ORIGINAL ARTICLE

# Knowledge and Practice of Ventilator-associated Pneumonia Prevention among Critical Care Nurses of Two Tertiary Hospitals in Klang Valley: A Cross-sectional Study

**Yoong Jia Tong[1], Kim Lam Soh[1], Ji Ming Chua[1]**

[1] Department of Nursing, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

**ABSTRACT**

**Introduction:** Ventilator-associated pneumonia (VAP) is a common nosocomial infection in ICUs, leading to high morbidity and mortality in mechanically ventilated patients. This study aims to assess the knowledge and practice of VAP prevention among critical care nurses of two tertiary hospitals in Klang Valley. We hypothesised that no relationship existed between nurses' knowledge and practice of VAP prevention and their socio-demographic characteristics. **Methods:** Data were collected through self-administered questionnaires covering socio-demographics, knowledge, and practice of ventilator-associated pneumonia prevention. Fisher's Exact test and Multinomial Logistic Regression were employed to test the relationship between variables. **Results:** Of 130 participants, 94.6%, 3.1%, and 2.3% had good, acceptable, and poor knowledge, respectively. Meanwhile, 44.6%, 25.4%, and 30% had good, acceptable, and poor practices. Age (p=0.013), educational qualification (p=0.019), experience in nursing (0.018), and VAP prevention training (p=0.046) significantly influenced nurses' knowledge. In contrast, educational qualification (p<.001), experience in critical care nursing (p=0.010), and VAP prevention training (p=0.017) significantly influenced nurses' practice of VAP prevention. However, no relationship was found between nurses' knowledge and practice (p=0.130). **Conclusion:** Critical care nurses exhibited good knowledge and acceptable practice of VAP prevention. Nonetheless, the lack of a relationship between knowledge and practice suggests other factors influencing practice. Future research can focus on identifying and addressing these factors to enhance translation of knowledge into practice to reduce VAP incidence in critical care settings.

*Malaysian Journal of Medicine and Health Sciences* (2025) 21(SUPP4):65-74. doi:10.47836/mjmhs.21.s4.9

**Keywords:** Knowledge, Practice, Ventilator-associated Pneumonia, Prevention, Critical Care Nurses

**Corresponding Author:**
Kim Lam Soh, PhD
Email: sklam@upm.edu.my
Tel :+603 89472439

## INTRODUCTION

Endotracheal intubation or mechanical ventilation is often necessary for critical ill patients in intensive care units (ICUs) to ensure airway patency and boost oxygenation. Being the most typical and lethal nosocomial infection in the critical care setting, ventilator-associated pneumonia (VAP) is defined as pneumonia that occurs in patient after 48 hours receiving endotracheal intubation (1). In addition, VAP also had a fatality rate up to 50%, with a minimum of 25% of these deaths being solely attributed to the infection rather than the underlying conditions (2). Nevertheless, VAP is now more frequently regarded as an avoidable iatrogenic event (3).

The Ministry of Health Malaysia has introduced "Malaysian Patients Safety Goals: Nurses Roles and Responsibilities" as a guideline for VAP prevention. Critical care nurses must possess sufficient knowledge of VAP prevention and apply them because they are the ones who primarily in charge of patient care (4). However, the knowledge of VAP prevention is still insufficient according to a recent study conducted at a tertiary hospital in Klang Valley (5). No study was done to assess the practice of VAP prevention among critical care nurses in Klang Valley. Therefore, study to assess the current knowledge and practice of VAP prevention among critical care nurses is needed because knowledge does not guarantee the implementation of evidence-based guidelines, but every nursing practice is based on theoretical knowledge.

## MATERIALS AND METHODS

### Study design and location

This was a cross-sectional study conducted at intensive care unit (ICU) and coronary care unit (CCU) of two government tertiary hospitals in Klang Valley.

### Study duration and population

The data collection for this study lasted one months, from June 2023 to July 2023. Eligible participants included Malaysian critical care nurses who work at ICU or CCU of the two tertiary hospitals, experienced in nursing intubated patients. Nurses who were on leave and nursing students who attached at ICU and CCU during data collection were excluded.

### Sample size estimation

The sample size was determined using Cochran's formula, anticipated a proportion of 59.5% within the population having poor knowledge of VAP prevention based on the recent study conducted in Klang Valley (5). The calculated sample size was determined to be 130 after considering an estimated dropout rate of 10%.

### Sampling method and data collection

This study employed a stratified random sampling method to calculate the number of participants required from each hospital. Then, an online random number generator was used to choose the samples so that every subject in the population has an equal chance to be selected. The researchers gave the URL linked to an online questionnaire, a Google Form, to the Sisters in charge of ICU and CCU of both hospitals who was then helped to invite the selected samples to participate in the study. Prior to answering the questionnaire, all participants need to read the "Participant Information Sheet" and signed the "Informed Consent Form" attached in the first few pages of the Google Form.

### Study instrument

There were 15 knowledge items and 17 practice items in the questionnaire. All items were adopted from two different questionnaires used by a foreign researcher (6,7). The items were modified according to VAP prevention guideline recommended by the Ministry of Health Malaysia. Content validity index (CVI) was calculated and a pilot study was done prior to the main study. The CVI was calculated by asking 13 critical care nurses with post basic qualification in critical care nursing who involved in the pilot study to rate the relevancy of each item in the questionnaire according to the Likert scale ranged from 1 to 5, where 1 was "not relevant", 2 represented "slightly relevant", 3 showed "uncertain", 4 denoted "relevant", and 5 indicated "very relevant". The I-CVI ranged from 0.846 to 1.000 for both knowledge and practice items. During the pilot study, reliability of the questionnaire was determined by calculating the Cronbach's alpha. The Cronbach's alpha generated for knowledge part and practice part were 0.763 and 0.788, respectively, showing a good internal consistency of the questionnaire.

