

# Effectiveness of Implementing Ventilator Associated Pneumonia Prevention Bundle among Mechanically Ventilated Patients

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**Abstract:** Ventilator Associated Pneumonia (VAP) is the most common infectious complication among intubated patients for more than 48 hours. Aim: to examine the effectiveness of implementing Ventilator Associated Pneumonia prevention bundle among mechanically ventilated patients. Methods: A quasi experimental design (study/control) was utilized. Sample: A convenient sample of 104 patients, who admitted to the ICU, at Shebin El-Kom Menoufia University Hospital were recruited. Tools: Acute Physiology and Chronic Health Evaluation II (APACHE II) scale, Charlson Comorbidity Index Scale and Clinical Pulmonary Infection Score (CPIS). Results: There was a statistically significant reduction in the incidence rate of Ventilator Associated Pneumonia in the study group (26.9%) compared to (69.2%) in the control group post intervention. There was a statistically significant reduction in the mean duration of mechanical ventilation and the mean length of ICU stay in the study group ( $8.48 \pm 2.49$ ) ( $11.75 \pm 2.83$ ) compared to ( $11.27 \pm 2.17$ ) ( $15.07 \pm 2.22$ ) days in the control group respectively post intervention,  $P < 0.001$ . There is a relationship between co-morbidity conditions and the incidence of VAP among mechanically ventilated patients  $p < 0.001$ . Also, there is a relationship between severity of illness and the incidence of VAP among mechanically ventilated patients  $p < 0.001$ . Conclusion: Implementing Ventilator Associated Pneumonia prevention bundle can lead to a statistically significant reduction in the incidence of VAP, duration of mechanical ventilation and ICU length of stay. Recommendation: Establishing a multidisciplinary team to conduct a periodic in-service education courses for critical care nurses about the importance of VAP prevention bundle.

**Keywords:** Ventilator Associated Pneumonia Bundle, VAP Incidence Rate, Mechanical Ventilation, ICU length of stay.

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## 1. INTRODUCTION

Mechanical Ventilation (MV) is an effective intervention to save the life of critically ill patients and is widely used in Intensive Care Units (ICUs) to replace or assist spontaneous breathing [1]. However, prolonged mechanical ventilation can lead to increased risk of infection and other complications. Ventilator Associated Pneumonia (VAP) is the most common complication associated with mechanical ventilation with a high morbidity and mortality rate. VAP is the most commonly acquired ICU infection worldwide affecting nearly 10-30% of mechanically ventilated patients and accounting for nearly 25% of all types of ICU infections [2]. VAP is considered to be the second most frequent nosocomial infection in ICU that occurs after 48 hours or more after the initiation of mechanical ventilation [3]. In the United States, VAP causes up to 36,000 deaths per year. In Europe, about 18,900 cases of VAP have been estimated to occur each year with mortality rate up to 50% of cases and 76% in the most compromised patients [4]. In Egypt, it is estimated that VAP

occurs on 10% of mechanically ventilated patients and the risk of VAP increases as the duration of Mechanical Ventilation increases [5].

Mechanically ventilated patients are at risk of developing VAP due to alteration of the normal physiological responses aimed at protecting the lungs and airways. VAP can cause patients to have difficulty weaning off the ventilator and to increase duration of mechanical ventilation. VAP can prolong intubation by 4-9 days compared to patients without VAP, which results in increasing the ICU Length of Stay (LoS) and increasing financial costs among mechanically ventilated patients. Also, it can increase mortality to twice the level of patients who do not develop VAP [6]. According to the American Thoracic Society (ATS), every day of mechanical ventilation increase the risk of developing VAP by 3% during the first 5 days and 2% per day for 6-10 days and 1% per day after that [7].

Chronic diseases including coronary and respiratory disease, diabetes, and chronic renal failure are risk factors for VAP, [8,9,10] which lead to immune suppression, causing impairments of vital organs such as heart, liver, kidney, and lungs, making the patient more vulnerable to infection. Patients with chronic diseases had longer mechanical ventilation time and hospital length of stay [11]. Patients with co-morbidities conditions were 2.3 times more likely to develop VAP than patients without co-morbidities conditions [12]. The increased number of co-morbidities poses a greater risk of mortality in VAP patients and patients with  $\geq 2$  co-morbidities have been observed to have mortality of 61.7% [13].

Also, severity of illness is recognized as independent risk factors for VAP [14]. Moderate or high severity of illness are more likely to have VAP because it make the patient more susceptible to infection due to impairment of the immune system which lead to increase virulence of infectious microorganisms and is usually associated with more clinical complications and worse prognosis [12].

