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Research Article

Association between VAP Bundle Compliance and Ventilator-Associated Pneumonia Incidence: A Single-Center Retrospective Study in an Indonesian ICU

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) is a major source of morbidity and mortality in mechanically ventilated patients, with heterogeneous rates reported across Indonesian ICUs. Although evidence-based prevention bundles reduce VAP, real-world adherence is inconsistent. This study evaluated the association between VAP bundle compliance and VAP incidence among ICU patients at Wahidin Sudirohusodo Hospital in 2024.

Methods: We conducted a retrospective analytical study (January–December 2024) including adults ventilated ≥48 h with complete bundle documentation; patients with pre-existing pneumonia or incomplete records were excluded. VAP was defined by CDC criteria. Compliance with the five-element bundle (head-of-bed elevation, daily sedation interruption/readiness to extubate, stress-ulcer prophylaxis, DVT prophylaxis, and oral chlorhexidine) was recorded daily, calculated as a percentage, and categorized as 60% (3/5 elements), 80% (4/5), or 100% (5/5). Associations with VAP were analyzed statistically.

Results: Of the 385 patients who were on ventilators, 92 (23.9%) developed VAP. Of those, 52 (56.5%) died. The highest adherence was for head-of-bed elevation (91.5%), while the lowest was for DVT prevention (3.1%). In the VAP group (n=92), 65 subject manifested at 60% adherence (70.7%), 24 at 80% (26.1%), and 3 at 100% (3.3%). A higher level of adherence was significantly associated with a lower incidence of VAP ($p = 0.001$).

Conclusion: Higher adherence to the VAP preventive bundle is associated with a lower VAP rate. To increase bundle adherence and patient outcomes in ICU, targeted interventions are needed. These should include more staff training and regular audits, with an emphasis on DVT prevention and daily weaning.

Introduction

Intensive care units (ICUs) are designed to offer expert monitoring and organ support for patients with critical conditions. Mechanical ventilation is an essential treatment for individuals experiencing respiratory failure. Worldwide, about 40-50% of ICU patients need mechanical ventilation. However, using this treatment is linked to higher rates of illness and death; in fact, 45-60% of patients who are ventilated die while in the hospital. [1-2]. A significant concern for patients on mechanical ventilation is infection, particularly

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ventilator-associated pneumonia (VAP), the most frequent hospital-acquired infection in the ICU. Ventilator-associated pneumonia is a nosocomial infection that occurs after 48 hours of endotracheal intubation. It manifests in approximately 20 to 36 percent of patients experiencing critical illness. Within 1,000 days of mechanical ventilation, VAP can occur 2 to 16 times. This heterogeneity is influenced by diagnostic criteria, preventive methods, patient, and environmental-specific factors. Due to underlying health disorders, intubation, continuous use of invasive medical equipment, contaminated settings, and impaired immune systems, VAP is more likely to occur [3-4]. Several methods, such as VAP bundle, aim to prevent ventilator-associated pneumonia (VAP). This bundle was developed by the Institute for Healthcare Improvement (IHI) in 2004. It includes interventions shown to improve the level of care in intensive care units when used together. These interventions are: elevating the head of the bed (30°-45°), regularly interrupting sedation (daily weaning assessment), preventing peptic ulcers, preventing deep vein thrombosis, and providing oral care with chlorhexidine.

Retno et al. found that 72.7% of critically ill patients in Indonesia, precisely Bangka Belitung city, did not experience ventilator-associated pneumonia. In Samarinda hospital study found, 5.9% of 118 critical patients had VAP. Thus, continuous monitoring, early identification, and efficient prevention methods are crucial for reducing ventilator-associated pneumonia (VAP) in intensive care unit (ICU) patients. Damansyah et al. in Gorontalo, Indonesia, reported the impact of a VAP bundle intervention on VAP in patients receiving mechanical ventilation in the ICU of Prof. Dr. H. Aloei Saboe Hospital, Gorontalo City. The results showed that before the intervention, the average CPIS score was 4.75. After bundle implementation, the score decreased to 3.42 (p-value 0.001), indicating a significant impact of the VAP bundle on preventing VAP [5–9]. Indonesia has limited VAP prevention bundle and incidence research. This study aims to evaluate VAP bundle compliance and ventilator-associated pneumonia among ICU patients at Dr. Wahidin Sudirohusodo Hospital in Makassar.