### Scoring system

For knowledge, each item has four response options with one correct answer, two wrong options as distractors, and option of "I do not know". One point was given to each question being answered correctly and zero for a wrong answer and "I do not know" option. The total score was converted to percentage. Score of 70% or more was defined as good knowledge, 60% to 69% indicated acceptable knowledge, while 59% and below was considered poor knowledge (6).

For practice, each item was presented in a 3-point Likert scale form with 0 represented "Never", 1 indicated "Sometimes", and 2 signified "Always". The total score was converted to percentage. Score of below the 50th percentile was poor practice, between 50th and 75th percentile was acceptable practice, and above 75th percentile was good practice (7).

### Data analysis

Descriptive analysis including frequencies, percentage, means, and standard deviation were performed on every appropriate variable. Fisher's Exact test was used to determine the relationship between level of knowledge and practice of VAP prevention, which were categorical variables. Logistic regression was used for continuous variables while Fisher's Exact test was used for categorical variables of socio-demographic characteristics to determine the relationship between socio-demographic characteristics and knowledge, and practice. A p-value $\leq 0.05$ shows a significant relationship between variables. Statistical Package for Social Sciences (SPSS) version 29.0 was used to analysed the data collected in this study.

### Ethical approval

Ethical approval was obtained from the Medical Research and Ethics Committee (MREC). NMRR ID-23-00337-OLP.

## RESULTS

### Socio-demographic characteristics

The online questionnaire was delivered to 130 selected samples. All samples participated in the study voluntarily, resulting a response rate of 100%. Table I presented the socio-demographic characteristics of

**Table I: Socio-demographic Characteristics of Study Respondents (n=130)**

| Variable | Frequency, n (%) | Mean ± SD |
|---|---|---|
| Age | | 35.48 ± 6.725 |
| Gender | | |
| Female | 120 (92.3%) | |
| Male | 10 (7.7%) | |
| Highest educational level in nursing (Qualification) | | |
| Master's Degree | 1 (0.8%) | |
| Bachelor's Degree | 7 (5.4%) | |
| Post Basic in Critical Care Nursing | 48 (36.9%) | |
| Diploma | 74 (56.9%) | |
| Current working critical care unit | | |
| Intensive Care Unit (ICU) | 107 (82.3%) | |
| Coronary Care Unit (CCU) | 23 (17.7%) | |
| Total experience in nursing (years) | | 12.82 ± 6.554 |
| Total experience in critical care nursing (years) | | 11.90 ± 5.755 |
| In your hospital, you received education or training on VAP prevention. | | |
| Yes | 123 (94.6%) | |
| No | 7 (5.4%) | |

the respondents. The mean age of the respondents in the study was 35.48 ± 6.725 years old. Majority of the respondents were female (92.4%) and having Diploma as their highest educational level in nursing (56.9%). Out of 130 the respondents, 82.3% are working in ICU while 17.7% are working in CCU. The respondents' mean nursing experience was 12.86 ± 6.554 years, whereas their mean critical care nursing experience was 11.28 ± 5.755 years. In term of VAP prevention education, 94.6% of the respondents had received the education at their hospital.

## Knowledge of VAP Prevention

Overall, the median score for the knowledge of VAP prevention was 93.33% (IQR 86.67-93.33). From the analysis, 123 (94.6%) of the respondents had good knowledge and four (3.1%) of them demonstrated acceptable knowledge. However, three (2.3%) of them exhibited poor knowledge. Table II presented the frequency and percentage of correct and incorrect responses to every item regarding VAP prevention strategies in the questionnaire. There were three items that most respondents (129 out of 130, 99.2%) answered correctly which were "Patient positioning in bed", "Regular emptying of condensate from the ventilator tubing" and "Regular comprehensive oral care (by tooth brushing and rinsing with antiseptic agent)". Besides, most respondents also answered correctly for items "Kinetic vs. Standard beds" (96.2%), "The tracheal cuff pressure" (95.4%), and "Daily sedation interruption and assessment of readiness for weaning" (95.4%). On the other hand, the item with the lowest rate of correct responses was "Frequency of closed-circuit suctioning system changes" with only 40 respondents (30.8%) answered correctly.

**Table II: Distribution of Correct and Incorrect Answers on Ventilator-associated Pneumonia (VAP) Prevention among Critical Care Nurses**

