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ANALYSIS OF MODIFIABLE FACTORS ASSOCIATED WITH VENTILATOR-ASSOCIATED PNEUMONIA IN MECHANICALLY VENTILATED PATIENTS IN ICU

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Abstract

Ventilator-associated pneumonia (VAP) is reported as one of the highest nosocomial infection conditions in several countries. Risk factors can be classified into modifiable and non-modifiable factor. This study aims to analyze modifiable factors related to the incidence of VAP in patients using mechanical ventilation. This study used a prospective cohort observational analytic design with a quantitative involving 40 patients with mechanical ventilation in the ICU and selected using purposive sampling. Observation sheets and Clinical Pulmonary Infection Score (CPIS) were used as data collection tools. Hypothesis testing in this study utilized Somers's d, contingency coefficient, and Kendall's tau. The analysis revealed significant associations between the duration of mechanical ventilation (p=0.009), and level of consciousness (p=0.021) with the incidence of VAP. However, no significant associations were found between antibiotic use (p=0.075), ICU length of stay (p=0.135), and reintubation (p=0.253) with the incidence of VAP. The study showed that the length of time mechanical ventilation was used and the patient's level of consciousness were factors associated with the incidence of VAP in the ICU. Thus, special attention to modifiable factors can be one of the effective strategies in reducing the incidence of VAP in the ICU.

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INTRODUCTION

Nosocomial infections, also referred to as healthcare-associated infections (HAIs), arise in medical environments such as hospitals, intensive care units (ICUs), and hospices[1,2]. These infections are frequently associated with the use of invasive medical devices, including Ventilator-Associated Pneumonia (VAP)[3]. Data from the International Nosocomial Infection Control Consortium (INICC) reported the incidence of nosocomial infections in 45 countries from 2013 to 2018, 12,085 cases of VAP. VAP, a type of nosocomial infection, typically occurs after more than 48 hours of mechanical ventilation[4].

VAP is a type of nosocomial infection, typically occurs after more than 48 hours of mechanical ventilation[4].VAP can be caused by both non-Multi Drug Resistant (MDR) pathogens, such as Streptococcus pneumoniae, Methicillin-Sensitive Staphylococcus aureus (MSSA), or Pseudomonas aeruginosa, as well as MDR pathogens and Gram-positive bacteria such as Methicillin-Resistant Staphylococcus aureus (MRSA)[5]. The International Nosocomial Infection Control Consortium (INICC) reported a substantial decline in VAP cases, decreasing from 100,660 in 2016 to 32,216 in 2019 and 24,170 in 2021[6,7]. The incidence of VAP across 22 Asian countries, reporting incidences of 18.5, 15.2, and 9.0 per 1,000 ventilation days in low-income, upper-middle, and high-income countries, respectively[8]. Specific data on VAP incidence have not been included in the Indonesian Health Profile or the Basic Health Research reports[9,10]. The incidence report of VAP in the

Intensive Unit Care (ICU) of RSUD Dr. Soetomo showed a rate of 3.2 per 1,000 days of ventilator use in 2019, and 1.2 per 1,000 days of ventilator use in 2020 and 2021[11].

Modifiable risk factors for VAP include the use of nasogastric tubes, the use of immunosuppressive agents, mechanical ventilation lasting more than 48 hours, proton pump inhibitors (PPIs), tracheostomy, and transfusion of more than two units of blood products[12]. Significant risk factors for VAP identified in previous studies include reintubation (23.1% in early onset and 24% in late onset), nasogastric feeding (94.9% in early onset and 93.3% in late onset), proton pump inhibitors (92.3% in early onset and 94.7% in late onset), and prior antibiotic use (84.6% in early onset and 86.7% in late onset)[13].