Methods

This study was conducted in the ICU of Dr. Wahidin Sudirohusodo Hospital in Makassar using medical record data from January to December 2024. The inclusion criteria were adult patients >18 years old who used mechanical ventilators for more than 48 hours and had complete medical records regarding compliance with the implementation of the VAP bundle. VAP was defined according to the Centers for Disease Control and Prevention (CDC) criteria as the presence of a new or progressive pulmonary infiltrate on chest imaging accompanied by at least two of the following: fever (>38 °C), leukocytosis/leukopenia, purulent tracheal secretions, or a positive microbiological culture. Compliance with the five-element VAP prevention bundle was assessed daily. It comprised head-of-bed elevation, daily sedation interruption with assessment of readiness to extubate, peptic ulcer prophylaxis, deep vein thrombosis (DVT) prophylaxis, and oral chlorhexidine care. Bundle adherence was routinely checked by ICU anesthesiologists using a daily checklist and extracted for this analysis. The proportion of VAP bundle elements fulfilled in patients during ICU care. The compliance percentage is calculated by dividing the number of fulfilled elements by the total number of elements, then multiplying by 100%. This percentage is then categorized as low (60%, or 3 out of 5 elements), moderate (80%, or 4 out of 5 elements), or high (100%, or 5 out of 5 elements).

Data were cleaned and analyzed using IBM SPSS Statistics v27. Categorical variables were compared with the chi-square or Fisher's exact test; continuous variables were summarized as mean ± SD or median (IQR) according to distribution (Kolmogorov–Smirnov or Shapiro–Wilk) and compared using the independent t-test or Mann–Whitney U test. Statistical significance was defined as two-tailed $p < 0.05$. The study was conducted after obtaining a research permit from the Hasanuddin University Makassar Ethics Committee, number 303/UN4.6.45.31/PP36/2025.

Results

Of the total number of ICU patients, 385 fulfilled the inclusion criteria for the sample. Based on age distribution, most patients were in the 18–65 age group, numbering 329 patients (85.45%). There were 23 patients (5.97%) under 18, while 33 patients (8.57%) were over 65. In terms of gender, the majority of subjects were male (218; 56.60%) and female (167; 43.40%). This study also identified comorbidities. A total of 81 subjects (21.0%) had hypertension, while 304 (79.0%) did not. 27 subjects (7.0%) had diabetes mellitus, and 358 (93.0%) had no history of DM. For heart disease, 25 cases (6.4%) were recorded, while 360 subjects (93.5%) had no history of heart disease; most subjects were not immunosuppressed, with only 4 (1.0%) reported to have experienced this condition. Of the 385 subjects, based on mechanical ventilation duration, 19 (4.9%) were ventilated for <48 hours, 211 (54.8%) for 48 hours to 7 days, and 155 (40.3%) for >7 days. Distribution of ICU length of stay among subjects during the period from January to December 2024, the majority of patients (311, 80.78%) received treatment in the ICU for <14 days. Meanwhile, 74 patients (19.22%) received longer treatment (>14 days). A total of 154 subjects (40.0%) died during their ICU stay, while 231 subjects (60.0%) survived and were discharged from the intensive care unit. Distribution of samples according to Sequential Organ Failure Assessment (SOFA) scores in 385 patients who used mechanical ventilation in the ICU through 2024. The majority of patients (230; 59.74%) had SOFA scores in the mild category (0–6), 126 patients (32.72%) had moderate SOFA scores (7–12), while 29 patients (7.53%) had severe SOFA scores (>12) (Table 1).