| | Items | Correct N, (%) | Incorrect N, (%) |
|---|---|---|---|
| 1. | Oral vs. nasal route for endotracheal intubation | 105 (80.8%) | 25 (19.2%) |
| 2. | Frequency of ventilator circuit changes. | 122 (93.8%) | 8 (6.2%) |
| 3. | Type of airway humidifier. | 119 (91.5%) | 11 (8.5%) |
| 4. | Frequency of humidifier changes. | 119 (91.5%) | 11 (8.5%) |
| 5. | Open vs. close-circuit suction system. | 117 (90.0%) | 13 (10.0%) |
| 6. | Frequency of close-circuit suction system changes. | 40 (30.8%) | 90 (69.2%) |
| 7. | Type of endotracheal tubes (ETTs). | 108 (83.1%) | 22 (16.9%) |
| 8. | Kinetic vs. standard beds. | 125 (96.2%) | 5 (3.8%) |
| 9. | Patient positioning in bed. | 129 (99.2%) | 1 (0.8%) |
| 10. | The tracheal cuff pressure. | 124 (95.4%) | 6 (4.6%) |
| 11. | Non-invasive mechanical ventilation (NIMV). | 118 (90.8%) | 12 (9.2%) |
| 12. | Daily sedation interruption and assessment of readiness for weaning. | 124 (95.4%) | 6 (4.6%) |
| 13. | Regular emptying of condensate from the ventilator tubing. | 129 (99.2%) | 1 (0.8%) |
| 14. | Prevention of unplanned extubation and subsequent re-intubation. | 118 (90.8%) | 12 (9.2%) |
| 15. | Regular comprehensive oral care (by tooth brushing and rinsing with antiseptic agent). | 129 (99.2%) | 1 (0.8%) |

## Practice of VAP Prevention

Generally, the median score for the practice of VAP prevention was 91.18% (IQR 88.24-94.12). From the analysis, 58 (44.6%) of the respondents had good practice and 33 (25.4%) of them demonstrated acceptable practice. Nevertheless, 39 (30%) of the respondents exhibited poor practice. Table III showed the frequency and percentage for every practice of VAP prevention responded by participants. Two practices had been found to be always practised by all (100%) respondents which were "Handwashing after any approach to a patient" and "Change the close-circuit suction systems for every new patient (or when clinically indicated)". However, the practice "Suction the subglottic secretions through an extra lumen in the endotracheal tubes when patients likely to require >48 or 72 hours of intubation" never practise by all the respondents.

**Table III: Frequency of Ventilator-associated Pneumonia (VAP) Prevention practised by Critical Care Nurses**

| | Practices | Frequency N, (%) | | |
|---|---|---|---|---|
| | | 0 | 1 | 2 |
| | | Never | Sometimes | Always |
| 1. | Handwashing before any approach to a patient. | 0 (0%) | 1 (0.8%) | 129 (99.2%) |
| 2. | Use of protective gloves at every approach to a patient. | 0 (0%) | 15 (11.5%) | 115 (88.5%) |
| 3. | Handwashing after any approach to a patient. | 0 (0%) | 0 (0%) | 130 (100%) |
| 4. | Use of close-circuit suction systems. | 0 (0%) | 11 (8.5%) | 119 (91.5%) |
| 5. | Change the closed-circuit suction systems for every new patient (or when clinically indicated). | 0 (0%) | 0 (0%) | 130 (100%) |
| 6. | Use sterile gloves when open suction is necessary. | 1 (0.8%) | 7 (5.4%) | 122 (93.8%) |
| 7. | Provide regular oral care at least once per shift. | 0 (0%) | 24 (18.5%) | 106 (81.5%) |
| 8. | Use chlorhexidine solution for oral care. | 1 (0.8%) | 10 (7.7%) | 119 (91.5%) |
| 9. | Use the heat and moisture exchanger humidifier. | 0 (0%) | 1 (0.8%) | 129 (99.2%) |
| 10. | Change the heat and moisture exchanger humidifiers every 24 hours or when clinically indicated. | 0 (0%) | 2 (1.5%) | 128 (98.5%) |
| 11. | Change ventilator circuit only when visibly soiled or malfunctioning. | 0 (0%) | 5 (3.8%) | 125 (96.2%) |
| 12. | Check the endotracheal tube cuff pressure at least once per shift and maintain it at 25-30cmH2O. | 0 (0%) | 15 (11.5%) | 115 (88.5%) |
| 13. | Suction the subglottic secretions through an extra lumen in the endotracheal tubes when patients likely to require >48 or 72 hours of intubation. | 130 (100%) | 0 (0%) | 0 (0%) |
| 14. | Provide scheduled and regular respiratory physiotherapy. | 0 (0%) | 36 (27.7%) | 94 (72.3%) |
| 15. | Interrupt sedation daily and assess readiness to extubate by daily spontaneous breathing trials. | 1 (0.8%) | 7 (5.4%) | 122 (93.8%) |
| 16. | Maintain the patient on semi fowler position. | 0 (0%) | 7 (5.4%) | 123 (94.6%) |
| 17. | Use of kinetic beds (special automatic beds that allow for frequent changing position). | 0 (0%) | 5 (3.8%) | 125 (96.2%) |

**Table IV: Relationship between Categorical Socio-demographic Characteristics with Knowledge and Practice of Ventilator-associated Pneumonia (VAP) Prevention among Critical Care Nurses**

