Review

Ventilator-Associated Pneumonia (VAP) Prevention Strategy by Increasing Nurse Compliance in the Implementation of VAP Bundles and the Implementation of Pulmonary Infection Score: A Systematic Review

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ABSTRACT

Background: *Ventilator-associated pneumonia (VAP) is a nosocomial infection that occurs in patients receiving mechanical ventilation and is one of the main complications that can increase morbidity, mortality, and treatment costs in hospitals, especially in intensive care units (ICUs). The purpose of this study is to analyze the action of the VAP prevention strategy by increasing nurse compliance in the implementation of VAP bundles and the implementation of pulmonary infection score (CPIS)*

Methods: *In this method of Systematic Review with Literature Search and Selection, systematic searches are carried out in Sage Journal, Science Direct, and PubMed databases. The search feature uses Boolean logic by utilizing the principles of AND, OR, and AND NOT. The keywords used include: "VAP," "CPIS," "VAP Bundle," and "HAIs." Of the included studies published from 2020 to 2024, peer-reviewed research in nursing and medical journals.*

Results: *Overall, effective VAP prevention requires a holistic and integrated approach. Increasing nurse compliance in implementing the VAP Bundle and the implementation of CPIS in the early diagnosis of lung infections are two complementary strategies to prevent and manage VAP.*

Conclusion: *To achieve optimal outcomes, hospitals and healthcare facilities must provide ongoing training, facilitate access to adequate resources, and improve communication and collaboration between medical teams.*

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Introduction

Ventilator-associated pneumonia (VAP) is a significant nosocomial infection that develops in patients undergoing mechanical ventilation, particularly in intensive care units (ICUs). It represents a considerable complication, contributing to increased morbidity, mortality, and healthcare costs. VAP is reported to affect approximately 9–27% of patients who require mechanical ventilation for over 48 hours, posing a considerable challenge to patient recovery and clinical outcomes. Therefore, VAP prevention is critical in clinical practice to improve patient outcomes and reduce the overall burden on

the healthcare system. VAP prevention strategies involve a series of evidence-based approaches that must be applied systematically and consistently. One strategy that has proven effective is the implementation of the VAP Bundle – a package of preventive measures that includes standard procedures to reduce the risk of infection in patients receiving mechanical ventilation. The VAP bundle contains a series of measures that include, among other things, the prevention of aspiration, control of the patient's body position, regular airway cleaning, optimal use of ventilation, and prevention of pressure ulcers and thrombosis. The success of implementing this bundle depends on the compliance of medical personnel, especially nurses, in carrying out every component of preventive measures in the protocol (Salsabila & Anggraeni, 2024).

Nurse compliance in implementing the VAP bundle is a crucial factor in reducing the incidence of VAP. Research shows that high adherence to VAP bundles can significantly reduce the incidence of lung infections. However, this compliance is often hampered by various factors, such as a lack of understanding of the urgency of the protocol, a high workload, a lack of adequate training, and organizational factors in intensive care units. Therefore, it is essential to identify strategies to improve nurse compliance when implementing VAP bundles. This includes ongoing training, close supervision, and improved communication between health professionals.

On the other hand, to ensure that VAP can be detected early and managed appropriately, using assessment tools that can provide a clearer picture of the status of lung infection in ventilator patients is essential. One assessment tool widely used in clinical practice is the Pulmonary Infection Score (CPIS). CPIS is an assessment system that combines various clinical, radiological, and laboratory parameters to assess the likelihood of lung infection in patients receiving mechanical ventilation. CPIS includes measurements of clinical signs such as body temperature and leukocyte count, as well as pulmonary radiology and microorganism culture examination results. By using CPIS, medical personnel can make more precise and faster decisions in dealing with patients at high risk of lung infections so that interventions can be carried out earlier (Redho et al., 2021).