VAP has been proposed as an indicator of quality of care and its prevention is considered as an important practice for patient safety [15]. In the United States, the high cost associated with VAP has put pressure on hospitals to minimize VAP rates [16].

Many prevention guidelines are now available for VAP prevention. The Institute of Healthcare Improvement (IHI) introduced care bundle as a structured protocol for preventing the development of pneumonia in mechanically ventilated patients. Bundle is a small set of evidence based preventive practices that when implemented collectively helps in the prevention of a healthcare associated infection [17]. There is no clear consensus about what a VAP bundle should include [18, 19]. The VAP prevention bundle adopted by most hospitals are those given by the Institute of Healthcare Improvement and have shown to reduce VAP rates by 50 percent or more [13]. The IHI Ventilator bundle includes four nursing practices: elevation of the head of bed to 30 to 45 unless medically contraindicated, washing of hands before and after contact with each patient, continuous removal of subglottic secretions, and change of ventilator circuit every 48 hours for mechanically ventilated patients [21]. Recently the European guidelines reemphasized the need for the implementation of multimodal approach to decrease the incidence of VAP [22] these guidelines support maintaining the endotracheal cuff pressure between 20 to 25 mm Hg. Maintaining the endotracheal cuff pressure within the therapeutic range prevent leak or passage of secretions from the Oropharynx into the airway and causing aspirated pneumonia. Also, continuous maintaining the endotracheal cuff pressure is associated with decrease micro-aspiration of gastric content that may reduce significantly the occurrence of VAP [23]. Therefore, the recommended bundle components used in the current study are hand hygiene, elevation of the head of bed, continuous removal of subglottic secretions, change of ventilator circuit and maintaining the endotracheal cuff pressure between 20 to 25 mm Hg. Ventilator circuit changes must kept minimal and limited only when visible soiling is observed [24].

### Significance of the Study

VAP is a safety issue in critically ill patients receiving mechanical ventilation. Although the incidence rate of VAP have been decreased with the development of preventative strategies in the past decades, however, VAP remains one of the most common causes of nosocomial infections and mortality in the ICU. Initiation of ventilator bundles has proven as an effective strategy of reducing VAP, mostly where all components have been adhered to. However, the guidelines for the prevention of VAP are not consistently implemented in hospitals. Healthcare providers are still facing many challenges in the management of VAP. These challenges include lack of unified diagnostic criteria and inconsistency in the implantation of the preventative strategies across organization. Prevention of VAP is given a priority in all quality control programs as it may help in improving clinical outcome and reduce costs.

Critical care nurses are at the forefront of quality health care improvement using the best evidence based practice available. Critical care nurses are dealing with mechanically ventilated patients all the time. Therefore, involving nurses in identifying patients at risk and preventing the occurrence of VAP will reduce medical cost, reduce duration of mechanical ventilation and its serious sequels and ultimately decrease ICU length of stay and utilization of healthcare resources.

### **Aim of the Study**

The aim of the current study was to examine the effectiveness of implementing ventilator associated pneumonia prevention bundle among mechanically ventilated patients.

### **Research Hypotheses**

1. Patients who receive VAP prevention bundle are less likely to develop VAP compared to patients who don't receive VAP prevention bundle.
2. Patients who receive VAP prevention bundle will have less duration of mechanical ventilation and length of ICU stay compared to patients who don't receive VAP prevention bundle.
3. There is a relationship between the incidence of VAP and severity of illness among mechanically ventilated patients
4. There is a relationship between the incidence of VAP and co-morbidity condition among mechanically ventilated patients.

## **2. METHODS**

Design: A quasi experimental design (study/control) was utilized to examine the study Hypotheses.

Setting: The study was conducted at the Surgical Intensive Care Unit (SICU) and Anesthesia ICU at the University Hospital of Menoufia University.

Sample: A convenient sample of one hundred and four adult patients was recruited for this study. These patients were approached over a 12 months period from the beginning of March 2020 to the end of February 2021. These patients met the following inclusion criteria: a) intubated patients for more than 48 hours on mechanical ventilation; b) adult patients aged 19- 65 years old. Patients were excluded from participating in the study if they have any of the following conditions: a) Patients with chronic tracheostomy as these patients require long-term use of mechanical ventilation; b) Patients intubated for less than 48 hours as VAP occurs after 48 hours of the initiation of mechanical ventilation. Patients who met the study inclusion criteria were divided alternatively and randomly into two groups; 52 patients each. The study group received VAP prevention bundle and control group received the routine hospital care which included oropharyngeal suctioning and oral care only.