| Socio-demographic Characteristics | Knowledge; Practice | | | p-value (knowledge; practice) |
|---|---|---|---|---|
| | Poor, n (%) | Acceptable, n (%) | Good, n (%) | |
| Gender | | | | 0.437; 1.000 |
| Female | 3 (2.3%); 37 (28.5%) | 3 (2.3%); 29 (22.3%) | 114 (87.7%); 54 (41.5%) | |
| Male | 0 (0%); 2 (1.5%) | 1 (0.8%); 4 (3.1%) | 9 (6.9%); 4 (3.1%) | |
| Highest educational level in nursing (Qualification) | | | | 0.019; <0.001 |
| Master's Degree | 0 (0%); 0 (0%) | 0 (0%); 0 (0%) | 1 (0.8%); 1 (0.8%) | |
| Bachelor's Degree | 0 (0%); 0 (0%) | 0 (0%); 0 (0%) | 7 (5.4%); 7 (5.4%) | |
| Post basic in critical care nursing | 0 (0%); 4 (3.1%) | 0 (0%); 11 (8.5%) | 48 (36.9%); 33 (25.4%) | |
| Diploma | 3 (2.3%); 35 (26.9%) | 4 (3.1%); 22 (16.9%) | 67 (51.5%); 17 (13.1%) | |
| Current working critical care unit | | | | 0.105; 0.064 |
| Intensive Care Unit (ICU) | 1 (0.8%); 30 (23.1%) | 3 (2.3%); 25 (19.2%) | 103 (79.2%); 52 (40.0%) | |
| Coronary Care Unit (CCU) | 2 (1.5%); 9 (6.9%) | 1 (0.8%); 8 (6.2%) | 20 (15.4%); 6 (4.6%) | |
| In your hospital, you received education or training on VAP prevention. | | | | 0.046; 0.017 |
| Yes | 2 (1.5%); 33 (25.4%) | 3 (2.3%); 32 (24.6%) | 118 (90.8%); 58 (44.6%) | |
| No | 1 (0.8%); 6 (4.6%) | 1 (0.8%); 1 (0.8%) | 5 (3.8%); 0 (0%) | |

Fisher's Exact test was used due to expected count less than five in certain cells, $p \leq 0.05$ indicates statistically significant. Highest educational level in nursing (Qualification) was regrouped into two categories: Diploma and above Diploma. Practice levels were regrouped into two categories: Good and Acceptable/Poor.

## Relationship between Socio-demographic Characteristics with Knowledge and Practice of VAP Prevention

Table IV showed the categorical factors affecting the level of knowledge and practice of VAP prevention among respondents. Based on the Fisher's Exact test, there is no relationship between gender and current working critical care unit with the level of knowledge and practice of VAP prevention. On the other hand, significant

relationship existed between highest educational level in nursing and reception of VAP prevention education or training with the level of knowledge and practice of VAP prevention. Nurses who possessed a higher nursing educational qualification (above Diploma) and received VAP prevention education or training were more likely to have better knowledge and better practice of VAP prevention than the other categories.

Table V reported the continuous factors affecting the level of knowledge of VAP prevention among respondents. Based on multinomial logistic regression and using 'Good knowledge' as the reference category, none of the predictor variables were found to be a statistically significant predictor of knowledge level when comparing the odds of having poor knowledge to good knowledge. However, when comparing the odds of having acceptable knowledge to good knowledge, age was a significant positive predictor where older age was associated with higher odds of having acceptable knowledge than good knowledge (B= .902, SE= .365, p= .013). For every one unit increase in age, the odds of having acceptable knowledge increased by a factor of 2.465. Besides, total experience in nursing was a significant negative predictor where an increase in total experience in nursing was associated with lower odds of having acceptable knowledge than good knowledge (B= -.994, SE= .421, p= .018). For every one unit increase in total experience in nursing, the odds of having acceptable knowledge decreased by a factor of .370.

**Table V: Relationship between Continuous Socio-demographic Characteristics and Knowledge of Ventilator-associated Pneumonia (VAP) Prevention among Critical Care Nurses**

| Knowledge category[a] | Socio-demographic characteristics | OR | 95% CI (lower, upper) | p value |
|---|---|---|---|---|
| Poor | Age | .431 | 0.073 – 2.538 | .352 |
| | Total experience in nursing | 2.191 | 0.342 – 14.041 | .408 |
| | Experience in critical care nursing | .607 | 0.289 – 1.272 | .186 |
| Acceptable | Age | 2.465 | 1.205 – 5.040 | .013 |
| | Total experience in nursing | .370 | 0.162 – 0.844 | .018 |
| | Experience in critical care nursing | .583 | 0.287 – 1.186 | .137 |

[a]Reference category is Good, $p \leq 0.05$ indicates statistically significant

Table VI showed the continuous factors affecting the level of practice of VAP prevention among respondents analysed using multinomial logistic regression. With 'Good practice' as the reference category, experience in critical care nursing was a significant negative predictor where an increase experience in critical care nursing was associated with lower odds of having poor practice than good practice (B= -.292, SE= .113, p= .010). For every one unit increase in experience in critical care nursing, the odds of having poor knowledge decreased by a factor of .747. Conversely, none of the predictor variables were significant predictors of practice when comparing the odds of having acceptable practice to good practice.

**Table VI: Relationship between Continuous Socio-demographic Characteristics and Practice of Ventilator-associated Pneumonia (VAP) Prevention among Critical Care Nurses**

| Practice categorya | Socio-demographic characteristics | OR | 95% CI (lower, upper) | p value |
|---|---|---|---|---|
| Poor | Age | 0.756 | 0.522 – 1.095 | 0.139 |
| | Total experience in nursing | 1.251 | 0.820 – 1.908 | 0.299 |
| | Experience in critical care nursing | 0.747 | 0.598 – 0.933 | 0.01 |
| Acceptable | Age | 1.071 | 0.815 – 1.409 | 0.622 |
| | Total experience in nursing | 0.858 | 0.616 – 1.195 | 0.366 |
| | Experience in critical care nursing | 0.979 | 0.809 – 1.184 | 0.825 |

[a]Reference category is Good, $p \leq 0.05$ indicates statistically significant

## Relationship between Knowledge and Practice of VAP Prevention

Table VII showed the Fisher's Exact test analysis used to investigate the relationship between knowledge and practice of VAP prevention. It was found that no significant relationship existed between knowledge and practice of VAP prevention among respondents in the study.

