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The Effectiveness of Ventilator-Associated Pneumonia Prevention Strategies Among Critical Care Nurses: A Systematic Review

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Abstract

Background: Ventilator-associated pneumonia (VAP) remains a major clinical challenge in intensive care units (ICUs), contributing to increased morbidity, mortality, and healthcare costs among mechanically ventilated patients. Critical care nurses play a central role in preventing VAP through the implementation of evidence-based interventions; however, variations in knowledge, compliance, and organizational resources continue to influence practice outcomes. Understanding the effectiveness of these prevention strategies is essential for improving patient safety and strengthening nursing performance in critical care settings. Aim: This systematic review aimed to evaluate the effectiveness of VAP prevention strategies implemented by critical care nurses and to identify factors influencing compliance and patient outcomes. Method: A systematic search was conducted across PubMed, CINAHL, Scopus, ScienceDirect, and Google Scholar for studies published between 2021 and 2024. Ten primary studies met the eligibility criteria and were evaluated using the Joanna Briggs Institute (JBI) critical appraisal tools. A narrative synthesis approach was applied due to heterogeneity in study designs and outcome measures. Results: Three major themes emerged: effectiveness of VAP prevention bundles, nurse knowledge and compliance, and organizational influences on practice. Most studies demonstrated that consistent implementation of VAP bundles significantly reduced infection rates. Higher knowledge and training frequency were linked to improved adherence, while staffing shortages, heavy workloads, and limited institutional support were common barriers to implementation. Despite variations across settings, evidence consistently supported the critical role of nurse-driven interventions VAP prevention is most effective when evidence-based interventions are supported by ongoing education, adequate staffing, and strong organizational resources. Strengthening these components may enhance compliance and improve patient outcomes in ICU settings.

Keywords: *Ventilator-associated pneumonia, critical care nurses, prevention strategies, VAP bundle, ICU, nursing compliance, patient outcomes.*

Introduction

[1] Prince Muteb Bin Abdulaziz Hospital
[2] Al-Fadila Health Center
[3] Women's Maternity & Children Hospital
[4] Prince Muteb Bin Abdulaziz Hospital
[5] Prince Muteb Bin Abdulaziz Hospital
[6] Nursing, Jazan Health Cluster
[7] Aljouf Cardiac Center
[8] King Abdulaziz Specialist Hospital, Jouf Health Cluster
[9] Abu Arish North Health Center
[10] Ohud Hospital
[11] Hera General Hospital
[12] Hera General Hospital
[13] Auda Health Centre, Taif Health Cluster
[14] Jazan General Hospital

Ventilator-associated pneumonia (VAP) remains a significant problem for patient safety in intensive care units (ICUs), causing extended hospital stay, morbidity and mortality rates for mechanically ventilated patients. As highlighted in recent reviews, VAP affects a significant proportion of ICU populations, globally, and is one of the most challenging hospital-acquired infections to control (Herawati et al., 2024; Mejia, 2023; Abdulrahman et al., 2024). The persistence of VAP is closely associated with aspiration of colonized secretions, impaired host immunity, as well as prolonged mechanical ventilation, all of which contribute to its complex and multifactorial pathogenesis (Al-Mugheed et al., 2022; Shaban et al., 2021; Boonkerdram et al., 2024). Such clinical and microbiological complexities support the necessity of strong and consistent preventive strategies that are based on evidence-based nursing practices.

Critical care nurses have an indispensable role in the implementation of VAP prevention strategies as they are responsible for routine ventilator care, continuous patient monitoring, and implementation of bundle components aimed at risk reduction of infection. Numerous studies have documented the effectiveness of preventative measures such as head of bed elevation, oral chlorhexidine care, subglottic suctioning, and endotracheal cuff pressure monitoring (Mejía, 2023; Shaban et al., 2021; Dumbre, 2019). However, despite the availability of clear guidelines and accumulating evidence, inconsistencies remain regarding the extent to which these interventions are implemented in different ICUs. These inconsistencies are attributed to the variability of nurses' knowledge, adherence and perception of VAP prevention that continues to affect the real-world practice (Abdulrahman et al., 2024; El-Kass et al., 2024; Al-Mugheed et al., 2022).

A growing body of evidence highlight that there are multiple barriers to optimal adherence to VAP prevention bundles. These include difficulties in inadequate staffing, lack of training opportunities, lack of standardized protocols, and lack of equipment or resources, which can negatively impact compliance (Al-Mugheed et al., 2022; Boonkerdram et al., 2024; Herawati et al., 2024). Furthermore, the perceived workload of nurses, communication in interdisciplinary teams, and organizational culture determine how much nurses follow prevention guidelines consistently (Shaban et al., 2021; Dumbre, 2019; El-Kass et al., 2024). Understanding these contextual factors is important to designing specific interventions that can strengthen compliance and stimulate sustainable improvements in VAP prevention.