Calculation of Sample Size: A convenient sample of 104 patients was recruited to participate in the study. Sample size was calculated based on power analysis. Provided 80% power to detect a difference in the percent of patients receiving the VAP prevention bundle at least 20% between groups, using a two-sided test and a 5% significant level of 0.05 and medium treatment effect size of 0.5. Medium effect size was used to calculate the sample size in the present study because we anticipated a large effect of the VAP prevention bundle on the selected outcomes based on finding of the previous study [25]. Based on this calculation a sample size of 84 is adequate to test the study hypotheses. Another 20 patients were added to compensate for the attrition rate based on the overall mortality rate of mechanically ventilated patients, so the final sample was 104 patients.

### **Instruments**

#### **I) A Semi Structured Demographic Questionnaire**

The researcher collected data about patient's age, gender, marital status, diagnosis, duration of mechanical ventilation, ICU and hospital length of stay. Data were extracted from the patient's medical record by the researcher at the initial data collection point after admission to the surgical and anesthesia ICU.

#### **II) Acute Physiology and Chronic Health Evaluation II (APACHE II) Scale**

APACHE II was developed by Knaus et al., (1985) [26]. APACHE II was designed to measure the severity of disease for patients within 48 hours of ICU admission. The APACHE II score ranged from 0 to 71 and was computed based on

several measurements such as patient's age and 12 routine physiological measurements: PaO<sub>2</sub> (depending on FiO<sub>2</sub>), Body Temperature, Mean Arterial Pressure (MAP), Arterial pH, Heart Rate, Respiratory Rate, Serum Sodium, Serum Potassium, Creatinine, Hematocrit, White Blood Cell Count, Glasgow Coma Scale. The scoring system of the scale interpreted as: 5 to 9 had 8% mortality risk, 10 to 14 had 15% mortality risk, 15 to 19 had 25% mortality risk, 20 to 24 had 40% mortality risk, 25 to 29 had 55% mortality risk, 30 to 34 had 75% mortality risk and >34 had 85% mortality risk.

The reliability of the APACHE II Scale was reported in a study of two hundred mechanically ventilated patients. Internal consistency was evaluated using Cronbach's alpha and was 0.95 ( $p < 0.001$ ) for the total scale [27]. The validity of the APACHE II scale was shown to be high when used in mechanically ventilated patients with Bravais-Pearson Correlation Co-efficient, 0.86 ( $p < 0.01$ ) [27]. In the present study, the reliability of the APACHE II scale was tested by test-retest reliability on 10 patients and the Cronbach's Co-efficient Alpha was 0.89 ( $p < 0.001$ ).

### III) Charlson Co-morbidity Index

Charlson Co-morbidity Index was designed to categorize co-morbidities of patients based on the International Classification of Diseases (ICD). It consists of 19 categories of co-morbidity and predicts the Ten –year survival in patient with multiple co-morbidities. Each condition is assigned with score from 0 to 6 depending on the risk of dying associated with this condition. A score of zero indicates that no co-morbidities were found and higher scores indicating greater co-morbidity. Patients with a score >5 have essentially a 100% risk of dying at one year [28]. The scoring system of the scale interpreted as: 0 points had 98% estimated 10-year survival, 1 point had 96%, 2 points had 90%, 3 points had 77 %, 4 points had 53%, 5 points had 21%, 6 points had 2%, and 7 points or more had 0% estimated 10-year survival.

The Charlson Co-morbidity Index has well established reliability and validity. Alpha Co-efficient for the internal consistency of the Charlson Co-morbidity Index ranged from 0.86 to 0.95 and indicated excellent reliability [29]. In the present study, the reliability of the Charlson Comorbidity Index was tested by test-retest reliability using the internal consistency and the Cronbach's Co-efficiency Alpha was 0.92 ( $P < 0.001$ ).

### IV) Clinical Pulmonary Infection Score (CPIS)

Clinical Pulmonary Infection Score was developed by Pugin et al., (1991) [30] to simplify the diagnosis of VAP. The CPIS is calculated from the first five items such as (Body Temperature, Leukocyte Count, Tracheal Secretions, Arterial Oxygenation (PaO<sub>2</sub>/FiO<sub>2</sub>) and Chest Radiograph). The CPIS cultures were calculated from the CPIS baseline score by adding two more points when gram stains or cultures were positive. The total CPIS can range from 0 to 12. A score of more than six at baseline or after incorporating the culture result was considered suggestive of VAP and CPIS less than six indicate free of VAP.

