ORIGINAL ARTICLE

Factors Associated with Outcomes of *Acinetobacter baumannii* Infection in Ventilator-Associated Pneumonia in the ICU of Dr. Moewardi General Hospital, Surakarta

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ABSTRACT

Introduction: *Acinetobacter baumannii* is a nosocomial pathogen with high mortality rates in intensive care units (ICUs) and is commonly associated with ventilator-associated pneumonia (VAP). Due to declines in physiological and immune functions, *A. baumannii* can trigger septic shock complications, thereby increasing mortality risk. This study aimed to identify the risk factors associated with outcomes in VAP patients in the ICU of Dr. Moewardi General Hospital, Surakarta.

Methods: This retrospective cohort study was conducted at Dr. Moewardi General Hospital, Surakarta, using patient medical records. Data were analyzed with Chi-square and Mann-Whitney U tests, followed by multiple logistic and linear regression to determine correlations between risk factors and outcomes (recovery, mortality, length of stay/LOS).

Results: This study included 80 patients with VAP caused by *A. baumannii*. Most patients were under 60 years old (52.5%), had good nutritional status (75%), were on ventilators for less than 10 days (63.75%), and had mild comorbidities (51.25%). Moderate-severe comorbidities (p=0.001) and malnutrition (p=0.005) were significantly associated with increased mortality. In addition, ventilator use ≥10 days was significantly associated with LOS (p<0.001).

Conclusion: Moderate-severe comorbidities and malnutrition were risk factors for mortality in patients with *A. baumannii*-related VAP, while ventilator use ≥10 days was a risk factor for prolonged hospitalization. Identifying these factors can help medical personnel manage conditions that worsen VAP outcomes and reduce the risk of *A. baumannii*-related mortality.

INTRODUCTION

Acinetobacter baumannii has emerged globally as a nosocomial pathogen that is difficult to treat. It is a Gram-negative aerobic coccobacillus and part of the "ESKAPE" group, which includes six multidrug-resistant and virulent pathogens.[1] Pneumonia is the most common nosocomial infection caused by *A. baumannii*, particularly in intensive care unit (ICU) patients requiring mechanical ventilation.[2] Ventilator-associated pneumonia (VAP) remains a significant cause of morbidity and mortality despite advances in prevention and treatment with antibiotics and supportive care. It also imposes a significant economic burden on healthcare systems and accounts for more than half of antibiotic prescriptions in ICUs.[3] According to the International Nosocomial Infection Control (INIC), the prevalence of VAP is about 12 per 1,000 mechanical

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ventilation-days.[4] Prolonged mechanical ventilation further worsens patient outcomes, significantly increases mortality, lengthens ICU stays, and raises healthcare costs.[5] Due to impaired physiological and immune function, hospital stay and duration of mechanical ventilation can increase, thereby raising susceptibility to VAP.[6]

In the ICU, VAP is one of the most common respiratory infections, accounting for 8.65% of cases.[7] Data show that the incidence of VAP per 1,000 patient-days is higher than that of other types of pneumonia, including community-acquired pneumonia (CAP), ventilator-associated tracheobronchitis (VAT), and non-ventilator hospital-acquired pneumonia (NV-HAP) (5.83 vs. 6.0 vs. 8.92).[7] The majority of VAP cases are caused by multi-drug resistant (MDR) *A. baumannii*, accounting for up to 45%.[7] The mortality rate of pneumonia associated with *A. baumannii* infection ranges from 48% to 64%.[8,9] Mortality is often influenced by MDR *A. baumannii* infection and septic shock.[10]

Identification of risk factors for VAP plays a key role in clinical prevention. By identifying these factors, more reliable support can be provided for VAP prevention, and cases can be managed more effectively. Therefore, this study aimed to analyze the relationship between risk factors for *A. baumannii* infection in VAP and patient outcomes in the ICU of Dr. Moewardi General Hospital, Surakarta.