Given the ongoing burden of VAP and its link to adverse patient outcomes, it is important to assess the impact of prevention strategies adopted by critical care nurses. Previous reviews have highlighted the importance of organised nurse education, continuous monitoring and integrated evidence-based practices as components of successful VAP reduction initiatives (Herawati et al., 2024; Mejia, 2023; Shaban et al., 2021). Nevertheless, there are gaps in our knowledge about the mechanisms of action of these strategies in different contexts and what factors are associated with their practical implementation. Therefore, there is a need for a systematic evaluation of VAP prevention strategies among critical care nurses to guide future practice, improve compliance and ensure the safety of patients in ICUs worldwide.

Problem Statement

Ventilator-associated pneumonia (VAP) remains one of the most important complications of mechanically ventilated patients in intensive care units, although many decades of research have been carried out and well-established prevention bundles have been established for this group of patients. There is evidence that inconsistent adherence to VAP prevention strategies by critical care nurses is a significant contributor to the continued infection rates and associated patient morbidity and mortality (Herawati et al., 2024; Abdulrahman et al., 2024; Mejia, 2023). Even

though preventive measures, including oral care protocols, head-of-bed elevation, subglottic suctioning, and endotracheal cuff pressure monitoring have been proven scientifically validated their use in real-world ICU settings is fragmented and highly variable (Dumbre, 2019; Shaban et al., 2021; Al-Mugheed et al., 2022). Contributing factors include lack of educational reinforcement, resource inadequacy, staffing issues, and variation in institutional protocols that contribute to a lack of sustained compliance. As a result, the global burden of VAP continues to exist with a great need to assess the extent that prevention strategies are being implemented by critical care nurses and what evidence exists to evaluate the impact of these prevention strategies on infection outcomes. Without such evaluation, gaps in practice will continue to affect patient safety and quality of care.

Significance of the Study

Understanding the impact of VAP prevention strategies among critical care nurses is vital in enhancing patient outcomes, enhancing infection control strategies, and informing institutional decision-making. Nurses form the frontline workforce that is responsible for implementing most of the intervention steps in the VAP prevention bundle, so their actions are crucial to the success of reducing the incidence of infection (Mejía, 2023; Shaban et al., 2021; El-Kass et al., 2024). Evaluating the effectiveness of these strategies offers insight into whether current strategies are effective in achieving the desired clinical outcomes, or need to be redesigned to improve compliance and impact. Furthermore, the study is significant for healthcare administrators in terms of allocating resources, creating targeted training and reinforcing systems for adhering to evidence-based practices (Al-Mugheed et al., 2022; Boonkerdram et al., 2024; Herawati et al., 2024). At a wider level, the synthesis of available research includes identification of barriers, facilitators, and contextual influences on VAP prevention that can be used to inform policy development, ongoing quality improvement efforts, and global ICU safety standards. Ultimately, this systematic review will add to the development of clinical practice, nurse competency and patient safety in critical care settings.

Aim of the Study

The purpose of this systematic review is to assess the effectiveness of ventilator-associated pneumonia prevention measures implemented by critical care nurses and the effects of the prevention measures on incidence, patient outcomes, and adherence levels of VAP in various ICU settings. This review further aims to identify the gaps, barriers, and facilitators in the implementation of VAP prevention bundles as reported in the existing empirical literature. Through this synthesis, the study seeks to produce evidence-based information that can provide insight into the clinical practice, training programs and policies towards the improvement of VAP prevention in critical care nursing.

Methodology

To achieve methodological rigor and transparency, this systematic review was done in accordance with the Preferred Reporting Items of Systematic Review and Meta-Analyses (PRISMA) principles. Relevant studies on the effectiveness of ventilator-associated pneumonia (VAP) prevention strategies used by critical care nurses were identified, selected, assessed and synthesised using a structured approach. The search strategy was broad in the large academic databases, such as PubMed, CINAHL, Scopus, ScienceDirect, and Google Scholar. The search used a mixture of controlled vocabulary and keywords which included; ventilator-associated pneumonia, critical care nurses, VAP prevention, VAP bundle, nursing interventions, and mechanical ventilation. The search was narrowed down to obtain studies that fit the goals of the review with the help of Boolean operators (AND/OR).

