# Analysis of the Quality of Antibiotic Use in Pediatric Inpatients with Bronchopneumonia

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## Abstract

Bronchopneumonia is lobular pneumonia characterized by the presence of infected areas with spots approximately 3-4 cm in diameter surrounding and involving the bronchi. Bronchopneumonia is the leading cause of morbidity and mortality in children under five years old globally, with more than 800,000 deaths in 2019. In Indonesia, pneumonia is the leading cause of death during the post-neonatal period, with the infant mortality rate due to pneumonia reaching 0.16% in 2021. Central Java, including the city of Semarang, records a relatively high number of pediatric pneumonia cases, with thousands of cases each year. Data from RS Roemani Muhammadiyah Semarang show a significant increasing trend in pediatric bronchopneumonia cases from 2020 (167 cases) to 2023 (887 cases). Antibiotic therapy is the primary treatment for bronchopneumonia in children. The improper selection of antibiotics can lead to bacterial resistance and high treatment costs due to prolonged hospital stays. The aim of the study is to determine the appropriateness of antibiotic prescriptions using the Geyssens method. Rizky's (2024) research at a private hospital in Semarang shows the inaccuracy in the use of antibiotics in hospitalized pediatric pneumonia patients. Only 39% of patients received antibiotic therapy rationally, while 61% experienced antibiotic administration that was too short. Data collection was conducted retrospectively based on the medical records of inpatients at RS Roemani Muhammadiyah Semarang for the period of April – June 2024. The qualitative analysis of empirical antibiotic prescriptions was evaluated using the Gyssens method. The number of pediatric inpatients with bronchopneumonia who met the inclusion criteria was 109 patients. There were 65 male patients (59.63%) and 44 female patients (40.36%), with the most common age being 2 years old (22%), and the average length of stay was four days. Ceftriaxone is the antibiotic that is frequently used. Evaluation of the appropriateness of prescriptions based on the Gyssens method yielded a total of 146 antibiotic regimens from 109 patients due to the combination of antibiotic use and the replacement of antibiotic therapy during hospitalization. Appropriate antibiotic prescriptions (58.9%) and inappropriate (41.1%).

**Keywords:** bronchopneumonia, accuracy of antibiotic use, Geyssens method.

## 1. INTRODUCTION

Pneumonia is an acute infection of the lung tissue caused by various microorganisms such as bacteria, fungi, and viruses, and it remains a global health issue with high morbidity and mortality rates. Based on anatomy, pneumonia is classified into bronchopneumonia and lobar pneumonia. Bronchopneumonia is characterized by an uneven and scattered pattern of inflammation in the form of patches in more than one lung lobe, while lobar pneumonia causes homogeneous consolidation in one lung lobe filled with exudate (Coutts, 1904).

Bronchopneumonia is one of the global health issues with a high mortality rate, especially in children under five years old. Global data from 2019 recorded more than 800,000 infant deaths due to pneumonia, making it the leading cause of morbidity and mortality in children (Howie dan Murdoch, 2019). In Indonesia, pneumonia ranks as the leading cause of post-neonatal mortality, with a relatively high prevalence of cases in several provinces, including Central Java (Kemenkes RI, 2022). In the city of Semarang, cases of pneumonia in toddlers are quite high, with thousands of cases recorded each year (Dinas Kesehatan Kota Semarang, 2021). Specifically at Roemani Muhammadiyah Hospital Semarang, the number of pediatric broncopneumonia cases has significantly increased from 2020 to 2023, although it slightly decreased in 2024.

Management of pneumonia in children according to the IDAI Medical Service Guidelines 2011 includes the administration of oxygen therapy if saturation is below 92%, antipyretics, analgesics, nebulization, balanced fluids for severe cases, and antibiotics. This therapy aims to reduce symptoms and improve the child's respiratory function. High cases of pediatric bronchopneumonia will lead to increased antibiotic use. The high use of antibiotics requires special attention to prevent resistance and ensure the effectiveness of treatment (IDAI, 2011)

Evaluation of antibiotic use can be conducted quantitatively using the ATC/DDD method and DU 90%, as well as qualitatively using the Gyssens method to assess the appropriateness of indications and the effectiveness of therapy. Irrational use of antibiotics can lead to increased length of hospital stay, treatment costs, and the risk of antibiotic resistance.

Research by Rizky (2024) at a private hospital in Semarang shows that only 39% of patients receive antibiotic therapy rationally, while the other 61% experience an excessively short duration of antibiotic administration. This inaccuracy has the potential to increase the risk of infection recurrence, prolong the duration of hospitalization, and add to the cost burden for patients and healthcare facilities (Rizky et al., 2024).

