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ANALYSIS OF FACTORS RELATED TO THE INCIDENCE OF VENTILATOR-ASSOCIATED PNEUMONIA (VAP) IN THE INTENSIVE CARE UNIT

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ABSTRACT
Ventilator-associated pneumonia (VAP) occurs in patients who have been on mechanical ventilation with an endotracheal tube (ETT) for at least 48 hours. This type of pneumonia typically arises as a result of nosocomial infections or Healthcare-Associated Infections (HAIs) and is commonly linked to the use of ventilators in hospital settings. This study was to identify the factors associated with the incidence of VAP among patients admitted to the Intensive Care Unit of Abdoel Wahab Sjahranie Hospital, Samarinda. Method: A cross-sectional study was conducted. The study population consisted of all patients who had undergone mechanical ventilation in the ICU without a prior history of pneumonia, totaling 118 respondents, using the HAIs bundle observation tool and direct observation. Chi-square and multiple logistic regression were used for statistical analysis, along with a predictive model. The results showed that the prevalence of VAP among respondents in the ICU was 5.9%. Factors significantly associated with the incidence of VAP included duration of ventilator use ($p = 0.000$), oral hygiene procedures ($p = 0.000$), head-of-bed elevation to 30–45° ($p = 0.007$), hand hygiene compliance ($p = 0.015$), and aseptic suctioning procedures ($p = 0.043$). The multivariate analysis identified duration of ventilator use ≥96 hours as the most dominant factor, with the highest Odds Ratio (OR = 13.975; 95% CI: 0.753–227.435). Duration of ventilator use was the most significant factor associated with an increased risk of VAP, with patients ventilated for ≥96 hours being 13 times more likely to develop VAP compared to those ventilated for <96 hours. Proper oral hygiene, appropriate head-of-bed elevation (30–45°), compliance with hand hygiene, and aseptic suctioning procedures were also found to be significantly associated with VAP incidence among ICU patients at Abdoel Wahab Sjahranie Hospital

Keywords: hand hygiene; ICU infection; mechanical ventilation duration; oral hygiene; ventilator-associated pneumonia

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INTRODUCTION

Ventilator-Associated Pneumonia (VAP) is one of the most common complications experienced by patients undergoing treatment in the Intensive Care Unit who are on mechanical ventilation for more than 48 hours. VAP falls under the category of nosocomial infections or Healthcare-Associated Infections (HAIs), which contribute to increased morbidity, mortality, length of stay, and overall healthcare costs (Klompas et al.,2022). According to global data, VAP ranks as the second most frequent cause of nosocomial infections in the United States, accounting for approximately 25% of all infections occurring in ICUs. In Japan, the mortality rate due to nosocomial pneumonia ranges between 5–10 per 1,000 patients. In Europe, research by Gillespie indicates that around 10% of ICU patients develop nosocomial infections, with 47% of these cases being pneumonia (Maria, 2022; Wibowo, 2023).

Studies in Indonesia have also reported a relatively high prevalence of VAP, such as at RSU Haji Surabaya (10.5%), RSUD Soekarno Bangka Belitung (27.3%), and RSU Kabupaten

Tangerang (6.7%) (Nugroho, 2021; Wulan, 2024; Maria, 2022). At RSUD Abdoel Wahab Sjahranie Samarinda, the incidence rate of VAP increased from 4.5‰ in 2023 to 9.4‰ in 2024, exceeding the national standard of <5.8‰ as outlined in Regulation of the Minister of Health (PMK) No. 27 of 2017 (PPI Committee, 2023).Several risk factors are suspected to contribute to the occurrence of VAP, including prolonged use of mechanical ventilation, poor oral hygiene, improper head positioning, non-aseptic suctioning techniques, and non-compliance with hand hygiene protocols. These factors may facilitate the colonization of pathogenic microorganisms in the respiratory tract and lead to aspiration into the lungs, eventually resulting in infection (Susanti et al., 2015; Klompas et al., 2022).Surveillance data from the Infection Prevention and Control (IPC) team at RSUD AWS indicate a significant rise in VAP cases in 2024. This situation suggests a gap between the hospital's infection prevention policies such as the implementation of the VAP bundle and their actual practice in clinical settings. Therefore, further analysis is required to identify factors associated with the occurrence of VAP in this hospital, serving as an evidence based foundation for infection control policy making.This study is of particular importance, as no similar research has yet been conducted at RSUD Abdoel Wahab Sjahranie Samarinda, a type A teaching hospital in East Kalimantan Province. The primary objective of this research is to analyze the factors associated with the incidence of VAP among ventilated patients in the Intensive Care Unit of RSUD AWS Samarinda in the year 2025.

