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# Ventilator-Associated Pneumonia Among Saudian's Critically Ill Patients Preventive Measures and Incidence, Systemic Review

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**Abstract:** *Introduction:* VAP infections are associated with health risks, such as the development of sepsis, lung damage, and increased mortality rates. The higher mortality rate among VAP patients is mainly related to risks posed by severe pathogens that may enter the respiratory tract. Applying various preventive measures reduces the risk and incidence of VAP. This study aimed to determine the incidence and effects of VAP in Saudi Arabia. The study also determined measures that can be undertaken to prevent ventilated patients from developing VAP. *Methods:* A systematic review design was used. The included studies were published after 2015 in the English language and relevant to the topic of concern. *Results:* Eleven articles were selected for inclusion in the study. The incidence of VAP in Saudi Arabia was low during the study period. Using the VAP prevention and treatment bundle led to reduced VAP infection rates among mechanically ventilated patients in the ICU. *Conclusion:* The use of the VAP prevention and treatment bundle and other strategies reduced the risk of ventilated patients developing VAP. The use of the VAP prevention bundle may have helped reduce the incidence of VAP in both hospitals, as well as their mortality rates, and may have increased the rate at which patients were transferred from the ICU.

**Keywords:** Ventilator, Associated Pneumonia, Critically Ill Patients, Preventive Measures

## 1. Introduction

VAP patients face a broader array of critical health problems than ventilated patients who test negative for VAP [11]. These problems are compounded by higher hospital costs, which may not be met, especially when the patient's family has meagre financial resources [19]. Patients also have higher VAP-attributable mortality rates than those without the infection. A recent study of the impact of pneumonia among ventilated patients in the ICU determined that 24–76% of fatalities occurring in the ICU are due to VAP [12]. Additionally, VAP patients are 2–10 times more likely to die than other patients in ICU.

The higher mortality rate among VAP patients is mainly related to risks posed by severe pathogens that may enter the respiratory tract. Also conducted a retrospective study to determine VAP patient outcomes among those suffering from the exacerbation of chronic obstructive pulmonary disease. The study checked for the occurrence of VAP among patients who required endotracheal intubation for more than 48 hours between January 2008 and December 2009 [14]. The results revealed the following: 153 patients required intubation and that the mortality risk was comparable between those who had VAP and those who did not; VAP patients had longer hospital stays and required mechanical ventilation longer than those who did not have the infection; and VAP negatively affected the health outcomes of critically ill

patients in ICUs [14]. High mortality rates may also be tied to the underlying disease, the antibiotic regimen administered, and the infecting microorganisms [3].

Besides its impact on patients, VAP is associated with several other impacts. First, the additional costs of treating VAP, as well as longer hospital stays, increase the costs of treatment. In a study conducted by [16], patients with VAP were two times more likely have longer stays than patients without VAP ($p<0.0001$), and according to [1], the additional costs associated with VAP are an estimated $5,000–20,000 for each patient. Other studies conducted to evaluate the economic impact of VAP have observed higher estimates, particularly for cases involving multi-drug resistant organisms. [3] found that the cure rate for these infections tends to be low, hospital stays are longer, patient outcomes are worse, and the economic burden on both the hospital and the public health system is high.

With increasing mortality rates due to VAP infection and pathogenesis, it is important to explore some of the significant VAP prevention measures. The VAP prevention bundle enables healthcare staff to acquire adequate knowledge about ways to reduce VAP infections among critically ill patients [15]. The VAP care bundle comprises evidence-based practices for the continuous care of VAP patients. These practices include elevating the head of a VAP patients' beds to 30–45°, enabling them to lie in a supine or semi-recumbent position, which will help prevent the aspiration of gastric and oropharyngeal contents [15] Another practice involves interrupting daily sedation since the sedation of endotracheally intubated patients can lead to the accumulation of sedatives associated with the increased use of the ventilators, as well as to assess patients for extubation, which decreases the risk of VAP [15]. The duration of mechanical ventilation should also be reduced as ventilator use is, in itself, a risk factor for the development of VAP.

