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Quantitative Evaluation of Antibiotic Utilization Using the ATC/DDD and DU90% Methods and Length of Hospital Stay Among Pediatric and Adult Pneumonia Patients in Bima

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Abstract: The primary treatment modality for pneumonia is antibiotic therapy, yet improper use can accelerate bacterial resistance and diminish therapeutic effectiveness. The study aims to evaluate the patterns of antibiotic utilization among hospitalized pediatric and adult patients with pneumonia in a hospital in Bima City, as well as to examine the factors influencing the length of hospital stay during the period of January to August 2020. The evaluation employed the WHO ATC/DDD methodology combined with DU 90% analysis using a descriptive cross-sectional design. Data were obtained retrospectively from medical records, and total sampling. A total of 95 patients met the inclusion criteria, representing all age categories with complete and legible documentation. Quantitative analysis showed that the total antibiotic consumption in pediatric patients reached 39.27 DDD per 100 patient-days, while in adult patients it reached 121.26 DDD per 100 patient-days. Ceftriaxone was the antibiotic with the highest DDD value in pediatric and adult patients, with 19.53 and 98.00 DDD/100 patient-days respectively. In the pediatric group, antibiotics within the DU 90 percent segment comprised ceftriaxone, gentamicin, cefotaxime, and azithromycin, whereas in adults, the DU 90 percent segment included ceftriaxone and azithromycin. A total of 97.6 percent of prescriptions were aligned with the hospital formulary. The bivariate analysis indicates that the presence of comorbidities is significantly associated with the length of hospital stay among pneumonia patients ($p < 0.05$). Meanwhile, patient age and nutritional status did not show a significant association ($p > 0.05$). Overall, the findings demonstrate a predominance of ceftriaxone use in the management of pneumonia in the hospital. These results highlight the importance of ongoing quantitative surveillance to monitor prescribing trends, and support implementation of antimicrobial stewardship programs to minimize resistance risk and maintain optimal therapeutic outcomes.

Keywords: Antibiotic use; antimicrobial Stewardship Program; ATC/DDD; ceftriaxone; DU 90%; pneumonia

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1. INTRODUCTION

Pneumonia continues to represent a major health burden and remains one of the leading causes of illness and death among both children and adults globally. Data from the World Health Organization indicate that in 2019 alone, approximately 740,180 deaths occurred among children under five due to pneumonia, representing about 14% of all fatalities in this age category (World Health Organization, 2019). A similar concern is reflected in UNICEF reports, which estimate that more than 700,000 young children lose their lives to pneumonia every year, predominantly in low- and middle-income nations (UNICEF, 2023). In Indonesia, multicenter findings demonstrate that pneumonia accounts for nearly 15% of childhood deaths and ranks as the second most frequent cause of mortality in children under five (Kartasasmita et al., 2022). More recent surveillance from the Greater Jakarta metropolitan area documented 73,694 pediatric pneumonia cases between 2020 and 2022, corresponding to an incidence rate of around 1.1% (Putri et al., 2024). Taken together, these figures emphasize that pneumonia remains a persistent public health challenge. As such, continuous monitoring and strengthened preventive strategies are essential to reduce disease burden and improve survival outcomes.

Antibiotic therapy remains the cornerstone of pneumonia management. However, inappropriate prescribing practices continue to be a concern, as irrational antibiotic use contributes substantially to the development of antimicrobial resistance. Evidence indicates that improper antibiotic utilization may

reach as high as 40–62% (Farida et al., 2020). The consequence of rising resistance is clinically significant, as it reduces treatment effectiveness, complicates patient recovery, and increases healthcare costs (Dadgostar, 2019). Current international recommendations emphasize empiric therapy for hospitalized adults with community-acquired pneumonia (CAP). For mild to moderate severity, treatment regimens typically involve a combination of beta-lactams and macrolides, while for severe presentations, the same combination remains advised. As an alternative approach, beta-lactams may be paired with respiratory fluoroquinolones (Martin-Loeches et al., 2023).

