Original Article

Analysis of Risk Factors for Antimicrobial Resistance in Nosocomial Pneumonia

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Abstract

Background: Antibiotic resistance is often linked to nosocomial pneumonia, one of the most prevalent hospital-acquired illnesses. Determining risk factors is crucial for management and preventative plans. To develop preventative and control measures, this research was conductedto identify the variables linked to antibiotic resistance in nosocomial pneumonia patients.

Method: In this retrospective cohort analysis, 237 individuals with nosocomial pneumonia were included. Odds Ratios (OR) were computed for relevant factors after data were evaluated using the chi-square or Fisher's exact test to find significant relationships between patient characteristics and antibiotic resistance.

Results: Of the 237 patients, 58.2% exhibited antibiotic resistance. Several variables were found to be significantly associated with antibiotic resistance: age >59 years (OR=1.68; P=0.049), intensive care unit (ICU) admission (OR=2.65; P=0.002), high care unit (HCU) admission (OR=2.16; P=0.028), history of prior antibiotic use (OR=2.42; P=0.004), and endotracheal tube (ETT) use (OR=2.04; P=0.024). Patients older than 59 years had a 1.68-fold higher risk. Those admitted to the ICU and HCU had 2.65-fold and 2.16-fold higher risks, respectively. Patients with a history of prior antibiotic use had a 2.42-fold increased risk, and those with ETT use had a 2.04-fold increased risk.

Conclusion: Older age, admission to intensive care units (ICU/HCU), previous antibiotic use, and endotracheal tube use are significant factors associated with antibiotic resistance in nosocomial pneumonia. These findings highlight key areas for targeted interventions to mitigate resistance.

Keywords: antimicrobial resistance, hospital-acquired pneumonia, intensive care, nosocomial pneumonia, risk factor

INTRODUCTION

With greater incidence rates in low- and middle-income countries than in high-income ones, healthcare-associated infections (HAIs) represent a worldwide health burden.[1] Lower respiratory tract infections, especially ventilator-associated pneumonia (VAP) and hospital-acquired pneumonia (HAP), are significant sources

of morbidity and death among HAIs.[2] Both HAP and VAP increase the risk of infection by resistant bacteria,[3,4] lengthen hospital stays, and raise healthcare expenses.[5]

Antimicrobial resistance (AMR) pathogens are responsible for millions of deaths and substantial economic burdens worldwide.[6,7] Infections caused by multidrug-resistant organisms (MDROs) in nosocomial pneumonia are associated with treatment failure, disease progression, and worse prognoses.[8–10]

Inappropriate antibiotic use is a primary driver of AMR.[11,12] Thus, it is essential to determine the clinical, microbiological, and environmental risk factors linked to AMR to create efficient preventive and control plans.[8] Previous research has identified several common risk factors.[13–15] However, variations in findings across different populations and hospital settings highlight the necessity for specific studies within local contexts.[16]

At Dr. Moewardi Hospital Surakarta, a tertiary referral hospital in Central Java, there has been no comprehensive study on AMR risk factors in nosocomial pneumonia. This study was conducted to fill this gap by comprehensively analyzing the risk factors and patient characteristics associated with antimicrobial resistance in nosocomial pneumonia.

METHOD

This research used a retrospective cohort technique and an analytical observational strategy. Patients with nosocomial pneumonia who were hospitalized at Dr. Moewardi Hospital in Surakarta between January 1, 2024, and December 31, 2024, made up the research population. This study employed a consecutive sampling method, whereby all subjects who met the inclusion criteria within a specified time frame were enrolled until the required sample size was achieved.

Inclusion criteria consisted of patients aged over 18 years with a nosocomial pneumonia, defined as new infiltrates or worsened CXR after 48 hours of hospital admission, by diagnosis of the attending physician based on medical history, physical examination, laboratory findings, and chest radiography. The exclusion criterion was incomplete medical records that precluded assessment of the predefined risk factor parameters. The inclusion and exclusion criteria were satisfied by 237 research participants in total.

Data was gathered using patient medical data between March and April of 2025. Ethical approval for the study was obtained from the Ethics Committee of Dr. Moewardi General Hospital, Surakarta, prior to study initiation.