A preliminary study, conducted through interviews on September 19 and September 30, 2024, revealed that the duration of mechanical ventilation ranged from 2 to 30 days, while the length of ICU stay varied from 2 days to 3 months. The most commonly used method of mechanical ventilation is Endotracheal Tube (ETT). Some patients in the ICU had experienced reintubation 1-2 times. All patients received treatment in the form of PPIs and antibiotics, and were fitted with NGTs. In the past month, 15 cases of VAP were reported in ICU 1, while instances of VAP in ICUs 2 and 3 were infrequently recorded. This hospital has implemented a VAP Bundle policy consisting of 14 actions, with monitoring carried out three times a day on each shift. Several actions in the VAP bundle, such as oral hygiene 3 times a day, semi-recumbent sleeping position, suction per 2-4 hours, and maintaining a cuff tube pressure of 20 cmH_20 were consistently applied in all three ICUs. The background description above underscores that understanding the risk factors associated with VAP is crucial to strengthening prevention and control efforts. This study examines the association between modifiable risk factors for VAP in patients attached to mechanical ventilation in the ICU.

METHOD

This study employed a prospective cohort observational analytic design with a quantitative approach. The study population comprised patients receiving mechanical ventilation in the ICU at one of the type B regional public hospital in Jakarta. A total of 40 mechanically ventilated patients in the ICU participated in the study. The sample size is determined based on the sample calculation results from an unknown population (inpatients with uncertain variations) so that a formula is used based on the proportion of the population in previous studies with an additional patient of 10%. The sampling method employed was non-probability sampling, specifically purposive sampling, based on predefined inclusion and exclusion criteria.

The Inclusion criteria encompassed patients who are attached to mechanical ventilation for <48 hours with the ETT method, patients aged >18 years, who get a VAP Bundle in the form of oral hygiene three times a day, semi-recumbent sleep position, suction, and maintain cuff tube pressure 20 cmH_2O, and patients get PPI drugs (omeprazole 2 x 40 mg) which are evaluated based on nursing action notes in medical records. Exclusion criteria included patients who had experienced VAP before the implementation of the study and the patient's family was not willing to give consent to make the patient a research respondent [12,14].

The research was conducted in a type B regional public hospitals located in Jakarta from November to December 2024. The researcher obtained ethical approval at a type B hospital in Jakarta on October 28, 2024, as evidenced by Ethical Clearance Letter No. 095/KEPK.RSUDT/2024. Clear and comprehensive information was provided to the participants regarding the research objectives, procedures, potential risks, and benefits. Participants were also given the opportunity to make an informed decision and signed an informed consent form.

Data collection was conducted using instruments and direct observation. The instruments included

observation sheets and the standardized Clinical Pulmonary Infection Score (CPIS)[15]. The CPIS has been widely used in clinical practice as an attempt to improve the diagnosis of VAP. The validity value of this instrument showed the Area Under Curve (AUC) curve analysis reached 0.76 in the derivation cohort and 0.67 in the validation cohort. The sensitivity of CPIS for diagnosing VAP was reported at 45%, while the specificity was 89% when using CPIS cut-off points ≥ 7. This shows that CPIS is sensitive enough to identify VAP patients[16].

The observation sheets were used to record and analyze the relationship between modifiable risk factors and the incidence of VAP during ICU treatment. Patients were observed for a period of 5 days. This study employed correlative non-parametric hypothesis analysis to assess the relationship between variables.

The statistical tests used included *Somers' d, Contingency Coefficient*, and *Kendall Tau*. In this study, ordinal-scale independent and dependent variables, such as oral hygiene frequency, level of consciousness, reintubation, and age, were analyzed in relation to the incidence of VAP using the *Somers' d test*. Meanwhile, nominal-scale independent variables, including antibiotic use and gender, were analyzed against the ordinal-scale dependent variable related to VAP incidence using the *Contingency Coefficient test*[17]. Additionally, ratio-scale independent variables were analyzed against the ordinal-scale dependent variable related to VAP incidence using *Kendall's Tau test*[18].

