

Patterns of Antibiotic Use Among Pediatric Inpatients with Pneumonia at Banyu Bening Islamic General Hospital in 2025

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ABSTRACT

Background: Pneumonia remains one of the leading causes of morbidity and mortality among children worldwide. Appropriate antibiotic use plays a crucial role in achieving successful treatment outcomes while preventing the emergence of bacterial resistance.

Objective: This study aimed to describe the patterns of antibiotic use among hospitalized pediatric patients diagnosed with pneumonia at BanyuBening Islamic General Hospital in 2025.

Methods: A descriptive retrospective study was conducted using the medical records of pediatric patients hospitalized with pneumonia between January and December 2025. A total of 120 patients who met the inclusion criteria were included in the study. The collected data were analyzed descriptively using frequency distributions and percentages.

Result: The results showed that the majority of patients were in the 0–5-year-old age group (75,83%), were female (51,67%), and were hospitalized for 1–5 days (95,00%). Antibiotic use was dominated by injectable formulations (92,50%). Monotherapy was used more frequently than combination therapy, with ceftriaxone being the most commonly prescribed antibiotic (56,67%). By class, cephalosporins were the most commonly used (66,67%), and the ceftriaxone-gentamicin combination was the most common combination (12,50%). The frequency of administration was 98,33%. The frequency of administration was 98,33%. Antibiotic use was dominated by the cephalosporin class, particularly ceftriaxone, with a very high rate of correct dosing frequency

Conclusion: Antibiotic therapy for hospitalized pediatric patients with pneumonia was predominantly based on cephalosporins, particularly ceftriaxone, with a very high level of adherence to the recommended dosing frequency.

Keywords: antibiotics; pneumonia; pediatric; hospitalization

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Introduction

Pneumonia is an acute infection or inflammation of the lung parenchyma characterized by pulmonary infiltrates accompanied by symptoms such as cough and dyspnea. The disease may be caused by various infectious agents, including bacteria, viruses, fungi, or aspiration of foreign substances. Among bacterial pathogens, *Streptococcus pneumoniae* is recognized as one of the most common causes of pneumonia (M. Zahra & Rosfadilla, 2025). Pneumonia remains a major public health concern in children because it can lead to severe complications and death if not appropriately managed (Ma et al., 2025).

According to the World Health Organization (WHO), pneumonia is the leading infectious cause of death among children worldwide. In 2019, the disease was responsible for approximately 740,180 deaths among children under five years of age, accounting for nearly 14% of all deaths in this age group (WHO, 2019). In Indonesia, childhood pneumonia continues to represent a substantial public health burden. Data from the Indonesian Ministry of Health reported 1,017,290 pneumonia cases in 2018, while the 2023 Indonesian Health Survey documented 86,363 cases nationwide (Badan Kebijakan Pembangunan Dinas Kesehatan Jawa Tengah, 2023). Meanwhile, Boyolali Regency recorded 254 successfully managed cases of childhood pneumonia during the same period (Dinas Kesehatan Kabupaten Boyolali, 2023) Kesehatan, 2023; Kementerian Kesehatan RI, 2019). In Central Java Province, 56,221 pneumonia cases among children under five were identified and managed in 2023 (.

Antibiotics remain the primary therapeutic option for bacterial pneumonia. However, inappropriate antibiotic use contributes to the emergence of antimicrobial resistance, a condition in which bacterial growth can no longer be effectively inhibited by antibiotics administered at standard therapeutic doses (Muntasir et al., 2021). Appropriate antibiotic therapy is therefore essential to improve treatment outcomes, reduce morbidity and mortality, and minimize the development of antimicrobial resistance (Manan et al., 2025). Consequently, evaluating antibiotic utilization among pediatric patients with pneumonia is important to promote the rational use of antibiotics in clinical practice.

Previous studies have demonstrated variations in antibiotic prescribing patterns among hospitalized pediatric patients with pneumonia. (Dosi et al., 2025) reported that β -lactam antibiotics, particularly injectable cefotaxime, were the most frequently prescribed agents in pediatric pneumonia patients hospitalized at Fatmawati General Hospital, Jakarta. Most patients received antibiotic therapy for 5–10 days, and the overall appropriateness of antibiotic use was considered high. Similarly, (Madury et al., 2024) found that ceftriaxone was the most frequently prescribed antibiotic for monotherapy, whereas the penicillin–aminoglycoside combination was the most commonly used combination regimen in pediatric pneumonia patients treated at Wonosari Regional Hospital. These findings suggest that antibiotic prescribing patterns may vary among healthcare facilities, highlighting the importance of generating local evidence to support antibiotic stewardship and evaluate prescribing practices.