Variables collected included: age (cut-off median:59 years old), gender, ward (general ward, high care unit/HCU, intensive care unit/ICU), comorbidities (pulmonary, extrapulmonary), body mass index (BMI), albumin levels, history of antibiotic use within the past 90 days, history of gastric acid suppressants use (PPIs, H2RAs, dopamine receptor antagonists, antacids), and history of

indwelling invasive medical device use (endotracheal tube/ETT, tracheostomy, nasogastric tube/NGT, central venous catheter, arterial catheter, hemodialysis catheter, chest tube, pigtail catheter). Antibiotic resistance data were obtained from culture and antimicrobial susceptibility test results.

Frequencies and percentages were used to represent categorical data, while mean±standard deviation (SD) or median (range) were used to represent numerical data when they were not normally distributed.

In bivariate analysis, the association between each independent variable and the prevalence of antibiotic resistance was evaluated using the chi-square test or Fisher's exact test. The relationship strength was assessed using 95% Confidence Intervals (CI) and Odds Ratios (OR). Variables were deemed significant if the value of P was less than 0.05.

RESULT

The study involved 237 patients with nosocomial pneumonia, comprising 176 patients with HAP and 61 patients with VAP. Of 58.2% patients exhibited antibiotic resistance, while 41.8% did not.

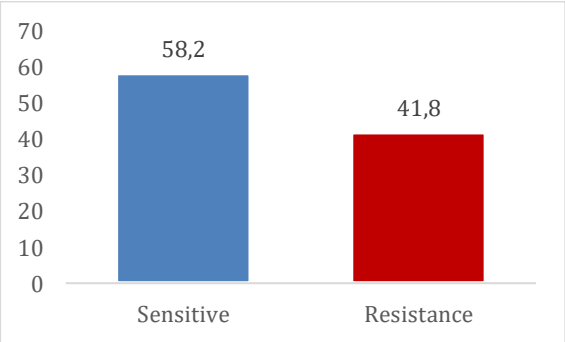

Figure 1. Incidence of Antimicrobial Resistance

Table 1 shows that the mean age of patients was 57.59±13.57 years. The majority of patients (51.1%) were aged ≤59 years and male (58.2%). Most patients were admitted to intensive care units (ICU=41.4%; HCU=24.9%), with the remainder admitted to general wards (33.8%). Extrapulmonary comorbidities were found in 49.4% of patients.

Most patients had a normal BMI (70.0%), but 50.2% experienced hypoalbuminemia. Of 74.8% of patients had a history of antibiotic use in the previous 90 days. The most common indwelling invasive medical devices used were NGT (43.5%) and ETT (25.4%).

Table 1. Baseline Characteristics of Subjects

Variable	n	%
Age (mean±SD)	57.59±13.57	
≤59 years old	121	51.1%
>59 years old	116	48.9%
Sex		
Male	138	58.2%
Female	99	41.8%
Admitted to		
Normal Ward	80	33.8%
Intensive-care Unit	98	41.4%
High-care Unit	59	24.9%
Comorbid		
Pulmonary		
No	197	57.0%
Yes	40	16.9%
Extrapulmonary		
No	120	50.6%
Yes	117	49.4%
Mixed		
No	177	74.7%
Yes	60	25.3%
BMI		
Normal	166	70.0%
Underweight	42	17.7%
Overweight	17	7.2%
Obese	12	5.1%

Variable	n	%
Albumin		
≥3.5 mg/dL	118	49.8%
<3.5 mg/dL	119	50.2%
Prior Antibiotic Use		
No	59	25.2%
Yes	175	74.8%
Use of Gastric Acid Suppressants		
PPI		
No	127	53.6%
Yes	110	46.4%
AH2		
No	143	60.3%
Yes	94	39.7%
Dopamine receptor antagonist		
No	234	98.7%
Yes	3	1.3%
Antacids		
No	225	94.9%
Yes	12	5.1%
History of Indwelling Invasive Device		
ETT		
No	176	74.6%
Yes	60	25.4%
Tracheostomy		
No	228	96.2%
Yes	9	3.8%
NGT		
No	134	56.5%
Yes	103	43.5%
Venous catheter		
No	204	86.1%
Yes	33	13.9%
Arterial catheter		
No	233	98.3%
Yes	4	1.7%
Hemodialysis catheter		
No	225	94.9%
Yes	12	5.1%
Water-sealed drainage		
No	229	96.6%
Yes	8	3.4%
Pigtail		
No	222	93.7%
Yes	15	6.3%

Note: SD=standard devision; BMI=body mass index; PPI=proton pump inhibitor; AH2=histamine-2 receptor antagonist; ETT=endotracheal tube; NGT=nasogastric tube.