RESULTS AND DISCUSSION

Frequency distribution of respondent characteristics, modifiable VAP risk factors, and VAP incidence

Table 1 Frequency Distribution of Respondents Based on Age and Gender

Variable	Frequency (*f*)	Percentage (%)
Age		
Advanced Adults: >60 years	23	57,5
Middle Adult: 41-60 years	13	32,5
Adulthood: 21-40 years old	4	10
Total	40	100
Gender		
Male	17	42,5
Female	23	57,5
Total	40	100

Table 1 shows results of the study of 40 respondents showed that Most (57.5%) of the respondents were in the advanced adult category (>60 years old) and female.

Table 2 Frequency Distribution of Respondents Based on Duration of Mechanical Ventilation Use, Level of Consciousness, Antibiotic Use, and Reintubation

Variable	Frequency (*f*)	Percentage (%)
Duration of Mechanical Ventilation Use		
<48 hours	8	20
≥48 hours	32	80
Total	40	100
Level of Consciousness		
Coma	2	5
Soporcoma	4	10
Sopor	8	20
Somnolent	9	22,5
Apathy	6	15
Compos Mentis	11	27,5
Total	40	100
Antibiotic Usage		
Cephalosporin Generation III	18	45
Cephalosporin Generation IV	2	5
Beta-Lactam	20	50
Total	40	100
Reintubation		
Reintubated	3	7,5
Not Reintubated	37	92,5
Total	40	100

The study involving 40 respondents revealed that almost all (80%) respondents used mechanical ventilation for ≥48 hours. Judging from the level of consciousness, almost half (27.5%) were in a Compos Mentis condition. In terms of antibiotic use, half (50%) received beta-lactams. Almost all respondents (92.5%) did not experience reintubation.

Table 3 Distribution of Median Respondents Based on Length of Stay ICU

Variable (Day)	Mean ± SD	Median (Min-Max)	95% CI	
			Lower	Upper
Length Of Stay	6.08 ± 2.129	5 (5-13)	5.39	6.76

Table 3 shows that the length of ICU stay among respondents during data collection ranged from a

minimum of 5 days to a maximum of 13 days, with a median duration of 5 days.

Table 4 Frequency Distribution of VAP Incidence

Incidence of VAP	Frequency (*f*)	Percentage (%)
VAP (CPIS Score ≥ 6)	12	30
No VAP (CPIS Score <6)	28	70
Total	40	100

Table 4 shows the incidence of VAP in 40 respondents. Most (70%) of the respondents, namely 28 people, did not experience VAP, while the remaining 12 respondents (30%) experienced VAP.

Relationship between Duration of Mechanical Ventilation Use and the Incidence of VAP

Table 5 Analysis of the Relationship between the Duration of Mechanical Ventilation Use and the Incidence of VAP in Patients Installed with Mechanical Ventilation in the ICU (n=40)

Duration of Mechanical Ventilation Use	Incidence of VAP				Total		p-value	R
	VAP		No VAP					
	f	%	*f*	%	*f*	%		
<48 hours	6	75	2	25	8	100	0,009	0,563
≥48 hours	6	18,8	26	81,2	32	100		

Table 5 shows that most respondents (75%) with mechanical ventilation duration <48 hours experienced VAP. Meanwhile, a small proportion (18.8%) of respondents with mechanical ventilation duration ≥48 hours experienced VAP. Somers' d test yielded a p-value of 0.009 (<0.05), indicating a significant association between mechanical ventilation duration and VAP incidence. The r-value (rho) of 0.563 suggests a moderate positive correlation, meaning that a longer duration of mechanical ventilation is associated with a higher incidence of VAP.

This finding is in line with the results of a previous study that reported a significant association between the duration of mechanical ventilation and the incidence of VAP (p-value = 0.001). Their study highlighted that prolonged mechanical ventilation increases exposure to nosocomial risks during hospitalization[19]. Another study showed that duration of mechanical ventilation significantly increased the risk of VAP, with a p-value of 0.000. Prolonged mechanical ventilation is recognized as a major risk factor for VAP, as prolonged use facilitates bacterial colonization and subsequent infection[11].