METHODS

This study employed an analytical and observational design with a retrospective cohort approach and was conducted at Dr. Moewardi Hospital, Surakarta. Medical record data were collected from patients diagnosed with pneumonia caused by *A. baumannii* who required invasive ventilation in the ICU between January and December 2023. Inclusion criteria were patients diagnosed with pneumonia due to *A. baumannii* who had received invasive ventilation for at least 48 hours. Data extracted from medical records included age, sex, duration of ventilator use, comorbidities, nutritional status, and outcomes. Patient outcomes were classified as recovery, death, or length of stay (LOS). Medical records with incomplete data were excluded.

In this study, the sample was selected using the total sampling method, which included the entire population as research subjects. The independent variables were risk factors for VAP, including age, sex, length of ventilator use, comorbidities, and nutritional status. The dependent variables were outcomes such as recovery, death, and LOS. This study received ethical approval from the Ethics Committee for Health Research at Dr. Moewardi General Hospital, Surakarta, on 10 September 2024, under certificate number 2.208/IX/HREC/2024.

The data were extracted from patients' medical records, organized in an Excel spreadsheet, and analyzed using the International Business Machines Corporation (IBM) Statistical Package for the Social Sciences (SPSS) for univariate, bivariate, and multivariate analyses. The correlation between risk factors and outcomes (death or recovery) was tested using the Chi-square test, followed by multivariate analysis with multiple regression. The association between risk factors and LOS was examined using the Mann-Whitney U test, followed by multiple linear regression.

RESULTS

Among the patients, 88 were diagnosed with pneumonia due to *A. baumannii*, confirmed by bacterial culture from tracheal aspiration specimens. Eight cases were excluded because of incomplete medical records, leaving 80 patients in the final analysis. The data collected included age, sex, length of ventilator use, comorbidities (Charlson Comorbidity Index/CCI), nutritional status (body mass index/BMI), and patient outcomes. Outcomes were classified as recovery, death, and LOS. The study procedure is illustrated in Figure 1.

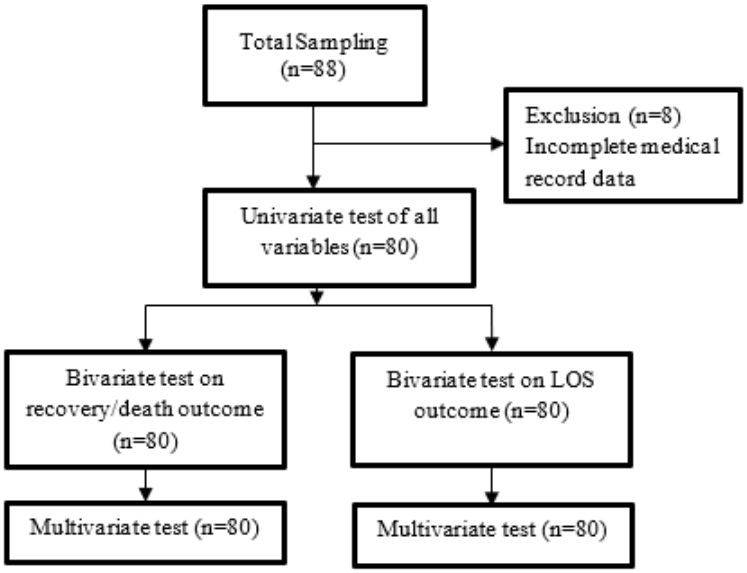

Figure 1. Sample collection and testing process

Patient characteristics of those diagnosed with pneumonia and with *A. baumannii* bacterial culture results admitted to the ICU of Dr. Moewardi Hospital between January and December 2023 are presented in Table 1. The results of the bivariate Chi-square test showed that comorbidities significantly affected patient recovery and death ($p<0.001$). Most patients had mild comorbidities (51.25%). Another factor that affected patient recovery and death was nutritional status ($p<0.001$). The majority of patients had good nutritional status. Furthermore, the correlation coefficient test for comorbidities ($r=0.466$) and nutritional status ($r=398$) showed that the relationship between these risk factors and patient outcomes had a relatively strong strength of association ($r=0.25–0.5$).

Bivariate analysis of other risk factors, including age ($p=0.358$), sex ($p=0.654$), and duration of ventilator use ($p=0.408$), showed $p>0.05$, indicating no significant association between these factors and patient outcomes. Among the patients, 32.5% recovered, while 52.5% died.

