summed up to give the total knowledge score with the following formula (mean score/total number of items multiplied by 100).

This study also used the ventilator bundle checklist. The original English version of the ventilator bundle observation checklist was adapted from the Centers for Disease Control and Prevention (CDC, 2021) and the Institute for Healthcare Improvement (IHI, 2021). This observation checklist comprised five (5) important elements based on the adapted ventilator bundle: (1) head-of-bed elevation- a semi-recumbent position that could be achieved by elevating the head of the bed to an angle of 30–45 degrees; (2) daily sedation hold; (3) peptic ulcer disease prophylaxis using pantoprazole or ranitidine, as prescribed by the physician; (4) DVT prophylaxis via administration of subcutaneous heparin or enoxaparin (Clexane) and application of anti-embolism stockings such as thromboembolic deterrent stockings as prescribed; and (5) daily oral care with the help of a suction toothbrush and chlorhexidine gluconate 0.05%. The kappa value was acceptable at 0.87 (McHugh, 2012).

Data collection was performed in three phases. In phase I, a pre-test session was conducted for all nurses who participated in the study to assess the level of knowledge of nurses on VAP and the ventilator bundle checklist. The pre-test used a self-constructed 20-item tool about the understanding of VAP and its prevention using a ventilator bundle to test the pre-intervention knowledge level of the group. Thus, critical care experts verified the test questions' content. Phase II involved the structured educational intervention, which was provided after the completion of pre-test evaluations. Phase III, comprised of the post-test evaluation, was carried out among all nurses who participated in the study after the educational intervention. The researchers used several data-gathering instruments to collect significant data associated with nurses' knowledge of preventing VAP using a ventilator bundle checklist among critically ill patients.

*2.5. Data analysis*

Data were entered in the statistical analysis software (SPSS) version 26 (IBM Corporation, 2013). Frequencies and percentages were used, and inferential statistics were used to analyze the data paired sample t-test statistical test to measure the difference in the mean VAP knowledge score before and after the implementation of the education program. A p-value less than 0.05 was considered significant. Participants' demographics, such as gender, age, academic degree, and nursing specialization, were presented in frequencies and percentages.

*2.6. Ethical considerations*

The researchers ensured adherence to ethical guidelines by obtaining approval from the Regional Ethics Committee of the Ministry of Health, Buraidah, Qassim, with approval number H-04-Q-001 and the hospital authorities. All data collection adhered to hospital protocols and research ethics. Participant confidentiality was prioritized; data were anonymized, and informed consent was obtained after thoroughly explaining the study's purpose and nature. Participants were also assured of their right to withdraw and decline to answer specific questions.

## 3. Results

*3.1. Profile characteristics of the nurses*

In this study, 250 nurses working in different ICUs at two government hospitals in Buraidah, Al Qassim Region, Saudi Arabia, were given the questionnaire. Results indicate that nurses who participated in this study were 32-41 years old (n=103, 41.2%), females (n=144, 57.6%). A majority of them were married (n=139), and 55.6% earned > 10000 Saudi Riyal. Regarding their education, the majority earned their Bachelor of Science in Nursing (n=122), or 31.2%, and had between 5 to 10 years of experience (n=90), or 36.0% (Table 1).

**Table 1.** Profile characteristics of the nurses

| Profile Characteristics | | Frequency | Percentage |
|---|---|---|---|
| Age | 21 – 31 | 92 | 36.8 |
| | 32 – 41 | 103 | 41.2 |
| | 42 – 51 | 55 | 22.0 |
| Gender | Female | 144 | 57.6 |
| | Male | 106 | 42.4 |
| Marital status | Single | 106 | 42.4 |
| | Married | 139 | 55.6 |
| | Divorced | 3 | 1.2 |
| | Widowed | 2 | 0.8 |
| Monthly family income | <5000 Saudi Riyal | 39 | 15.6 |
| | 5001 - 10000 Saudi Riyal | 78 | 31.2 |
| | >10000 Saudi Riyal | 133 | 53.2 |
| Education | Diploma | 89 | 35.6 |
| | Bachelor | 122 | 48.8 |
| | Master | 39 | 15.6 |
| Work experience | 6 months - 1 year | 12 | 4.8 |
| | 1 - 5 years | 77 | 30.8 |
| | 5 - 10 years | 90 | 36.0 |
| | > 10 years | 71 | 28.4 |