The duration of mechanical ventilation can be reduced by interrupting sedation and conducting spontaneous breathing trials. The use of subglottic secretion drainage, which bypasses the ETT cuff, is also recommended for the care of VAP patients since suction cannot access the area below the vocal cords [15]. Studies have shown that subglottic secretion drainage reduces the duration of mechanical ventilation among ventilated patients, which subsequently reduces the risk of VAP and decreases the number of days spent in the ICU on antibiotic therapy [10]. Furthermore, the VAP care bundle includes the avoidance of scheduled ventilator circuit changes as these changes increase the condensation of gases in the ventilator's circuitry [15]. Pneumococcal vaccinations should also be given to patients who require intubation during their treatment [20]. Pneumococcal vaccinations protect patients from contracting pathogens that can result in pneumonia among those intubated in the ICU. On other occasions, senior clinicians recommend the provision of oral care with an antiseptic agent as a means of preventing VAP among patients. Post-operative coughing, deep breathing, and early ambulation are also encouraged, as is the cleaning of IV catheters shortly after use to remove pathogens that might be attached to the surfaces of these devices [20].

Antibiotic regimens are used depending on the risk of multidrug-resistant organisms. The appropriateness of the antibiotics to be used depends on the type of organism being targeted, and thus, bacterial cultures are often collected to determine sensitivity. The antibiotic therapy's appropriateness depends on the choice of antibiotic (i.e., the target organism should be susceptible), as well as the dosage, which should be optimal, and ensure the correct route of administration to be effective [3]. Other factors to consider are resistance patterns observed in the particular ICU in the past, the rationale for de-escalating or stopping the regimen, and knowledge of the organisms that may be present [17]. Antibiotics should be administered at the right time. Studies have shown that a delay in administering the right antibiotic therapy has a significant impact on the duration of ventilation, which subsequently increases the risk of VAP. In a study conducted by [16], a delay of more than two days increased the duration of ventilation ($p<0.0001$). Additionally, delaying the administration of antibiotics when appropriate is associated with a 91% mortality rate according to [17]. Thus, as soon as VAP is suspected, cultures should be taken and the appropriate treatment should begin. Proper hand hygiene before and after patient care is also a significant preventive measure as most healthcare associations advocate routine hand hygiene measures; this practice should, therefore, be followed by clinicians and healthcare workers in the Kingdom of Saudi Arabia (KSA). Hand hygiene includes not only hand washing but also changing gloves regularly and using disinfectants. To ensure that such preventive measures are followed and implemented within healthcare facilities, nurses and healthcare providers should be frequently and thoroughly educated on these and related issues.

## 2. Problem Statement

Several measures and VAP care bundles are used to prevent VAP in ICUs. As preventive measures, hygiene interventions have also been put in place in various hospitals. However, as of yet, these measures have not been sufficiently implemented as VAP infections among critically ill patients continue. Studies have also shown that the number of critically ill patients in need of ventilator machines has significantly increased in the recent past, with estimations showing an increasing trend in the future [23].

## 3. Research Objectives

The primary objective of this study was to explore and describe VAP prevention measures, and the consequences of VAP for critically ill patients. The specific objectives were as follows:

i) To determine prevention interventions and other measures taken to mitigate risk factors for VAP infection among ventilated patients in ICUs.
ii) To determine the incidence of VAP and assess its consequences.

# 4. Research Questions

PICO Components

Patients – incidence and preventive measure of mechanically ventilated patients who develop VAP in the ICU

i) What is the incidence of VAP in the KSA, and what are its effects on patients?
ii) What measures are taken to prevent the development of VAP among ventilated patients?

# 5. Conceptual Framework

Pneumonia can be acquired through the mechanical ventilators used to aid the respiratory system of critically ill patients [21]. Accordingly, appropriate preventive measures should be adopted to ensure that these devices do not cause infections among patients. Before the implementation of preventive measures, policymakers and other healthcare players must identify the risk factors and determine to what degree VAP affects ventilated patients in the ICU. This conceptual framework, therefore, underpins the current research study.