METHOD

This study employed a quantitative observational design with a cross-sectional approach, which aimed to examine the association between various risk factors and the incidence of Ventilator-Associated Pneumonia (VAP). The study population consisted of all patients who had undergone mechanical ventilation in the Intensive Care Unit of RSUD Abdoel Wahab Sjahranie Samarinda. A total sampling technique was used, resulting in 118 respondents who met the inclusion criteria.Data were collected through direct observation, medical record review, and checklists related to hand hygiene practices, oral hygiene care, head-of-bed (HOB) elevation, and suction procedures. The independent variables included age, type of intubation, duration of ventilator use, oral hygiene procedures, head-of-bed elevation at 30–45°, suction practices, and compliance with hand hygiene protocols. The dependent variable was the incidence of VAP, which was identified using a Clinical Pulmonary Infection Score (CPIS) of ≥6.Data were analyzed using the chi-square test to determine the associations between variables, followed by multivariate logistic regression to identify the dominant factors influencing the incidence of VAP.

RESULT

Table 1.
Frequency distribution of respondents based on patient characteristics in the Intensive Care Unit of RSUD A. Wahab Sjahranie

No	Variable	Frequency (n=118)	Percentage (%)
1	VAP		
	Yes	7	5.9
	No	111	94.1
2	Age		
	< 60 years	83	70.3
	≥ 60 years	35	29.7
3	Gender		
	Male	64	54.2
	Female	54	45.8

No	Variable	Frequency (n=118)	Percentage (%)
4	Type of Airway Intubation		
	ETT (Endotracheal Tube)	103	87.3
	TC (Tracheostomy)	15	12.7
5	Duration of Ventilator Use		
	≥ 96 hours	23	19.5
	< 96 hours	95	80.5
6	Oral Hygiene		
	Appropriate	97	82.2
	Inappropriate	21	17.8
7	Head-of-Bed Elevation (30°–45°)		
	Appropriate	91	77.1
	Inappropriate	27	22.9
8	Hand Hygiene		
	Compliant	98	83.1
	Non-compliant	20	16.9
9	Suction Technique		
	Aseptic	103	87.3
	Septic	15	12.7
10	Comorbidities		
	Yes	60	50.8
	No	58	49.2
11	History of Surgery		
	Yes	77	65.3
	No	41	34.7

As shown in Table 1, the prevalence of Ventilator-Associated Pneumonia (VAP) among patients treated in the Intensive Care Unit of RSUD A. Wahab Sjahranie was 5.9%. The highest proportion of respondents was under 60 years of age (70.3%). Among the respondents, 87.3% were intubated using an endotracheal tube (ETT), and 19.5% had been on mechanical ventilation for more than 96 hours. Appropriate oral hygiene care was performed in 82.2% of patients, and proper head-of-bed elevation at 30°–45° was implemented in 77.1% of cases. Aseptic suction techniques were applied in 87.3% of cases, and 83.1% of respondents demonstrated compliance with hand hygiene protocols. Additionally, 50.8% of patients had comorbid conditions, and 65.3% had a history of surgery.

Table 2.
Association between Risk Factors and the Incidence of VAP in the Intensive Care Unit of RSUD A. Wahab Sjahranie.

Variable	Ventilator-Associated Pneumonia				Total		P *value*	OR (95%CI)
	VAP		Non-VAP					
	f	(%)	f	(%)	f	(%)		
Age								
< 60 years	4	4.8	79	95.2	83	100	0.422	0.540
≥ 60 years	3	8.6	32	91.4	35	100		(0.114 – 2.550)
Type of Airway Intubation								
ETT	4	3.9	99	96.1	103	100	0.043	0.162