There were different types of infections in the sputum and blood, which are shown in (Table 2). The most common organisms found in sputum cultures were A. baumannii (27 cases), P. aeruginosa (12 cases), E. coli (11 cases), B. cepacia and K. pneumoniae (9 cases), C. albicans (6 cases), E. cloacae and C. tropicalis (4 cases), P. mirabilis and S. maltophilia (2 cases), and the least common was S. marcescens (1 case). In blood cultures, the most common organisms were B. cepacia (23 cases), A. baumannii (10 cases), A. species and E. faecalis (3 cases), P. aeruginosa (2 cases), and E. coli and E. faecium (1 case).

(Table 3) shows the level of compliance with each component of the VAP prevention bundle in patients treated with ventilators. The highest compliance was oral hygiene with chlorhexidine (94.0%), head-of-bed elevation ≥30° (91.2%), and stress ulcer prophylaxis (91.2%). Daily weaning assessments were performed with moderate compliance (51.7%), whereas Deep Vein Thrombosis (DVT) prophylaxis had the lowest compliance, with only 3.1% of patients receiving it.

(Table 4) In the studied group of 385 patients, 23.9% developed ventilator-associated pneumonia (VAP), while 76.1% did not. The results suggest that about one-fourth of the patients in this study developed a ventilator-associated infection.

Table 1- Characteristics of Subjects

Subject		n	%
Age	<18 years	23	6.0%
	18-65 years	329	85.46%
	>65 years	33	8.6%
Gender	Male	218	56.60%
	Female	167	43.40%
Hypertension	Present	81	21.0%
	Absent	304	79.0%
Diabetes Mellitus (DM)	Present	27	7.0%
	Absent	358	93.0%
Heart Disease	Present	25	6.40%
	Absent	360	93.50%
Autoimmune Disease under Immunosuppression	Present	4	1.0%
	Absent	381	99.0%
Ventilation Duration	<48 hrs	19	4.9%
	48 hrs – 7 days	211	54.8%
	>7 days	155	40.3%
Length of ICU Stay	<14 days	311	80.78%
	>14 days	74	19.22%
ICU Mortality	Present	154	40.0%
	Absent	231	60.0%
SOFA	Mild (0-6)	230	59.74%
	Moderate (7-12)	126	32.72%
	Severe (>12)	29	7.53%

*The demographic profile among 385 mechanically ventilated ICU patients.

Table 2- Types of Microorganisms by Examination

Culture type	Microorganism	Frequency of Cases
Sputum	Acinetobacter baumannii	27
	Pseudomonas aeruginosa	12
	Escherichia coli	11
	Burkholderia cepacia	9
	Klebsiella pneumoniae	9
	Candida albicans	6
	Enterobacter cloacae	4
	Candida tropicalis	4
	Proteus mirabilis	2
	Stenotrophomonas maltophilia	2
	Serratia marcescens	1

Blood	Burkholderia cepacia	23
	Acinetobacter baumannii	10
	Achromobacter species	3
	Enterococcus faecalis	3
	Pseudomonas aeruginosa	2
	Escherichia coli	1
	Enterococcus faecium	1

*Microorganisms were isolated in 130 of 385 mechanically ventilated patients (33.8%) based on sputum and/or blood cultures.

Table 3- Adherence Level to VAP Bundle Components

VAP Bundle Component	Performed (n)	Not Performed (n)	Percentage of Implementation (%)
Head-of-Bed Elevation ≥30°	351	34	91.2%
Oral Hygiene with Chlorhexidine	362	23	94.0%
Daily Weaning Assessment	199	186	51.7%
Stress Ulcer Prophylaxis	351	34	91.2%
DVT Prophylaxis	12	373	3.1%

*Displays the adherence rates for individual components of the VAP bundle.

Table 4- Incidence of VAP

VAP Incidence	Frequency	Percentage (%)
VAP	92	23.9%
Non-VAP	293	76.1%
Total	385	100%

*Data show VAP Incidence

Among the 92 subjects who developed VAP. Most cases (70.65%, n=65) occurred despite 60% adherence. Smaller proportions had VAP with 80% adherence (25.26%, n=24), and notably, 3.26% (n=3) developed VAP even with 100% bundle adherence (Table 5).

(Figure 1) shows that the number of VAP cases decreased progressively with increasing compliance with the VAP bundle.