Implementing CPIS in managing patients receiving mechanical ventilation also has excellent benefits in identifying and reducing the risk of VAP. CPIS can help dynamically monitor the progression of a patient's condition and provide a more unambiguous indication of when a therapeutic intervention, such as antibiotic administration, is needed. This assessment system can be essential in VAP prevention efforts by providing more accurate guidance for medical personnel in overall patient management. Combining the VAP Bundle strategy with the implementation **of** CPIS can significantly improve the effectiveness of VAP prevention. By implementing the right bundle and utilizing objective assessment tools such as CPIS, medical personnel—primarily nurses—can have more explicit guidance to prevent and detect possible lung infections early. Therefore, a deeper understanding of the relationship between nurse compliance in implementing the VAP Bundle and the application of CPIS in diagnosing lung infections is essential to improve ICU care quality (Ananda & Sony, 2022).

This Systematic Review aims to explore and analyze the existing evidence regarding the effectiveness of VAP prevention strategies through increasing nurse compliance in implementing VAP

Bundles and applying CPIS in the early diagnosis of lung infections in ICU patients. By collecting, integrating, and summarizing the results from a range of related studies, this review is expected to provide more precise, evidence-based guidance on the best ways to prevent VAP and improve the quality of care for patients receiving mechanical ventilation. This study also aims to provide recommendations for enhancing nurse compliance in the practice of VAP Bundles and the implementation of CPIS and provide a clearer picture of the challenges and solutions in implementing the two strategies in daily clinical settings. It is hoped that the results of this review can make a meaningful contribution to the development of clinical practice and infection management in ICU patients more effectively and efficiently (Al-Tamimi et al., 2022).

Methods

Search Strategy

Literature Search and Selection: Systematic searches use Sage Journal, Science Direct, and PubMed databases. The search feature uses Boolean logic, utilizing the principles of AND, OR, AND NOT. The keywords used include: "VAP," "CPIS," "VAP Bundle," and "HAIs." Of the included studies published from 2020 to 2024, peer-reviewed research in nursing and medical journals.

Eligibility Criteria

1. Inclusion Criteria

This study focuses on ICU patients on a ventilator 48 hours after receiving an endotracheal tube (ETT). The intervention involves implementing the VAP (Ventilator-Associated Pneumonia) bundle and assessing compliance using the clinical pulmonary infection score (CPIS). The results include quantitative findings on patients' adherence to the VAP bundle and pneumonia infection scoring. However, patients admitted with an initial diagnosis of pneumonia, those not eligible for CPIS (score less than 6), and those with pneumonia criteria lasting less than 48 hours were excluded from the study.

Selection Process

This research article adopts a systematic review design, utilizing the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a structured and transparent review approach. The PRISMA framework provides a standardized methodology that enhances the rigor and reproducibility of the review process, including clear criteria for study selection, data extraction, and quality assessment. By adhering to these guidelines, the study ensures that the evidence synthesized is comprehensive and reliable, enabling a critical evaluation of the available literature. This methodical approach identifies trends, gaps, and implications within the research domain, ultimately supporting the development of evidence-based conclusions and recommendations.

Data Collection Process

For each study, data were extracted regarding the study design, sample size, methodology, key findings, and statistical significance. A structured table was created to summarize the findings, which were compiled based on diagnostic accuracy, disease monitoring, and implementation of VAP and CIPS bundles.