Other studies have also shown no significant association between the duration of mechanical ventilation and the incidence of VAP attributed to the implementation of a VAP prevention package, including maintaining the head of the bed at ≥30°, ensuring proper oral hygiene, and optimizing secretion management, which can effectively reduce the risk of VAP even with prolonged mechanical ventilation[20].

Relationship between Level of Consciousness and the Incidence of VAP

Table 6 Analysis of the Relationship between Level of Consciousness and the Incidence of VAP in Patients Installed with Mechanical Ventilation in the ICU (n=40)

Level of Consiousness	Incidence of VAP				Total		p-value	R
	VAP		No VAP					
	f	%	*f*	%	*f*	%		
Coma	2	100	0	0	2	100	0,021	0,239
Soporcoma	2	50	2	50	4	100		
Sopor	4	50	4	50	8	100		
Somnolent	1	11,1	8	88,9	9	100		
Apathetic	1	16,7	5	83,3	6	100		
Compos Mentis	2	18,2	9	81,8	11	100		

Table 6 illustrates that all patients (100%) with coma and half (50%) of those with soporcoma and sopor developed VAP. In contrast, the majority (81.8%) of patients with a compos mentis level of consciousness did not experience VAP.

Somers' d analysis yielded a p-value of 0.021 (<0.05) and an r-value of 0.239, indicating a weak positive correlation between the level of consciousness and VAP incidence. This suggests that a decline in a patient's level of consciousness is associated with a

higher likelihood of developing VAP.

Several studies have shown a significant correlation between decreased level of consciousness and increased risk of VAP with a p-value of <0.001[21]. Low level of consciousness, especially coma, as a contributing factor to VAP, with a p-value of 0.009 [22].

Impaired consciousness in patients decreases physiological reflexes such as swallowing and coughing, increasing the risk of aspiration and airway obstruction. This condition facilitates the entry of food, fluid, or bacteria into the lower respiratory tract, which is a major contributing factor to VAP [23,24]. Researchers argue that patients with low levels of consciousness are more prone to aspiration and bacterial entry into the lower respiratory tract, which is a major factor in the pathogenesis of VAP.

Relationship between Antibiotic Use and the Incidence of VAP

Table 7 Analysis of the Relationship between Antibiotic Use and the Incidence of VAP in Patients Installed with Mechanical Ventilation in the ICU (n=40)

Antibiotic Use	Incidence of VAP				Total		p-value	r
	VAP		No VAP					
	f	%	*f*	%	*f*	%		
Cephalosporin Generation III	4	22,2	14	77,8	18	100	0,075	0,339
Cephalosporin Generation IV	2	100	0	0	2	100		
Beta-Lactam	6	30	14	70	20	100		

Table 7 shows that the almost all of patients receiving third-generation cephalosporins (77.8%) and beta-lactam antibiotics (70%) did not develop VAP. The contingency coefficient test yielded a p-value of 0.075 (>0.05), indicating no significant association between antibiotic use and VAP incidence.

This is in line with reports that beta-lactams are often given in cases of VAP (75%)[13]. A study reported among patients who experienced VAP, beta-lactam antibiotics were the most commonly used (30%), followed by third-generation cephalosporins (22.2%). Hypothesis analysis in the study also showed no significant relationship between antibiotic use and the incidence of VAP, with a p-value of 0.15. The most commonly used antibiotic in the VAP group was a third-generation cephalosporin (38.9%) [11].

ICU patients are often given prophylactic antibiotics to prevent nosocomial infections, especially when undergoing invasive procedures such as surgery or insertion of invasive devices (e.g., ETT or chest drainage). The primary objective of prophylactic antibiotic administration is to minimize the risk of infection by preventing the colonization of pathogenic microorganisms. Additionally, these antibiotics play a vital role in reducing the incidence of surgical site infections and other complications related to invasive device use [25]. In mechanically ventilated patients, the appropriate use of prophylactic antibiotics can help reduce the risk of nosocomial infections, such as VAP, even in cases of prolonged ventilation. Beta-lactam antibiotics are commonly used as prophylaxis in patients at high risk of nosocomial infections [26]. However, generation II and IV cephalosporins which have a very broad spectrum, their use is not recommended as prophylaxis due to the increased risk of resistance [27]. Therefore, these generations of cephalosporins are more commonly used for therapy than for prophylaxis.

