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Research Article

Comparative Analysis of Antimicrobial Susceptibility Profiles in Hospitalized Pneumonia Patients at RSUD Mardi Waluyo, Blitar City

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ABSTRACT

Pneumonia was a communicable respiratory infection associated with substantial morbidity and mortality across diverse age groups globally. Transmission occurred via direct exposure to respiratory secretions or aerosolized droplets expelled by infected individuals through coughing or sneezing. Previous investigations on antibiotic susceptibility patterns of pneumonia-causing bacterial pathogens were conducted at RSUD Dr. Soetomo Surabaya (2020) and RSUD Dr. Saiful Anwar Malang (2022). This study aimed to analyze and compare the antimicrobial susceptibility profiles of bacterial isolates from hospitalized pneumonia patients at RSUD Mardi Waluyo, Blitar City. A quantitative methodology was employed, using an observational analytic design with a cross-sectional approach to assess antibiotic resistance patterns. Statistical analysis yielded a p-value of 0.002 ($p < 0.05$), indicating a significant difference in antimicrobial effectiveness between Gram-positive and Gram-negative bacterial infections. The majority of patients were males over 60 years old. *Staphylococcus aureus* was identified as the predominant Gram-positive pathogen, while *Klebsiella pneumoniae* was the most prevalent Gram-negative species. Azithromycin, Erythromycin, and Levofloxacin showed the highest susceptibility among Gram-positive bacteria, whereas Amikacin, Ceftazidime, and Gentamicin were most effective against Gram-negative isolates.

INTRODUCTION

Pneumonia remains a significant global health concern, characterized by high morbidity and mortality rates, and it is the leading infectious cause of death across all age groups (Cillóniz et al., 2021). It is an acute inflammatory condition of the pulmonary alveoli, resulting from infections caused by various pathogens, including bacteria, viruses, and fungi (KEMENKES RI, 2020). Transmission primarily occurs through direct contact with respiratory secretions and via aerosolized droplets expelled during coughing or sneezing by infected individuals. Clinically, pneumonia is categorized into two primary types: community-acquired pneumonia (CAP) and hospital-acquired pneumonia (HAP) (Papadakis et al., 2022).

Previous studies on antibiotic susceptibility patterns and bacterial profiles associated with pneumonia have been conducted at RSUD Dr. Soetomo Hospital, Surabaya (2020), and Dr. Saiful Anwar Hospital, Malang (2022). The previous study identified Gram-negative bacteria as the predominant causative pathogens in pneumonia cases, with *Acinetobacter baumannii* and *Klebsiella pneumoniae* being the most frequently isolated species. In this study, *Acinetobacter baumannii* exhibited the highest susceptibility to Cefoperazone-Sulbactam (75%), while *Klebsiella pneumoniae* showed an 83% sensitivity to both Ceftazidime and Amikacin. Additionally, *Streptococcus viridans* demonstrated a 44% susceptibility to Levofloxacin (Yulia et al., 2020).

These findings indicate variations in bacterial prevalence and antibiotic susceptibility patterns across different studies. Therefore, further investigation is warranted to analyze the correlation between bacterial profiles and antimicrobial resistance patterns among hospitalized pneumonia patients at Mardi Waluyo Hospital, Blitar City. Based on these findings, researchers aim to investigate the correlation between bacterial profiles and antimicrobial susceptibility patterns in hospitalized pneumonia patients at Mardi Waluyo Hospital, Blitar City. The outcomes of this study are expected to serve as a valuable reference for clinicians in selecting appropriate antibiotic therapy for bacterial pneumonia management at Mardi Waluyo Hospital, Blitar City.

METHODS

This study employed a quantitative research approach with an observational analytic design. A cross-sectional study design was utilized to evaluate the antibiotic susceptibility patterns of bacterial pathogens responsible for pneumonia. As this research relied on pre-existing hospital data, it was classified as a retrospective study.

The study population comprised all hospitalized patients diagnosed with pneumonia at RSUD Mardi Waluyo, Blitar, from January 2022 to October 2024. The sample included patients over 18 years old who had sputum cultures and antimicrobial susceptibility tests. Patients with incomplete data, pulmonary comorbidities like tuberculosis or bronchiectasis, or HIV coinfection were excluded.

Total sampling was applied. Univariate and bivariate analyses were conducted using SPSS version 29. The Mann-Whitney test was used for statistical comparison. A p-value < 0.05 was considered statistically significant. Ethical approval was obtained from the Health Research Ethics Committee of Mardi Waluyo Hospital (No. 800/216.1.1/410.302.3/KEP/X/2024).