Results

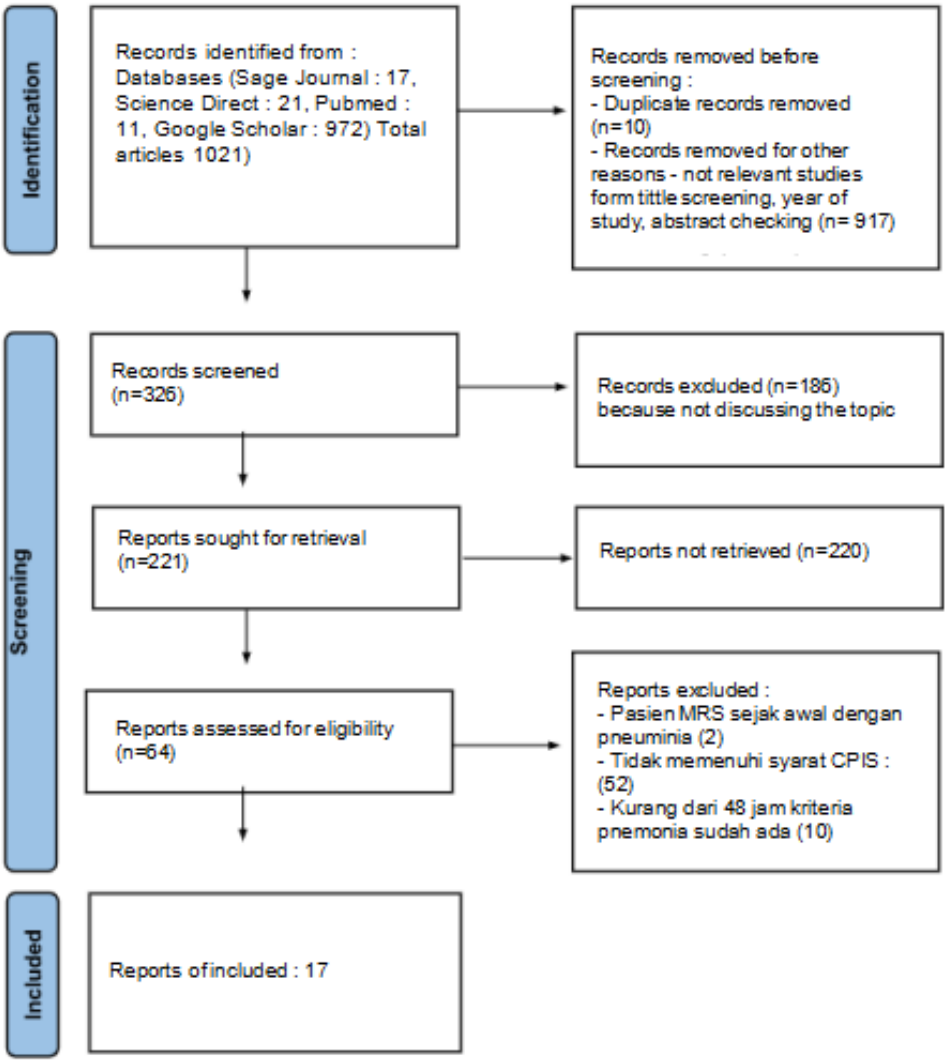

Figure 1. Flowchart PRISMA

Table 1. Data Distraction Method

No.	Article Title; Writer; Year	Methods (Design, Samples, Variables, Instruments, Analysis)	Research Results
1.	Concordance between the National Healthcare Safety Network (NHSN) Surveillance Criteria and Clinical Pulmonary Infection Score (CPIS) Criteria for Diagnosis of Ventilator-associated Pneumonia (VAP) (Venkateswaran et al., 2021)	Desain: A prospective study Sample:273 patients Variable independent: CPIS (Clinical pulmonary infection score) and NHSN surveillance criteria Dependent Variable: Incidence of Ventilator-Related Pneumonia Instruments: Comparing CPIS and NHSN Analysis: Spearman Rank Test	NHSN surveillance criteria have lower sensitivity in detecting VAP cases and should be modified to achieve better outcomes.
2.	Knowledge Of The Nursing Team On Ventilator-Associated Pneumonia (VAP) Prevention Strategies In The Intensive Care Unit Ulin Hospital Banjarmasin (Trifianingsih et al., 2024)	D: Quantitative descriptive research. S: 73 total Nurse- ICU RS Ulin (total sampling) V: (i) Distribution of Research Respondents' Frequency by Age, Gender, Education, and Length of Service (d) Frequency distribution of nurses' knowledge about VAP Prevention Strategies I: Relationship between nurses' knowledge level and VAP A: Correlational analysis	The level of knowledge of nurses about VAP prevention strategies in the ICU room of Ulin Banjarmasin Hospital, which is 51 people (69.8%), is in a suitable category, only 10 people (13.7%) and less than 12 people (16.5%).
3.	Nurse knowledge and confidence in the care of mechanically ventilated patients in the emergency department (Sanders Hendrix & Rochani, 2023)	D: A descriptive correlational study S: The sample consisted of **48 nurses** working in a 75-bed ED at a medical center that handles more than 100,000 visits annually. This represented half of the eligible nursing staff in the ED. V: (i) Statistical significance was noted in factors influencing nurse confidence in managing ventilated	A study exploring the self-reported confidence and knowledge levels of emergency department (ED) nurses highlighted variability in both areas, alongside limited access to educational opportunities. Findings indicated that increased confidence was linked to a higher frequency of exposure to