Prior antibiotic therapy may disrupt the balance of the respiratory tract microbiome, creating an environment conducive to the growth of pathogens that cause VAP. Long-term antibiotic use during treatment also contributes to increased antibiotic resistance in VAP-causing bacteria [23,28]. The distribution of patients in the VAP and No VAP groups was uneven, especially because the number of IV-generation cephalosporins was small and all of them experienced VAP, making the statistical analysis less sensitive in detecting the true relationship between the variables. In addition, the incidence of VAP is not only influenced by the use of antibiotic types, but also by other factors, such as duration of mechanical ventilator use, level of consciousness, and age.

Relationship between Reintubation and the Incidence of VAP

Table 8 Analysis of the Relationship between Reintubation and the Incidence of VAP in Patients Installed with Mechanical Ventilation in the ICU (n=40)

Reintubation	Incidence of VAP				Total		p-value	r
	VAP		No VAP					
	f	%	*f*	%	*f*	%		
Reintubated	2	66,7	1	33,3	3	100	0,253	0,396
Not Reintubated	10	27	27	73	37	100		

Table 8 indicates that the most (66.7%) of respondents who underwent reintubation developed VAP, while nearly all (73%) of those who did not undergo reintubation did not experience VAP. The results of Somers' d test yielded a p-value of 0.253 (>0.05), suggesting no significant association between reintubation and VAP incidence.

A study reported no significant association between reintubation and VAP (p=0.823). This is because researchers only analyzed the first episode of VAP to more clearly identify factors contributing to VAP[29]. In line with another study report, only 30% of reintubated patients experienced VAP, indicating that reintubation is not directly associated with VAP [22]. Different results suggested that there was a significant relationship between reintubation and the incidence of VAP (p = 0.002). The proportion of patients who experienced reintubation was higher in the VAP group (44%) compared to the non-VAP group (25.5%). This indicates that reintubation contributes as a risk factor for VAP [30].

Reintubation refers to the reinsertion of an endotracheal tube in patients who experience extubation failure. Patients requiring reintubation are at an increased risk of developing VAP [31]. Reintubation may increase the risk of aspiration and bacterial colonization in the respiratory tract which facilitates infection and subsequently elevates the risk of VAP [4]. In this study, there no significant association between reintubation and VAP because the number of patients who experienced reintubation and VAP was very small, only 2 out of a total of 40 respondents, so the variation in data was limited and not enough to show a strong association between reintubation and VAP incidence.

Relationship between Length of Stay ICU and the Incidence of VAP

Table 9 Analysis of the Relationship between Length of Stay ICU and the Incidence of VAP in Patients Installed with Mechanical Ventilation in the ICU (n=40)

Variable	p-value	r
Incidence of VAP Length of Stay ICU	0,135	0,227

In Table 9, the Kendall tau test results indicated a p-value of 0.135 (>0.05), suggesting no significant association between ICU length of stay and the VAP incidence. Contrary to a study report that showed a p-value of <0.001, indicating a statistically significant difference in ICU length of stay between VAP and non-VAP patients. Their study showed that VAP patients tended to have longer ICU stays compared to those without VAP [31]. Similarly, another study identified a significant correlation between ICU length of stay and incidence of VAP, with a p-value of 0.001[32].

Patients who are treated for a long time in the ICU often undergo various medical procedures, such as intubation and tracheostomy, which can increase the risk of infection. Each invasive procedure carries additional risks for contamination and infection [11]. A long stay in the ICU may increase the risk of microbial colonization in the respiratory tract. With a longer time, there is a greater chance for pathogenic microorganisms to colonize the respiratory tract, which may contribute to the development of VAP [4].