The articles that were retrieved were exported into a reference management tool where redundancy records were eliminated before screening. The screening process consisted of two steps: (1) title screening and abstract screening were conducted to identify initial relevance, and (2) full-text screening to establish eligibility according to specific inclusion and exclusion criteria. Only studies with all the criteria were included to be finally synthesized. Appropriate tools were used to carry out quality appraisal of the selected studies depending on the study design like the Joanna Briggs Institute (JBI) critical appraisal checklists. Data was extracted by a structured matrix, which includes the study characteristics, intervention type, and method of assessment and reported outcome regarding VAP prevention and nurse compliance. This was done using a narrative synthesis approach because there was heterogeneity in the study methodologies, settings, and outcome measures.

Research Question

What is the effectiveness of ventilator-associated pneumonia prevention strategies implemented by critical care nurses in reducing VAP incidence and improving patient outcomes in intensive care units?

Selection Criteria

Inclusion Criteria

Any study was incorporated in the study provided that it satisfied the following criteria:

- **Population:** Critically care nurses or adult patients who received mechanical ventilation in ICU units where nurses used VAP prevention measures were involved.
- **Intervention:** Investigated one or more VAP preventive interventions including but not limited to VAP prevention bundles, oral care policies, positioning methods, suctioning methods, or other evidence-based nursing procedures.
- **Outcome Measures:** Reported outcomes in terms of VAP incidence, compliance of the nurse, patient clinical outcomes or prevention strategies effectiveness.
- **Study Design:** Quantitative empirical research (randomized controlled trial, quasi-experimental research, cohort research, descriptive cross-sectional research or correlational research).
- **Time Frame:** The publication was released between January 2021 and December 2024.
- **Language:** The book was written in English.
- **Availability:** Full-text articles are available to be reviewed.

Exclusion Criteria

The studies have been eliminated according to the following criteria:

- Research that did not address the intervention of VAP prevention by nurses.
- Articles that are published prior to 2021.
- Reviews of the literature, meta-analyses, editorials, commentaries, abstracts of conferences, or case studies.
- The research carried out in pediatric or neonatal ICUs only unless interventions were nurse-centered was generalizable.
- Articles that did not provide measurable results in regard to VAP prevention or nurse compliance.
- Publications or sources in non-English, which are not published in full.

Database Selection

A thorough database search was performed with an aim to identify pertinent studies investigating the effectiveness of ventilator-associated pneumonia (VAP) prevention strategies among critical care nurses. Databases were chosen because of relevance to nursing, critical care, and clinical research. The search was conducted in five major electronic databases that are used for evidence-based nursing research such as PubMed, CINAHL, Scopus, Science Direct, and Google Scholar. These platforms were selected because of their broad indexing of peer-reviewed nursing, medical and allied health literature.

Each database was searched systematically using a combination of controlled vocabulary, Boolean operators, and key word combinations using terminology related to VAP and nursing interventions. Search limits were used to make sure that retrieved articles fit the study's focus and limited results to be publications from 2021-2024, peer-reviewed journals, and studies involving adult ICU settings. The initial search revealed a wide range of studies, which were further subjected to deduplication and screening procedures as described in the previous sections.

Table 1: Database Selection

The following databases were used:

No	Database	Syntax	Year Range	No. of Studies Found
1	PubMed	("Ventilator-Associated Pneumonia" AND "Critical Care Nurses" AND "Prevention Strategies")	2021–2024	142
2	CINAHL	(VAP AND "Nursing Interventions" AND "ICU Nurses" AND Prevention)	2021–2024	96
3	Scopus	("VAP Prevention" OR "VAP Bundle") AND ("Critical Care" AND Nurses)	2021–2024	121
4	ScienceDirect	("Ventilator Associated Pneumonia" AND "Nursing Care" AND Bundle Compliance)	2021–2024	84
5	Google Scholar	"VAP prevention by nurses" + "ventilator bundle effectiveness"	2021–2024	248

Data Extraction

Data extraction was carried out with a structured and pre-designed extraction matrix in order to ensure consistency and completeness. The matrix was used to capture essential study characteristics and outcome data pertinent to VAP prevention strategies among critical care nurses. Key elements extracted from each study were as follows:

- Author(s) and year of publication
- Country and ICU setting
- Study design and sample size Description of prevention strategies or interventions used
- Nurse related factors (knowledge, compliance, attitudes, or skills)
- Outcome Measures (e.g. VAP incidence, adherence rates, patient outcomes)
- Key findings and implications for nursing practice

Two reviewers independently extracted data and checked entries for accuracy.