No.	Article Title; Writer; Year	Methods (Design, Samples, Variables, Instruments, Analysis)	Research Results
		patients in that the lack of availability of educational offerings at the workplace decreased confidence (d) Participants reported overall confidence in the management of patients requiring mechanical ventilation I: exploring the relationship between education on VAP prevention and nurses' knowledge and confidence. A: **Correlational analysis**	relevant clinical scenarios. As EDs nationwide aim to enhance patient outcomes, prioritizing VAP prevention education for ED nurses is critical. Evidence-based educational initiatives, integrated into orientation programs and ongoing professional development, could address lower confidence and knowledge areas. Open-ended survey responses revealed an intense desire among nurses for more professional development opportunities, underscoring the need for structured, accessible training.
4.	Case Study of Effective Airway Cleaning on Pneumonia Patients in Ajibarang Hospital (Ekowati et al., 2022)	D: Case Study S: 2 People V: (i) administration of chest physiotherapy (d) Effect of chest physiotherapy I: Observation A: T-test	The study results show that the problem of ineffective airway clearance can be solved with chest physiotherapy and reduced shortness of breath.
5.	Bundles of care for prevention of ventilator-associated pneumonia caused by carbapenem-resistant Klebsiella pneumoniae in the ICU (Zhou et al., 2021)	D: Quasi-experiment study S: A total of 102 patients undergoing mechanical ventilation in the ICU of our hospital were randomly assigned into a research group (n=51, bundles of care) and a control group (n=51, routine care) V: (i) The time of mechanical ventilation, the incident of VAP, time of ICU stay, and the ICU hospital- -	Implementing bundles of care for patients undergoing mechanical ventilation in the ICU has proven to improve clinical outcomes significantly. These care bundles can shorten the duration of mechanical ventilation, reduce the risk of nosocomial infections, lower the incidence of ventilator-associated pneumonia (VAP), and decrease patient mortality. Additionally, such interventions positively

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		capitalization costs were compared between the two groups (d) The pathogenic bacteria in the sputum were compared between the two groups by collecting patients' lower respiratory tract secretions and sending the specimens to the microbiology laboratory immediately. The identification of pathogenic bacteria was performed with an automatic micro-organ- ism identification and drug sensitivity analyzer I: Comparison of hand hygiene rate of nurses A: The paired t-test	impact nursing practices by enhancing hand hygiene compliance and fostering better patient medication adherence. These measures improve patient safety and contribute to the overall quality of care in critical care settings.
6.	Vap Bundle Intervention in Neonates with Respiratory Distress Syndrome Attached to Mechanical Ventilators: Case Study (Sasadhara et al., 2024)	Desain: Case study implementing the five elements of VAP bundle Subject/ Re responded: The intervention was carried out for 5 days in a neonatal patient intubated with a mechanical ventilator in the PICU-NICU Independent Variables: 1. Head Elevation 30-45º 2. Oral Hygiene use Chlorhexidine Gluconate 0,12% 3. Sedation Termination Protocol and Daily Extubating Readiness Assessment 4. Preventing Deep Vein Thrombosis (DVT) 5. Giving Stress Ulcer Prophylaxis	Implementing VAP bundle interventions in neonatal patients with respiratory distress syndrome on mechanical ventilation has effectively prevented clinical signs of VAP, including fever, bradycardia or tachycardia, tachypnoea, dyspnea, and purulent secretions. Adherence to comprehensive and protocol-based VAP bundles reduces the incidence of ventilator-associated pneumonia and shortens the duration of mechanical ventilation. This, in turn, minimizes bacterial contamination risks and prevents the onset of secondary conditions that could further deteriorate the patient's health.