The validity of the CPIS was shown to be high when used in mechanically ventilated patients ( $r_2 = 0.233$ ,  $p < 0.0001$ ). The reliability of the CPIS scale was reported in a study of 50 adult patients who were connected to mechanical ventilation. Internal consistency was evaluated using Cronbach's co-efficiency Alpha and was 0.81 for the total scale [31]. In the present study, the reliability of the CPIS was tested by using the internal consistency and Cronbach's Co-efficiency Alpha was 0.98.

### Ethical Consideration

All necessary official permissions for conducting the study were obtained from the Research Ethics Committee at the Faculty of Nursing and University Hospital director to carry out the study after explaining the purpose of the study. A verbal consent was obtained from the patients' relatives. At the initial interview, relatives were informed about the purpose, procedure, and benefits of participating in the study. The researcher explained to the relatives that participation in the study is voluntary and they can withdraw from the study at any time without penalty. Confidentiality and anonymity of patient's information were assured through coding all data and put all collected data sheets in a secured cabinet. Questionnaires were fulfilled by the researcher.

### Pilot Study

A pilot study was conducted on 10% of the study sample (10 patients) to test the practicality and applicability of the tools and detect any problems that might encountered during data collection and to estimate the time needed to fill in the study questionnaire. Subjects participating in the pilot study were excluded from the final analysis.

**Data Collection Procedure**

A total sample of 104 adult mechanically ventilated patients was randomly assigned into two equal groups, 52 patients each (study and control group). Both groups were matched against the study inclusion criteria as much as possible. The researcher handled the control group first. The control group followed the usual routine hospital care and the study group received the VAP prevention care bundle.

Data were obtained from participants in surgical and anesthesia ICU at Menoufia University which included: 1) Semi Structured Demographic Questionnaire; 2) APACHE II Scale; 3) The Charlson Co-morbidity Index; 4) The Clinical Pulmonary Infection Score (CPIS) for both study and control groups. The CPIS was assessed daily until the participants wean off the ventilator or until the participants diagnosed with VAP.

**The Study Group (Intervention)**

The study group was assigned to receive the VAP prevention bundle interventions twice daily until the patient weaned from the mechanical ventilation or diagnosed with VAP. VAP prevention bundle included the following items: hand hygiene, elevation of the head of bed, continuous removal of subglottic secretions, change of ventilator circuit every 48 hours and maintaining the endotracheal cuff pressure between 20 to 25 mm Hg. [32]. To measure the endotracheal tube cuff pressure, the cuff manometer was connected to pilot balloon of endotracheal tube then the cuff pressure appear on the screen of the endotracheal tube cuff pressure manometer to adjust endotracheal tube cuff pressure within the normal therapeutic range (25cm H<sub>2</sub>O). The researcher checked the endotracheal tube cuff pressure twice daily.

**The Control Group**

The control group was assigned to receive the routine hospital care which included oropharyngeal suctioning as needed and oral hygiene twice daily. Intermittent suctioning for 10 seconds was applied.

**3. DATA ANALYSIS**

Categorical variables were reported as frequency and percentage; continuous variables were reported as mean and standard deviation. Comparison of results between the study and the control group was done for continuous variables using 2-sample t- tests and for categorical variables using Pearson  $\chi^2$ . All analyses used 2-sided tests and a P value less than or equal to 0.05 was considered statistically significant.

**4. RESULTS**

**Characteristics of the Study Sample**

One hundred and four adult patients were admitted to surgical ICU and Anesthesia ICU at Menoufia University Hospital were approached over a 12 months period from the beginning of March 2020 to the end of February 2021.

**Table (1): The Demographic Characteristics of the Study Sample (N=104)**

Demographic Characteristics	Study Group (n=52)		Control Group (n=52)	
	No	%	No	%
<i>Age</i> X ± SD	57.79 ±2.87		58.40 ±4.42	
<i>Gender</i>				
• Male	34	65.4%	30	57.7%
• Female	18	34.6%	22	42.3%
<i>Marital status</i>				
• Single	14	26.9%	11	21.1%
• Married	34	65.4%	38	73.1%
• Widowed	4	7.7%	3	5.8%
<i>ICU</i>				
• Surgical ICU	30	57.7 %	28	53.8%
• Anesthesia ICU	22	42.3%	24	46.2%

The mean age of the participants in the study group and control group was (57.79 ±2.87 and 58.40 ±4.42) years old respectively. Regarding gender, more than half of participants in both study and control groups were male (65.4%) and (57.7%) respectively. The majority of the participants in both study and control groups were married (65.4%) and (73.1%) respectively. Participants in the study group (57.7 %) and the control group (53.8%) were recruited from the surgical ICU.