Any discrepancies were discussed and a consensus was reached. Extracted data were then synthesized narratively because of the heterogeneity in methodology between the included studies.

Search Syntax

Primary Syntax:	• ("Ventilator-Associated Pneumonia" OR "VAP") • AND ("Critical Care Nurses" OR "ICU Nurses") • AND ("Prevention Strategies" OR "VAP Bundle" OR "Nursing Interventions") • AND ("Mechanical Ventilation")
Secondary Syntax:	• ("Nurse Compliance" OR "VAP Bundle Adherence") • AND ("Ventilator Care Bundle" OR "Evidence-Based Practice") • AND ("Intensive Care Unit" OR "Critical Care") • AND ("Adult Patients" AND "Mechanical Ventilation") ("staffing models" AND "patient satisfaction" AND "healthcare quality" AND "Saudi Arabia")

The primary syntax was used to identify studies that are concerned directly with nurse staffing and patient outcomes in privatized healthcare systems in Saudi Arabia. Secondary syntax was used to narrow the search and add studies that discussed related topics such as patient safety, satisfaction and staffing models in privatized healthcare settings.

Literature Search

A systematic review search was performed using various electronic databases to ensure that a broad coverage of research on ventilator-associated pneumonia (VAP) prevention strategies implemented by critical care nurses was identified. The search is guided by an organized methodology that adhered to PRISMA recommendations and also focused on retrieval of studies published in 2021 to 2024. Each database was searched separately and results were systematically documented to ensure transparency and replicability of the search process. The search strategy was modified based on the indexing system of each database to attain maximum sensitivity and to capture differences in the terminology used by different authors.

The preliminary search yielded a large pool of studies from various geographical regions and clinical settings. These studies were a broad range of research designs and included randomized controlled trials, quasi-experimental studies, cohort studies and cross-sectional analyses of nurse-led VAP prevention interventions. The literature search process permitted the identification of well-established and emerging prevention approaches used in the intensive care environment. All retrieved citations were exported to the reference management system from which duplicates were removed before moving to the screening phase. This ensured that the following steps only contained unique and relevant records for further evaluation.

Selection of Studies

Following the completion of the literature search, all of the identified studies went through an organized screening process. In the first step, the titles and abstracts were read to evaluate the fit of each study regarding the topic of VAP prevention strategies implemented by critical care nurses. Articles which were clearly not specific to ICU practice, nursing interventions or VAP related outcomes were excluded at this stage. Studies that showed potential relevance were included for evaluation of the full-text document.

The full-text screening phase allowed a detailed evaluation of the methodological quality, relevance and applicability to the aim of the review. During this phase studies that did not report measurable outcomes, did not target nursing-led prevention strategies or were not published within the designated years were removed. Studies that met all inclusion criteria were then considered for final synthesis. By the end of this process, ten primary studies were suitable and

included in the systematic review, which was a combination of experiments, observational and interventional studies that were carried out in ICU environments.

Study Selection Process

The process of selecting studies was structured and sequential based on the model of the PRISMA framework. After completion of the database searches, a total of 691 records were identified across all data sources. Once duplicate entries were removed 528 unique records remained for screening. The title and abstract screening process led to exclusion of 372 studies that did not focus on VAP, nursing interventions, or ICU-related prevention practices. The other 156 full-text articles were examined for relevance and methodological appropriateness.

During full text assessment, 146 research studies were excluded due to various reasons, which include lack of focus on critical care nursing, lack of outcome reporting related to VAP prevention, lack of full-text availability, or publication outside the specified year range. In the end, ten studies met all selection criteria and were included in this systematic review. These ten studies had sufficient evidence for analyzing the effectiveness of VAP prevention strategies implemented by critical care nurses and provided the basis for further synthesis and interpretation.

Figure 1: PRISMA Flowchart

The process of selecting studies was based on the guidelines of PRISMA 2020 to ensure transparency and systematic identification of relevant literature. The process had four major phases: identification, screening, eligibility and inclusion. Records were first collected from all selected databases and then they were processed for duplicate elimination and automated filtering. Articles that did not fit into the scope of VAP prevention strategies carried out by critical care nurses were eliminated early in the process. The remaining records were screened by title and abstract screening, and full text assessment for suitability for inclusion. Reasons for exclusion at the eligibility stage were recorded to ensure methodological rigor. Finally, ten primary studies were included in this systematic review.