No.	Article Title; Writer; Year	Methods (Design, Samples, Variables, Instruments, Analysis)	Research Results
		Dependent Variable: Respiratory Distress Syndrome with mechanical ventilator installed Instruments: Observation Sheet Analysis: Spearman Rank Test	
7.	Effect of Oral Hygiene on Prevention Ventilator Associated Pneumonia (VAP) in The Intensive Room of The Hospital Granmed Lubuk Pakam (Pitriani et al., 2023)	Design: Quasi experiment with pretest-posttest Subject/ Re responded: 35 respondents with ventilators installed Independent Variable: Effect of oral hygiene Dependent Variable: Prevention of Ventilator-Associated Pneumonia (VAP) Instruments: Observation Sheet Analysis Percentage, mean, and paired t-test	Oral Hygiene affects the Prevention of Ventilator-Associated Pneumonia (VAP) in the Intensive Room of Grandmed Lubuk Pakam Hospital.
8.	Effect of an educational intervention on compliance with care bundle items to prevent ventilator-associated pneumonia (Mogyoródi et al., 2023)	Desain: A prospective, before-and-after study was performed Subject/ Re responded: A 29-bed mixed medical-surgical intensive care unit, 251 patients Independent Variables: Factors (age, length of use, mechanical ventilator, oral hygiene) Dependent Variable: Incidence of Ventilator VAP-Related Pneumonia Instrument: All the individual bundle component Analyze: Spearman Rank test	A study evaluating the impact of a ventilator-associated pneumonia (VAP) prevention program revealed significant improvements in incidence densities, risk reduction, and compliance with preventive measures. Data from 251 patients showed reduced VAP incidence density from 29.3/1000 to 15.3/1000 ventilator days following program implementation. The risk of developing pneumonia decreased significantly (hazard ratio 0.34, 95% CI: 0.19–0.61, p = 0.001). At

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			three months post-implementation, compliance with all individual bundle components improved markedly, with complete compliance rising from 16.2% to 62.2% ($p < 0.001$). However, after 12 months, adherence to most bundle components returned to baseline levels, except for maintaining head-of-bed elevation, which remained consistent. These findings underscore the need for sustained efforts to ensure long-term compliance with preventive measures.
9.	The Relationship Between Nurses' Knowledge Level and Behavior on Vap Incidence (Lestari et al., 2024)	D: Analytical research with *a cross-sectional* design. S: 32 nurses who cared for 32 NICU babies. Total sampling. V: (i) Distribution of Research Respondents' Frequency by Age, Gender, Education, and Length of Service (d) Frequency distribution of nurses' knowledge about VAP Prevention Strategies I: Relationship of nurses' knowledge level and behavior with VAP A: correlational analysis	A study conducted in the NICU of Koja Hospital found a significant relationship between nurses' level of knowledge and their behaviour about the incidence of ventilator-associated pneumonia (VAP), with a p-value of < 0.05. These findings indicate that higher knowledge levels among nurses are associated with improved behaviours, which may contribute to reducing VAP cases. Conclusion: There is a meaningful correlation between nurses' knowledge and their behaviour in preventing VAP, emphasizing the importance of education and training programs in enhancing clinical outcomes in NICU settings.