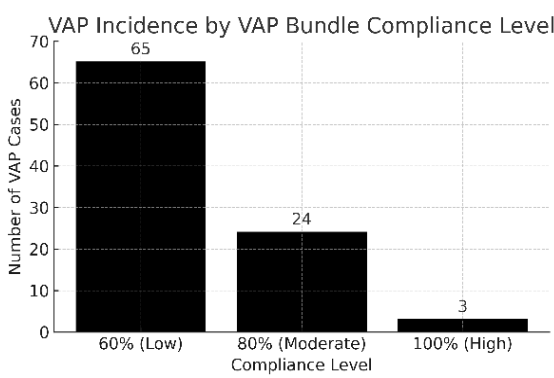

Figure 1- SOFA Score in VAP and Non-VAP

(Table 6) showed that of the total 385 patients who used mechanical ventilators, 92 patients (23.9%) experienced VAP. Of these, 52 patients (56.5%) died, while 40 patients (43.5%) survived.

(Figure 2) shows the distribution of SOFA scores among 385 ventilated patients. The VAP group comprised 92 subjects with VAP, most of whom had moderate SOFA scores (7–12), and a small proportion had severe SOFA scores (>12), resulting in a higher median SOFA score in the VAP group compared to the non-VAP group.

(Table 7) shows the implementation of each component of the VAP bundle in 92 VAP patients. VAP occurrence in relation to head-of-bed elevation ≥30° among the 92 subjects who developed VAP. A very high proportion of VAP cases (93.4%, n=86) occurred despite the implementation of head-of-bed elevation. Only 6 cases (6.6%) of VAP occurred when head-of-bed elevation was not performed. The implementation of oral hygiene with chlorhexidine in 92 VAP cases. A high proportion of VAP incidents (81.5%, n=75) occurred despite this bundle component being performed. Conversely, 17 cases of VAP developed when oral hygiene was not implemented. Implementation of daily weaning assessment in 92 VAP was performed only in 29 cases (31.5%), while VAP occurred in 63 cases (68.5%) where it was not performed. Implementation of stress ulcer prophylaxis (SUP) among the 92 VAP cases. While 63 VAP incidents (68.4%) occurred despite SUP being performed, 29 cases developed when SUP was not implemented. (Table 7) demonstrates the implementation of DVT prophylaxis among the 92 VAP cases. Only 8.6% (n = 8) of VAP episodes occurred in patients who had received DVT prophylaxis, whereas 91.4% (n = 84) developed in those without prophylaxis.

(Table 8) presents the chi-square test results, evaluating the correlation between VAP bundle adherence and VAP incidence in a study population of 385 individuals. The findings show a statistically significant association between VAP bundle adherence and VAP occurrence (p=0.001). Specifically, in the low adherence group (60%), VAP developed in 65 of 216 patients. However, in moderate adherence group (80%), 24 of the 162 patients developed VAP. Although only 3 of the 7 patients with 100% adherence (high) developed VAP, the results statistically suggest that high adherence to the VAP bundle is associated with a lower incidence of VAP. (Table 9) VAP bundle adherence percentages specifically for the group that did not develop VAP. High adherence was observed for oral hygiene with chlorhexidine (97%), stress ulcer prophylaxis (98%), and head-of-bed elevation ≥30° (90%). Daily weaning assessment showed moderate adherence (58%). Critically, DVT prophylaxis showed very low adherence (1.3%) even in the non-VAP group, similar to the VAP group.

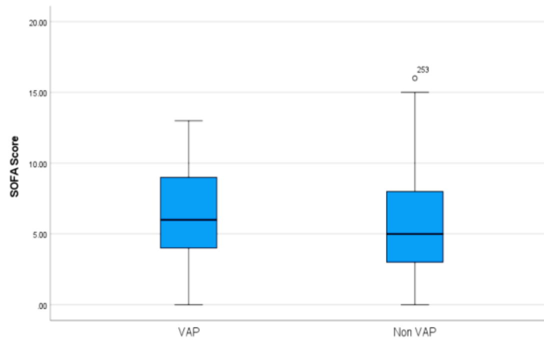

Figure 2- Number of VAP Cases by VAP Bundle Level Adherence

Table 5- Level of Adherence to VAP Bundle

VAP Adherence Level	Frequency	Percentage (%)
60%	65	70.65%
80%	24	25.26%
100%	3	3.26%
Total	92	100%

*Overall adherence to the VAP prevention bundle among patients with VAP (n = 92); data are n (%). Overall adherence reflects the number of bundle elements implemented: 60% = 3/5, 80% = 4/5, 100% = 5/5.