The results of the bivariate analysis (Table 2) indicate that several variables were significantly associated with antibiotic resistance (P<0.05). Patients aged over 59 years were more likely to develop antibiotic resistance (OR=1.68; 95% CI=1.00–2.84; P=0.049).

Admission to the ICU was also associated with a significantly increased risk (OR=2.65; 95% CI=1.44–4.89; P=0.002), as was admission to the HCU (OR=2.16; 95% CI=1.09–4.30; P=0.028). A history of prior antibiotic use emerged as another significant factor (OR=2.36; 95% CI=1.30–4.31; P=0.004), along with ETT use (OR=2.04; 95% CI=1.09–3.80; P=0.024). These findings suggest that patient age, care unit admission, previous antibiotic exposure, and invasive device use may contribute to an increased risk of antibiotic resistance.

DISCUSSION

The results of this study indicate the average age of respondents was 57.59±13.57 years. Most patients were ≤59 years of age (51.1%) and male (58.2%). Of 66% patients were treated in the intensive care units (ICU=98 patients; HCU=59 patients), and 75.1% of patients had extrapulmonary comorbidities.

These results align with a 2016 study by Han et al in China, which reported that 413 patients hospitalized with HAP had a mean age of 55.0±18.3 years, 31.2% were over 65 years of age, 72.2% were male, and 38.0% were admitted to the intensive care unit upon initial hospitalization for HAP.[15]

Table 2 Bivariate Analysis of Risk Factors Affecting Antimicrobial Resistance in Nosocomial Pneumonia

Variabel	Sensitive (n=99)	Resistance (n=138)	OR	95% CI	p
Age					
≤59 years old	58 (58.6%)	63 (45.7%)	1.68	1.00-2.84	0.049*
>59 years old	41 (41.4%)	75 (54.3%)			
Sex					
Male	59 (59.6%)	79 (57.2%)	1.10	0.65-1.86	0.718
Female	40 (40.4%)	59 (42.8%)			
Admitted to					
Normal Ward	45 (45.5%)	35 (25.4%)	---	---	---
Intensive-care Unit	32 (32.3%)	66 (47.8%)	2.65	1.44-4.89	0.002*
High-care Unit	22 (22.2%)	37 (26.8%)	2.16	1.09-4.30	0.028*
Comorbid					
Pulmonary	47 (47.5%)	55 (39.9%)	0.73	0.44-1.23	0.234
Extrapulmonary	76 (76.8%)	102 (73.9%)	0.86	0.47-1.56	0.616
BMI					
Normal	71 (71.7%)	95 (68.8%)	---	---	---
Underweight	17 (17.2%)	25 (18.1%)	1.10	0.55-2.19	0.788
Overweight	6 (6.1%)	11 (8.0%)	1.37	0.48-3.88	0.553
Obese	5 (5.1%)	7 (5.1%)	1.05	0.32-3.43	0.940
Albumin					
≥3.5 mg/dL	53 (53.5%)	65 (47.1%)	1.29	0.77-2.17	---
<3.5 mg/dL	46 (46.5%)	73 (52.9%)			
Prior Antibiotic Use					
No	34 (35.1%)	25 (18.2%)	2.36	1.30-4.31	0.004*
Yes	65 (65.7%)	113 (81.9%)			
History of Stomach Acid Suppression Drugs					
PPI	48 (48.5%)	62 (44.9%)	0.87	0.52-1.45	0.588
AH2	42(42.4%)	52 (37.7%)	0.82	0.48-1.39	0.462
Dopamin RA	1 (1.0%)	2 (1.4%)	1.44	0.13-16.12	1.000
Antacids	5 (5.1%)	7 (5.1%)	1.00	0.31-3.26	0.994
History of Indwelling Invasive Device					
ETT	18 (18.2%)	43 (31.2%)	2.04	1.09-3.80	0.024*
Tracheostomy	1 (1.0%)	8 (5.8%)	6.03	0.74-49.02	0.084
NGT	36 (36.4%)	67 (48.6%)	1.65	0.97-2.80	0.062
Venous Catheter	12 (12.1%)	21 (15.2%)	1.30	0.61-2.79	0.497
Arterial Catheter	1 (1.0%)	3 (2.2%)	2.18	0.22-21.25	0.642
HD catheter	2 (2.0%)	10 (7.2%)	3.79	0.81-17.69	0.070
WSD	3 (3.0%)	5 (3.6%)	1.20	0.28-5.16	0.803
Pigtail	6 (6.1%)	9 (6.5%)	1.08	0.37-3.14	0.886