No.	Article Title; Writer; Year	Methods (Design, Samples, Variables, Instruments, Analysis)	Research Results
10.	Diagnosis of ventilator-associated pneumonia in critically ill adult patients (Fernando et al., 2020)	D: Systematic review and meta-analysis S: 25 jurnal, 1639 pasien V:(i) Endotracheal aspirate (ETA), Bronchoalveolar Lavage (BALL), protected specimen brush (PSB), and Clinical infection pulmonary score (CPIS) (d) diagnosis VAP I: PICOT *framework* A: -	This systematic review and meta-analysis revealed that traditional clinical indicators, such as fever, purulent secretions, leucocytosis, chest radiography, and cultures from three sampling methods (ETA, PSB, BAL), along with the Clinical Pulmonary Infection Score (CPIS), demonstrate low specificity for diagnosing ventilator-associated pneumonia (VAP). Dependence on these indicators alone may lead to misdiagnosis and the inappropriate use of antimicrobials. These findings emphasize the challenges and uncertainty surrounding VAP diagnosis, highlighting the urgent need for more accurate diagnostic tools to guide clinicians in initiating and discontinuing empirical antibiotic therapy for suspected VAP.
11	Evaluation of ventilator-associated pneumonia care practice in the intensive care units of a comprehensive specialized hospital in Northwest Ethiopia (Debas et al., 2024)	D: A prospective observational study S: 319 patients V:(i) standards for the prevention of ventilator-associated pneumonia • Intubated patients should be positioned in a semi-recombinant position (30–450) for as much of the time as possible Maintenance of	The study identified suboptimal compliance with VAP care bundles, reflecting inadequate adherence to recommended practices. Key areas requiring improvement include endotracheal tubes with subglottic suction, measurement of endotracheal tube cuff pressure, humidification with heat and moisture exchangers, oral care with chlorhexidine, and daily sedation review and vacation. It is recommended that these

No.	Article Title; Writer; Year	Methods (Design, Samples, Variables, Instruments, Analysis)	Research Results
		• Adequate endotracheal tube cuff pressure between 20–25 cmH2O • Oral hygiene with 0.5% Chlorhexidine solution eight hourly • Sedation must be reviewed, and daily sedation vacation and readiness to wean and extubation has to be assessed • Peptic ulcer prophylaxis • Deep vein thrombosis (DVT) prophylaxis Using Endotracheal tubes with subglottic suction • Humidification with heat and moisture exchangers Scheduled drainage of condensate from ventilator circuits (d) VAP I: Observasi ceklist A: The prevalence of VAP and an interventional study and its impact on VAP rate and compliance with the existing protocols	findings be shared with intensive care unit staff to enhance awareness among physicians and critical care nurses. Ensuring the availability of necessary equipment and strict adherence to guidelines is essential. Frequent audit cycles and integrating the VAP care bundle into daily nursing monitoring charts are suggested to improve reliability and foster evidence-based practices. Additionally, further research is encouraged to assess the prevalence of VAP and to explore the impact of interventional strategies on VAP rates and protocol compliance.
12	Effectiveness of Chest Physiotherapy in Cerebrovascular Accident Patients with Aspiration Pneumonia (Waseem et al., 2021)	D: Quasi-experiment study S: 35 people V: (i) Effect of chest physiotherapy (d) Effect of chest physiotherapy I: Observation A: The paired t-test	The results of the study showed that the impact of chest physiotherapy on heart rate and respiratory rate before and after treatment had significant differences so that it was effective in overcoming pneumonia

No.	Article Title; Writer; Year	Methods (Design, Samples, Variables, Instruments, Analysis)	Research Results
13	A comparison of diagnostic algorithms and clinical parameters to diagnose ventilator-associated pneumonia (Rahimibashar et al., 2021)	D: a prospective observational study **S:** 45 patients vap 40 patients control V:(i) HELICS criteria CDC/NHSN Clinical infection pulmonary score (CPIS) (d) diagnosis VAP I: Observation sheet A: -	Ventilator-associated pneumonia (VAP) continues to be a significant cause of morbidity and mortality in modern intensive care units (ICUs). The ideal diagnostic approach for VAP remains uncertain. When using the HELICS criteria as the reference standard, the Clinical Pulmonary Infection Score (CPIS) demonstrated the highest diagnostic accuracy. In contrast, the sensitivity of the CDC/NHSN criteria was only slightly higher than that of a positive Tracheal Aspirate Culture (TAC) combined with a serum procalcitonin level greater than 0.5 ng/ml. The accuracy of the diagnostic algorithm improved when serum procalcitonin levels above 0.5 ng/ml were incorporated. However, including a positive quantitative TAC did not contribute to enhanced diagnostic accuracy.
14.	Case Study of Effective Airway Cleaning on Pneumonia Patients in Ajibarang Hospital (Ekowati et al., 2022)	**D**: Case Study S: 1 Person V:(i) Complementary therapy of chest physiotherapy and practical coughing ability (d) airway clearance is ineffective I: Format of medical surgical nursing assessment and patient nursing progress records A: Analyze qualitatively by comparing the theory and previous authors	The results of the study showed that after three consecutive days of intervention, it was found that both respondents showed that the problem of airway cleanliness in both respondents was resolved.