# 6. Methodology

### *6.1. Systematic Review Approach*

The purpose of this study was to determine, the incidence of VAP infections in Saudi Arabia, and the measures taken to prevent their occurrence. The systematic review approach involved summarising high-level evidence studies to answer the research questions and utilising specific methods to address or reduce bias. This design was suitable to synthesise the existing literature, assess the evidence, and collect information regarding the effects of VAP among adult trauma patients in ICUs [2]. Systematic reviews rank high in the hierarchy of studies, and they are often used in evidence-based practices [9]. The Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines were used to direct this review.

### *6.2. Inclusion and Exclusion Criteria*

The literature relevant to the effects of VAP in adult trauma patients in the ICU was obtained according to pre-defined inclusion and exclusion criteria. Those that did not meet the criteria were excluded, as well as those that did not include the effects of VAP among patients in the ICU [22].

The included study designs were survey studies, retrospective and prospective studies, and qualitative studies. Only studies published after 2015 were included to ensure the inclusion of recent and up-to-date evidence and information. Those published in the English language were included to avoid additional translation costs, while those published in other languages were excluded. However, this approach could have biased the results since the Arabic language is commonly used in Saudi Arabia. Articles that focused on Saudi Arabian populations were given priority to demonstrate the incidence of VAP infections.

### *6.3. Search Strategy*

The researcher searched various electronic databases, as well as journals and websites. The academic databases that were searched to identify the literature sources included PubMed, Science Direct, and Google Scholar. The review process was comprehensive as the search process adhered to the standard guidelines for conducting a systematic review [4]. Each of the articles was individually screened to ensure that it met the inclusion criteria. Additional sources included bibliographies and reference lists from related articles. Lastly, grey literature was considered to expand the range of available material.

The key search terms were 'VAP', 'pneumonia', 'ICU', 'ventilated', 'patients', '', 'outcomes of VAP', and 'incidence'. These search terms were adapted for use in different databases. The Boolean operators AND OR were used to combine the search terms and further refine the results.

### *6.4. Study Identification*

The researcher evaluated the titles and abstracts of the articles generated after performing the initial search process to determine eligibility for inclusion. When the abstract of the article was deemed relevant, the researcher examined the full text to check for its appropriateness according to the inclusion criteria specified.

### *6.5. Article Appraisals*

Quality appraisals revealed the quality of the included studies and their usefulness. In the appraisal, various aspects were considered, including the research design, questions, the methodology adopted, and data collection and analysis methods utilised. The Critical Appraisal Skills Programme (CASP) checklist was used to guide the appraisal and judge the quality of the included articles.

### *6.6. Data Abstraction and Outcome Measures*

The data obtained from each publication were the country in which the study was conducted, the publication year, the authors' names, and the number and type of patients studied. Various outcome measures were evaluated, including VAP infection rates as characterised by the number of infections per 1,000 ventilator days, the impact of VAP on patient outcomes, mortality, length of stay in the ICU and hospital, the microorganism associated with the VAP infections, and the duration of mechanical ventilation.

### *6.7. Data Analysis*

A narrative synthesis was used in the analysis of the studies included in the systematic review. Narrative synthesis is an analytical method that collates study findings into a coherent narrative [8]. It also describes the characteristics of the studies and their differences. A narrative synthesis was used in this study because the included studies involved

mixed methods and were heterogeneous, as discussed in a later section. Narrative synthesis is criticised for lacking transparency and being prone to bias. However, the use of critical appraisal tools and the researcher's awareness of the possibility of bias likely addressed the concern.

The data collection period was in March–April 2019. The medical records of adult ICU patients were reviewed retrospectively. The inclusion criteria were adult ICU patients aged 18 years or older, with or without VAP, as indicated in the medical records of adult patients who had been treated in the ICU, who could be identified (i.e., age, gender, and nationality), and had complete patient outcome information. Additionally, data pertaining to mortalities in the ICU were considered if they were not 'do not resuscitate' (DNR) cases, and the length of stay in the ICU was determined at least one calendar day. Patients were excluded if they were under age 18, were a DNR mortality, or had unknown identification or outcome information.