Several studies conducted in Indonesia have shown that ceftriaxone is the most frequently prescribed antibiotic for hospitalized pneumonia cases. This pattern aligns with findings reported by Prasetyo and Kusumaratni (2018), and similar observations were noted earlier by Farida, Trisna and Nur (2017). Quantifying antibiotic use through standardized methodologies such as ATC/DDD and DU90% enables consistent assessment of utilization patterns. These approaches allow not only the detection of prescribing trends but also the identification of antibiotics that dominate overall consumption. Such monitoring strategies play an important role in supporting antimicrobial stewardship programs within hospital settings. More recent evidence suggests that the combined use of ATC/DDD and DU90% methods is effective for identifying antibiotics with the highest utilization burden. Consequently, these tools can serve as a framework for regulatory and stewardship-driven policy interventions (Masalma et al., 2024).

Building upon this context, the present study aims to characterize antibiotic utilization patterns among pediatric and adult pneumonia patients hospitalized in a secondary-level hospital in Bima City, a setting where empirical data remain limited. Despite the availability of established pneumonia treatment guidelines, evidence on real-world antibiotic consumption using standardized quantitative approaches, particularly in non-tertiary hospitals, is still scarce, and comparative analyses between pediatric and adult populations are uncommon. To address this gap, this study applies the ATC/DDD and DU90% methodologies to quantify antibiotic use and examines factors associated with length of hospital stay. The findings are expected to support the evaluation of therapeutic rationality, provide baseline data for antimicrobial stewardship initiatives, and contribute context-specific evidence relevant to similar healthcare settings.

2. MATERIALS AND METHOD

2.1 Study Design and Type

This study employed an observational approach with a cross-sectional design to assess antibiotic use among pediatric, adult, and geriatric pneumonia patients, as well as to analyze factors influencing the length of hospitalization. Data were obtained retrospectively from inpatient medical records using a total sampling technique covering the period from January to August 2020 in a hospital located in Bima, West Nusa Tenggara. The inclusion criteria consisted of all pneumonia patients across age groups who received antibiotic therapy during hospitalization and had complete medical documentation. Patients referred to other facilities, those discharged against medical advice, and prescriptions containing antibiotics without an ATC code were excluded. A medical record was considered complete if it included the patient's full treatment course and contained essential information such as name, age, sex, body weight, pneumonia classification, prescribed antibiotic(s), formulation strength, dosage, route of administration, frequency, and treatment duration..

2.2 Data Analysis

The collected data were subjected to univariate and bivariate analyses to describe antibiotic use patterns and to explore their association with clinical characteristics among pneumonia patients. Univariate analysis was performed to summarize patient demographics and clinical variables, including age group (pediatric and adult), sex, type of pneumonia diagnosis, presence of comorbidities, nutritional status, length of hospital stay, and patterns of antibiotic prescribing (type, route of administration, dosage, frequency, and duration), as well as compliance with the hospital formulary.

Bivariate analysis was subsequently conducted to examine associations between selected independent variables and the duration of hospitalization. The independent variables included age group, comorbid conditions, and nutritional status, while the dependent variable was length of treatment or hospital stay, which was categorized according to the study criteria. Associations between categorical variables were analyzed using the chi-square test.

The collected data were analyzed using both univariate and bivariate approaches, including an assessment of compliance between prescribed antibiotics and the hospital formulary. Further quantitative evaluation employed the ATC/DDD method. Defined Daily Dose (DDD) values for each antibiotic were sourced from the official WHO database available at https://www.whocc.no/atc_ddd_index. Total antibiotic consumption in grams was calculated using the formula: dose × frequency × duration of therapy. The calculation of DDD per 100 patient-days was determined using the following formula:

$$\text{DDD/100 patient-days} = \frac{The\ number\ of\ antibiotics\ used\ (g)}{WHO\ DDD\ Standard\ (g)} \text{ x } \frac{100}{Total\ length\ of\ hospital\ stay}$$

The DU90% segment was determined by ranking antibiotics from the highest to the lowest level of use and calculating the cumulative percentage until reaching 90%. Bivariate analysis was conducted using the chi-square test to assess associations between categorical variables, including age, comorbid conditions, and nutritional status, in relation to the length of treatment among pneumonia patients.