Based on the aforementioned issues, this study aims to qualitatively evaluate the use of antibiotics in pediatric patients with bronchopneumonia in the inpatient ward of RS Roemani Muhammadiyah using the Gyssens method. It is hoped that the results of this study can provide recommendations to improve the rational use of antibiotics, reduce the incidence of resistance, and decrease the length of hospitalization and treatment costs for patients.

## 2. METHOD

This research method uses a descriptive observational design with a cross-sectional approach, where data is collected at a specific point in time. Data collection was conducted retrospectively through the recording of medical records of pediatric bronchopneumonia patients who were hospitalized at RS Roemani Muhammadiyah Semarang from April to June 2024. The inclusion criteria in this study include pediatric patients aged 0–9 years with a diagnosis of bronchopneumonia (ICD-10: J18.0) who were hospitalized at RS Roemani Muhammadiyah Semarang during the period of April–June 2024. Meanwhile, the exclusion criteria include patients with other infections, patients who discontinue treatment on their own request, and patients who leave against medical advice.

## 3. DATA ANALYSIS

**Patient Characteristics**

The description of the patient's characteristics includes the patient's age and gender:

$$\text{a. Patient's age} = \frac{\text{The number of patients of a certain age}}{\text{Number of patients}} \times 100\%$$

$$\text{b. Male} = \frac{\text{Number of male patients}}{\text{Number of patients}} \times 100\%$$

$$\text{c. Female} = \frac{\text{Number of female patients}}{\text{Number of patients}} \times 100\%$$

**Analysis of Antibiotic Profile Data Based on Percentage**

$$\text{Type of antibiotic} \quad \frac{\text{certain types of antibiotics}}{\text{The number of antibiotic therapy regimens}} \times 100\%$$

**Chi-Square Analysis to Describe the Rationality of Antibiotic Use**

$$\mathcal{X}^2 = \sum_{i=1}^{k} \frac{(0_i - E_i)^2}{E_i}$$

## 4. RESULTS AND DISCUSSION

This study uses a descriptive observational research type with a cross-sectional approach where data collection is conducted simultaneously at one time (Wang dan Cheng, 2020). Data collection was conducted retrospectively by recording data through the E-medical records of pediatric patients with bronchopneumonia at RS Roemani Muhammadiyah Semarang who were hospitalized from April to June 2024. The population in this study consists of all pediatric patients diagnosed with bronchopneumonia who were hospitalized at RS Roemani Muhammadiyah Semarang.The aim of this study is to determine the rational use of antibiotics in pediatric patients with bronchopneumonia in the inpatient ward of RS. Roemani Muhammadiyah from April to June 2024.

Sampling was conducted using the purposive sampling technique, which is part of the nonprobability sampling technique. Nonprobability sampling is a sampling technique that does not give every member of the population an equal chance to be selected as a sample. This technique considers certain criteria to determine the sample, namely inclusion criteria and exclusion criteria (Firmansyah dan Dede, 2022). The population used consists of all pediatric inpatients diagnosed with bronchopneumonia from April to June 2024, totaling 186 patients. The sample that met the inclusion criteria consisted of 109 patients. The research results are divided into 4 parts:

**Patient Characteristics**

### A. Gender

The research results show that out of a total of 109 pediatric bronchopneumonia patients at RS Roemani Muhammadiyah Semarang during the period of April – June 2024, the majority of the patients were male, totaling 65 individuals (59.63%), while the female patients numbered 44 individuals (40.36%). Patient charecteristics based on gender show table 1.

**Table 1. Patient characteristics based on gender**

| No. | Gender | Amount Patient | Percentage |
|---|---|---|---|
| 1. | Male | 65 patient | 59,63% |
| 2. | Female | 44 patient | 40.36% |

These results are similar to previous research by Sangadji et al. (2022), which also showed a higher prevalence in male patients. The higher risk in boys is related to the smaller diameter of their lungs compared to girls, making them more susceptible to respiratory infections (Sangadji

dkk., 2022). Chamekh et al. (2017) revealed that gender differences affect immune vulnerability caused by genetic factors. Males with XY chromosomes have a more vulnerable immune system compared to females with XX chromosomes. This happens because the X chromosome plays a role in the production of Micro RNA, which is important for the immune system. The higher number of X chromosomes in females, which results in more Micro RNA, leads to the conclusion that women's immune systems are stronger against infections compared to men (Chamekh dkk., 2017).

**B. Patient Age**

The research results show that the age distribution of bronchopneumonia patients is dominated by the age group of 1-5 years, peaking at the age of 2 years with 22% of patients. Age factor is one of the main risks in cases of bronchopneumonia, as supported by Kevat's (2022) research, which found that pneumonia occurs more frequently in children aged toddler to 9 years, with the highest prevalence in the 1-5 year age group at 90% (Table 2).