A preliminary survey conducted at BanyuBening Islamic General Hospital, revealed that pneumonia was one of the most frequently diagnosed infectious diseases in 2025. During that year, 897 patients were hospitalized with pneumonia, including 453 pediatric cases, exceeding the number of adult pneumonia cases. Given the high incidence of pediatric pneumonia and the critical importance of rational antibiotic use, this study was conducted to describe the patterns of antibiotic use among hospitalized pediatric patients with pneumonia at BanyuBening Islamic General Hospital in 2025. The findings are expected to provide valuable information and serve as an evidence base for evaluating antibiotic prescribing practices and improving the quality of healthcare services, particularly in promoting rational antibiotic use among pediatric patients with pneumonia.

Methods

This study employed a descriptive retrospective design to describe the patterns of antibiotic use among hospitalized pediatric patients with pneumonia. The study was conducted at BanyuBening Islamic General Hospital using the medical records of pediatric patients diagnosed with pneumonia who were hospitalized between January to December 2025.

The study population consisted of 453 pediatric patients diagnosed with pneumonia during the study period. The minimum sample size was determined using the Slovin formula with a 5% margin of error, resulting in a minimum required sample of 82 patients. To improve the representativeness of the study, 120 patients who fulfilled the eligibility criteria were included through simple random sampling.

The inclusion criteria comprised pediatric patients younger than 18 years of age who were diagnosed with pneumonia and hospitalized at BanyuBening Islamic General Hospital during the study period. Patients with incomplete medical records were excluded from the analysis.

Data were collected retrospectively using a structured data collection form based on patients' medical records. The collected variables included patient characteristics (sex, age, and length of hospital stay), dosage forms of antibiotics, patterns of antibiotic use (monotherapy or combination therapy), antibiotic classes, and the appropriateness of antibiotic administration frequency.

Data were processed and analyzed descriptively using Microsoft Excel. The results are presented as frequencies and percentages in tabular form. The interpretation of antibiotic use was performed with reference to the World Health Organization (WHO) recommendations

(2014) and the Indonesian Ministry of Health Guideline for Antibiotic Use (2021). This study received ethical exemption from the Health Research Ethics Committee (HREC), Universitas Muhammadiyah PKU Surakarta, Indonesia, under Ethical Exemption No. 26.2105/II.3.AU.10/H.09/VII/2026.

Result and Discussion

Tabel 1. Demographic and Clinical Characteristics of Hospitalized Pediatric Patients with Pneumonia

Characteristic	Category	Number of Patients (n = 120)	Percentage (%)
Sex	Male	58	48.33
	Female	62	51.67
Age	0–5 years	91	75.83
	6–11 years	27	22.50
	12–17 years	2	1.67
Length of Hospital Stay	1–5 days	114	95.00
	6–11 days	5	4.17
	12–17 days	1	0.83

According to Table 1, most patients were 0–5 years old (75.83%), indicating that pneumonia predominantly affected children under five years of age. This finding is consistent with the well-established evidence that pneumonia remains one of the leading causes of morbidity and mortality among young children. The high incidence observed in this age group may be attributed to the increased susceptibility of young children to respiratory tract infections, which is influenced by several factors, including immunization status, exclusive breastfeeding, nutritional status, and environmental exposure (Gestari et al., 2022; Rezeki et al., 2025). Similarly, (Qian et al., 2024) reported that community-acquired pneumonia occurred more frequently among children younger than five years than in older pediatric age groups, highlighting the vulnerability of this population and the need for effective preventive strategies.

Female patients accounted for 51.67% of the study population, slightly exceeding the proportion of male patients (48.33%). Although females were marginally more represented, the relatively small difference suggests that pneumonia affects both sexes with a comparable distribution. This finding differs from several previous studies that reported a predominance of male patients, indicating that the sex distribution of pediatric pneumonia may vary across populations and healthcare settings.