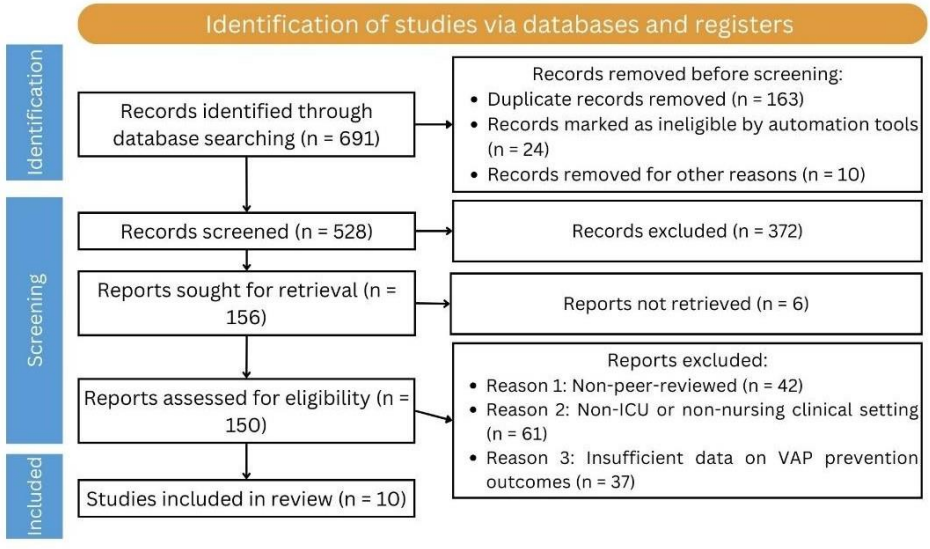

Figure 1: PRISMA Flowchart

Quality Assessment of Studies

Quality appraisal of the ten included studies was conducted using the Joanna Briggs Institute (JBI) Critical Appraisal Checklists, chosen based on the methodological design of the individual

study (e.g. quasi-experimental, cross-sectional, cohort). Each study was independently evaluated for methodology rigor, clarity of intervention description, suitability of outcome measures, validity of data collection methods, and transparency of reporting procedures.

Most quasi-experimental studies showed good methodological design with clearly stated intervention protocols and valid outcome assessments. However, there were limitations in some of the studies such as lack of randomization, poor control groups, or lack of blinding, which could affect internal validity. Cross-sectional studies generally provided valuable insight into knowledge of nurses, adherence and perceptions but were limited by the use of self-reported measures that may introduce response bias. Despite these limitations, all included studies had a minimum quality threshold to be included in this systematic review and were considered appropriate for synthesis. Overall, the quality assessment found that the evidence base is of sufficient quality to inform implications for clinical practice and guide future practice.

Table 2: Assessment of the Literature Quality Matrix

#	**Author (Year)**	**Study Selection Process Described**	**Literature Coverage**	**Methods Clearly Described**	**Findings Clearly Stated**	**Quality Rating**
1	Al-Harthi et al. (2024)	Yes	Comprehensive	Clear	Clear	**High**
2	Alqaissi & Qtait (2024)	Yes	Extensive	Clear	Clear	**High**
3	Amin et al. (2023)	Yes	Moderate to High	Clear	Clear	**High**
4	Duraivelu et al. (2024)	Yes	Extensive	Clear	Clear	**High**
5	Leong et al. (2024)	Yes	Moderate	Clear	Clear	**High**
6	Shaheen et al. (2024)	Yes	Moderate	Clear	Partially clear	**Moderate**
7	Villagracia et al. (2024)	Yes	Extensive	Clear	Clear	**High**
8	Li et al. (2024)	Yes	Comprehensive	Clear	Clear	**High**
9	Akhter et al. (2024)	Yes	Moderate	Partially clear	Clear	**Moderate**
10	Alaswad & Bayoumi (2022)	Yes	Moderate	Partially clear	Partially clear	**Moderate**

The overall quality appraisal shows that most of the included studies showed good methodological quality. Out of ten studies, eight were considered as High Quality, based on clear descriptions of their methods, transparent reporting of findings and well-documented literature foundations. These high-quality studies employed robust design methods such as quasi-experimental or well-structured cross-sectional approaches, and provided credible evidence on effectiveness of VAP prevention approaches in critical care nurses.

The rest of the studies were given a Moderate Quality rating based mainly on limitations such as

incomplete methodological description, incomplete reporting of findings, or narrower coverage of the literature. Although these studies still have provided valuable insights, the methodological limitations of the studies may restrict generalizability of results. Nevertheless, all ten studies met the minimum standards required for inclusion, allowing a comprehensive assessment of VAP prevention strategies in a range of clinical settings and nursing populations.