**Table (2): APACHE II Score of the Study Sample (N = 104)**

APACHE II Score	Mortality Risk	Study Group (n=52)		Control Group (n=52)		test	P -value
		No	%	No	%		
<b>APACHE II score</b>							
■ 5-9	8%	4	7.7%	4	7.7%	<b>X<sup>2</sup></b>  4.68	0.321 <sup>ns</sup>
■ 10-14	15%	7	13.5%	9	17.3%		
■ 15-19	25%	24	46.3%	21	40.4%		
■ 20-24	40%	9	17.3%	11	21.2%		
■ 25-29	55%	8	15.2%	7	13.5%		
X ± SD		18.50 ±5.07		19.31 ±6.01		<b>t test</b>	0.461 <sup>ns</sup>
Range		9- 27		9- 27		-.741 -	

**NB:** ns= not significant (p>0.05)

Table (2): shows the total mean score of APACHE II scale of participants in the study and the control groups which was (18.50 ±5.07) and (19.31 ±6.01) respectively. About 46.3% and 40.4% of the participants in the study and the control groups have APACHE II score ranged from 15 to 19 which indicate a 25% mortality risk. Seventeen percent and 21.2 % of the participants in the study and the control groups have APACHE II score ranged from 20 to 24 which indicate a 40% mortality risk. A total of 15 participants from both study and control group have APACHE II score ranged from 25-29 which indicate a 55 % mortality risk [8(15.2%) in the study group and 7 (13.5 %) in the control group].

**Table (3): Charlson Co-morbidity Index of the Study Sample (N=104)**

Charlson Co-morbidity Index	Estimated 10-year Survival	Study Group (n=52)		Control Group (n=52)		test	P -value
		No	%	No	%		
<b>Charlson score</b>							
● 1	96%	8	15.4%	9	17.3%	<b>X<sup>2</sup></b>  0.513	0.972 <sup>ns</sup>
● 2	90%	15	28.8%	14	26.9%		
● 3	77%	20	38.5%	19	36.5%		
● 4	53%	6	11.5%	7	13.5%		
● 5	21%	3	5.8%	3	5.8%		
X ± SD		3.50 ±0.87		3.61 ±1.19		<b>t test</b>	0.640 <sup>ns</sup>
Range		1-5		1-5		-.469-	

**NB:** ns= not significant (p>0.05)

Table (3): demonstrates that the total mean score of the Charlson Co-morbidity Index of participants in the study and control groups was (3.50 ± 0.87) and (3.61 ± 1.19) respectively. Thirty eight percent and 36.5% of the participants in the study and the control groups have Charlson Co-morbidity Index score 3 which indicate 77% estimated 10-year survival.

About 29 % and 26.9% of the participants in the study and the control groups have Charlson Co-morbidity Index score 2 which indicate 90% estimated 10-year survival. While only 5.8% in the study group and 5.8% in the control group have a Charlson Co-morbidity Index score 5 which indicate 21% estimated 10-year survival.