Regarding the length of hospitalization, 95.00% of patients were admitted for 1–5 days, suggesting that most children experienced favorable clinical improvement within one week of treatment initiation. The duration of hospitalization among pediatric pneumonia patients is influenced by multiple factors, including disease severity, underlying comorbidities, clinical condition at admission, and response to antimicrobial therapy ((Ehsanul Huq, Michiko Moriyama, Ryota Matsuyama & Reo Kawano, Mohammad Jobayer Chisti, Md Tariqujjaman, 2021). Therefore, the predominance of shorter hospital stays observed in this study may reflect satisfactory clinical responses to the treatment provided.

Tabel 2. Distribution of Antibiotic Dosage Forms Among Hospitalized Pediatric Patients with Pneumonia

Dosage Form	Number of Patients (n)	Percentage (%)
Injection	111	92.50
Tablet	3	2.50
Syrup	6	5.00
Total	120	100.00

As shown in Table 2, injectable antibiotic formulations were prescribed in 92.50% of patients, whereas oral syrup and tablet formulations accounted for 5.00% and 2.50%, respectively.

The predominance of injectable antibiotics indicates that parenteral administration remains the preferred route for hospitalized pediatric patients with pneumonia (N. L. Zahra et al., 2023). In inpatient settings, the selection of the administration route is determined by several clinical considerations, including the patient's condition, the need for close therapeutic monitoring, and the requirement for rapid therapeutic effects during the acute phase of infection (Kemenkes RI, 2021). Another factor to consider when choosing an injectable formulation is that it offers several advantages, including: its effects set in more quickly than with oral administration; it can be administered to uncooperative or unconscious patients; and it is extremely useful in emergency situations. Consequently, the high utilization of injectable antibiotics observed in this study reflects current clinical practice in managing hospitalized children with pneumonia and is consistent with findings reported by (Ramdani et al., 2024)

Tabel 3. Patterns of Antibiotic Use Among Hospitalized Pediatric Patients with Pneumonia

Antibiotic	Number of Patients (n = 120)	Antibiotic (%)	Class (%)
Monotherapy			
Penicillins			
Amoxicillin (P)	13	10.83	10.83
Cephalosporins			
Cefixime (O)	2	1.67	
Cefotaxime (P)	10	8.33	66.67
Ceftriaxone (P)	68	56.67	
Combination Therapy			
Penicillins + Aminoglycosides			
Amoxicillin (P) + Gentamicin (P)	1	0.83	0.83
Cephalosporins + Aminoglycosides			
Cefotaxime (P) + Gentamicin (P)	3	2.50	
Ceftriaxone (P) + Gentamicin (P)	15	12.50	15.83
Ceftazidime (P) + Gentamicin (P)	1	0.83	
Penicillins + Cephalosporins			
Amoxicillin (P) + Ceftriaxone (P)	1	0.83	0.83
Cephalosporins + Sulfonamides			
Cefotaxime (P) + Cotrimoxazole (O)	2	1.67	
Ceftriaxone (P) + Cotrimoxazole (O)	1	0.83	2.50
Cephalosporins + Macrolides			
Ceftriaxone (P) + Azithromycin (O)	1	0.83	
Ceftriaxone (P) + Erythromycin (O)	1	0.83	
Cefotaxime (P) + Erythromycin (O)	1	0.83	2.50
Total	120	100	100

P = Parenteral; O = Oral

The distribution of antibiotics prescribed to hospitalized pediatric patients with pneumonia is presented in Table 3.

Overall, antibiotic monotherapy (77.50%) was prescribed more frequently than combination therapy (22.50%). This finding suggests that a single antibiotic was considered sufficient for managing most pediatric pneumonia cases included in this study. Empirical monotherapy is generally recommended as the initial treatment strategy because it effectively targets the most likely bacterial pathogens while avoiding unnecessary therapeutic complexity (Yun, 2024). Furthermore, the Indonesian Ministry of Health Guideline for Antibiotic Use recommends that empirical antibiotic selection should consider the patient's clinical condition, the most probable causative organisms, and local antimicrobial resistance patterns to ensure effective and rational therapy (Kemenkes RI, 2021).

Among all antibiotic classes, cephalosporins were the most frequently prescribed, accounting for 66.67% of total antibiotic use. This predominance is likely associated with the role of third-generation cephalosporins, particularly ceftriaxone, as recommended empirical

therapy for community-acquired pneumonia because of their broad-spectrum activity against common lower respiratory tract pathogens (Kato et al., 2022b). In addition, microbiological confirmation is often unavailable during the early stages of treatment, making broad-spectrum empirical antibiotics the preferred initial therapeutic option (Yun, 2024).