2.3 Ethical Considerations

Ethical approval for this study was granted by the Health Research Ethics Committee of the Faculty of Health Sciences, Syarif Hidayatullah State Islamic University Jakarta. The approval reference number is Un.01/F.10/KP.01.1/KE.SP/04.08.006/2021.

3. RESULTS AND DISCUSSION

Data for this study were obtained from the medical records of hospitalized pneumonia patients across all age groups at a Class C hospital in Bima City during the period January–August 2020. Of the 222 medical records initially screened, 95 met the inclusion criteria and were included in the final analysis, comprising 83 pediatric and 12 adult patients. The remaining 127 records were excluded for the following reasons: incomplete clinical data (n = 2), referral to another facility (n = 1), discharge against medical advice (n = 9), absence of antibiotic therapy during hospitalization (n = 1), presence of concomitant infectious diagnoses other than pneumonia (n = 47), and medical records that could not be accessed because they were retained in the hospital Casemix unit (n = 67).

The 47 excluded cases categorized as “other infections” referred to patients who were diagnosed with pneumonia in combination with additional infectious conditions, such as gastrointestinal, urinary tract, or systemic infections, which could independently influence antibiotic selection and consumption patterns. To ensure homogeneity of the study population and to allow a more accurate evaluation of antibiotic use specifically for pneumonia, these cases were excluded. The inclusion criteria were therefore limited to patients with a primary diagnosis of pneumonia who received antibiotic therapy during hospitalization, regardless of age. Patients with non-infectious comorbidities were eligible for inclusion, provided that pneumonia was the sole infectious diagnosis documented in the medical record.

3.1 Patient Demographic Characteristics

Table 1 presents the demographic and clinical characteristics of pediatric and adult patients included in this study, including sex distribution, age categories, pneumonia classification, insurance status, and length of hospital stay. In this study, the “presence and type of comorbidities” refers specifically to underlying non-infectious chronic or acute conditions, such as cardiovascular disorders, respiratory

diseases, or nutritional disorders, that coexisted with pneumonia at the time of hospitalization. Consistent with the study's inclusion criteria, comorbidities did not include additional infectious diseases; patients with pneumonia accompanied by other infectious diagnoses were excluded from the analysis.

Table 1. Demographic profile of pediatric and adult patients

Variable	Number (n)	Percentage (%)
Gender		
Male	47	49.5
Female	48	50.5
Age Group		
<5 Years	80	84.22
5-9 Years	1	1.05
10-18 Years	2	2.1
19-60 Years (Adult)	7	7.37
>60 Years (Elderly)	5	5.26
Type of Pneumonia		
CAP	94	98.95
HAP	1	1.05
VAP	0	0
Presence of Comorbidities		
Present	30	31.6
Absent	65	68.4
Health Insurance		
BPJS (National Health Insurance)	82	86.3
Umum (Self-paid)	13	13.7
Length of Stay (LOS)		
≤7 Days	85	89.5
>7 Days	10	10.5

Keterangan: CAP = *Community-Acquired Pneumonia*, HAP = *Hospital-Acquired Pneumonia*, VAP = *Ventilator-Acquired Pneumonia*

The findings show that pediatric patients constituted 87.37% of the study population, while adults and geriatric patients accounted for 12.63%. This pattern indicates that pneumonia cases requiring hospitalization were predominantly observed in children. According to the American Thoracic Society (2019), children under five years of age exhibit a higher susceptibility to pneumonia. In Indonesia, pneumonia ranks as the second leading cause of mortality in this age group and contributes to approximately 15% of deaths among children under five (Windi et al., 2021). Factors such as age, nutritional status, immunization coverage, and exposure to air pollution are believed to play a significant role in increasing the likelihood of pneumonia (Tejada et al., 2018). National estimates show that the prevalence of pneumonia based on clinical diagnosis or reported symptoms reached 10.8% across all age groups, and among children under five, the prevalence nearly tripled compared with the 2018 national health survey findings (increasing from 4.8% to 15.0%) (Kementerian Kesehatan Republik Indonesia, 2023). Globally, pneumonia accounts for roughly 14% of deaths in children younger than five (WHO, 2022). Consistent with these observations, the dataset from this study shows that pneumonia was substantially more common among younger children compared to adults. Community-acquired pneumonia (CAP) was the most frequently identified type, although the specific causative pathogens, whether bacterial or viral, could not be determined. Recent epidemiological data suggest that Haemophilus influenzae non-type B and Respiratory Syncytial Virus (RSV) are the predominant causes of pneumonia in children aged 2–59 months hospitalized across selected regions in Indonesia, including Yogyakarta, Semarang, and Tangerang. RSV incidence peaked during the rainy season, particularly between November and March, contributing to seasonal fluctuations in hospital admissions (Dewi et al., 2022).