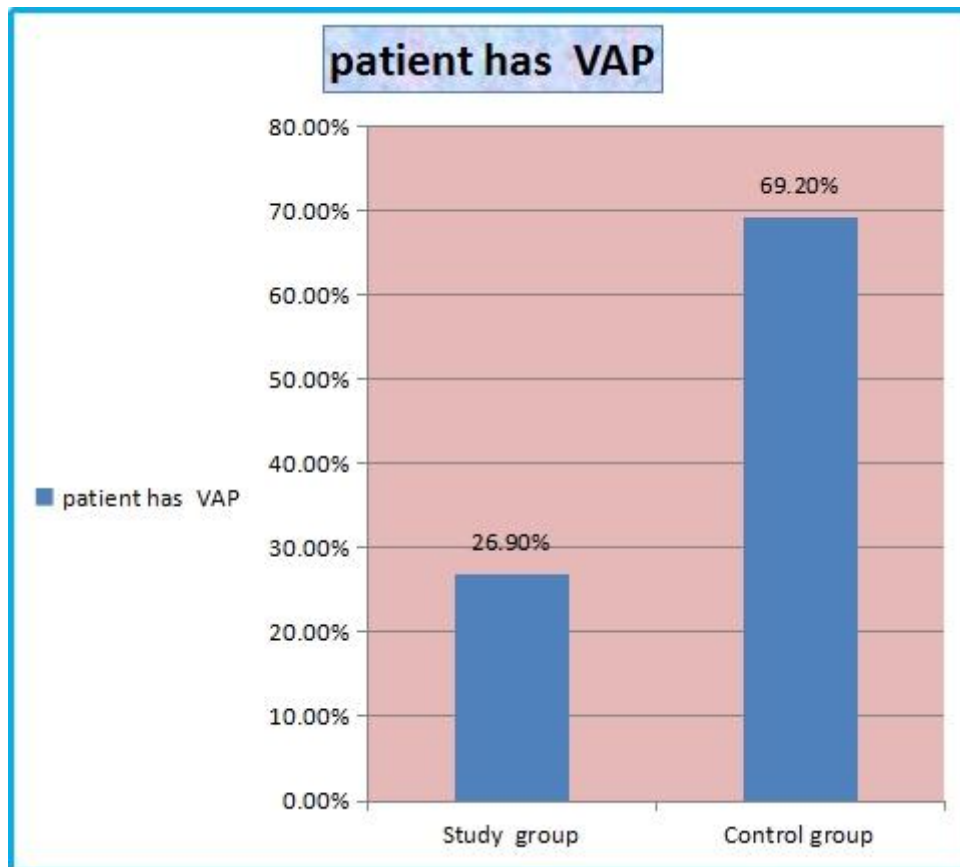
**Table (4): The Effect of Ventilator Associated Pneumonia Prevention Bundle on Incidence of VAP rate Post Intervention**

Incidence of VAP	Study Group (n=52)		Control Group (n=52)		X <sup>2</sup>	P -value
	No	%	No	%		
• Confirmed VAP	14	26.9%	36	69.2%	18.64	0.000 <sup>(HS)</sup>
• No VAP	38	73.1%	16	30.8%		

**NB:** <sup>(HS)</sup> ( $p < 0.001$ )

Table (4): Illustrates that there was a highly statistically significant reduction in the incidence of VAP rate in the study group compared to the control group post intervention  $p < 0.001$ . In the study group 26.9% of the participants have VAP while 69.2% of participants in the control group have VAP. There was a 22% reduction in the VAP incidence rate in the study group than in the control group.

Figure (1): The Effect of Ventilator Associated Pneumonia Prevention Bundle on Incidence of VAP Post Intervention.



**Figure (1): This figure showed that there was a highly statistically significant reduction in the VAP incidence rate in the study group compared to the control group post intervention.**

**Table (5): The Effect of VAP Prevention Bundle on Duration of Mechanical Ventilation and ICU Length of Stay Post Intervention**

Items	Study Group (n=52)	Control Group (n=52)	Independent t test	P -value
Ventilator days				
X ± SD	8.48 ± 2.49	11.27 ± 2.17	-6.072-	0.000 <sup>(HS)</sup>
Range	5 - 13	6 - 13		
ICU Length of Stay				
X ± SD	11.75 ± 2.83	15.07 ± 2.22	-6.672-	0.000 <sup>(HS)</sup>
Range	9 - 17	10 - 17		
Hospital Length of Stay				
X ± SD	16.21 ± 3.36	19.81 ± 3.57	-5.283-	0.000 <sup>(HS)</sup>
Range	9 - 23	10 - 23		

NB: <sup>(HS)</sup> (p<0.001)

Table (5) Illustrates that there was a highly statistically reduction in the mean duration of mechanical ventilation in the study group (8.48 ± 2.49) days compared to (11.27 ± 2.17) days in the control group post intervention p<0.001. There was a highly statistically significant reduction in the mean ICU length of stay in the study group (11.75 ± 2.83) days compared to (15.07 ± 2.22) days in the control group post intervention p < 0.001. Also, there was a highly statistically significant reduction in the mean hospital length of stay in the study group (16.21 ± 3.36) days compared to (19.81 ± 3.57) days in the control group post intervention p<0.001.

**Table (6): The Relationship between the Incidence of VAP and Severity of Illness Post Intervention**

Items	Incidence of VAP			
	Study Group		Control Group	
	r	P -value	r	P -value
APACHE II Score	0.774**	0.000	0.610**	0.000

\*\* Correlation is significant at the 0.01 level (2-tailed).