A 95% confidence level is applied in this study. A p-value of <0.05 indicates a statistically significant relationship between the dependent and independent variables, whereas a p-value

>0.05 suggests no significant association between them. This study received ethical approval from the Health Research Ethics Committee of Mardi Waluyo Blitar Hospital, under approval No. 800/216.1.1/410.302.3/KEP/X/2024.

RESULTS

Based on Table 1, the demographic data showed that most patients were male and over 60 years old.

Based on Table 2, Gram-negative bacterial infections demonstrated a higher prevalence among elderly individuals, with the greatest incidence observed in males aged 60 years and above. In contrast, Gram-positive infections were more frequently identified in younger male patients, particularly those within the 18–44 year age group, whereas the distribution among females appeared uniform across all age categories.

Table 1. Demographic Data of Patients

	Frecuency	**Percent**
Age		
18-44th	11	25%
45-59th	11	25%
>60th	22	50%
Gender		
Male	26	59.1%
Female	18	40.9%
Education		
Elementary school	14	31.8%
Junior High school	11	25%
Senior High school	11	25%
etc	8	18.2%
Occupation		
Civil Servant	1	2.3%
Private Sector	6	13.6%
Unemployed	37	84.1%
Residence		
Blitar	43	97.7%
Outside Blitar	1	2.3%
Comorbidities		
Diabetes	7	15.9%
Hypertension	3	6.8%
CKD	5	11.4%
etc	15	34.1%
No comorbidities	14	31.8%

Table 2. Characteristics of Samples Based on the Age of Patients

Gram			Age 18-44	45-59	>60	Total
Gram Negative	Gender	Male	0 (0%)	6 (22.2%)	9 (33.3%)	15 (55.6%)
		Female	2 (7.4%)	3 (11.1%)	7 (25.9%)	12 (44.4%)
Gram Positive	Gender	Male	7 (41,2%)	2 (11.8%)	2 (11.8%)	11(64.7%)
		Female	2 (11.8%)	2 (11.8%)	2 (11.8%)	2 (11.8%)

Table 3. Characteristics of Samples Based On Bacterial Species

Gram	Bacterial Species	Total	%
Positive	*Staphylococcus aureus*	8	18.2
	Streptococcus spp	3	6.8
	Staphylococcus spp	2	4.5
	Streptococcus pneumoniae	2	4.5
	Enterococcus spp	1	2.3
	Streptococcus gordonii	1	2.3
	Streptococcus porcinus	1	2.3
	Total	18	40.9
Negative	*Klebsiella pneumoniae*	16	36.4
	Escherichia coli	4	9.1
	Enterobacter cloacae	3	6.8
	Pseudomonas aeroginosa	3	6.8
	Total	26	59.1%

Based on Table 3, **Gram-negative bacterial isolates** constituted the majority (59.1%) of pathogens identified in hospitalized pneumonia patients, surpassing Gram-positive organisms (40.9%).

The predominant Gram-negative species was *Klebsiella pneumoniae*, followed by *Escherichia coli*, *Enterobacter cloacae*, and *Pseudomonas aeruginosa*. Among Gram-positive isolates, *Staphylococcus aureus* was the most frequently detected pathogen.
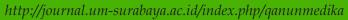
Table 4. Descriptive Tables of Sensitivity Antimicrobials

Antimicroba	Sensitivity	Gram Bacteria		Total
		Positive	Negative	
Amikacin	R	6	0	6
		100.0%	0.0%	100.0%
	I	0	5	5
		0.0%	100.0%	100.0%
	S	2	21	23
		8.7%	91.3%	100.0%
Ampicillin	R	5	22	27
		18.5%	81.5%	100.0%
	S	2	0	2
		100.0%	0.0%	100.0%
Amoxicillin-Clavulanate	R		8	8
			100.0%	100.0%
	I		5	5
			100.0%	100.0%
	S		10	10
			100.0%	100.0%
Ampicillin-Sulbactam	R		6	6
			100.0%	100.0%
	I		1	1
			100.0%	100.0%
	S		6	6
			100.0%	100.0%
Azithromycin	S	4		4
		100.0%		100.0%
Aztreonam	R		7	7
			100.0%	100.0%
	S		19	19
			100.0%	100.0%
Cefazoline	R	0	6	6
		0.0%	100.0%	100.0%
	S	2	2	4
		50.0%	50.0%	100.0%
Cefepime	R		1	1
			100.0%	100.0%
	I		1	1
			100.0%	100.0%
	S		12	12
			100.0%	100.0%
Cefotaxime	R	0	6	6
		0.0%	100.0%	100.0%
	I	0	4	4