Table 6- VAP Mortality

VAP Incidence	Frequency	Percentage (%)
Present	52	56.6%
Absent	40	43.4%
Total	92	100%

*ICU mortality among patients with ventilator-associated pneumonia (n = 92); data are n (%).

Table 7- Description of VAP Occurrence in VAP Bundle

VAP Bundle Component	Performed (n)	Not Performed (n)	Percentage of Implementation (%)
Head-of-Bed Elevation ≥30°	86	6	93.4%
Oral Hygiene with Chlorhexidine	75	17	81.5%
Daily Weaning Assessment	29	63	31.5%
Stress Ulcer Prophylaxis	63	29	68.4%
DVT Prophylaxis	8	84	8.6%

*Implementation of individual VAP bundle components in patients with VAP (n = 92); counts show performed/not performed and the percentage performed for each component.

Table 8- Chi-Square Test for The Relationship Between VAP Bundle Adherence and VAP Incidence

VAP Incidence			Total	P value
Adherence Level	**Non-VAP**	**VAP**		
60% (Low)	151	65	216	*p = 0.001*
80% (Moderate)	138	24	162	
100% (High)	4	3	7	
Total	293	92	385	

* Association between overall VAP bundle adherence and VAP incidence among mechanically ventilated patients (n = 385); chi-square test, p = 0.001.

Table 9- Percentage of VAP Bundle Adherence in The Group wihtout VAP

VAP Bundle Component	Performed (n)	Not Performed (n)	Percentage (%)
Head-of-Bed Elevation ≥30°	265	28	90%
Oral Hygiene with Chlorhexidine	287	6	97%
Daily Weaning Assessment	170	123	58%
Stress Ulcer Prophylaxis	288	5	98%
DVT Prophylaxis	4	289	1.3%

*Adherence to individual VAP bundle components in patients without VAP (n = 293); data are n (%) with the percentage indicating the proportion performed

Discussion

This study provides a general overview of the clinical characteristics of ICU patients on ventilators, including age, sex, comorbidities, duration of hospital stay, and ventilator use. The majority of patients did not have comorbid conditions, with varying lengths of stay from short to very long, and a relatively high mortality rate. (Table 1) shows the demographic and clinical profile of the study population and indicates substantial time at risk for ventilator-associated pneumonia (VAP): most patients were adults and male, a large proportion were exposed to ≥48 hours of mechanical ventilation, and many had prolonged ICU stays. Together with the baseline distribution of SOFA categories, this pattern is consistent with mortality observed in mechanically ventilated populations and with established colonization–microaspiration pathways that accumulate with device-days. These observations support minimizing unnecessary sedation, promoting early weaning, and ensuring consistent implementation of evidence-based prevention practices [1–3,10-11].

In (Table 2), microbiological culture results from patients on mechanical ventilators indicated that the most frequently identified microorganisms in sputum cultures were Acinetobacter baumannii (27 cases), followed by Pseudomonas aeruginosa (12 cases), Escherichia coli (11 cases), Burkholderia cepacia (9 cases), and Klebsiella pneumoniae (9 cases). These findings align with the research by Papazian et al. Microorganisms associated with VAP vary with factors including the duration of mechanical ventilation, the length of hospitalisation and ICU stay prior to the onset of VAP, the timing and cumulative exposure to antimicrobials, local ecology, and potential epidemiological phenomena in specific ICUs. Common Gram-negative microorganisms involved in VAP include Pseudomonas aeruginosa, Escherichia coli, Klebsiella pneumoniae, and Acinetobacter species. Staphylococcus aureus is the primary Gram-positive microorganism involved [11].