A substantial proportion of patients without comorbidities experienced shorter hospital stays, with 68.4% discharged within fewer than seven days, which is consistent with evidence indicating that short-course antibiotic therapy (5–7 days) is sufficient and yields comparable clinical outcomes to longer regimens in uncomplicated pediatric and community-acquired pneumonia (Rebecca G et al., 2020). In contrast, longer hospitalizations were more frequently associated with the presence of comorbidities or

greater disease severity. Although health insurance type (BPJS) was recorded and descriptively presented, it was not included in the bivariate analysis because this study focused on clinical determinants of length of stay; nevertheless, the potential influence of insurance-related policies on hospitalization duration warrants further investigation.

3.2 Antibiotic Utilization Profile

Table 2 provides an overview of antibiotic utilization patterns among pediatric and adult patients, including the type of therapy administered (single-agent or combination), the distribution of each regimen, and the route of administration.

Table 2. Antibiotic utilization profile in pediatric and adult patients

Variable	Number (n)	Percentage (%)
Type of Antibiotic Use		
Single	105	78.36
Combination	29	21.64
Distribution of Antibiotic Use		
Single Therapy		
Ceftriaxone	55	53.40
Cefotaxime	28	27.18
Gentamicin	8	7.77
Cefixime	4	3.88
Azithromycin	4	3.88
Meropenem	3	2.91
Ceftazidime	1	0.97
Combination Therapy		
Cefotaxime + Gentamicin	11	33.33
Ceftriaxone + Gentamicin	9	27.27
Ampicillin + Sulbactam	4	12.12
Cefotaxime + Azithromycin	3	9.09
Gentamicin + Meropenem	3	9.09
Ceftriaxone + Meropenem	1	3.03
Ceftriaxone + Azithromycin	1	3.03
Ceftriaxone + Metronidazole	1	3.03
Route of Administration		
Intravenous	150	93.75
Oral	10	6.25

The findings of this study indicate that all hospitalized pneumonia patients received empirical antibiotic therapy, reflecting the absence of sputum or blood culture examinations to establish an etiological diagnosis, primarily due to limitations in laboratory capacity and human resources. This practice is consistent with previous reports from RSUD Dr. Soetomo, where empirical antibiotic prescribing was also universally applied to pneumonia patients under similar diagnostic constraints (Aryani et al., 2017), and is in line with national and international pneumonia treatment algorithms that recommend prompt empirical therapy for hospitalized patients when microbiological confirmation is unavailable.

Analysis of prescribing patterns showed that monotherapy predominated (78.36%), while combination therapy accounted for 21.64% of prescriptions. Ceftriaxone was the most frequently prescribed single agent (53.40%), followed by cefotaxime (27.18%) and gentamicin (7.77%), whereas the most common combination regimens were cefotaxime–gentamicin (33.33%) and ceftriaxone–gentamicin (27.27%), with most antibiotics administered intravenously. This pattern is concordant with pneumonia management guidelines, which recommend parenteral beta-lactam antibiotics, particularly third-generation cephalosporins, as first-line empirical therapy for hospitalized patients with non-severe to moderate community-acquired pneumonia, and endorse the addition of an aminoglycoside in selected cases with more severe clinical presentations or suspected Gram-negative involvement. Similar prescribing trends have been reported in pediatric pneumonia cases in East Kolaka, where cefotaxime–gentamicin was also the predominant combination therapy (M. Rahmat Masdin et al., 2025).