The findings of our study do not follow the above theory because the researcher restricted observing patients to the 5th day. This caused most patients to have a total number of treatment days of 5 days. In other words, the

variation of data on this variable is uneven so statistical analysis becomes less sensitive in detecting the true relationship between variables. In addition, the condition of patients when they first entered the ICU had already experienced worsening or deterioration of their condition so the incidence of VAP occurred earlier and was not related to the length of ICU treatment. Future researchers are expected to extend the data collection period or consider using retrospective methods. The retrospective method allows access to patient data that has been treated previously so that the number of samples that can be analyzed becomes larger. With a larger sample size, the relationship between ICU length of stay and the incidence of VAP can be analyzed more accurately. This method also allows for a wider variation in the duration of patient care, which can enrich the analysis and results of the study

CONCLUSION

In this study, the incidence of VAP accounted for 30% of cases. Modifiable risk factors associated with VAP included the duration of mechanical ventilation ≥48 hours and the level of consciousness, such as coma. Conversely, factors such as antibiotic use, reintubation, and ICU length of stay were not significantly correlation with VAP. These findings underscore the essential role of nurses in VAP prevention by optimizing the duration of mechanical ventilation and continuously monitoring patients' level of consciousness, serving as an effective strategy to mitigate the risk of VAP in the ICU. Future implications highlight the importance of nursing interventions in maintaining optimal ventilation duration to prevent VAP. Further research is recommended to explore other potential risk factors and to assess the effectiveness of nurse-led interventions in VAP reduction.

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REFERENCES

1. Divatia J V, Pulinilkunnathil JG, Myatra SN. Nosocomial Infections and Ventilator-Associated Pneumonia in Cancer Patients [Internet]. Oncologic Critical Care. Switzerland: Springer Nature; 2020. 1419–1439 p. Available from: https://doi.org/10.1007/978-3-319-74588-6_125
2. Sikora A, Zahra F. Nosocomial Infections. [Internet]. Treasure Island (FL); 2023. Available from: http://www.ncbi.nlm.nih.gov/books/nbk559312/
3. Mert D, Demirkıran BÇ, İskender G, Avşar Z, Timuroğlu A, Binay S, et al. Six-year evaluation of device-associated nosocomial infections in intensive care units. J Infect Dev Ctries [Internet]. 2024;18(6):937–42. Available from: https://doi.org/10.3855/jidc.19426
4. Xu Y, Lai C, Xu G, Meng W, Zhang J, Hou H, et al. Risk factors of ventilator-associated pneumonia in elderly patients receiving mechanical ventilation. Clin Interv Aging [Internet]. 2019;14(Jun 7):1027–38. Available from: https://doi.org/10.2147/CIA.S197146
5. Alfaray RI, Mahfud MI, Faizun RS. Duration Of Ventilation Support Usage And Development Of Ventilator-Associated Pneumonia: When Is The Most Time At Risk? Indones J Anesthesiol Reanim [Internet]. 2019;1(1):26–31. Available from: https://doi.org/10.20473/ijar.v1i12019.26-31
6. Rosenthal VD, Bat-Erdene I, Gupta D, Belkebir S, Rajhans P, Zand F, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary of 45 countries for 2012-2017: Device-associated module. Am J Infect Control [Internet]. 2020 Apr 1;48(4):423–32. Available from: https://doi.org/10.1016/j.ajic.2019.08.023
7. Rosenthal VD, Duszynska W, Ider BE, Gurskis V, Al-Ruzzieh MA, Myatra SN, et al. International

Nosocomial Infection Control Consortium (INICC) report, data summary of 45 countries for 2013-2018, Adult and Pediatric Units, Device-associated Module. Am J Infect Control [Internet]. 2021;49(10):1267–74. Available from: https://doi.org/10.1016/j.ajic.2021.04.077