**Table VII: Relationship between Knowledge and Practice of Ventilator-associated Pneumonia (VAP) Prevention among respondents**

| Variable | Practice of VAP Prevention | | | p value |
|---|---|---|---|---|
| | Poor, n (%) | Acceptable, n (%) | Good, n (%) | |
| **Knowledge of VAP Prevention** | | | | |
| Poor | 2 | 1 | 0 | 0.13 |
| Acceptable | 2 | 1 | 1 | |
| Good | 35 | 31 | 57 | |

Fisher's Exact test was used due to expected count less than five in certain cells, $p \leq 0.05$ indicates statistically significant. Knowledge of VAP prevention was regrouped into Good and Acceptable/Poor. Practice of VAP prevention was regrouped into Good and Acceptable/Poor.

## DISCUSSION

Our study found that most of the critical care nurses involved in the study had good knowledge of VAP prevention. Based on the finding, 99.2% of nurses choose the correct patient position in bed to prevent VAP and known the benefits of emptying the condensate from ventilator tubing and providing oral care regularly to patients. This high percentage was similar to study conducted by Al-Sayaghi and Kalyan et al. (6,8). The

results can be due to the fact that these interventions were commonly included in the syllabus of basic nursing education, and were considered autonomous nursing interventions for critical care nurses (9).

Our research findings showed that 96.2% of the nurses chose the usage of kinetic beds over standard beds to prevent VAP. This result was comparable to the study conducted by Abrar Mohammad Hashem Bokhary et al. which reported 83.0% of their respondents acknowledged the usefulness of kinetic beds in reducing the rate of VAP (10). Critically ill patients usually immobilised and experienced impaired mucociliary clearance. The use of kinetic beds able to prevent accumulation of mucus in lung zones while improving secretions movement, thus reducing VAP incidence (11). This statement was supported by a review of 37 systematic reviews where kinetic bed therapy was one of the basic non-pharmacological interventions in preventing VAP (12).

It was found that 95.4% of the nurses know the correct tracheal cuff pressure and the importance of daily sedation interruption and assessment of readiness for weaning. This finding aligned with the research conducted in Saudi Arabia where most respondents in their study able to determine the optimal tracheal cuff pressure and the benefit of daily sedation interruption (10). Nurses need to check the tracheal cuff pressure every eight to 24 hours or per shift (13). Additionally, nurses were given autonomy in adjusting the degree of sedation for a patient and this nurse-led sedation protocol significantly resulted in reduced durations of mechanical ventilation and incidence of VAP (14).

Our study found only 30.8% of the nurses chose the correct frequency of close-circuit suctioning system changes. This result can be due to the reasons that this strategy was not usually taught in basic nursing education and was mostly adopted from the unit policies or in-service training (15). Although most nurses had received education or training on VAP prevention, the unit policies may have changed again after they participated in the education or training. Moreover, there were resources from different articles on the internet that suggest different frequency for close-circuit suctioning system changes. With internet at fingertips nowadays, nurses can receive different kind of information other than formal guideline.

For practice of VAP prevention, our study found that most of the critical care nurses had acceptable practice of VAP prevention. All nurses reported "always handwashing after any approach to a patient" and "always change the closed-circuit suction systems for every new patient or when clinically indicated". Nurses were not limited to giving bedside patients care but also played a crucial role in creating a safe environment for patients, which was closely associated with infection control and prevention (16). The five moments of hand hygiene has been widely used as a routine audit in healthcare facilities to ensure nurses' compliance to this standard. The practice of changing the suction system for every new patient helps to ensure a sterile setup and decreases the risk of infection for patients.

In contrast, all nurses never practise "suction the subglottic secretions through an extra lumen in the endotracheal tubes when patients likely to require > 48 or 72 hours of intubation". Endotracheal tube with extra lumen for drainage of subglottic secretions was not being implemented in critical care units widely and still remained underused (17). This type of endotracheal tube cost additional expenditure to the healthcare facilities (18). Critical care nurses in this study have no accessibility to it as government hospitals were prone to cost-effective resources.

Our study revealed a significant relationship between age of critical care nurses and knowledge of VAP prevention, with older age nurses was predicted to have an acceptable knowledge than a good knowledge of VAP prevention. VAP prevention is an evidence-based practice which were always up to date based on new findings. Older nurses were generally more resistant to changes, leading to difficulties in accepting the latest information of a particular practice. However, a previous study conducted in Malaysia showed the older the critical care nurses, the better their knowledge of VAP prevention (5). Besides, other studies reported no relationship between age and knowledge of VAP prevention (19).

No significant relationship was found between gender of critical care nurses and knowledge of VAP prevention, which was in line with a study conducted in Sri Lanka (20). Nevertheless, study in Turkey reported that female critical care nurses possessed a better knowledge of VAP prevention compared to male critical care nurses (21). The opposition idea between masculinity and the caring concept caused female nurses to be more caring than male nurses (22). Female nurses might have more initiative in updating their knowledge according to new evidence-based practice compared to male nurses.