### *6.8. Data Synthesis and Analysis*

The clinical-pulmonary infection score (CPIS) method was used by ICU doctors to assess cases of VAP. If a patient received a CPIS score ≥6, then the patient was diagnosed with VAP. When exploring the ICU records at KFMC, two patients who had VAP were identified. However, one VAP trauma patient was excluded because he was under age 18, while a 74-year-old adult Saudi male admitted due to postoperative intestinal obstruction was included. After four days of post-intubation in the ICU, signs and symptoms of pneumonia were observed. The patient stayed in the ICU for 30 days.

Since only one case of VAP was identified, a comparison based on VAP was impossible. However, mortalities and patient outcomes were compared. Descriptive statistics were used to show the differences between the two hospitals in terms of mortalities and the reported patient outcomes. Correlation analysis was used to investigate the relationship between patient age and length of stay in the ICU.

### *6.9. Characteristics of the Included Studies*

Eleven studies were selected for inclusion in the systematic review. These studies utilised different study designs, including cross-sectional, retrospective observational, surveillance, prospective, and descriptive analysis. However, the included studies focused on the incidence of VAP in Saudi Arabia, and determining the effectiveness of measures undertaken to reduce the prevalence of infection.

### *6.10. Characteristics of Individual Studies*

*1. Incidence of VAP in Saudi Arabia*

Study carried out a cross-sectional study to assess the VAP rate in public hospitals and identify VAP prevention activities in the Makkah region of Saudi Arabia [5]. The researchers collected data in January and December of 2013 and analysed it using Mann-Whitney U and Kruskal-Wallis H tests. These tests compared the mean differences in the rates of infection according to location, hospital size, and data collection procedure [5]. The measures of outcome were the VAP rate per 1,000 ventilator days and VAP-related preventive measures in place in the hospitals. The results obtained showed an overall VAP rate of 6.89 cases per 1,000 ventilator days. However, there were significant differences in the VAP rates of hospitals in four major cities. The mean ± SD rates in Makkah, Jeddah, Taif, and Qunfudah were 5.88 ± 3.24, 12.64 ± 11.13, 7.66 ± 4.97, and 4.16 ± 3.17, respectively, although there were no significant differences in the incidence of VAP in hospitals that had preventive approaches in place. Nonetheless, there were differences in hospital VAP rates among hospitals that had varying bed capacities and had supervised preventive approaches in place. The preventive measures that some of the studied hospitals used were a subglottic aspiration closed suction system and chlorhexidine oral care [5].

In another studycarried out retrospective observational research to determine the epidemiological patterns of VAP in ICU hospitals in the Al Qassim region of the KSA and the sensitivity patterns of the causative organisms [7]. The study included patients who were admitted to the ICU during the 2012–2016 study period and met the CDC's criteria for VAP while excluding patients who were admitted before and after the study period, as well as those who were not ventilated. The measure of outcome in the study was the VAP rate per 1,000 ventilator days. The total number of patients admitted to the ICU during the study period was 5,475, and of these, 69 (1.26%) developed VAP [7]. The data were analysed using chi-square tests, and a *p*-value of 0.05 was considered statistically significant. The results obtained showed that during the study period, 20.24% of the 331 healthcare-associated infections were VAP cases. Male cases were significantly more numerous than female cases, at 78% and 22%, respectively, and most of the cases occurred in patients aged 60 years or older. There VAP rate increased from 16% in 2012 to 27% in 2015 [7]. The most common VAP-associated organisms were *Acinetobacter baumannii* and *Pseudomonas aeruginosa* The researchers concluded that there was an increasing trend of VAP infections in the hospitals studied in the Al Qassim region and that most of the infections were in male patients aged >60 years. Accordingly, these represented risk factors for VAP development [7].

Also conducted a study to estimate the prevalence of VAP in critical patients in Gulf Cooperation Council (GCC) countries (i.e., Bahrain, Saudi Arabia, and Oman) [13]. The six-year surveillance study used data from 2008–2013, and the aggregated VAP infection rates were calculated. The results showed that 368 VAP events were diagnosed, and the overall VAP rate was 4.8 per 1,000 ventilator days, and ventilator utilisation in the period was 0.57. Over time, there was wide variability in the VAP rates in different types of ICUs, although they decreased over time [13]. The risk of developing VAP in GCC hospitals was 217% higher than in US National Healthcare Safety Network hospitals. The researchers concluded that the overall VAP infection rate per 1,000 ventilator days was low. However, there was a high risk of VAP infections among adult and neonatal ICU patients.