8. Bonell A, Azarrafiy R, Huong VTL, Le Viet T, Phu VD, Dat VQ, et al. A Systematic Review and Meta-analysis of Ventilator-associated Pneumonia in Adults in Asia: An Analysis of National Income Level on Incidence and Etiology. Clin Infect Dis [Internet]. 2019;68(3):511–8. Available from: https://doi.org/10.1093/cid/ciy543
9. Kementerian Kesehatan Republik Indonesia. Profil Kesehatan Indonesia Tahun 2021. Sibuea F, Hardhana B, Widiantini W, editors. Jakarta: Kementerian Kesehatan Republik Indonesia; 2022.
10. Badan Penelitian dan Pengembangan Kesehatan. Laporan Nasional: Riskesdas 2018. Kementerian Kesehatan Republik Indonesia. Jakarta: Lembaga Penerbit Badan Penelitian dan Pengembangan Kesehatan; 2019. hal 156.
11. Dewi APTT, Mertaniasih NM, Semedi BP, Alimsardjono L, Endraswari PD. Risk factors of ventilator-associated pneumonia in intensive care patients at tertiary referral hospital. Bali Med J [Internet]. 2023;12(2):1441–5. Available from: https://doi.org/10.15562/bmj.v12i2.4446
12. Baran Aİ, Çelik M, Arslan Y, Demirkıran H, Sünnetçioğlu M, Sünnetçioğlu A. Evaluation of risk factors in patients with ventilator-associated pneumonia caused by acinetobacter baumannii. Bali Med J [Internet]. 2020;9(1):253–8. Available from: https://doi.org/10.15562/bmj.v9i1.1751
13. Behera AK, Guruprasad H, Shivram, Navoday, Divya, Reddy M, et al. Incidence, Risk Factors and Microbiological Profile of Ventilator Associated Pneumonia Patients in ICU in Tertiary Care Hospital. J Adv Med Pharm Sci [Internet]. 2024;26(3):37–44. Available from: https://doi.org/10.9734/jamps/2024/v26i3675
14. Kemenkes RI. Data dan Informasi Kesehatan Profil Kesehatan Indonesia 2021. Jakarta: Kemenkes RI; 2021.
15. Pugin J, Auckenthaler R, Mili N, Janssens JP, Lew PD, Suter PM. Diagnosis of ventilator-associated pneumonia by bacteriologic analysis of bronchoscopic and nonbronchoscopic "blind" bronchoalveolar lavage fluid. Am Rev Respir Dis [Internet]. 1991;143(5 I):1121–9. Available from: https://doi.org/10.1164/ajrccm/143.5_pt_1.1121
16. Gaudet A, Martin-Loeches I, Povoa P, Rodriguez A, Salluh J, Duhamel A, et al. Accuracy of the clinical pulmonary infection score to differentiate ventilator-associated tracheobronchitis from ventilator-associated pneumonia. Ann Intensive Care [Internet]. 2020;10(1). Available from: https://doi.org/10.1186/s13613-020-00721-4
17. Dahlan MS. Statistik Untuk Kedokteran dan Kesehatan Seri 1 Edisi 6. Jakarta: Salemba Medika; 2017.
18. Setyawan DA. Statistika Kesehatan Analisis Bivariat Hipotesis Penelitian. Vol. 1, Tahta Media Group. Sukoharjo: Tahta Media Group; 2022.
19. Meng H, Shi Y, Xue K, Liu D, Cao X, Wu Y, et al. Prediction model, risk factor score and ventilator-associated pneumonia: A two-stage case-control study. J Microbiol Immunol Infect [Internet]. 2024;(November). Available from: https://doi.org/10.1016/j.jmii.2024.11.005
20. Affanin RN, Victoria AZ, Nuraeni A. Hubungan Lama Penggunaan dan Frekuensi Oral Hygiene Pasien Dengan Ventilator Mekanik Terhadap Ventilator-Associated Pneumonia (VAP) di Ruang ICU. Pena Nurs [Internet]. 2022;1(1):13–21. Available from: https://doi.org/10.31941/pn.v1i01.2075
21. Yu Z, Li X, Lv C, Tian Y, Suo J, Yan Z, et al. Epidemiological characteristics of ventilator-associated pneumonia in neurosurgery: A 10-year surveillance study in a Chinese tertiary hospital. Infect Med [Internet]. 2024;3(3):100128.