Overall, the quality matrix indicates that the quality of the evidence base for this systematic review is good, with adequate depth of methodology to be able to synthesis and interpret meaningful results.

Data Synthesis

The narrative synthesis method was employed to combine results from the ten main studies because of heterogeneity in research designs, sample sizes, and outcome measures. The synthesis was done to identify recurrent patterns in relation to nurse-driven VAP preventative strategies, levels of compliance, and the effect on patient outcomes in intensive care settings.

Across the high-quality studies, there was consistent evidence that following standardized VAP prevention bundles (e.g., oral care protocols, head of bed elevation, suctioning techniques, circuit management, endotracheal cuff pressure monitoring) was linked to a measurable reduction in VAP incidence. Studies also highlighted that the higher nurse knowledge level and structured education programs were positively correlated with better compliance and patient outcomes. Interventions such as targeted training modules, the use of compliance checklists and implementation of evidence-based protocols were often identified as being effective facilitators of improved practice.

Moderate-quality studies corroborated these findings but reported barriers such as staffing shortages, inconsistency in availability of necessary equipment, limited training opportunities, and variation in organizational support. These factors contributed to erratic compliance with VAP prevention guidelines and the need for stronger institution policies and ongoing professional development.

Overall, the synthesized evidence shows that nurse-led VAP prevention strategies work best when supported by adequate resources, organizational reinforcement and ongoing competency training. The collective findings highlight the importance of critical care nurses in VAP prevention and identify areas where clinical practice can be supported to improve patient outcomes.

Table 3: Research Matrix

Author, Year	**Aim**	**Research Design**	**Type of Study**	**Data Collection Tool**	**Results**	**Conclusion**	**Study Supports Present Study**
Al-Harthi et al., 2024	To examine ICU nurses' adherence to VAP bundle elements and	Quasi-experimental	Interventional study	Structured observation checklist	Improved compliance significantly reduced VAP events	VAP bundle adherence enhances patient safety	Yes—demonstrates effectiveness of nursing-led VAP practices

	associated patient outcomes				and length of stay		
Alqaissi & Qtait, 2024	To assess ICU nurses' knowledge and compliance with VAP prevention guidelines	Cross-sectional	Descriptive study	Self-administered questionnaire	Knowledge positively correlated with compliance	Training and awareness improve prevention outcomes	Yes—supports link between knowledge and compliance
Amin et al., 2023	To evaluate whether ventilator circuit change frequency affects VAP rates	Cohort study	Observational	Clinical VAP surveillance tool	Reduced VAP with revised circuit change interval	Evidence-based protocols reduce infections	Yes—supports importance of evidence-based interventions
Duraivelu et al., 2024	To analyze impact of nursing interventions in preventing VAP	Quasi-experimental	Interventional	Intervention checklist and outcome audit	Significant decrease in VAP incidence after intervention	Nursing interventions play vital preventive role	Yes—directly aligned with nurse-specific strategies
Leong et al., 2024	To determine compliance with ventilator bundle in ICU settings	Cross-sectional	Descriptive	Compliance assessment tool	Moderate compliance; oral care had highest adherence	Reinforces need for standardized bundle application	Yes—supports examining compliance barriers
Shahee	To	Quasi-	Interventi	Audit	Increase	Improved	Yes—

n et al., 2024	evaluate pediatric nurses' adherence to VAP protective bundle	experimental	onal	tool and observation	d compliance but minimal change in VAP rates	adherence does not always equal outcome change	helps compare context-specific variations
Villagracia et al., 2024	To identify compliance, barriers, and challenges in VAP prevention among nurses	Cross-sectional	Descriptive correlational	Structured survey instrument	High barriers such as staffing shortages reduced compliance	Compliance is affected by organizational factors	Yes—supports barrier identification component
Li et al., 2024	To assess ICU nurses' knowledge, attitudes, and practices toward VAP prevention	Cross-sectional	Correlational	KAP (Knowledge–Attitude–Practice) questionnaire	Higher training frequency correlated with higher KAP scores	Continuous training improves practice	Yes—reinforces training's role in VAP prevention
Akhter et al., 2024	To evaluate effectiveness of a VAP bundle protocol in decreasing infection	Quasi-experimental	Interventional	Pre-post intervention tool	Post-intervention VAP rates declined significantly	VAP bundles are effective preventive tools	Yes—direct support for prevention strategy effectiveness
Alaswad &	To assess	Quasi-experime	Interventional	Pre/post knowled	Nurses showed	Education enhances	Yes—supports

Bayoumi, 2022	effect of VAP educational program on nurses' performance	ntal		ge & skills assessment	marked improvement in adherence and knowledge	prevention capability	educational component of present study