(Table 3) In general, the low level of compliance with several components of the VAP bundle, such as daily weaning and DVT prophylaxis, shows that the bundle has not been done comprehensively. In fact, full compliance with all elements of the bundle has been proven to reduce the incidence of VAP. Routine weaning is performed to assess the patient's readiness to be weaned off the ventilator in order to minimize the duration of ventilator use. Long-term ventilator use not only increases the risk of VAP but also increases mortality rates and is related to poor clinical prognosis, this proves the importance of comprehensive implementation of the VAP bundle [2].

(Table 4) indicates a substantial burden of healthcare-associated infection, as reflected by the proportion of patients who developed VAP in a mechanically ventilated ICU population. This underscores the importance of standardized surveillance using ventilator-days as denominators, routine feedback to frontline teams, and persistent efforts to shorten exposure time when clinically feasible [1–3,10-11].

(Table 5) and (Figure 1), considered together, show a graded inverse association between VAP bundle adherence and VAP occurrence: most events arose when overall adherence was 60% (65/92; 70.7%), fewer at 80% (24/92; 26.1%), and very few at 100% (3/92; 3.2%). This consistent pattern across counts and visualizations indicates that better implementation of bundle elements is linked to fewer VAP events. Residual cases despite full adherence are plausible given patient susceptibility, pathogen virulence, and day-to-day variation in care. Operationally, the signal favors reliable delivery of all bundle elements (not single measures in isolation), supported by routine monitoring and timely feedback to sustain performance [12-13].

(Table 6) shows that mortality among patients with VAP is substantial and aligns with prior literature on mechanically ventilated populations. Evidence showing that early microbiological response is associated with outcomes reinforces the need for timely recognition, rapid microbiology turnaround, and stewardship-guided therapy pathways [14].

(Table 7) indicates that most VAP cases occurred despite head-of-bed elevation and oral chlorhexidine care, suggesting that these measures, while important, are insufficient when applied in isolation. Overall, the low level of compliance with several components of the VAP bundle, particularly daily weaning and DVT prophylaxis, indicates that the bundle has not been implemented completely. The use of DVT prophylaxis may be limited due to the possibility of post-operative bleeding or an increased risk of bleeding in patients with a history of coagulopathy. However, full compliance with all elements of the bundle has been consistently shown to reduce the incidence of VAP. Combined with active implementation strategies, continuous education, and transparent monitoring, this has proven to be the key to success in VAP prevention efforts in various intensive care institutions [13].

(Table 8) confirms a statistically significant inverse association between overall VAP-bundle adherence and VAP incidence (χ^2, $p = 0.001$): 65/216 at 60% adherence, 24/162 at 80%, and 3/7 at 100%. This pattern is consistent with evaluations of VAP-prevention bundles and reviews highlighting head-of-bed elevation, chlorhexidine oral care, endotracheal cuff-pressure control, and subglottic suctioning [5,12-13].

(Table 9) suggests that high adherence to most bundle elements in non-VAP patients, despite persistently low pharmacologic DVT prophylaxis, indicates that prevention hinges on a reliable combination of key measures (e.g., head-of-bed elevation, oral care, and ventilator management). The recurring gap in DVT prophylaxis across groups points to a system-level target for process improvement, that balances safety against bleeding risks.

This study has several important limitations to noted. First, the retrospective analytical study design limits the ability to conclude a causal association between compliance with the ventilator bundle and the incidence of VAP. Second, although some results show a significant relationship, the sample size for certain groups, such as recipients of DVT prophylaxis, is still relatively small, which may affect the statistical validity and accuracy of the effect estimates. Third, variability in the implementation of the intervention across healthcare professionals and intensive care units may also introduce bias or inconsistent data. In addition, not all components of the bundle were evaluated in depth for the quality of implementation or the timing of application, which could affect their effectiveness.

Conclusion

The study found low adherence to VAP bundle. However collective bundle implementation reduced VAP incidence. Not all components, including DVT prophylaxis, were statistically significant for this reduction. These findings emphasize the need for DVT prophylaxis education and audits on daily weaning protocols. More adherence to these procedures may reduce VAP.

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