From a pharmacological perspective, cephalosporins are β -lactam antibiotics that work by inhibiting bacterial cell wall synthesis through binding to Penicillin-Binding Proteins (PBPs), thereby inhibiting peptidoglycan formation, which causes the bacterial cell wall to become unstable and eventually undergo lysis (Jacobs et al., 2024). This mechanism of action produces a bactericidal effect, enabling cephalosporins to inhibit the growth of and kill various bacteria that cause pneumonia and are sensitive to β -lactam antibiotics (Kato et al., 2022a). The predominant use of ceftriaxone in this study was also reported by (Saputri et al., n.d.) in pediatric pneumonia patients undergoing inpatient care.

Among individual antibiotics, ceftriaxone was the most commonly prescribed agent, representing 56.67% of all prescriptions. The high frequency of ceftriaxone use indicates its central role in the empirical management of pediatric pneumonia at BanyuBening Islamic General Hospital. As a third-generation cephalosporin, ceftriaxone exhibits broad-spectrum antibacterial activity and is widely recommended for hospitalized patients with community-acquired pneumonia (Kato et al., 2022b). The choice of ceftriaxone as empirical therapy is also supported by the characteristics of hospitalized patients, who generally require intravenous antibiotics with broad-spectrum activity before microbiological test results are available. In addition, ceftriaxone has a long half-life, allowing for once-daily dosing, which simplifies treatment administration and improves adherence to hospital protocols. In contrast, injectable amoxicillin or ampicillin require more frequent administration, limiting their use.

Although the (WHO, 2014) recommends ampicillin or penicillin combined with gentamicin as first-line therapy for severe childhood pneumonia, ceftriaxone is recommended as an alternative when the initial regimen fails to achieve an adequate clinical response. Therefore, the predominance of ceftriaxone observed in this study may reflect physicians' clinical judgment, patient condition, and institutional antibiotic prescribing policies. Comparable prescribing patterns have also been documented by (Dosi et al., 2025), who reported that third-generation cephalosporins remained the most frequently prescribed antibiotics for hospitalized pediatric pneumonia patients.

Although monotherapy predominated, combination antibiotic therapy was administered to 22.50% of patients. The combination of ceftriaxone and gentamicin was the most frequently prescribed regimen (12.50%). Combination therapy is generally reserved for patients with suspected severe infections, inadequate clinical response to initial therapy, or situations requiring broader empirical antimicrobial coverage (Kemenkes RI, 2021). Ceftriaxone and gentamicin possess complementary mechanisms of action. Ceftriaxone inhibits bacterial cell wall synthesis, whereas gentamicin inhibits bacterial protein synthesis by binding to the 30S ribosomal subunit (Jacobs et al., 2024). Damage to the bacterial cell wall induced by β -lactam antibiotics may enhance aminoglycoside penetration into bacterial cells, thereby producing a synergistic antibacterial effect in selected infections (Lisnasari, 2023). Similar prescribing patterns were also reported by (Salasanti et al., 2024) who identified ceftriaxone-gentamicin as one of the most commonly prescribed combination regimens in hospitalized pediatric pneumonia patients.

Tabel 4. Appropriateness of Antibiotic Administration Frequency Among Hospitalized Pediatric Patients with Pneumonia

Hospitalized Pediatric Patients with Pneumonia						
Antibiotic	Dose Interval	(n)	Appropriate		Inappropriate	
			(n)	%	(n)	%
Monotherapy						
Amoxicillin (P)	Every 8 h	13	13	100		
Cefixime (O)	Every 12 h	2	2	100		

Cefotaxime (P)	Every 6–8 h	10	10	100		
Ceftriaxone (P)	Every 12–24 h	68	68	100		
Combination Therapy						
Amoxicillin (P) + Gentamicin (P)	Every 8 h / 24 h	1	1	100		
Cefotaxime (P) + Gentamicin (P)	Every 6–8 h / 24 h	1	3	300		
Ceftriaxone (P) + Gentamicin (P)	Every 12–24 h / 24h	15	13	86,67	2	13,33
Ceftazidime (P) + Gentamicin (P)	Every 8 h / 24 h	1	1	100		
Amoxicillin (P) + Ceftriaxone (P)	Every 8 h / 12–24 h	1	1	100		
Cefotaxime (P) + Cotrimoxazole (O)	Every 6–8 h / 6–12 h	2	2	100		
Ceftriaxone (P) + Cotrimoxazole (O)	Every 12–24 h / 6–12 h	1	1	100		
Ceftriaxone (P) + Azithromycin (O)	Every 12–24 h / 24 h	1	1	100		
Ceftriaxone (P) + Erythromycin (O)	Every 12–24 h / 6–8 h	1	1	100		
Cefotaxime (P) + Erythromycin (O)	Every 6–8 h / 6–8 h	1	1	100		
Total		120	118	98,33	2	1,67