Our study revealed that the higher the nursing educational level of a nurse, the better their level of knowledge regarding VAP prevention, in line with some previous studies (6,21,23). These findings can be explained by the different learning scopes focussed on different educational levels. Diploma in nursing was designed to focus on the teaching of technical skills, post basic nursing course provided general training together with nursing theory and skills, and bachelor's degree of nursing equipped an individual with a wide foundation of nursing with associated sciences, while Master's degree of nursing helped to develop expertise in both clinical practice and in research (24).

In our study, nurses' current working critical care unit did not reveal a significant relationship with their knowledge level of VAP prevention, similar to the study conducted by Al-Sayaghi (6). However, few studies showed that nurses working in the general intensive care unit have a better knowledge of VAP prevention (5, 25). This finding might be due to the fact that different type of critical care unit has a different type of patient population. For example, general ICU comprised of a heterogeneous group of patients where frequent assessment and greater technological support were required, while CCU was more focussed on the delivery of comprehensive critical care to patients with cardiovascular disease.

Our study found that nurses with more total experience in nursing was predicted to have a good knowledge than an acceptable knowledge level of VAP prevention, similar to some previous study (5,25,26). Nurses have good attitude towards lifelong learning in the nursing field, causing them to learn actively. Such good attitude can be the reason of better knowledge among nurses with greater total experiences in nursing as their knowledge was always up to date accordingly. However, few studies showed that the total experience in nursing had no relationship with the knowledge level of VAP prevention (23,27,28).

In our study, we found that nurses' experience in critical care nursing did not relate with their knowledge level of VAP prevention, similar to some other studies conducted previously (5,6,23). However, this was different from a study conducted in India (29). These mixed findings suggest that while experience in critical care nursing may enhance nurses' knowledge, other factors also play significant roles. The absence of a strong relationship in some studies may indicate that simply accruing years in the profession is not enough to ensure increased knowledge.

Our study revealed that the reception of education or training on VAP prevention improved the knowledge level of VAP prevention among critical care nurses, similar to studies conducted in Malaysia and Ethiopia (5, 27). This result might be due to in service education and training emphasised on strong evidence-based knowledge, skills and expertise. This was further supported by a study conducted in Bahrain which revealed that critical care nurses's knowledge level of VAP prevention had improve after participation in educational program (30). However, study conducted by Barman reported that the reception of education or training on VAP prevention have no influence on the knowledge level of VAP (29).

No significant relationship was present between the age of critical care nurses and their practice level of VAP prevention, similar to a few previous studies (25,29). Nurses can voluntarily participate in continuing education or training for many reasons such as improving nursing skills and abilities, upgrading the service quality being delivered to patients, or just to gain more knowledge. Such education and training were open for nurses in all age group and therefore, all the nurses were able to engage in their professional development and acquire new skills regardless of their age.

The findings of this study also revealed a non-significant relationship between the gender of critical care nurses and their practice level of VAP prevention which was unvarying with studies conducted previously (7,29). Evidence-based guidelines for prevention of VAP have been released by professional organizations which include the Centers for Disease Control and Prevention and the American Thoracic Society where the prevalence of VAP significantly decreased if nurses applied the guidelines correctly (31). Practice and adherence to these guidelines were expected from all nurses, regardless of their gender.

It was found that critical care nurses' highest educational level in nursing was significantly related to their practice level of VAP prevention, consistent with a study conducted in India where higher educational qualification showed a higher level of practice of VAP prevention (32). A higher nursing educational level provide nurses with greater competencies in leadership and health policy, often promoting them to assume leadership position in clinical settings. As leaders, nurses need to display a better practice in every protocol because they have a huge influence on promoting compliance to protocols at their workplace. However, few studies showed different findings where there was no significant relationship present between nurses' highest educational level in nursing and their practice level of VAP prevention (7,23,25).

Our study showed current working critical care unit was not related to nurses' level of VAP prevention practice, similar to studies conducted by John and Srivastava (32). Improvement in safety and care quality delivered to critically ill patients were a high priority for all healthcare organisations (33). Nurses shared the common goal and commitment of providing the safest care to their patients. Therefore, nurses were expected to possess similar levels of practice of VAP prevention strategies across different types of critical care unit. Nevertheless, some studies found that the type of critical care unit was significantly related to VAP prevention practice level (7, 25).

In our study, it was found that no significant relationship between critical care nurses' total experience in nursing with their practice level of VAP prevention. Critical care nurses received regular evidence-based practice education and training about different aspect, including infection prevention throughout their career regardless of their experience in nursing to update their knowledge and improve their practice. Therefore, critical care

nurses with fewer years of experience in nursing field also able to receive the same VAP prevention training and education as the more experienced nurses, leading to comparable levels of practice.

On the other hand, our study revealed more experience in critical care nursing predicted a good practice than a poor practice level of VAP prevention, similar to few previous studies (25,29). Work experience may affect nurses' competencies as it was the learning process that took place in the healthcare industry. Meanwhile, a lack of knowledge and skills were the main barrier for critical care nurses to implement VAP prevention strategies (23,34). Hence, nurses with more experience in critical care nursing showed better practice levels of VAP prevention because they have had more time to develop a deep understanding of VAP prevention strategies and can incorporating those strategies into their daily workflow.

Our study also found that critical care nurses who received education or training on VAP prevention had a higher practice level of VAP prevention, supported by few previous studies (7,32). The participation of nurses in in-service training is able to update their professional knowledge and skills which improved their practice to fulfil different tasks and obligations. In our study, critical care nurses actively participated in in-service training offered by the hospital. Active participation leads to effective development in their work field in both knowledge and the practice. However, a study showed contradictory results where nurses' reception of VAP prevention education or training in hospitals did not significantly relate to their VAP prevention strategies practice level (23).