Note: BMI=body mass index; PPI=proton pump inhibitor; AH2=histamine-2 receptor antagonist; ETT=endotracheal tube; NGT=nasogastric tube; OR=Odds Ratio; CI=Confidence Interval; *Significant at P<0.05.

Han et al's study reported that the most common comorbidities were stroke at 12.8%, ischemic heart disease at 6.5%, chronic obstructive pulmonary disease at 6.1%, and heart failure at 5.6%.[15] Slightly different results were reported by Kim et al

in 2022 in Korea, where of 25,369 HAP patients, 57% were aged >70 years, respondents were predominantly male at 53.8%, and 27.3% were treated in the ICU.[13]

This study confirms a high prevalence of antimicrobial resistance (58.2%) in nosocomial pneumonia patients at Dr. Moewardi Hospital Surakarta, consistent with global concerns regarding AMR.[5,17] These results highlight the need for more efficient infection prevention and control techniques in healthcare settings.

Although gastric acid suppressants (such as proton pump inhibitors and H2 blockers) were not significantly associated with antimicrobial resistance in this study, these variables were included due to their potential biological relevance.[18] Acid suppression increases gastric pH, promotes upper gastrointestinal bacterial overgrowth, and may enhance the risk of aspiration-related pneumonia in hospitalized and critically ill patients.

Previous studies have also suggested a possible link between acid-suppressive therapy, gut colonization by resistant microorganisms, and healthcare-associated infections, particularly in ICU settings.[18] Given this evidence, gastric acid suppressants were considered potential risk factors for antimicrobial resistance in nosocomial pneumonia, even though no significant association was observed in our cohort.

This study also highlights the importance of nutritional status. Although most patients had a normal BMI, 50.2% experienced hypoalbuminemia. A study revealed that albumin was a protective factor for nosocomial pneumonia. Hypoalbuminemia reflects poor nutritional status or a high systemic inflammatory response, which can increase susceptibility to nosocomial infections by resistant bacteria. Optimizing nutritional status, including maintaining adequate albumin levels, can be an important part of infection prevention strategies in the ICU.[19]

In this study, neither BMI nor serum albumin showed a statistically significant association with antimicrobial resistance. Although low BMI and hypoalbuminemia are frequently used as surrogate markers of poor nutritional and inflammatory status in clinical practice, they do not fully capture the multidimensional nature of malnutrition.

In line with the World Health Organization, malnutrition is a broad condition that reflects imbalances in nutrient intake and utilization rather than a single cut-off of BMI or albumin. Our data did not include a validated composite nutritional score; therefore, BMI and albumin were analyzed only as individual proxy variables. Previous evidence suggests that malnutrition may increase susceptibility to multidrug-resistant infections, particularly when combined with broad-spectrum antibiotic exposure.

Maataoui et al reported that amoxicillin treatment in children with severe acute malnutrition doubled fecal ESBL-producing *Enterobacteriaceae* colonization compared with placebo.[20] This supports the hypothesis that nutritional vulnerability and antimicrobial exposure

interact in shaping resistance patterns, even though such an interaction could not be formally evaluated in our dataset.

Several characteristics, such as advanced age, admission to an intensive care unit, a history of past antibiotic usage, and a history of using an indwelling invasive device (e.g., ETT), were shown to be significant risk factors for antibiotic resistance in nosocomial pneumonia.