Table (6) Showed that there is a relationship between the incidence of VAP and the total APACHE II score between the study and the control groups post intervention with r =0.774 and r=0.610 respectively (P< 0.001).

**Table (7): The Relationship between the Incidence of VAP and Co-morbidities Post Intervention.**

Items	Incidence of VAP			
	Study Group		Control Group	
	R	P -value	r	P -value
Charlson Co-morbidity Index Score	0.600**	0.000	0.781**	0.000

\*\* Correlation is significant at the 0.01 level (2-tailed).

Table (7) Showed that there is a relationship between the incidence of VAP and the total mean score of charlson co-morbidity index in the study and the control groups post intervention with r =0.600 and r=0.781 respectively (P < 0.001).



## 5. DISCUSSION

Ventilator Associated Pneumonia (VAP) is a serious complication of invasive Mechanical Ventilation (MV) and is associated with increased ICU Length of Stay, duration of MV and increased morbidity and mortality rates [33]

### The Effect of VAP Prevention Bundle on the VAP Incidence Rate

Implementation of VAP prevention bundle has been proven to be effective in reducing the VAP incidence rate resulting in decreasing the ICU length of stay and improving recovery outcomes of mechanically ventilated patients [34].

The current study hypothesized that patients who receive VAP prevention bundle are less likely to develop VAP compared to patients who don't receive the VAP prevention bundle. The present study findings supported the hypothesis and revealed that there was a highly statistically significant reduction in the VAP incidence rate in the study group compared to the control groups post intervention. The finding of the current study are similar to what was reported by Akdogan et al., [25] who examined the effectiveness of implementing VAP prevention bundle on the VAP incidence among 104 mechanically ventilated patients and found that there was a statistically significant reduction in the VAP incidence rate in the study group compared to the control group post intervention.

Also, the findings of the current study are similar to what was reported by [34, 35, 36, 37] who examined the effect of VAP prevention bundle on the incidence of VAP among mechanically ventilated patients and found that there was a statistically significant reduction in the incidence rate of VAP in the study group compared to the control group post intervention.

In addition, the current study findings are consistent with what was reported by [38, 39] who examine the effect of VAP bundles using closed tracheal suction system on the incidence rate of VAP among mechanically ventilated patients for more than 48 hours in ICU. Patients were monitored for developing VAP within 72 hours of intubation and they found that there was a statistically significant reduction in the incidence rate of VAP in the study group compared to the control group post intervention.

Also, similar findings were reported by [40, 41, 42, 43, 44] who evaluated the effect of VAP bundles with continuous endotracheal tube cuff pressure control system on the VAP incidence among mechanically ventilated patients in the ICU. The tracheal cuff pressure was monitored either once every 8 hours (control group) or continuously using a pneumatic device (study group). Findings revealed that there was a statistically significant reduction in the incidence rate of VAP 13.6% in the study group compared to 25.7% in the control group who was diagnosed with VAP. These findings can be explained by the fact that implementation of VAP bundle in combining with continuous control of endotracheal tube cuff pressure was associated with decreased micro-aspiration of gastric content that may reduce significantly the occurrence of VAP.

However, the findings of the current study are different from what was reported by Goel et al., [45] who examined the impact of care bundle approach to reduce VAP in the ICU in a tertiary care teaching hospital in North India and found that VAP prevention bundle did not significantly decreased the VAP incidence rate post intervention. A possible explanation of the study findings may be attributed to using a different VAP prevention bundle that focused only on head of bed elevation (HoB) and daily sedative interruption.

### The Effect of VAP Prevention Bundle on Duration of Mechanical Ventilation and ICU Length of Stay

The incidence of VAP increased from 5% of patients receiving one day of mechanical ventilation to 65% of patients receiving 30 days of mechanical ventilation [46]. The current study hypothesized that patients who receive VAP prevention bundle have less duration of MV and shorter ICU length of stay compared to patients who do not receive VAP prevention bundle. The findings of the current study revealed that there was a highly statistically significant decrease in the duration of mechanical ventilation and ICU length of stay in the study group compared to the control group post intervention. These findings are similar to Burja et al., [47] findings who examined the effect of VAP prevention bundle on the duration of the MV and ICU length of stay in 129 mechanically ventilated patients and found that the mean duration of the MV and ICU Length of Stay were significantly reduced in the study group compared to control group post intervention.