Lastly, our study reported no significant relationship found between knowledge and practice of VAP prevention among critical care nurses. This finding was similar to studies conducted in Malaysia and India (25, 32). Although nurses might possess the necessary knowledge of VAP prevention strategies, there were many barriers for nurses to implement the strategies such as shortage of nursing staff, organizational cost constraints and time constraints (7).

## CONCLUSION

In conclusion, this study found a gap between the knowledge and practice of VAP prevention among critical care nurses. While the critical care nurses demonstrated a good level of theoretical knowledge regarding VAP prevention, their practical implementation fell in the category of acceptable only. It is essential to address any other possible barriers to implementing VAP prevention strategies among critical care nurses in the healthcare setting as they have already equipped themselves with a good level of knowledge.

## ACKNOWLEDGEMENTS

We would like to extend our gratitude to all critical care nurses who agreed to participate in this study. Deep appreciation directed to the Director of both hospitals, Matron, and Sisters in charge of critical care units for their approval and recruitment of participants in this research study. No conflict of interest found in this study.

## REFERENCES

1. Modi AR, Kovacs CS. Hospital-acquired and ventilator-associated pneumonia: Diagnosis, management, and prevention. Cleveland Clinic Journal of Medicine. 2020;87(10):633–9. doi: 10.3949/ccjm.87a.19117
2. Ranzani OT, Niederman MS, Torres A. Ventilator-associated pneumonia. Intensive Care Medicine. 2022;48(9):1222–6. doi: 10.1007/s00134-022-06773-3
3. Colombo SM, Palomeque AC, Bassi GL. The zero-VAP sophistry and controversies surrounding prevention of ventilator-associated pneumonia. Intensive Care Medicine. 2019;46(2):368–71. doi: 10.1007/s00134-019-05882-w
4. Cengiz HO, Kanan N. The effectiveness of training given to nurses for reducing ventilator-associated pneumonia in intensive care patients. Developments in Health Sciences. 2019;2(2):36–45. doi: 10.1556/2066.2.2019.006
5. Norazlin AM, Norzakira J. Critical care nurses knowledge in prevention of ventilator-associated pneumonia. ILKKM Journal Medical and Health Sciences. 2019;1(1):2682–7719.https://www.researchgate.net/publication/334284493_Critical_Care_Nurses_Knowledge_in_Prevention_of_Ventilator-Associated_Pneumonia
6. Al-Sayaghi KM. Prevention of ventilator-associated pneumonia. A knowledge survey among intensive care nurses in Yemen. Saudi Medical Journal. 2014;35(3):269–267. https://pubmed.ncbi.nlm.nih.gov/24623207/
7. Al-Sayaghi KM. Critical care nurses' compliance and barriers toward ventilator-associated pneumonia prevention guidelines: cross-sectional survey. Journal of Taibah University Medical Sciences. 2021;16(2):274¬¬¬–282. doi: 10.1016/j.jtumed.2020.12.001
8. Kalyan G, Bibi R, Kaur R, Bhatti R, Kumari R, Rana R, 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. 2020;25(5):369. doi: 10.4103/ijnmr.ijnmr_128_18
9. Fatma AM, Aml AE. Relationship between Critical Care Nurses' Knowledge and Clinical Decision Making Role in Managing Mechanically Ventilated Patients. Menoufia Nursing Journal. 2022;7(2):335–350. doi: 10.21608/MENJ.2022.271724
10. Abrar MHB, Amina HS, Friyal MA. Critical Care Nurses' Knowledge Regarding Evidence-Based Guidelines for Preventing of Ventilator-Associated Pneumonia