**Table 2. Patient characteristics by age**

| No | Patient Age | Amount Patient | Percentage |
|---|---|---|---|
| 1 | < 1 th | 7 | 6,42% |
| 2 | 1 th | 15 | 13,76% |
| 3 | 2 th | 24 | 22% |
| 4 | 3 th | 21 | 19,3% |
| 5 | 4 th | 21 | 19,27% |
| 6 | 5 th | 11 | 10,1% |
| 7 | 6 th | 5 | 4,6% |
| 8 | 7 th | 3 | 2,75% |
| 9 | 8 th | 2 | 1.8% |

This is due to the child's immune system still developing, so as they get older, the risk of bronchopneumonia decreases (Kevat dkk., 2022). Mambo's research (2023) also shows that 77% of patients aged 0-5 years are at high risk of developing pneumonia due to suboptimal levels of immunoglobulin G (IgG). IgG only reaches optimal levels at the age of 7-8 years, making younger children more susceptible to respiratory tract infections (Mambo dkk., 2023).

**Antibiotic Usage Profile**

The use of antibiotics in the treatment of pediatric inpatient bronchopneumonia includes four main groups, namely third-generation cephalosporins, aminoglycosides, penicillin, and macrolides (Table 3).

**Table 3. Antibiotic Use Profile**

| Name of Antibiotics | Group | Amount | Percentage (%) |
|---|---|---|---|
| Ceftriaxone | Cephalosporin | 66 | 45.2 |
| Cefotaxim | generation 3rd | 25 | 17.1 |
| Cefoperazon | | 3 | 2.1 |
| Sulbactam | | | |
| Cefixime oral | | 1 | 0.7 |
| Amikacin | Aminoglikosida | 3 | 2.1 |
| Gentamicin | | 27 | 18.5 |
| Ampicillin | Penicilin | 9 | 6.2 |
| Ampicilin Sulbactam | | 6 | 4.1 |
| Amoxycyllin oral | | 4 | 2.7 |
| Azithromycin oral | Macrolide | 2 | 1.4 |
| | **Total** | 146 | 100 |

Ceftriaxone is a third-generation cephalosporin, becoming the most widely used antibiotic with a percentage of 45.2%. Ceftriaxone is in accordance with the IDAI Medical Service Guidelines (IDAI, 2011). The effectiveness of ceftriaxone is supported by the microbial map data from RS Roemani Muhammadiyah Semarang (2022), which shows its sensitivity to pneumonia-causing bacteria in the pediatric ward. These results are consistent with the study by Rukminingsih and Apriliyani (2021) at RS Elisabeth Semarang, which reported that ceftriaxone is the most commonly used antibiotic for pediatric pneumonia with a percentage of 83.1% (Rukminingsih dan Mangunwijaya, 2021). Ceftriaxone is used as empirical antibiotic therapy for various infections, including bloodstream infections, pneumonia, bacterial meningitis, and lower respiratory tract infections caused by bacteria such as Streptococcus pneumoniae, Klebsiella pneumoniae, and Staphylococcus aureus. The mechanism of action is time-dependent, with maximal effectiveness when the drug's plasma concentration is above the minimum inhibitory concentration for more than 60-70% of the dosing interval (Eldougdoug dkk., 2023).

**The Rationality of Antibiotic Use**

The qualitative evaluation of antibiotic use aims to determine rational and prudent antibiotic use (Kemenkes RI, 2015). Rationality of antibiotic use by Chi-Square Test (Table 4).

**Table 4. Rationality of antibiotic use by Chi-Square Test**

| Antibiotic Status | Amount of Data | | Total | p-VALUE |
|---|---|---|---|---|
| | N | % | | |
| Rational | 86 | 58,9 | 146 | 0.00* |
| Irrational | 60 | 41,1 | | |

The evaluation using the Gyssens flowchart is conducted by categorizing each antibiotic administration into 6 categories, namely category VI (inappropriate use due to incomplete medical records), category V (inappropriate use due to non-indication), category IVa (inappropriate use because there are other more effective antibiotics), category IVb (inappropriate use because there are other safer antibiotics), category IVc (inappropriate use because there are other cheaper antibiotics), category IVd (inappropriate use because there are other antibiotics with a narrower or more specific spectrum), category IIIa (inappropriate use because the administration duration is too long), category IIIb (inappropriate use because the administration duration is too short), category IIa (inappropriate use due to incorrect dosage), category IIb (inappropriate use due to incorrect administration interval), category IIc (inappropriate use due to incorrect administration method), and category I (incorrect administration timing), while 0 indicates appropriate and rational antibiotic use (not included in categories I to VI) (Kemenkes RI, 2015).