		0.0%	100.0%	100.0%
	S	2	15	17
		11.8%	88.2%	100.0%
Cefoxitin	R	4	1	5
		80.0%	20.0%	100.0%
	I	0	2	2
		0.0%	100.0%	100.0%
	S	4	3	7
		57.1%	42.9%	100.0%
Ceftazidime	R		5	5
			100.0%	100.0%
	I		4	4
			100.0%	100.0%
	S		17	17
			100.0%	100.0%
Ceftriaxone	R	0	6	6
		0.0%	100.0%	100.0%
	I	0	2	2
		0.0%	100.0%	100.0%
	S	1	4	5
		20.0%	80.0%	100.0%
Chloramphenicol	R	0	6	6
		0.0%	100.0%	100.0%
	I	0	1	1
		0.0%	100.0%	100.0%
	S	9	12	21
		42.9%	57.1%	100.0%
Ciprofloxacin	R	2	8	10
		20.0%	80.0%	100.0%
	I	0	2	2
		0.0%	100.0%	100.0%
	S	13	5	18
		72.2%	27.8%	100.0%
Clindamycin	R	2		2
		100.0%		100.0%
	S	6		6
		100.0%		100.0%
Colistin	R		1	1
			100.0%	100.0%
			1	1
			100.0%	100.0%
Cotrimoxazole	R	4	0	4
		100.0%	0.0%	100.0%
	I	4	0	4

Antibiotic	Category			Total
		100.0%	0.0%	100.0%
	S	0	3	3
		0.0%	100.0%	100.0%
Erythromycin	R	2		2
		100.0%		100.0%
	I	3		3
		100.0%		100.0%
	S	10		10
		100.0%		100.0%
Fusidic Acid	R	2		2
		100.0%		100.0%
Gentamicin	R	6	1	7
		85.7%	14.3%	100.0%
	I	0	1	1
		0.0%	100.0%	100.0%
	S	5	24	29
		17.2%	82.8%	100.0%
Imipenem	I		1	1
			100.0%	100.0%
	S		12	12
			100.0%	100.0%
Levofloxacin	R	4	6	10
		40.0%	60.0%	100.0%
	I	0	2	2
		0.0%	100.0%	100.0%
	S	12	9	21
		57.1%	42.9%	100.0%
Meropenem	R		5	5
			100.0%	100.0%
	I		3	3
			100.0%	100.0%
	S		18	18
			100.0%	100.0%
Moxifloxacin	R		3	3
			100.0%	100.0%
	S		10	10
			100.0%	100.0%
Oxacilin	R	3	5	8
		37.5%	62.5%	100.0%
	S	3	0	3
		100.0%	0.0%	100.0%
Penicillin	R	8		8
		100.0%		100.0%
	S	1		1
		100.0%		100.0%

Penicillin G	R	3		3
		100.0%		100.0%
	S	3		3
		100.0%		100.0%
Piperacillin	R		3	3
			100.0%	100.0%
	S		10	10
			100.0%	100.0%
Piperacillin-Tazobactam	R		1	1
			100.0%	100.0%
	S		13	13
			100.0%	100.0%
Tetracycline	R	4	6	10
		40.0%	60.0%	100.0%
	S	9	17	26
		34.6%	65.4%	100.0%
Tobramicyn	R	8	1	9
		88.9%	11.1%	100.0%
	S	0	11	11
		0.0%	100.0%	100.0%
Trimethoprim	R	5		5
		100.0%		100.0%
Trimethoprim-Sulfamethoxazole	R		6	6
			100.0%	100.0%
	S		11	11
			100.0%	100.0%
Vancomycin	R	7		7
		100.0%		100.0%
	I	1		1
		100.0%		100.0%
Total	R	75	120	195
		38.5%	61.5%	100.0%
	I	8	34	42
		19.0%	81.0%	100.0%
	S	88	264	352
		25.0%	75.0%	100.0%
		171	418	589
		29.0%	71.0%	100.0%
		100.0%	100.0%	100.0%

Table 5. Wilcoxon Hypothesis Test

	SIR
Mann-Whitney U	302764.000
Wilcoxon W	45470.000
Z	-3.065
Asymp.Sig. (2-tailed)	.002