Variable	Ventilator-Associated Pneumonia		Total		P *value*	OR (95%CI)
TC	3	20	12	80	15	100		(0.032 – 0.810)
Duration of Ventilator Use								
≥ 96 hours	6	26.1	17	73.9	23	100	0.000	33.176
< 96 hours	1	1.1	94	98.9	95	100		(3.754 – 293.229)
Oral Hygiene								
Inappropriate	6	28.6	15	71.4	21	100	0.000	38.400
Appropriate	1	1	96	99	97	100		(4.316 – 341.681)
Head-of-Bed 30°–45°								
Inappropriate	5	18.5	22	81.5	27	100	0.007	10.114
Appropriate	2	2.2	89	97.8	91	100		(1.839 – 55.635)
Hand Hygiene								
Non-compliant	4	20	16	80	20	100	0.015	7.917
Compliant	3	3.1	96	96.9	98	100		(1.618 – 38.739)
Suction Technique								
Aseptik	3	20	12	80	15	100	0.043	6.188
Septik	4	3.9	99	96.1	103	100		(1.234 – 31.029)
Comorbidities								
Yes	5	8.3	55	91.7	60	100	0.439	2.545
No	2	3.4	56	96.6	58	100		(0.474 – 13.678)
History of Surgery								
Yes	4	5.2	73	94.8	77	100	0.693	0.694
No	3	7.3	38	92.7	41	100		(0.148 – 3.262)

The results of the study showed that out of 118 patients who underwent mechanical ventilation in the Intensive Care Unit of RSUD Abdoel Wahab Sjahranie, 5.9% developed Ventilator-Associated Pneumonia (VAP). The chi-square test revealed significant associations between the incidence of VAP and the following risk factors: duration of ventilator use (p = 0.000), oral hygiene practices (p = 0.000), head-of-bed elevation at 30°–45° (p = 0.007), hand hygiene compliance (p = 0.015), and suction technique (p = 0.043).

Table 3.
Final Model of Multivariate Analysis of Risk Factors Associated with the Incidence of VAP in the Intensive Care Unit of RSUD A. Wahab Sjahranie

Variable	B	SE	Wald	p-value	OR	95% CI
Ventilator Duration ≥ 96 Hours	2.637	1.423	3.433	0.064	13.975	0.859 – 227.435
Oral Hygiene	2.126	1.229	2.990	0.084	8.379	0.753 – 93.234
Suction Technique	2.194	1.297	2.863	0.091	8.970	0.706 – 113.897
Hand Hygiene Compliance	2.541	1.303	3.800	0.051	12.689	0.986 – 163.259

The multiple logistic regression analysis revealed that ventilator duration of ≥96 hours was the most dominant factor associated with the incidence of Ventilator-Associated Pneumonia (VAP), with an Odds Ratio (OR) of 13.975 (95% CI: 0.859–227.435). This indicates that patients who were on mechanical ventilation for 96 hours or more were approximately 14 times more likely to develop VAP compared to those ventilated for less than 96 hours. These findings underscore the importance of close monitoring and timely evaluation of ventilator duration as a preventive measure against VAP.

DISCUSSION

Association Between Patient Age and VAP

Although age ≥60 years did not show a statistically significant association in this study, the clinical trend aligns with the theory of immunosenescence, which highlights the decline in both cellular and humoral immunity among the elderly. Khayati (2020) reported an odds ratio (OR) of 3.10 ($p = 0.019$) for advanced age as a risk factor for VAP, while Nugroho (2023) found a positive correlation ($r = 0.54$; $p = 0.001$) between older age and CPIS scores. Additionally, older patients tend to have higher APACHE II scores and longer ICU stays, suggesting an indirect contribution of age to VAP incidence through increased comorbidities, chronic inflammation, and prolonged ventilator use.

Association Between Type of Airway and VAP

The predominance of endotracheal tube (ETT) use in this study reflects standard ICU practice. Although the association was not statistically significant, literature supports that ETT carries a higher risk of microaspiration than tracheostomy. Panjaitan, Sinatra, & Siahaan (2021), through a review of 15 studies, concluded that ETT use increases VAP risk by 1.6 to 2.4 times, primarily due to cuff leakage, biofilm formation, and impaired mucociliary clearance. These findings support early consideration for tracheostomy in patients anticipated to require prolonged mechanical ventilation.