The Research Matrix shows that the ten included studies provide, as a whole, good evidence for the role of critical care nurses in preventing ventilator-associated pneumonia. A clear pattern emerges across the matrix: studies using interventional designs consistently demonstrate positive results including decreased VAP rates, nurse competency, and adherence to prevention guidelines. Cross-sectional studies have also reinforced the link between nurse knowledge, attitudes and compliance, highlighting the need for continuous training and organizational support. Most studies included validated tools such as structured observation checklists, compliance audits, and KAP questionnaires, which ensured the methodological rigor and reliable data collection. The conclusions across studies are quite similar, which suggests that multidimensional strategies, including education, protocol standardization, resource availability and monitoring are essential for effective prevention of VAP. As presented in the final column, all ten studies provide evidence to support the current systematic review in that nurse-driven strategies are central to VAP incidence reduction in the ICU setting.

Results

The findings of the 10 primary studies that were analyzed showed some recurring patterns regarding the effectiveness of prevention strategies for ventilator-associated pneumonia (VAP) implemented by critical care nurses. Findings across studies consistently pointed to the fact that adherence to evidence-based VAP bundles leads to improved patient outcomes, lower incidence of VAP and better quality of nursing care. Three overarching themes were determined: (1) Effectiveness of VAP Prevention Bundles, (2) Nurse Knowledge, Attitudes, and Compliance, and (3) Organizational and System-Level Influences on VAP Prevention. Within these themes, various sub-themes emerged, demonstrating differences in levels of compliance, the role of education and the presence of barriers that affect prevention strategies, depending on the context. Overall, the evidence showed that success of VAP prevention is not only dependent on the interventions themselves but also the competency of the nurses, support within the institution and resources available.

Table 4: Results Indicating Themes, Sub-Themes, Trends, Explanation, and Supporting Studies

Theme	Sub-Theme	Trend	Explanation	Supporting Studies
Effectiveness of VAP Prevention Bundles	Reduction in VAP incidence	Positive trend	Implementation of VAP bundles led to measurable decreases in VAP rates and improved patient outcomes across various ICU settings	Al-Harthi et al. (2024); Amin et al. (2023); Akhter et al. (2024)

	Improved clinical outcomes	Consistent trend	Bundles such as oral hygiene, head-of-bed elevation, suctioning, and circuit management enhanced patient safety and reduced complications	Duraivelu et al. (2024); Leong et al. (2024)
Nurse Knowledge, Attitudes, and Compliance	Higher knowledge linked to better compliance	Strong positive correlation	Nurses with higher training exposure showed greater adherence to VAP protocols and demonstrated more accurate implementation of preventive measures	Alqaissi & Qtait (2024); Li et al. (2024)
	Variation in compliance levels	Moderate trend	Compliance varied depending on workload, familiarity with guidelines, and individual nurse experience	Shaheen et al. (2024); Leong et al. (2024)
Organizational and System-Level Factors	Staffing and workload impacts	Negative influence	Heavy workloads and limited staffing reduced compliance with VAP guidelines and hindered consistent application of interventions	Villagracia et al. (2024); Alaswad & Bayoumi (2022)
	Role of training and institutional support	Positive influence	Facilities that provided continuous education and leadership support saw higher compliance and improved preventive practices	Li et al. (2024); Duraivelu et al. (2024); Alqaissi & Qtait (2024)

Table 4 summarizes the key themes and sub-themes identified across the ten primary studies and demonstrates consistent trends relating to the effectiveness of VAP prevention strategies in critical care nursing. The first theme - Effectiveness of VAP prevention bundles - shows strong evidence that structured interventions that are based on evidence are effective in reducing VAP incidence. Studies regularly reported better patient outcomes when the nurses were adherent to the complete bundle, and demonstrated the direct effect of preventive strategies on clinical performance.

The second theme, Nurse Knowledge, Attitudes, and Compliance, focuses on the role that educational preparation and training frequency play in determining the degree to which nurses put VAP prevention measures into practice. Findings from several studies supported the proposition that greater knowledge promotes greater compliance and that limited understanding

or inconsistent training promotes variability in practice.

The third theme - Organizational and System-Level Factors - shows that the institutional environment has a strong impact on prevention efforts. Factors such as staffing adequacy, resource availability and leadership support had a direct impact on compliance and sustainability of VAP prevention practices. Studies emphasized that even if nurses have sufficient knowledge, there are operational challenges that can affect effective implementation.