Based on Table 4, for Gram-positive bacteria, Vancomycin, Clindamycin, Azithromycin, and Erythromycin demonstrated the highest susceptibility rates, indicating their continued effectiveness as primary therapeutic agents. In the case of Gram-negative bacteria, Carbapenems (e.g., Meropenem and Imipenem) remained the most effective antibiotics, with Amikacin also exhibiting substantial activity. Conversely, high resistance levels were observed in Gram-positive isolates against Ampicillin, Ciprofloxacin, Levofloxacin, Tetracycline, and Gentamicin, suggesting limited clinical utility. Similarly, Gram-negative isolates showed notable resistance to Ampicillin and Cefazolin, reducing their appropriateness for empirical therapy. Antibiotics with inconsistent susceptibility, such as Cefazolin and Chloramphenicol for Gram-positive, and Fluoroquinolones (e.g., Ciprofloxacin) for Gram-negative bacteria, exhibited diminished efficacy and are not recommended as first-line treatment options.

Table 5 presents the results of a **comparative analysis of antimicrobial effectiveness** against **Gram-positive and Gram-negative bacteria** causing pneumonia at **Mardi Waluyo Hospital, Blitar City.** The analysis reveals a **p-value of 0.002 (p < 0.05)**, explaining that **Gram-negative bacteria showed higher resistance**, requiring tailored therapy.
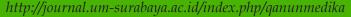
DISCUSSION

The results of this study highlight a higher incidence of pneumonia in males, particularly in older adults. This aligns with prior data indicating that biological and hormonal differences may influence susceptibility, with estrogen providing a protective immune effect in females. Microbiological analysis confirmed that *Klebsiella pneumoniae* was the most frequent Gram-negative isolate, while *Staphylococcus aureus* was the predominant Gram-positive species. These findings support previous research and emphasize the role of environmental and hygienic factors in bacterial colonization.

The novelty of this study lies in its analysis of antimicrobial susceptibility patterns from a regional hospital perspective, offering locally relevant insights that are often underrepresented in national datasets. These findings provide critical guidance for empirical therapy tailored to local resistance trends.

Antimicrobial resistance (AMR) is a growing global threat, and this study reinforces the urgency of implementing antibiotic stewardship programs. Resistance among Gram-negative bacteria to commonly used antibiotics such as Ampicillin and Cefazolin calls for revisiting treatment guidelines. Increased resistance in Gram-negative bacteria may be attributed to their structural defenses, like outer membranes and efflux pumps. Addressing AMR requires not

only surveillance but also clinician education and diagnostic support (Kharazmkia et al., 2022; Munita & Arias, 2016; Seid et al., 2025; WHO, 2014).

Previous research showed that pneumonia incidence is lower in females than in males due to the protective role of estrogen. Estrogen enhances immune response against pneumonia by mediating endothelial nitric oxide synthase 3 (NOS3), which is constitutively expressed in lung macrophages and plays a critical role in host defense against infections (Yang et al., 2014). In contrast, males exhibit a stronger inflammatory response, characterized by excessive neutrophil infiltration in lung tissue and elevated levels of cytokines and chemokines, including IL-17A, CXCL1, and CXCL2 (Chamekh et al., 2017). CD4+ T cells that produce IL-17 regulate bacterial infections through the secretion of neutrophil-attracting substances and factors that stimulate granulocyte formation, such as the CXC chemokine CXCL2/MIP-2 and G-CSF, which play a crucial role in the recruitment of neutrophils (Jin et al., 2014).

The study also analyzed the distribution of pneumonia cases based on age groups. The prevalence was approximately 25% in both the 18–44 and 45–59 age groups, while the highest incidence (50%) was observed in individuals aged ≥60 years. These results were derived from 44 analyzed samples. Similarly, a study by Kautsar at Cut Meutia North Aceh General Hospital, conducted from January to December 2022, involving 107 pneumonia patients, found that the largest affected age group was ≥60 years (45.8%). Advanced age is a major risk factor for pneumonia, as it is associated with declining immune function, reduced lung elasticity, and weakened respiratory muscle strength, leading to impaired mucociliary clearance (Arianti, 2020).
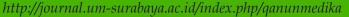
Gram-negative bacteria are the predominant pathogens in pneumonia due to their enhanced capacity for colonization in the respiratory tract, particularly in immunocompromised individuals or those with compromised respiratory epithelium. Their structural composition, including an outer membrane enriched with lipopolysaccharides, confers increased resistance to antimicrobial agents, thereby complicating therapeutic management (Assefa, 2022; Kharazmkia et al., 2022).