Table 1. Bivariate analysis of recovery and death outcomes

Risk Factor	Recovery n (%)	Death n (%)	r	p-value
Age				
18-59 years old	22 (27.5)	20 (25)	0.102	0.358
≥60 years old	16 (20)	22 (27.5)		
Sex				
Male	18 (22.5)	22 (27.5)	0.023	0.654
Female	20 (25)	20 (25)		
Length of ventilator use				
<10 days	26 (32.5)	25 (31.25)	0.092	0.408
≥10 days	12 (15)	17(21.25)		
Comorbidities				
Mild	30 (37.5)	11 (13.75)	0.466	<0.001
Moderate-severe	8 (10)	31 (38.75)		
Nutritional status				
Not malnourished	36 (45)	24 (30)	0.398	<0.001
Malnourished	2 (2.5)	18 (22.5)		

The relation between risk factors and LOS outcomes is shown in Table 2. The Mann-Whitney U test indicated that length of ventilator use ($p<0.001$) was significantly associated with LOS, with more prolonged use corresponding to a more extended ICU stay (4.2–21 days). Sex was also significantly associated with LOS ($p=0.034$). Other variables, including age ($p=0.180$), comorbidities ($p=0.228$), and nutritional status ($p=0.307$), showed no significant correlation with LOS.

Table 2. Bivariate analysis of length of stay (LOS) outcomes

Risk Factor	Mean (Median) LOS	p-value
Age		
18–59 years old	10.6 (9.5)	0.180
≥60 years old	9.9 (5)	
Sex		
Male	18 (4)	0.034
Female	20 (8.5)	
Length of ventilator use		
<10 days	4.2 (4)	<0.001
≥10 days	21 (19)	
Comorbidities		
Mild	9.5 (6)	0.228
Moderate-severe	11.1 (6)	
Nutritional status		
Not malnourished	10 (6)	0.307
Malnourished	11 (6.5)	

A multivariate test using multiple logistic regression assessed the relationship between risk factors and patient mortality. The analysis showed that moderate-severe comorbidities had a significant effect on mortality (p=0.001; odds ratio/OR=7.296), meaning that patients with moderate-severe comorbidities were approximately seven times more likely to die. Malnutrition was also significantly associated with mortality (p=0.005; OR=13.966). Other variables, including length of ventilator use ≥10 days, males, and age ≥60 years old, did not have a significant influence on mortality. The results of the multivariate analysis are summarized in Table 3.

Table 3. Multivariate analysis of recovery and death outcomes

Risk Factor	p-value	Odds Ratio	95% Confidence Interval	
			Lower Limit	Upper Limit
Comorbidities, moderate-severe	0.001	7.269	2.153	24.535
Malnutrition	0.007	13.966	2.052	95.042
Age ≥60 years old	0.260	0.453	0.114	1.797
Sex	0.552	1.148	0.406	5.397
Length of ventilator use ≥10 days	0.718	0.772	0.190	3.137

Multivariate analysis using multiple linear regression was performed to examine the relationship between risk factors and LOS. The results, presented in Table 4, showed that the length of ventilator use had a significant effect on LOS (p<0.001; regression coefficient/β=0.833), indicating that patients who use a ventilator for ≥10 days are at higher risk of longer ICU stays. In contrast, other risk factors, including age ≥60 years old (p=0.098), sex (male; p=0.265), moderate-severe comorbidities (p=0.733), and malnutrition (p=0.743), did not significantly affect LOS in VAP patients with *A. baumannii* infection. Based on the analysis of variance (ANOVA) results (F=20.478, p<0.001), the combination of risk factors (age, sex, awareness, length of ventilator use, comorbidities, and nutritional status) had a significant collective effect on LOS.