Economic evidence supports these prescribing patterns, as ceftriaxone has been identified as the most cost-effective monotherapy and the ceftriaxone–gentamicin combination as the most cost-effective regimen for pneumonia management (Amrina et al., 2025). The frequent use of ceftriaxone and cefotaxime reflects their broad-spectrum activity, favorable safety profile, and guideline recommendations as first-line empirical agents. However, caution remains necessary, particularly in neonates, due to the high protein-binding capacity of ceftriaxone and rare adverse effects such as nephrolithiasis in pediatric patients (Midhun et al., 2024), underscoring the continued importance of antimicrobial stewardship.

3.3 Compliance of Antibiotic Use With the Hospital Formulary

Table 3 presents data on the alignment of prescribed antibiotics with the hospital formulary, offering an overview of the distribution of compliant and non-compliant antibiotic use based on drug type, formulation, and dosage strength.

Table 3. Compliance of antibiotic prescribing with the hospital formulary

Antibiotic Class	Generic Name	Dosage Form and Strength	Number of Uses (n)	Percentage (%)	Compliance
Macrolides	Azithromycin	Tablet (500 mg)	5	2.9	√
Third-Generation Cephalosporins	Cefixime	Capsule (100 mg) Capsule (200 mg) Syrup (100 mg/5 ml)	1	0.6	√
	Cefotaxime	Injection (1 gram vial)	47	27.6	√
	Ceftrazidime	Injection (0,5 gram) Injection (1 gram vial)	1	0.6	√
	Ceftriaxone	Injection (1 gram vial)	69	40.6	√
Aminoglycosides	Gentamicin	Injection (40 mg/ml)	36	21.2	√
Carbapenems	Meropenem	Injection (500 mg)	6	3.5	√
Imidazole Derivatives	Metronidazole	Tablet (500 mg)	1	0.6	√
Penicillin & Beta-lactamase Inhibitor Combination	Ampicillin-Sulbactam	-	4	2.4	x
Compliance with the Hospital Formulary					**97,6%**

Overall, 97.6% of antibiotic prescriptions were consistent with the hospital formulary, indicating strong adherence to internal pneumonia treatment guidelines and supporting rational, effective, and cost-efficient therapy. High formulary compliance is essential to limit unnecessary costs and reduce the risk of antimicrobial resistance, as emphasized by the Kementerian Kesehatan RI (2016), and is consistent with findings from RS DKT Kediri (Prasetyo and Kusumaratni, 2018). Nevertheless, ongoing optimization of antibiotic selection remains necessary in line with resistance risks and antimicrobial stewardship priorities.

3.4 Calculation of DDD per 100 Patient-Days in Pediatric and Adult Patients

Table 4. Calculation of DDD per 100 patient-days in pediatric and adult groups

No	Antibiotics	Route	ATC Code	WHO DDD (g)	DDD/100 Patient-Days	
					Anak	Dewasa
1	Ceftriaxone	P	J01DD04	2	19,53	98,00
2	Gentamicin	P	J01GB03	0,2	6,54	-
3	Cefotaxime	P	J01DD01	4	5,91	0,58
4	Azithromycin	P	J01FA10	0,5	3,54	-
5	Meropenem	P	J01DH02	3	1,18	-
6	Metronidazole	P	J01XD01	1,5	1,15	6,15
7	Azithromycin	O	J01FA10	0,3	-	15,38
8	Cefixime	O	J01DD08	0,4	1,12	-
9	Ceftazidime	P	J01DD02	4	-	1,15
10	Ampicillin-Sulbactam	P	J01CR01	6	0,3	-
Total					**39,27**	**121,26**

Table 4 presents the calculated DDD values for pediatric and adult pneumonia patients.The results demonstrate that ceftriaxone was the most frequently administered antibiotic across both age groups. In pediatric patients, total usage reached 1,953.31 grams, corresponding to 19.53 DDD per 100 patient-days, while in adults, ceftriaxone use amounted to 9,800 grams with a value of 98.00 DDD per 100 patient-days. Gentamicin ranked second among pediatric prescriptions, with a total consumption of 653.67 grams and 6.54 DDD per 100 patient-days, followed by cefotaxime at 590.92 grams and 5.91 DDD per 100 patient-days. In adult patients, metronidazole showed comparatively higher utilization, reaching 615.38 grams and 6.15 DDD per 100 patient-days. With the exception of oral azithromycin administered in adult cases, all antibiotics were prescribed via the parenteral route.