In addition, the present study findings are congruent to what was reported by Karagözoğlu et al.,[48] who examined the effect of VAP prevention bundle on the ICU length of stay in 94 mechanically ventilated patients and found a statistically significant decrease in the duration of MV and the ICU length of stay in the study group compared to the control group after intervention. Similar findings have been reported by Jadot et al.,[49] who examined the impact of VAP bundle in Belgian in 120 mechanically ventilated patients in the ICU and found that there was a statistically significant reduction in the duration of MV and the ICU Length of Stay in the study group post intervention.

However, the findings of the current study are different from what was reported by Branco et al., [50] who did not find a significant difference in the mean duration of MV and ICU length of stay among mechanically ventilated patients. A possible explanation of [50], findings may be due to that most of his participants have advanced age with one or more comorbidity diseases which are factors that lower the immunity and increase the risk of VAP and subsequently increasing the duration of MV and ICU length of stay.

#### The Relationship between the Incidence of VAP and Severity of Illness among Mechanically Ventilated Patients

The current study hypothesized that there is a relationship between the incidence of VAP and severity of illness among mechanically ventilated patients. The present study findings supported the hypothesis and revealed that there was a relationship between the incidence of VAP and severity of illness among mechanically ventilated patients. Similar findings were reported by [48, 51] who examined the association between the incidence of VAP and severity of illness among 94 mechanically ventilated patients and found that there was a statistically significant relationship between the incidence of VAP and the total mean score of APACHE II score.

However, the findings of the current study are different from what was reported by Heyland et al.,[52] who examined the relationship between the incidence of VAP and severity of illness among 50 mechanically ventilated patients and found that there was no statistically significant relationship between the incidence of VAP and severity of illness and report that patients with either low or high illness severity are less likely to have VAP develop. A possible explanation of the study findings may be that patients with very low-risk may not have sufficient exposure time to mechanical ventilation to acquire VAP, and high-risk patients may have received earlier treatment with antibiotics thus reducing the likelihood of acquiring VAP.

#### The Relationship between the Incidence of VAP and Co-morbidities among Mechanically Ventilated Patients

The increased number of co-morbidities poses a greater risk of mortality in VAP patients. The current study hypothesized that there is a relationship between the incidence of VAP and co-morbidity condition among mechanically ventilated patients. The findings of present study supported the hypothesis and revealed that there was a relationship between the incidence of VAP and co-morbidity condition among mechanically ventilated patients. The study findings are similar to [48] findings who reported that patients who developed VAP were more likely to be suffering from co-morbidity conditions causing immunosuppression such as chronic renal failure, diabetes mellitus, hypertension, tumor and steroid therapy. These patients were presumably more susceptible to infections.

However, the findings of the current study are different from what was reported by Noorifard et al.,[53] who evaluated the relationship between the incidence of VAP and co-morbidities condition among 197 mechanically ventilated patients and found that there was no statistically significant relationship between the incidence of VAP and co-morbidities condition. A possible explanation of the study findings may be due to using VAP diagnostic criteria depending only on clinical criteria not on microbiological confirmed diagnosis and some cases of VAP may be undetected by clinical criteria.

#### Limitations of the Study

- 1- The current study performed a short-term evaluation only, immediately after the introduction of VAP prevention measures. The efficacy of our measures could have been reduced over a long-term period due to a possible lack of nurses' adherence to the VAP prevention bundle over time.
- 2- The findings of the current study are limited in their generalization because of the convenience sample, using a single setting for data collection and lack of randomization which may contribute to sample selection bias and limits the generalization of the findings.

## 6. CONCLUSION

The present study findings supported the use of VAP prevention bundle in clinical practice as an effective and safe nursing intervention to reduce the incidence rate of VAP, reduce duration of MV and ICU length of stay.

## 7. RECOMMENDATIONS

- The VAP prevention measure included in the present study bundle are widely applicable and does not need any specialized equipment. It also promotes subglottic suctioning which has become the most useful measure for the prevention of VAP. Subglottic suctioning efficacy reported as high as 50% reduction of VAP incidence [54].
- Integration of the VAP prevention bundle into clinical practice of mechanically ventilated patients as a routine nursing care help to reduce the incidence rate of VAP, duration of mechanical ventilation and ICU length of stay.

### Implications for Nursing Practice

Implementing, sustaining, and evaluating results of EBP requires adept leadership and efficient interdisciplinary collaboration. Establishing a multidisciplinary team to conduct a periodic in-service education courses for critical care nurses about the importance of VAP prevention bundle

### Implications for Future Research

Large randomized trials are needed to confirm that VAP bundles that combine multiple prevention strategies may improve outcomes.

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