Table 4. Multivariate analysis of length of stay outcomes

Risk Factor	Regression Coefficient (β)	p-value	95% Confidence Interval	
			Lower Limit	Upper Limit
Length of ventilator use ≥10 days	0.833	**<0.001**	14.681	21.611
Age ≥60 years old	0.129	0.098	−0.506	5898
Sex	0.084	0.265	−1.344	4.812
Comorbidities, moderate-severe	0.027	0.733	−2.729	3.861
Malnutrition	−0.025	0.743	−4.269	3.060
F-test (Sig)	20.478 (<0.001)			
Adjusted R^2	0.597			

DISCUSSION

In this study, the subjects were patients diagnosed with pneumonia caused by *A. baumannii* in the ICU of Dr. Moewardi General Hospital, Surakarta, from January to December 2023. Of the 80 patients, 42 died, representing 52.5% of the study population and 8.6% of the total deaths in the ICU. The mortality rate in this study was higher than the recovery rate (47.5%) but lower than that reported in a systematic review of the World Health Organization (WHO) Southeast Asia region, which found the VAP mortality, particularly in India, reached 74.7%.[11] This higher mortality in that context is likely due to limited healthcare resources, emphasizing the need for active participation from multiple stakeholders.[11]

Comorbidities (p=0.001; OR=8.988) had a significant impact on patient mortality, indicating that patients with moderate-severe comorbidities (CCI≥3) had a nine-fold increased risk of death. This finding is consistent with a study in Lithuania, which showed that VAP patients with MDR *A. baumannii* monobacterial infections and CCI≥3 had a significant association with mortality.[12] Comorbidities worsen the condition of VAP, leading to serious complications such as sepsis, septic shock, hypoxemia, and organ dysfunction.[12] Another study reported that each one-point increase in CCI within 30 days post-diagnosis increased the risk of mortality by 21%.[13] A separate study showed that comorbidities also contributed to mortality in pediatric VAP patients (p=0.001, OR=8.40), with mortality due to VAP higher than that for CAP (12% vs. 2.5%, p=0.005).[14] Similarly, a study in the ICU of Dr. Hasan Sadikin General Hospital, Bandung, supports this, confirming that VAP mortality was significantly associated with LOS, ICU care, ventilator use, partial pressure of oxygen (PaO_2)/fraction of inspired oxygen (FiO_2) (P/F ratio), comorbidities, neutrophil-lymphocyte ratio (NLR), sequential organ failure assessment (SOFA) score, and nutritional status.[15] A previous study reported that comorbidities were not related to VAP incidence (p=0.668), but human immunodeficiency virus (HIV) positivity showed significant results (p<0.2), indirectly related to VAP incidence since the CCI includes a +6 point for acquired immunodeficiency syndrome (AIDS).[16]

The logistic regression test demonstrated a significant effect of malnutrition on patient mortality (p=0.005; OR=17.463). Inadequate nutrition can reduce muscle function and strength, increase inflammation and oxidative stress, and worsen pneumonia in patients.[17] A reduction in nutrient intake leads to malnutrition, which further exacerbates infections, particularly in elderly patients. Adequate nutrition improves respiratory muscle function and supports immune protection. Therefore, nutritional interventions can help control disease progression and improve respiratory function, ultimately reducing the incidence of disease and death.[18]

The length of ventilator usage ≥10 days was a risk factor that significantly affected LOS (p<0.001; β=0.978). A study in India showed that the ICU LOS for patients with monobacterial *A. baumannii* infections averaged 13.5 days, with 18 patients dying within 30 days after hospitalization.[19] Another systematic review found that a long duration of mechanical ventilation was significantly associated with increased risk of patient mortality, and that patients receiving invasive mechanical ventilation had reduced life expectancy.[20] The physiological reflexes of mechanically ventilated patients, such as swallowing and coughing, weaken, which impairs the clearance of respiratory secretions. As a result, the ability to clear mucus is reduced, allowing bacteria to penetrate directly into the lower airways. In addition, prolonged ventilation increases the risk of infections from moisture generators and fan vessels as sources of pathogens, further deteriorating the patient's condition.[6] Since patients with severe respiratory distress typically present in poor general condition, they may require more intensive care, including early intubation, which increases the duration of mechanical ventilation.