P = Parenteral; O = Oral

According to Table 4, the overall appropriateness of antibiotic administration frequency among hospitalized pediatric patients with pneumonia reached 98.33%, with 118 of 120 patients receiving antibiotics at the recommended dosing frequency. This high level of appropriateness indicates that the majority of antibiotic regimens prescribed in this study were consistent with the recommended dosing frequency used as the reference standard. Appropriate dosing frequency is an essential component of rational antibiotic use, as it contributes to optimal therapeutic outcomes while minimizing the risk of treatment failure and antimicrobial resistance (Dosi et al., 2025)

Only two cases (1.67%) of inappropriate dosing frequency were identified, both involving the combination regimen of ceftriaxone and gentamicin. According to the Indonesian Ministry of Health Guideline for Antibiotic Use (2021), gentamicin is recommended to be administered once daily (every 24 hours), whereas ceftriaxone is generally administered every 12–24 hours, depending on the patient's clinical condition. Adherence to these recommended dosing intervals is essential to maximize therapeutic efficacy while minimizing the risk of adverse effects (Kemenkes RI, 2021). In contrast, all other antibiotic regimens evaluated in this study were prescribed according to the recommended dosing frequencies, indicating that deviations from established guidelines were minimal.

The high proportion of appropriate antibiotic administration frequency observed in this study suggests that antibiotic prescribing practices at BanyuBening Islamic General Hospital generally complied with the therapeutic guidelines adopted as the study reference. These findings are consistent with those reported (Fadila et al., 2026) who emphasized that the appropriateness of antibiotic regimens is one of the key indicators for assessing the rational use of antibiotics among hospitalized patients with pneumonia. Maintaining appropriate dosing frequency is expected to optimize clinical outcomes, improve treatment effectiveness, and support antimicrobial stewardship efforts by promoting the rational use of antibiotics in pediatric patients with pneumonia.

Conclusion

Based on the findings of this study involving 120 hospitalized pediatric patients with pneumonia at BanyuBening Islamic General Hospital, Boyolali, Indonesia, in 2025, most patients were 0–5 years old (75.83%) and had a relatively short hospital stay of 1–5 days (95.00%). Injectable formulations were the predominant dosage form (92.50%), and antibiotic monotherapy was prescribed more frequently than combination therapy. Ceftriaxone was the most commonly prescribed individual antibiotic (56.67%), while cephalosporins represented the most frequently prescribed antibiotic class overall. Among combination regimens, ceftriaxone–gentamicin was the most frequently prescribed (12.50%). Furthermore, the appropriateness of

antibiotic administration frequency reached 98.33%, indicating a high level of adherence to the recommended dosing frequency. These findings provide valuable local evidence for evaluating antibiotic prescribing practices and supporting the rational use of antibiotics in the management of pediatric pneumonia.

Recommendations

BanyuBening Islamic General Hospital is encouraged to maintain the high level of compliance with recommended antibiotic prescribing practices while conducting regular evaluations of the small proportion of cases (1.67%) in which the administration frequency of combination antibiotic therapy did not comply with the recommended guidelines. Continuous implementation of institutional clinical pathways and antibiotic stewardship programs is also recommended to optimize empirical antibiotic prescribing and minimize the future risk of antimicrobial resistance.

Future studies are recommended to evaluate the quality of antibiotic use using quantitative assessment methods such as the Gyssens method, enabling a more comprehensive evaluation of prescribing appropriateness, including indications, dosage, administration frequency, and treatment duration. In addition, further research investigating the relationship between the appropriateness of antibiotic use and clinical outcomes, as well as treatment costs through cost-effectiveness analysis, would provide more comprehensive evidence to support rational antibiotic use in pediatric pneumonia management.

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