Association Between Ventilator Duration and VAP

Ventilator duration ≥96 hours was the strongest predictor of VAP in this study ($p < 0.001$; OR ≈ 14) and emerged as the dominant variable in the regression model. These findings are consistent with a meta-analysis by Anggryani et al. (2016), which showed a 10% increase in VAP risk for every additional 24 hours of ventilation, doubling after the fourth day. Awalin, Faridah, & Ridwan (2019) also reported a significant association ($p = 0.01$) for durations >5 days. Pathophysiologically, prolonged ETT placement fosters biofilm development and increases exposure to invasive procedures (e.g., suctioning, nebulization), facilitating the descent of pathogenic flora into the lower respiratory tract.

Association Between Oral Hygiene Practices and VAP

Inadequate oral care, particularly the absence of toothbrushing and chlorhexidine application, was significantly associated with VAP ($p < 0.001$). Wulandari (2024) demonstrated that implementing a VAP prevention bundle including oral hygiene reduced mean CPIS scores by 2 points by day 3. Khayati (2017) further found that decreasing the frequency of toothbrushing per day increased the risk of VAP by 1.8 times. The mechanism involves suppression of Gram-negative colonization in dental plaque and the oropharynx, which serve as key reservoirs for microaspiration.

Association Between Head-of-Bed Elevation and VAP

A supine position (<30°) was significantly associated with VAP ($p = 0.007$). Radionuclide studies by Torres et al. showed that gastric aspiration increased by 44% in supine positioning. Current SHEA/IDSA guidelines (Klompas et al., 2022) recommend maintaining head-of-bed elevation at 30–45° as a core component of VAP prevention bundles. Vincent (2011) estimated a Number Needed to Treat (NNT) of 10 patients to prevent one VAP episode through HOB elevation.

Association Between Hand Hygiene Compliance and VAP

Low compliance with hand hygiene practices (≤50% of WHO's Five Moments) was significantly associated with VAP ($p = 0.015$). Widaningsih (2022) found an OR of 3.5 among

nurses with <60% compliance. Fatmawati & Kusumajaya (2023) emphasized that implementing VAP bundles increased hand hygiene adherence to 78% and reduced VAP rates in the ICU by 25%. Cross-transmission from hands to patients has long been recognized as a major vector for ETT colonization.

Association Between Suction Technique and VAP

Non-aseptic suctioning was significantly associated with increased VAP incidence ($p = 0.043$). Awalin et al. (2019) observed that high-frequency suctioning (>6 times/day) without sterile gloves significantly raised VAP risk (RR = 1.9). Susanti et al. (2015) recommended the use of closed suction systems, which have been shown to reduce aerosol dispersion and Pseudomonas colonization at the distal ETT tip.

Association Between Comorbid Conditions and VAP

Although comorbidities were not significantly associated with VAP in this study, previous research suggests a potential role. Panjaitan et al. (2021) found that COPD increased VAP risk by 1.7 times. Susanti et al. (2015) also linked hypoalbuminemia (<2.5 g/dL) with impaired mucosal immunity and VAP susceptibility. The lack of significance in the current study may be due to a relatively small sample size or the confounding effect of prolonged ventilation overshadowing comorbidity impact.

Association Between Surgical History and VAP

While not statistically significant in this study, Shah (2022) reported a post-thoracic surgery VAP incidence of 17%, compared to 8% in non-surgical ICU patients ($p < 0.05$). Cunnion et al. proposed that prolonged anesthesia and intraoperative transfusions compromise pulmonary defenses, while postoperative immobility facilitates oropharyngeal colonization. These findings suggest the need for thorough preoperative risk assessment and early mobilization protocols to reduce postoperative VAP risk.

CONCLUSION

Based on the findings of this study, prolonged duration of mechanical ventilation emerged as the most dominant factor significantly associated with the incidence of Ventilator-Associated Pneumonia (VAP). However, procedural and behavioral variables oral hygiene practices, head-of-bed elevation, hand hygiene compliance, and aseptic suction techniques, also demonstrated substantial and actionable contributions to VAP prevention.A multimodal approach based on the VAP prevention bundle has been proven effective in various studies and should be strengthened at RSUD A. Wahab Sjahranie, Samarinda. This includes the implementation of compliance audits, regular staff training, and electronic monitoring systems for ventilator duration to facilitate timely extubation or tracheostomy conversion.

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