Ceftriaxone use of 19.53 DDD per 100 patient-days in pediatric patients and 98.00 DDD per 100 patient-days in adults indicates that within every 100 hospitalization days, consumption was equivalent to 19.53 g and 98 g of standard dosing, respectively. When compared with the total antibiotic utilization of 39.27 DDD per 100 patient-days in children and 121.26 DDD per 100 patient-days in adults, ceftriaxone accounted for 49.7% of pediatric prescriptions and 80.8% of adult prescriptions. It is important to note that DDD values represent consumption quantity rather than appropriateness or clinical quality; therefore, high consumption should be interpreted with caution. The marked predominance of ceftriaxone, which falls into the WHO AWaRe WATCH category, suggests a heightened risk of antimicrobial resistance if its use is not carefully regulated. These findings further emphasize the importance of implementing strong Antimicrobial Stewardship Programs (ASP) to promote rational antibiotic prescribing and ensure alignment with evidence-based clinical guidelines.

3.5 DU90% Profile Analysis in Pediatric and Adult Patients

Tables 5 and 6 present the calculated Drug Utilization (DU) 90% profiles for both pediatric and adult patient groups.

Table 5. DU90% profile calculation for pediatric patients

No	Generic Name	Route	ATC Code	DDD Total (g)	DDD/100 Patient-days	WHO DDD/100 Patient-days	Percentage (%)	Cumulative Percentage (%)	DU Segment
1	Ceftriaxone	P	J01DD04	1953,31	19,53	2	49,74	49,74	
2	Gentamisin	P	J01GB03	653,67	6,54	0,2	16,65	66,39	90%
3	Cefotaxime	P	J01DD01	590,92	5,91	4	15,05	81,44	
4	Azithromycin	P	J01FA10	353,51	3,54	0,5	9,00	90,44	
5	Meropenem	P	J01DH02	118,16	1,18	3	3,01	93,45	
6	Metronidazole	P	J01XD01	115,27	1,15	1,5	2,94	96,39	
7	Cefixime	P	J01DD08	111,67	1,12	0,4	2,84	99,23	10%
8	Ampicillin-Sulbactam	P	J01CR01	30,36	0,3	6	0,77	100,00	

Table 6. DU90% profile calculation for adult patients

No	Generic Name	Route	ATC Code	DDD Total (g)	DDD/100 Patient-days	WHO DDD/100 Patient-days	Percentage (%)	Cumulative Percentage (%)	DU Segment
1	Ceftriaxone	P	J01DD04	9800	98,00	200	85,13	85,13	90%
2	Azithromycin	O	J01FA10	923,08	15,38	30	8,02	93,15	
3	Metronidazole	P	J01XD01	615,38	6,15	150	5,35	98,50	
4	Ceftazidime	P	J01DD02	115,38	1,15	400	1,00	99,50	10%
5	Cefotaxime	P	J01DD01	57,69	0,58	400	0,50	100,00	

The DU90% analysis revealed that four antibiotics formed the DU90% segment in the pediatric group, namely ceftriaxone (49.74%), gentamicin (16.65%), cefotaxime (15.05%), and azithromycin (9.00%), yielding a cumulative proportion of 90.44%. In contrast, only two antibiotics comprised the DU90% segment in the adult group: ceftriaxone (85.13%) and azithromycin (8.02%), with a cumulative total of 93.15%. These findings demonstrate a strong predominance of broad-spectrum agents, particularly third-generation cephalosporins, across both age categories.