*2. Measures undertaken to reduce the risk factors and prevalence of VAP*

Study conducted a comparative interventional study to assess the effectiveness of adhering to VAP bundles in eliminating VAP infections and reducing the length of patients' ICU and hospital stays [13]. A multidisciplinary team comprised of nurses, a microbiologist, and a pulmonologist conducted the study in a 14-bed surgical ICU. The five stages of the VAP prevention bundle (i.e., bed elevation, deep venous thrombosis [DVT] prophylaxis, peptic ulcer prophylaxis, oral hygiene, and breaks from sedation and weaning assessment) were implemented. The data obtained during this period were compared to the surveillance reports from the ICU for 2013 [13]. The results obtained show that implementing the VAP bundle led to a 50% reduction in the incidence of infections, from 18.5% during pre-VAP implementation to 9% during the implementation period [13]. The VAP rate per 1,000 ventilator days also showed statistically significant reductions after the implementation of the VAP bundle, from 25 per 1,000 days in 2013 to 8.5 per 1,000 days in 2014 and 6 per 1,000 days in 2015, with a p-value of <0.007 [13]. The length of ICU and hospital stays for the VAP patients was also reduced significantly during the VAP bundle implementation period. Compliance with the VAP bundle and the VAP rate were significantly correlated. The comparative interventional study showed that the use of VAP prevention and treatment bundles in different ICUs among ventilated patients significantly reduces the prevalence of infection.

## 7. Summary of Findings

The VAP infections led to increased mortality rates, increased incidences of sepsis and multi-drug-resistant infections, longer ICU and hospital stays, and the development of comorbidities. The use of the VAP prevention and treatment bundle led to reduced VAP infection rates among mechanically ventilated patients in ICUs.

## 8. Discussion and Conclusion

Based on the results of the systematic review, the incidence of VAP infections in the KSA seems to be low, considering that very few patients in the KSA develop this type of infection. However, there was an increased risk of developing VAP due to cases of inadequate nurse training, the absence of strict supervision of ventilated patients, and other risk factors, such as old age and reintubation. Various studies have shown that old age and reintubation contribute to an increased risk of patients developing VAP. For instance, the studies conducted by [6, 18] showed similar results according to the systematic review. Likewise, the results obtained from KASH's and KFMC's ICUs show that age is a risk factor for developing VAP as older patients have reduced immunity and other comorbidities. The low incidence of VAP infections in the KSA was attributed to the use of the VAP prevention bundle. The retrospective study showed that nurses employed in KASH's and KFMC's ICUs were highly educated, experienced, and skilled and that they used other VAP prevention strategies, such as closed suctioning and changing the mechanical ventilator tubing every 48 hours, applying normal saline during mouth care, and avoiding chlorohexidine. These measures significantly reduced the risk of ventilated patients developing VAP. However, the development of VAP among patients leads to increased mortality rates and prolonged hospital and ICU stays. The increased mortality rates among ventilated patients who develop VAP could be due to the development of sepsis and multi-drug resistance.

Based on the data collected in the retrospective study carried out in KASH's and KFMC's ICUs, only one patient at one of the hospitals developed VAP; thus, a comparison was impossible. Observing only one case of VAP in one month may suggest the hospitals consistently use effective VAP prevention strategies. In both hospitals**,** the head of the bed was elevated from 30 to 45 degrees, adequate hand hygiene protocols were followed for each patient and each procedure, closed suctioning was used, normal saline was applied during mouth care, chlorhexidine was avoided, antiseptic techniques were used when handling the patients, and the patients' rooms were separated. Other measures taken included changing the mechanical ventilator tubing every 48 hours. In addition, healthcare workers were highly educated, experienced, and skilled. The use of the VAP prevention bundle may have helped reduce the incidence of VAP in both hospitals, as well as their mortality rates, and may have increased the rate at which patients were transferred from the ICU. However, it is also worth noting that the data were only collected for one month. Perhaps a longer data collection period, such as one year, may yield more data to assess frequencies and VAP trends at the hospitals and make thorough comparisons.

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