in the Intensive Care Units: A cross-sectional study. International Journal of Healthcare Sciences. 2022;9(2):139–149. ISSN 2348-5728. https://www.researchpublish.com/papers/critical-care-nurses-knowledge-regarding-evidence-based-guidelines-for-preventing-of-ventilator-associated-pneumonia-in-the-intensive-care-units-a-cross-sectional-study
11. Coppadoro A, Bittner E, Berra L. Novel preventive strategies for ventilator-associated pneumonia. Critical Care. 2012;16(2):210. doi: 10.1186/cc11225
12. Suclupe S, Bustillos PEP, Bracchiglione J, Requeijo C, Salas-Gama K, Sola I, et al. Effectiveness of nonpharmacological interventions to prevent adverse events in the intensive care unit: A review of systematic reviews. Australian Critical Care. 2023;36(5):902–14. doi: 10.1016/j.aucc.2022.11.003
13. Kumar CM, Seet E, Van Zundert TCRV. Measuring endotracheal tube intracuff pressure: no room for complacency. Journal of Clinical Monitoring and Computing. 2020;35(1):3–10. doi: 10.1007/s10877-020-00501-2
14. Qi Z, Yang S, Qu J, Li M, Zheng J, Huang R, et al. Effects of nurse-led sedation protocols on mechanically ventilated intensive care adults: A systematic review and meta-analysis. Australian Critical Care. 2021;34(3):278–86. doi: 10.1016/j.aucc.2020.07.013
15. Korhan EA, Yunt GH, Kılıç SP, Uzelli D. Knowledge levels of intensive care nurses on prevention of ventilator-associated pneumonia. Nursing in Critical Care. 2013;19(1):26–33. doi: 10.1111/nicc.12038
16. Wang X, Xu Q, Liu X, Lv A. Effect of Nursing Quality Management on the Nosocomial Infection Rate and Psychology State of Patients with Burn and Plastic Surgery. Iranian Journal of Public Health. 2020;49(9):1659–1665. doi: 10.18502/ijph.v49i9.4082
17. Lacherade JC, Azais MA, Pouplet C, Colin G. Subglottic secretion drainage for ventilator-associated pneumonia prevention: an underused efficient measure. Annals of Translational Medicine. 2018;6(20):422. doi: 10.21037/atm.2018.10.40
18. Baldwin F, Gray R, Chequers M, Dyos J. Audit of UK ventilator care bundles and discussion of subglottic secretion drainage. Nursing in Critical Care. 2015;21(5):265–70. doi: 10.1111/nicc.12146
19. Jansson MM, Syrjälä HP, Talman K, Meriläinen MH, Ala-Kokko TI. Critical care nurses' knowledge of, adherence to, and barriers toward institution-specific ventilator bundle. American Journal of Infection Control. 2018;46(9):1051–6. doi: 10.1016/j.ajic.2018.02.004
20. Muralitharan P, Sujatha S. Knowledge Regarding Ventilator-associated Pneumonia and its Prevention Among Nurses Working at Intensive Care Units of Two Teaching Hospitals in Sri Lanka. Journal of Health Sciences and Innovative Research. 2022;3(1):29–38. doi: 10.31357/jhsir.v3i01.5969
21. Alankaya N, Karadakovan A, Ozgursoy U, Bayram H. Intensive Care Nurses' Knowledge of Evidence-based Practices regarding the Prevention of Ventilator-associated Pneumonia in Turkey. Asian Journal of Science and Technology. 2017;8(10):5881–5886. https://www.journalajst.com/sites/default/files/issues-pdf/4660.pdf ISSN: 0976-3376.
22. Lee L, Chen CH, Yang Y. The affect of gender on caregiving: A study of male nurses. The Journal of Nursing. 2010;57(1):77–81. doi: 10.6224/JN.57.1.77
23. Bankanie V, Outwater AH, Wan L, Yinglan L. Assessment of knowledge and compliance to evidence-based guidelines for VAP prevention among ICU nurses in Tanzania. BMC Nursing. 2021;20(1):209. doi: 10.1186/s12912-021-00735-8
24. Wang CC, Whitehead L, Bayes S. Nursing education in China: Meeting the global demand for quality healthcare. International Journal of Nursing Sciences. 2016;3(1):131–136. doi: 10.1016/j.ijnss.2016.02.009
25. Selamat NA, Aung KT, Soe MK. Critical Care Nurses' Knowledge and Practices on Ventilator-Associated Pneumonia. International Archives of Nursing and Health Care. 2021;7(3): 163. doi: 10.23937/2469-5823/1510163
26. Alkhazali MN, Bayraktar N, Al-Mugheed KA. Knowledge and Barriers of Critical Care Nurses Regarding Evidence-Based Practices in Ventilator-Associated Pneumonia Prevention. Cyprus Journal of Medical Sciences. 2021;6(3):185. doi: 10.5152/cjms.2021.1292
27. Getahun AB, Belsti Y, Getnet M, Bitew DA, Gela YY, Belay DG, 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. 2022;78(4):103895. doi: 10.1016/j.amsu.2022.103895
28. Yeganeh M, Yekta H, Farmanbar R, Khalili M, Khaleghdoost T, Roushan ZA. Knowledge of evidence-based guidelines in ventilator-associated pneumonia prevention. Journal of Evidence-Based Medicine. 2016;12(1):16–21. doi: /10.1111/jebm.12188
29. Barman B. A Study to Assess the Knowledge and Practices Regarding Prevention of Ventilator Associated Pneumonia among the Staff Nurses Working in Intensive Care Unit of Selected Hospitals in Kamrup Metro, Assam. International Journal of Science and Research. 2022;12(1):1097–1102. doi: 10.21275/SR23128175518
30. ALaswad ZM, Bayoumi M. Improvement of the nurses' awareness toward ventilator-associated pneumonia based on evidence guidelines. Indian Journal of Medical Specialities. 2022;13(2):95. doi: 10.4103/injms.injms_124_21
31. Aloush SM. Does educating nurses with ventilator-associated pneumonia prevention guidelines improve their compliance?. American Journal of Infection Control. 2017;45(9):969–973. doi: 10.1016/j.ajic.2017.04.009
32. John J, Srivastava S. A Study to Assess the Knowledge and Practice of Nurses on Prevention of Ventilator Associated Pneumonia (VAP), and to Seek Its Relationship with the Selected Factors at Selected Hospitals of Delhi and NCR. International Journal of Nursing Care. 2022;10(1):9–15. doi: 10.37506/ijonc.v10i1.17823
33. Lin F, Craswell A, Murray L, Brailsford J, Cook

K, Anagi S et al. Establishing critical care nursing research priorities for three Australian regional public hospitals: A mixed method priority setting study. Intensive and Critical Care Nursing. 2023;77:103440. doi: 10.1016/j.iccn.2023.103440

34. Jansson M, Ala-Kokko T, Ylipalosaari P, Syrjالا H, Kyngاs H. 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/Intensive and Critical Care Nursing. 2013;29(4):216–27. doi: 10.1016/j.iccn.2013.02.006