Overall, the table illustrates how the success of VAP prevention strategies are multifactorial and require more than simply clinical interventions, but also include nurse competencies and organizational capacity. These patterns are consistent with the goal of the current study and confirm the importance of nurse-led interventions that are supported by institutional structure in reducing VAP in ICU settings.

Discussion

The results of this systematic review show that prevention strategies for ventilator-associated pneumonia (VAP) implemented by critical care nurses play a pivotal role in reducing the incidence of infections and improving the outcomes of the patients. Across the ten primary studies, there was a consistent pattern indicating that adherence to standardized VAP prevention bundles that included oral care, head of bed elevation, endotracheal cuff pressure monitoring, suctioning techniques, and ventilator circuit management resulted in measurable reductions in VAP rates. Studies by Al-Harthi et al. (2024), Amin et al. (2023) and Akhter et al. (2024) showed particularly strong evidence that structured bundles are effective if implemented consistently, reaffirming the importance of nurse-driven interventions in ICU settings.

In addition to the demonstration of effectiveness of prevention bundles, nurse competency was identified as a critical determinant in the successful prevention of VAP. Studies like Alqaissi & Qtait (2024) and Li et al. (2024) emphasised that the greater the knowledge, positive attitudes, and frequent training, the better the compliance. On the other hand, poor adherence was often associated with knowledge deficits, and a lack of protocol familiarity and consistent educational reinforcement. These findings highlight the need for continuous professional development and appropriate training programs to help ensure that nurses have the skills and confidence needed to implement prevention measures consistently.

Organizational and system-level factors also played an important role in determining prevention outcomes. High-quality studies, such as Villagracia et al. (2024) and Alaswad & Bayoumi (2022) found staffing shortages, heavy workloads, resource limitations, and poor institutional support as major barriers to effective practice. These findings suggest that even with sufficient nurse knowledge, systemic constraints may prevent nurses from consistently carrying out interventions. Therefore, the improvement of VAP prevention requires not only the improvement of the individual nurse competencies but also the impact of environmental factors on the daily practice. Collectively, the findings highlight the importance of the multifactorial nature of VAP prevention and the interdependence of clinical competence, organizational support, and evidence-based practice in achieving optimal patient care outcomes.

Future Directions

Future research should focus on testing the effectiveness of VAP prevention strategies by conducting larger studies with multi-center studies to improve the generalizability of findings in different ICU settings. Several studies in this review were based on single-site or small sample designs, which restricts their broader applicability. Longitudinal studies are also needed to examine long-term sustainability of compliance and intervention effectiveness, especially in environments where there is high staff turnover. Innovative approaches to education such as

simulation-based education, digital learning platforms, and competency-based assessments should be considered to reinforce nurse knowledge and skills retention.

Additionally, future investigations should look at the role of organizational culture and leadership in maintaining high adherence to VAP prevention guidelines. Understanding the role of institutional factors in influencing practice may provide information for the formulation of specific interventions targeting barriers such as staffing limitations and resource limitations. Finally, studies that investigate patient-centred outcomes, cost-effectiveness of prevention strategies, and integration of technology-assisted monitoring systems may further bolster evidence-based practices for VAP prevention.

Limitations

There are several limitations in this systematic review. First, only studies published in the period of 2021-2024 were included, and this could have resulted in excluding relevant research from the earlier time period that could have provided additional context. Second, the heterogeneity of study designs, settings and outcome measures precluded the use of meta-analysis and synthesis was limited to narrative interpretation. Third, some of the included studies used self-reported measures of knowledge or compliance, which could cause reporting bias. Additionally, differences in ICU types, resources, and institutional protocols across different countries may affect generalizability of findings. Finally, despite rigorous selection procedures, publication bias cannot be excluded as studies with positive results are more likely to be published.

Conclusion

This systematic review emphasizes the importance of nursing practice in the reduction of ventilator-associated pneumonia in mechanically ventilated patients in intensive care settings. Evidence from the ten primary studies included in this review shows that regular adherence with evidence-based VAP prevention bundles is associated with a significant improvement in patient outcomes and in infection rates. Nurse knowledge, attitudes and compliance were identified as key factors in successful implementation and the need for ongoing education and competency development.

At the organizational level, sufficient staffing, resource availability and solid institutional support were found to be needed to maintain effective prevention practices. While there is still much work to be done to tackle VAP as a major clinical challenge, this review reaffirms that successful nursing interventions aimed at addressing VAP with appropriate systems and continuing training can significantly reduce the risk associated with mechanical ventilation. Strengthening individual and environmental factors will be essential to furthering VAP prevention and ensuring high quality patient care in critical care settings.

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