Comparative analysis of the present study with previous research has revealed a consistent pattern in the bacterial profile of pneumonia cases. Among Gram-positive pathogens, *Staphylococcus aureus* was frequently identified, whereas *Klebsiella pneumoniae* was the most prevalent Gram-negative species. The high incidence of these bacterial infections is closely associated with suboptimal sanitation conditions and prolonged exposure to contaminated environments, both of which serve as significant risk factors for transmission (Hatmaningtyas, 2013; Wari Rahman et al., 2023).

Staphylococcus aureus is a gram-positive, catalase-positive, and coagulase-positive coccus that forms clusters (Omeed Sizar ; Stephen W.Leslie ; Chandrashekhar G.Unakal ., 2023). In this study, *Staphylococcus aureus* was subjected to antibiotic sensitivity testing, which revealed sensitivity to Amikacin, Cefoxitin, Chloramphenicol, Ciprofloxacin, Gentamicin, Levofloxacin, Oxacillin, and Tetracycline. On the other hand, the antibiotics that showed resistance included Ampicillin, Cefepime, Cotrimoxazole, Erythromycin, Penicillin, Penicillin G, Tobramycin, Trimethoprim, and Vancomycin. According to Clinical and Laboratory Standards Institute *S.aureus* does not exhibit intrinsic resistance to specific antibiotics. These findings are consistent with previous studies, which indicate that

Staphylococcus aureus exhibits resistance to vancomycin, linezolid, levofloxacin, amikacin, and teicoplanin (Luan et al., 2018; Weinstein, 2019).

Klebsiella pneumoniae is a gram-negative, rod-shaped bacterium with a non-capsular structure (Jing et al., 2024). In this study, *Klebsiella pneumoniae* was subjected to antibiotic sensitivity testing, which revealed sensitivity to Gentamicin, Aztreonam, Amikacin, and Tetracycline. The antibiotics with the highest resistance test results were Ampicillin, Chloramphenicol, Ciprofloxacin, Meropenem, and Ciprofloxacin. According to the Clinical and Laboratory Standards Institute (CLSI), *Klebsiella pneumoniae* exhibits intrinsic resistance to Ampicillin and Ticarcillin. Therefore, the resistance observed with Ampicillin is due to its intrinsic resistance properties (Weinstein, 2019). Chloramphenicol resistance is commonly caused by enzyme activity that adds acetyl groups to antibiotics. Acetylated chloramphenicol cannot be bound to the 50S subunit of the bacterial ribosome, so it is unable to inhibit protein synthesis (Patilaya et al., 2019).

Antimicrobial therapy remains the cornerstone of pneumonia management; however, its efficacy varies depending on the bacterial etiology. The increasing prevalence of antimicrobial resistance has substantially diminished the effectiveness of conventional antibiotics, necessitating a more targeted therapeutic approach. The rational selection of antimicrobial agents, guided by bacterial identification and susceptibility testing, is essential to achieving optimal clinical outcomes in pneumonia treatment (Ho & Ip, 2019; Munita & Arias, 2016; WHO, 2014). Statistical analysis using the Mann-Whitney test in this study demonstrated a significant difference in antimicrobial susceptibility between Gram-positive and Gram-negative bacteria, underscoring the importance of tailored antibiotic regimens based on pathogen-specific resistance patterns.

This study is an observational research based on medical records from the hospital under investigation. A limitation of this study is that the researchers had no control over the medical record data available at the hospital. The sample size in this study was relatively small due to the limited number of culture requests at the research site. To increase the sample size, the researchers extended the study duration to one year. Furthermore, not all patients with infections underwent sputum culture tests and antibiotic sensitivity testing, which introduces the possibility of discrepancies between the study results and the actual clinical situation.

CONCLUSION

This study reveals a higher prevalence of pneumonia in males, likely attributed to sex-related immunological variations, with estrogen exerting a protective effect in females. The highest incidence was observed in individuals aged ≥60 years, emphasizing the impact of age-related immunosenescence and declining respiratory function on pneumonia susceptibility. Microbiological analysis identified *Klebsiella pneumoniae* as the predominant Gram-negative pathogen and *Staphylococcus aureus* as the most frequently detected Gram-positive species, with poor sanitation and environmental exposure serving as key risk factors. Significant differences in antimicrobial susceptibility between Gram-positive and Gram-negative bacteria underscore the necessity for targeted antibiotic selection. Given the escalating threat of antimicrobial resistance, routine bacterial identification and susceptibility testing are essential for optimizing therapeutic strategies and improving patient outcomes.

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