Advanced age (>59 years) was found to increase the risk of resistance by 1.68 times (OR=1.68; 95% CI=1.00-2.84; P=0.049). This finding is consistent with existing literature, which attributes higher susceptibility to drug-resistant infections in older patients to factors such as immunosenescence and increased antibiotic exposure. Zuo et al also identified age as a significant predictor of drug-resistant nosocomial pneumonia in China (OR=2.209).[19] Kim et al reported that elderly patients with reduced mobility and prior antibiotic use were at increased risk of multidrug-resistant ventilator-associated pneumonia (VAP) in Korea.[13]

About 74.8% of the patients in this research had a history of using antibiotics during the previous 90 days, making it the most significant risk factor (OR=2.36; 95% CI=1.30-4.31; P=0.004). Previous antibiotic exposure, especially irrational or broad-spectrum use, drives the selection and proliferation of resistant bacteria.[11,12,21]

Research by Isigi et al. also reinforces that prior antibiotic use is a significant risk factor for HAIs in general.[21] Similarly, Migliara et al in Italy reported that prior exposure to agents such as aminoglycosides, linezolid, penicillin, and colistin increased the risk of infection in ICU patients by reducing antimicrobial efficacy and promoting selective pressure.[22]

Seligman et al also demonstrated that antibiotic administration within 10 days before HAP diagnosis was the only independent predictor of MDR infection (OR=3.45; P=0.002).[23] Bacterial persistence under antimicrobial stress involves mechanisms such as (p)ppGpp-mediated downregulation of growth-related genes, rendering bacteria less susceptible to antibiotics like beta-lactams that target actively dividing cells.[24]

In our study, the use of an ETT was significantly associated with antimicrobial resistance in nosocomial pneumonia (P=0.024). Patients with ETT had approximately a twofold higher odds of resistant infection in the bivariate analysis (OR=2.04; 95% CI=1.09-3.80). This finding is consistent with the established role of invasive airway devices in facilitating colonization and infection by multidrug-resistant organisms. The ETTs provide a direct conduit for pathogens to access the lower respiratory tract, promote biofilm formation on the tube surface, and are frequently used in patients who receive broad-spectrum antibiotics, all of which may contribute to the selection and persistence of resistant pathogens.[14]

In contrast, other indwelling invasive devices in our cohort, such as venous or arterial catheters, were not significantly associated with antimicrobial resistance. While these devices are also known to support bacterial colonization and biofilm

development, infections related to vascular catheters are typically localized to the bloodstream and may be easier to control by catheter removal.

Sano et al reported associations between feeding tubes or central venous catheters and resistant infections in other settings, highlighting that the impact of specific devices can vary depending on patient characteristics, exposure patterns, and local infection control practices.[14] Taken together, our findings underscore the particular importance of airway devices, especially ETTs, as a potential target for prevention strategies in nosocomial pneumonia.

Patients admitted to intensive care settings (ICU/HCU) showed a significantly increased risk of resistance. Patients admitted to ICU (OR=2.65; 95% CI=1.44-4.89; P=0.002) and HCU (OR=2.16; 95% CI=1.09-4.30; P=0.028) increase the risk of antimicrobial resistance. The ICU environment is recognized for its high antibiotic selection pressure, extensive use of invasive devices, and more frequent contact with MDROs.[10]

This observation is supported by studies such as Patil et al in India, who found ICU stay >7 days significantly increased the risk of nosocomial infections, with VAP being the most common (aOR=30.9; P=0.001).[25] Similarly, Santosaningsih et a in Malang reported that ICU stay >8 days was a significant risk factor for Carbapenem-resistant *Acinetobacter baumannii* (CRAB) acquisitionl.[26] Long ICU stays, invasive procedures, and prior broad-spectrum antibiotic use contribute to colonization and infection by MDR pathogens, especially in elderly or comorbid patients.[27–30]

This study has several limitations, including its retrospective design, which relies on the completeness of medical record data. A retrospective cohort design allows for the identification of risk factors but cannot fully establish causal relationships. Additionally, since the research was restricted to a single centre, its results may not apply to other comparable demographics and medical settings.

CONCLUSION

At Dr. Moewardi Hospital Surakarta, the incidence of antimicrobial resistance in nosocomial pneumonia patients is significantly correlated with advanced age (>59 years), admission to an intensive care unit (ICU/HCU), a history of antibiotic use within the previous 90 days, and endotracheal tube (ETT) use. These results highlight crucial areas for focused treatments and preventative measures to lessen the burden of antibiotic resistance to reduce the burden of antibiotic resistance.

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