A narrow DU90% pattern, such as the one observed in this study, indicates that the majority of antibiotic therapy is concentrated on a small number of agents that account for up to 90% of total use. This limited therapeutic diversity can intensify selective pressure on microorganisms toward the most frequently prescribed antibiotics, thereby increasing the likelihood of antimicrobial resistance (Thomas et al., 2022; Nunes et al., 2022). While such prescribing patterns are commonly seen in healthcare settings with restricted formularies, a narrow DU90% zone warrants careful monitoring. Strengthening antibiotic oversight policies is essential to maintain rational prescribing and ensure antibiotics are used only when clinically justified (Kulkarni et al., 2016; Nasution et al., 2023).

Based on the WHO AWaRe classification, ceftriaxone is included in the Watch group, while gentamicin and azithromycin belong to the Access category. The high use of Watch-group antibiotics observed in this study has important implications for antimicrobial stewardship, as excessive reliance on broad-spectrum agents increases the risk of antimicrobial resistance and may compromise future treatment effectiveness. Although such prescribing may reflect diagnostic limitations, WHO guidelines emphasize that Watch antibiotics should be used selectively and for well-defined indications. These findings highlight the need to strengthen institutional antimicrobial stewardship policies through AWaRe-oriented prescribing targets, routine audit and feedback, and clinician education to promote rational antibiotic use and support resistance prevention.

3.6 Bivariate Analysis

Table 7 presents the results of the bivariate analysis assessing the influence of age, nutritional status, and comorbidity on the length of hospital stay among pneumonia patients.

Table 7. Bivariate analysis of the association between age, nutritional status, and comorbidity with length of stay (LOS)

Factors	Length of Stay (LOS)		p-value
	≤7 Days	>7 Days	
Age			
Geriatric (>60 years)	3	0	
Non-Geriatric (≤60 years)	82	10	1,000[b]
Presence of Comorbidities			
Present	23	7	0,010[b]
Absent	62	3	
Nutritional Status			
Good	82	9	0,364[b]
Moderate/Poor	3	1	

[b]Fisher's Exact

The analysis revealed that neither age nor nutritional status showed a significant association with length of hospitalization. In contrast, the presence of comorbid conditions was strongly linked to prolonged hospital stay. Patients with comorbidities were more likely to remain hospitalized for more than seven days, whereas most patients without comorbid conditions completed treatment in a shorter period. However, the relatively small sample size limits the robustness of these findings, indicating that further research with a larger study population is needed to validate these observations. These findings are consistent with the results reported by Qalehsari et al. (2017), who observed that underlying health conditions such as cardiac disorders, renal impairment, or diabetes can worsen the clinical course of pneumonia. Such comorbidities increase the likelihood of complications and are associated with extended hospitalization. Therefore, comorbidity emerges as a critical determinant in pneumonia management and should be carefully considered when planning treatment and monitoring patient progress.

This study has several limitations that should be taken into account when interpreting the findings. Incomplete documentation in a portion of medical records led to the exclusion of some cases, which may have introduced selection bias. Additionally, the ATC/DDD methodology has inherent limitations,

as WHO-defined DDD values are standardized for adults, meaning that calculated antibiotic consumption in pediatric patients may not accurately reflect true dosing practices. For this reason, quantitative outcomes particularly within the pediatric subgroup should be interpreted cautiously. To achieve a more comprehensive assessment of prescribing appropriateness, complementary qualitative approaches such as the Gyssens method are recommended alongside quantitative evaluation.

4. CONCLUSION

The quantitative profile of antibiotic use among pediatric and adult pneumonia patients in a hospital in Bima demonstrated a strong predominance of ceftriaxone, a broad-spectrum third-generation cephalosporin. Compliance with the hospital formulary was high (97.6%), with nearly all prescribed antibiotics listed in the 2018 formulary. Total antibiotic consumption reached 39.27 DDD per 100 patient-days in pediatric patients and 121.26 DDD per 100 patient-days in adults, with ceftriaxone accounting for the highest utilization in both groups. The DU90% segment comprised ceftriaxone, gentamicin, cefotaxime, and azithromycin in pediatric patients, while in adults it included ceftriaxone and azithromycin only. Consistent with the preceding discussion, bivariate analysis confirmed a significant association between comorbidities and prolonged length of hospital stay ($p < 0.05$), supporting the observation that patients with underlying conditions required longer treatment durations and more intensive care, which may also contribute to higher antibiotic exposure.

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