*3.2. Nurses' knowledge of VAP*

Table 2 shows that the scores during the pre-test had generally low scores in the following areas: general knowledge of VAP (n=69, 27.6%), factors associated with VAP (n=90, 36%), international guidelines for prevention (n=52, 20.8%), and nurses' roles in prevention (n=41, 16.4%). On the contrary, in the post-test, there was a remarkable increase in the knowledge scores. Nurses correctly answered 238 (95.2%) questions on general knowledge, 187 (74.8%) on factors associated with VAP, 154 (61.6%) on international guidelines, and 184 (73.6%) on nurses' roles in prevention.

**Table 2.** Nurses' knowledge of VAP in two government hospitals

| Question Items | Pre-test | | | | Post-test | | | |
|---|---|---|---|---|---|---|---|---|
| | Correct Responses | | Incorrect Responses | | Correct Responses | | Incorrect Responses | |
| | f | % | f | % | f | % | f | % |
| General Knowledge of VAP | 69 | 27.6 | 181 | 72.4 | 238 | 95.2 | 12 | 4.8 |
| Knowledge of Factors Associated with VAP | 90 | 36 | 160 | 64 | 187 | 74.8 | 63 | 25.2 |
| Knowledge of International Guidelines for VAP Prevention | 52 | 20.8 | 198 | 79.2 | 154 | 61.6 | 96 | 38.4 |
| Knowledge of Nurses' Roles in Preventing VAP | 41 | 16.4 | 209 | 83.6 | 184 | 73.6 | 66 | 26.4 |

*3.3. Nurses' knowledge before and after the intervention*

Results in Table 3 indicate a statistically significant difference in the general understanding of VAP (t=-46.077, $p$=0.000), knowledge of factors associated with VAP (t=-41.945, $p$=0.000), knowledge of international guidelines for VAP Prevention (t=-26.624, $p$=0.000), and knowledge of nurses' roles in preventing VAP (t=-36.032, $p$=0.000) during the pre-test and post-test intervention.

## 4. Discussion

Due to the research gap identified in the corpora, this study assessed nurses' knowledge of VAP, focusing on the following areas: general knowledge of VAP, knowledge of factors associated with VAP, knowledge of international guidelines for VAP, and knowledge of nurses' roles in preventing VAP. In most recent studies, nurses have been identified as the key participants as they

provide direct care and involvement in the prevention of VAP-related cases, primarily in the ICUs (Abad et al., 2021; Dipanjali et al., 2020; Getahun et al., 2022; Jakhar et al., 2023). The present study found that more than half of the participants had between 5 and 10 years of experience. Nurses with more extended experience in the ICU (i.e.,> 4 years) were more likely to have undergone VAP bundle training, concurring with the study conducted by Abad et al. (2021). However, nurses' knowledge appeared similar to that of less experienced nurses, which differs from published data. In one study, for example, the average knowledge level was higher among more experienced ICU nurses (> 1 year experience) and those holding a remarkable degree in emergency and intensive care.

**Table 3.** Significant difference in the overall mean scores of nurses' knowledge of VAP during the pre-test and post-test intervention

| Key Areas of Evaluation | Pre-test | | Post-test | | | |
|---|---|---|---|---|---|---|
| | M | SD | M | SD | T | p-value |
| General Knowledge of VAP | 1.04 | 0.87 | 4.12 | 0.80 | -46.08 | 0.00 |
| Knowledge of Factors Associated with VAP | 1.27 | 0.98 | 4.06 | 0.88 | -41.95 | 0.00 |
| Knowledge of International Guidelines of VAP | 0.80 | 0.81 | 2.62 | 1.06 | -26.62 | 0.00 |
| Knowledge of Nurses' Roles in preventing VAP | 1.26 | 1.02 | 3.89 | 0.95 | -36.03 | 0.00 |