No.	Article Title; Writer; Year	Methods (Design, Samples, Variables, Instruments, Analysis)	Research Results
15.	Clapping, Vibration And Suction Interventions Against Oxygen Saturation Of Patients With Ventilators In The Intensive Room (Pakaya et al., 2021)	D: literature reviews S: 11 Jurnal V:(i) Clapping, Vibrasi dan Suction (d) Patients with ventilators I: PICOT framework A: -	From the 11 journals used as literature reviews, the results were obtained regarding the administration of clapping, vibration, and suction interventions against SPO2, tidal volume, and airway clearance in patients with ventilators installed in the ICU room. It was concluded that *clapping*, vibration, and *suction* mainly affected SPO2.
16	The Effect of Close Suction to Prevent Ventilator-Associated Pneumonia Based on the Sequence Organ Failure Assessment Score (Sofa) and Clinical Pulmonary Infection Score (Rahmalia HD et al., 2023)	Design: Quasi-experimental with a non-control group design with one intervention group Subject/ Re-responded: 20 patients with ventilators Independent Variable: Effect of Close Suction Dependent Variable: VAP Instruments: Observation Sheet Analysis: Percentage, mean, and paired t-test	Close suction prevents VAP in patients with mechanical ventilators, and VAP can be measured using SOFA and CPIS scores.
17	Advanced collateral physiotherapeutic approach in pneumonia (Naqvi, 2021)	D: Qualitative research S: 1 Klien V:(i)collateral physiotherapeutic approach (d) Pneumonia I: Physiotherapy interventions encompassing positioning of patients therapeutically, timely mobilization, and deep breathing exercises A: *Case Report*	Showing the effects of physiotherapy as an adjunct to the treatment of pneumonia. Physiotherapy is given for 7 days, each day consisting of 20 minutes. After physiotherapy, the patient acquires maximum lung expansion, does not experience breathing difficulties, lungs are clear of phlegm, and is functionally independent. Physiotherapy interventions include therapeutic positioning of the patient, mobilization, and deep breathing exercises.

Discussion

Ventilator-associated pneumonia (VAP) is a lung infection in patients receiving mechanical ventilation, particularly those on ventilators, for more than 48 hours. These infections are one of the leading causes of morbidity, mortality, and increased hospital treatment costs, especially in intensive care units (ICUs). VAP prevention entails a series of preventive measures implemented systematically and consistently, known as the VAP Prevention Bundle. The VAP bundle includes procedures scientifically proven to lower the risk of VAP, such as patient body positioning, oral care, airway management, aspiration prevention, and ulcer and thrombosis prevention. However, the effectiveness of the implementation of this bundle is highly dependent on the compliance of nurses in carrying out the protocols that have been set. Research shows that high adherence to preventive measures in VAP bundles is directly related to a decrease in the incidence of VAP. Conversely, low nurse compliance, which can be caused by various factors such as lack of training, high workload, and unclear procedures, can lead to failures in VAP prevention. Therefore, improving nurse compliance is one of the essential steps in VAP prevention. An ongoing training-based approach, increased awareness of the importance of protocols, and stricter oversight can help address these challenges (Al-Tamimi et al., 2022).