Available from: https://doi.org/10.1016/j.imj.2024.100128

22. Belay CM, Zewale TA, Amlak BT, Abebe TG, Hailu G. Incidence and Predictors of Ventilator-Associated Pneumonia Among Adult Intubated Patients in Bahir Dar Specialized Hospitals, 2021: A Retrospective Follow-Up Study. Int J Gen Med [Internet]. 2022;15(October):8173–82. Available from: https://doi.org/10.2147/IJGM.S380301
23. Karunarathna I, Kusumarathna K, Jayathilaka P, Rathnayake B, Gunathilake S, Senarathna R, et al. Understanding Ventilator-Associated Pneumonia : Causes, Prevention, and Management. 2024;(April). Available from: https://www.researchgate.net/publication/379568306
24. Wu D, Wu C, Zhang S, Zhong Y. Risk factors of ventilator-associated pneumonia in critically III patients. Front Pharmacol [Internet]. 2019;10(May):1–7. Available from: https://doi.org/10.3389/fphar.2019.00482
25. Martin-Loeches I, Leone M, Einav S. Antibiotic prophylaxis in the ICU: to be or not to be administered for patients undergoing procedures? Intensive Care Med [Internet]. 2020;46(2):364–7. Available from: https://doi.org/10.1007/s00134-019-05870-0
26. Zha S, Niu J, He Z, Fu W, Huang Q, Guan L, et al. Prophylactic antibiotics for preventing ventilator-associated pneumonia: a pairwise and Bayesian network meta-analysis. Eur J Med Res [Internet]. 2023;28(1):1–12. Available from: https://doi.org/10.1186/s40001-023-01323-z
27. Murdiana HE. The identification of drug related problems (DRPs) using profilaxis antibiotics in orthopedic surgical patients at a Government Hospital in Yogyakarta. J Ilm Farm [Internet]. 2021;17(2):210–25. Available from: https://doi.org/10.20885/jif.vol17.iss2.art10
28. Sun Y chen, Wang C yi, Wang H li, Yuan Y, Lu J hong, Zhong L. Probiotic in the prevention of ventilator-associated pneumonia in critically ill patients: evidence from meta-analysis and trial sequential analysis of randomized clinical trials. BMC Pulm Med [Internet]. 2022;22(1):1–12. Available from: https://doi.org/10.1186/s12890-022-01965-5
29. Liang Y, Zhu C, Tian C, Lin Q, Li Z, Li Z, et al. Early prediction of ventilator-associated pneumonia in critical care patients: a machine learning model. BMC Pulm Med [Internet]. 2022;22(1):1–9. Available from: https://doi.org/10.1186/s12890-022-02031-w
30. Gunalan A, Sastry AS, Ramanathan V, Sistla S. Early-vs Late-onset Ventilator-associated Pneumonia in Critically Ill Adults: Comparison of Risk Factors, Outcome, and Microbial Profile. Indian J Crit Care Med [Internet]. 2023;27(6):411–5. Available from: https://doi.org/10.5005/jp-journals-10071-24465
31. Chang PH, Lin TL, Chen YJ, Lai WH, Chen IL, Chang HC, et al. Risk Factors, Pathogens, and Outcomes of Ventilator-Associated Pneumonia in Non-Cardiac Surgical Patients: A Retrospective Analysis. Microorganisms [Internet]. 2024;12(7):1422. Available from: https://doi.org/10.3390/microorganisms12071422
32. Shah H, Ali A, Patel AA, Abbagoni V, Goswami R, Kumar A, et al. Trends and Factors Associated With Ventilator-Associated Pneumonia: A National Perspective. Cureus [Internet]. 2022;14(3):e23634. Available from: https://doi.org/10.7759/cureus.23634