*Note.* M=Mean; SD=Standard Deviation; *$p$<0.05.; **$p$<0.01.; ***$p$<0.001

The pre-test knowledge scores show that many nurses lacked a strong understanding of VAP, including its associated factors, preventative guidelines, and their role in preventing it. Similarly, in other studies, poor knowledge regarding VAP prevention during the pre-intervention has also been reported in other studies published in Iran (Bagheri-Nesami & Amiri, 2014), Yemen (Al-Sayaghi, 2014), and Taiwan (Lin et al., 2014) in Asia, Egypt (Ali, 2013) and Ethiopia (Wami et al., 2018). On the other hand, the post-test results show a significant improvement in knowledge following the educational intervention. In other studies conducted in Spain, for instance, Gatell et al. (2012) found that nurses' knowledge of VAP preventive measures has significantly increased post-intervention. In India, Sahni et al. (2017) surmised that the educational intervention improved ICU nurses' scientific knowledge about measures related to VAP prevention. Hamishehkar et al. (2014) agreed that nurses' knowledge of the ventilator bundle checklist improved after the training program.

According to Oner Cengiz and Kanan (2019), training programs effectively increase nurses' knowledge of VAP, its associated factors, and the preventative measures outlined in international guidelines. Mishra and Rani (2020) posited that nurses should monitor patients closely for signs of infection, including fever, increased sputum production, and changes in respiratory status, and report any concerns promptly. Education and training are crucial in enhancing nurses' knowledge and skills in preventing VAP, as depicted in the present study's post-intervention results. Several recently published studies support our study findings (Abad et al., 2021; Dipanjali et al., 2020; Getahun et al., 2022; Oner Cengiz & Kanan, 2019). However, it should be noted that the differences in healthcare delivery models in intensive care units and the lack of differences in specific guidelines and policies regarding training and practice of VAP prevention in ICUs may explain the differences in knowledge scores (Yin et al., 2022).

Therefore, healthcare organizations should invest in developing and implementing comprehensive training programs covering the latest evidence-based VAP prevention practices (Dipanjali et al., 2020). The program may include regular updates on guidelines, hands-on workshops, and simulations to enhance nurses' understanding and proficiency. Continuous education ensures that nurses stay up-to-date with advancements in VAP prevention strategies and fosters a culture of continuous learning and improvement. Several authors suggested that policymakers and hospital administrators should prioritize implementing and updating evidence-based VAP prevention guidelines (Abad et al., 2021; Getahun et al., 2022; Oner Cengiz & Kanan, 2019) to improve the quality of nursing care by empowering nurses to make informed decisions regarding patient care and reduce ventilator-associated pneumonia (VAP) rates. For nursing education institutions, Mishra and Rani (2020) highlighted that nursing deans should revise

undergraduate nursing curricula to incorporate acute care initiatives and explicitly focus on VAP prevention strategies.

## 5. Implications and limitations

Preventing VAP requires a multi-pronged approach that involves various strategies. Nurses must prioritize hand hygiene and follow strict infection control protocols to minimize the transmission of pathogens. They should also ensure proper oral care for ventilated patients, as oral bacteria can migrate to the lungs and cause infection. Maintaining proper patient positioning, including elevating the head of the bed and encouraging mobility, helps prevent aspiration and reduce the risk of VAP. On the other hand, owing to the limitations of this study, without a control group, it is impossible to isolate the effect of the educational program. Other factors might have influenced the nurses' knowledge gain. The one-group design with a potentially small sample size makes it challenging to know if the results apply to a broader population of nurses.

## 6. Conclusion

Nurses' knowledge of VAP prevention improved significantly following an educational intervention. A pre-test revealed low baseline knowledge across all four areas assessed: general VAP knowledge, factors associated with VAP, international VAP prevention guidelines, and nurses' roles in VAP prevention. However, post-test scores markedly increased in all areas, indicating the educational program's effectiveness. Hence, the findings suggest that educational interventions focused on VAP screening and bundle protocols could be beneficial. Further research with a more robust design (e.g., pre-test/post-test with a control group) is needed to confirm this.

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## Author contribution

MSA, FAA, NA: conceptualization and data collection; CPT, HNV, DAP, RAV: data analysis and manuscript preparation.

## Conflict of interest

The authors declare that there are no conflicts of interest.

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