Various studies have confirmed that increased nurse compliance in running VAP bundles can reduce the incidence of VAP. Several factors, such as regular training, tools such as checklists, and motivation and support from hospital leaders, can influence this compliance. In this context, implementing team-based interventions involving nurses, doctors, and other medical staff has proven to be more effective in ensuring that all components in the VAP bundle are executed correctly.

For example, structured training of nurses on proper oral care techniques, airway cleaning, and positioning of patients can reduce the risk of aspiration, which is one of the leading causes of VAP. In addition, strict monitoring of the patient's head position and the optimal use of mechanical ventilation also affect compliance with the protocol, reducing the frequency of VAP occurrence. In addition to prevention, early diagnosis of VAP is essential to prevent further complications and speed up treatment. This is where the Pulmonary Infection Score (CPIS) comes into play. CPIS is an assessment system that combines clinical parameters (such as body temperature, leukocyte count, and pulmonary radiological conditions), laboratory (microorganism cultures), and other clinical findings to assess the likelihood of lung infection in patients receiving mechanical ventilation (Sasadhara et al., 2024).

Although the VAP Bundle focuses on prevention and CPIS on early detection, these two strategies complement each other. They can improve the effectiveness of preventing and managing VAP in the ICU. Exemplary bundle implementation reduces the risk of VAP, while CPIS helps identify lung infections early, allowing for faster and more appropriate interventions. Thus, using CPIS in combination with increased compliance with VAP bundles helps prevent VAP and facilitates speedier treatment when an infection is detected. Nurses who are well-trained in implementing VAP bundles and understand how to use CPIS to monitor patient clinical status can work synergistically in mitigating the risk of VAP.

Therefore, integrating these two approaches will positively impact prevention and management efforts 5 (Rahimibashar et al., 2021).

While VAP prevention strategies through bundles and CPIS implementation have proven effective, some challenges remain. First, limited resources in ICU facilities can hinder consistent implementation of protocols, including a lack of adequate diagnostic tools for CPIS or a lack of staff trained to perform preventive procedures. Second, organizational factors such as poor communication between healthcare professionals or lack of support from hospital management can reduce the effectiveness of these strategies. In addition, individual factors such as nurses' attitudes towards protocols, fatigue levels, and excessive workload can be significant barriers to the optimal implementation of VAP bundles. Therefore, there needs to be a more structured and systematic effort to provide training, motivate nurses, and improve resource management (Fernando et al., 2020).

Consistent implementation of protocols, supported by regular monitoring and evaluation, can strengthen VAP prevention in ICUs and improve the quality of patient care. Therefore, evidence-based approaches involving nurses and diagnostic tools such as CPIS should continue to be encouraged to increase success in preventing VAP and improve clinical outcomes for patients receiving mechanical ventilation.

Conclusion

Overall, effective VAP prevention requires a holistic and integrated approach. Increasing nurse compliance in implementing the VAP Bundle and the implementation of CPIS in the early diagnosis of lung infections are two complementary strategies to prevent and manage VAP. To achieve optimal outcomes, hospitals and healthcare facilities must provide ongoing training, facilitate access to adequate resources, and improve communication and collaboration between medical teams. Future studies should explore the long-term impact of nurse compliance with the VAP Bundle on patient outcomes and the effectiveness of CPIS in various clinical settings. Additionally, research could examine the role of interdisciplinary teamwork and technological innovations, such as automated monitoring systems, in enhancing the early detection and prevention of VAP. Investigating barriers to compliance and developing targeted interventions to address these challenges would also provide valuable insights for improving clinical practice.

Authors Contributions

The authors' contributions to this literature review are comprehensive and synergistic: one author conducted an exhaustive literature search, identified seminal works, and developed an extensive database of sources; another author critically analyzed the literature, synthesized key findings, and contextualized them within the study's theoretical framework; while a third author meticulously organized the manuscript, integrated diverse perspectives, and ensured logical flow and coherence throughout the narrative.

Conflicts of Interest

This research uses the principle of maintaining confidentiality.

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