A previous study showed that patients with acute respiratory distress syndrome (ARDS) and VAP have ICU LOS ranging from 16 to 36 days, while coronavirus disease (COVID-19) patients with ARDS and VAP had LOS extended to 41 days, demonstrating that VAP worsens the patient's condition.[21] Another study reported that ICU patients with respiratory tract infection (RTIs) had longer LOS (17.8 days for VAP and 3.7 days for NV-HAP) compared to those without device-associated healthcare-associated infections (DA-HAIs). This group also experienced higher treatment costs and mortality rates.[7] Coronavirus disease patients with VAP had significantly longer mechanical ventilation duration (11 vs. 6 days), longer ICU stay (15 vs. 9 days), and higher ICU mortality rate (31% vs. 26%) compared to non-VAP patients.[22]

Age was not found to be a risk factor associated with mortality or LOS (p=0.260; OR=0.453), likely because the majority of patients in this study were adults (19-59 years old). Elderly patients in this study tended to have moderate-severe comorbidities (CCI≥3), which had a more substantial influence on patient mortality. Regarding age as a risk factor, a study conducted at Inegöl State Hospital, Turkey, found no association between age and patient mortality (p = 0.929).[23] Another study at Siriraj Hospital, Thailand, reported similar results, showing no significant effect of age on patient mortality, as other risk factors were more dominant and

age mainly reflected patients' overall clinical condition.[24] Furthermore, patient immunity is a key determinant of VAP prognosis. A study showed that variability in immune system function can influence inflammatory responses and clinical outcomes.[25] For example, patients with a strong primary immune response may still be susceptible to bacterial and viral infections due to imperfections in antiviral signaling pathways, thereby worsening the progression of VAP.[25]

This study showed that VAP patient mortality was higher among individuals over 60 years old. Age is related to physiological function, immune response, and coma, often contributing to death in VAP patients in the ICU. A previous study stated that increasing age affects the risk of death due to the gradual decline in organ function in older adults.[26] In geriatric patients with comorbidities, particularly heart disease, the risk of death increases further.[26]

This study found that male patients had a slightly higher mortality rate than female patients (27.5% vs. 25%). A study in China reported that, of 154 VAP patients, approximately 66.8% were males.[27] The study showed that the duration of mechanical ventilation within LOS in the ICU and hospital was significantly longer for male than female young patients ($p \leq 0.013$).[27] Males may be more likely to die than females due to this higher mortality rate ($p=0.042$). The study indicated that sex hormones play a key role in regulating organ function and the immune system.[27] Patients' neuroendocrine and endothelial responses also vary and are influenced by sex hormones. Different hormonal states may affect disease progression and response to treatment in ICUs.[27] In this study, the characteristics of VAP mortality were consistent with previous findings showing higher mortality in males. However, statistical analysis revealed no significant relationship between mortality and sex ($p=0.552$; OR=1.148). Furthermore, a study found that neither age nor sex significantly influenced nosocomial extensively drug-resistant (XDR) *A. baumannii* infection ($p=0.557$, $p=0.094$).[28]

A study in Southeast Asia showed that recurrent VAP increases mortality.[11] Ventilator-associated pneumonia has been identified as a significant problem in ICUs, leading to prolonged stays and marked antibiotic resistance. To reduce the risk of future VAP, it is essential to implement various educational interventions, such as staff training, hygiene awareness, continuous monitoring, and rational antibiotics administration.[11]

CONCLUSION

This study found that moderate to severe comorbidities and malnutrition were risk factors for mortality in patients with VAP caused by *A. baumannii*, while ventilator use for ≥10 days was a risk factor for more extended hospitalization. Different pathogens can trigger other inflammatory responses, leading to varied clinical outcomes. Identifying these risk factors can help medical personnel manage factors that worsen VAP outcomes and prevent the spread of *A. baumannii* infection, thereby reducing mortality.

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Conflict of Interest

The authors declared there is no conflict of interest.

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Authors' Contributions

Gathered, analyzed, and interpreted the data; prepared the tables and figures; drafted the manuscript; revised: LLCP. Writing and revising the manuscript: ASM. Reviewed the manuscript: LS, ES, MM. All authors contributed and approved the final version of the manuscript.

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