Based on the table above, a p-value of 0.00 was obtained. The value 0.00 < 0.05 (p-value < 0.05) means reject H0 and accept H1, indicating a difference in the proportion of rationality among antibiotics. When looking at the total table of tested antibiotics, there are 146 samples, and antibiotics with a rational status are clearly more numerous than those with an irrational status. There are 86 antibiotics with a Rational status and 60 antibiotics with an Irrational status.

**Table 5. Distribution of Antibiotic Status in Pediatric Bronchopneumonia Patients in the Inpatient from April to June 2024**

| Antibiotic Status | Amnount Data | |
|---|---|---|
| | N | % |
| **Rational** | | |
| 0 | 86 | 58,9 |
| **Irrational** | | |
| III b | 24 | 16,44 |
| IV a | 36 | 24,66 |
| **Total** | **146** | **100** |

Antibiotics with an irrational status are distributed in category III b with 24 (16.44%), and category IV a with 36 (24.66%). The antibiotics that fall into category IV a are amikacin inj, gentamicin inj, cefoperazone sulbactam, ampicillin sulbactam, amoxicillin oral, and azithromycin oral. Amikacin is used for pediatric pneumonia with severe infections that are already resistant to gentamicin. Muharni's (2020) research at one of the hospitals in Riau Province showed that 14 patients with severe pneumonia, 5 patients with moderate pneumonia, and 1 patient with mild pneumonia were given amikacin injection therapy. Observation for 48 hours after the administration of amikacin injection showed that patients with severe pneumonia experienced improvement in breathing / reduced shortness of breath (Muharni dkk., 2020).

Gentamycin falls into category IV A because it is combined with ceftriaxone or cefotaxime. Based on the management of pediatric pneumonia by IDAI, the first line is a combination of ampicillin and gentamicin, and the second line is monotherapy with ceftriaxone injection and monotherapy with cefotaxime injection (IDAI, 2011). Cefoperazone sulbactam falls into category IVA because it is a third-generation cephalosporin group intended for pediatric pneumonia with Multidrug-Resistant bacteria when combined with meropenem injection (Lin et al., 2021). Ampicillin sulbactam is indicated for atypical pneumonia caused by the bacterium *Acinetobacter baumannii.* Ampicillin sulbactam at a dose of 3 g every 6 hours is effective in killing the bacterium *Acinetobacter baumannii* (Onita dkk., 2023).

Ampicillin sulbactam therapy according to Permenkes No. 28 of 2021 is used for community-acquired pneumonia in children without Pseudomonas infection factors with ICU hospitalization (Kemenkes, 2021). The patient received oral azithromycin therapy, which falls into category IV A, because the patient received oral azithromycin after a combination therapy of ampicillin and gentamicin for 4 days. The patient is 2 years old, so it is less appropriate to administer oral macrolides. According to the IDAI pneumonia management guidelines (2011), macrolide antibiotics can be administered to patients over 5 years old suspected of Mycoplasma Pneumoniae infection (IDAI, 2011). Amoxicillin pulv therapy falls into category IV a because it is administered together with ceftriaxone injection for 3 days. The patient had complaints of vomiting, making the administration of oral therapy less effective. According to the management of pediatric pneumonia by IDAI (2011), injectable ceftriaxone therapy is recommended for patients who cannot receive oral preparations (IDAI, 2011). Oral cefixime therapy is given after two days of ceftriaxone injection. Cefixime falls into category IV a because it is less effective as an empirical antibiotic for pediatric bronchopneumonia. Cefixime is a third-generation cephalosporin commonly used for the treatment of

various infections in children, with broad-spectrum antibacterial activity and a relatively long elimination half-life (Tamur, 2024).

The administration of antibiotic therapy in category III B averages less than 3 days. Based on the journal (Kuitunen and Renko, 2024), the administration of antibiotics for pneumonia cases for 3-5 days is as effective as a 7-10 day treatment in killing bacteria (Kuitunen dan Renko, 2024). According to the clinical practice guidelines for pediatric bronchopneumonia at RS Roemani in 2022, antibiotics are administered for 3 - 5 days. Ikawati's research (2023) states that the administration of empirical antibiotics should be at least 72 hours; if it is less than 72 hours, there is a risk of antibiotic resistance because the bacteria have not been completely eradicated (Ikawati, 2023).

## 5. CONCLUSION

From the research results, it can be concluded that the rational use of antibiotics in category 0 is 86 regimens or 58.9%. The use of irrational antibiotics was 60 regimens or 41.1%. The irrational use of antibiotics is indicated in categories IV A and III B. The percentage of antibiotic use in category IV A (inappropriate choice of antibiotic because there are other more effective antibiotics) is 24.66%. The percentage of irrational antibiotic use in category III B (antibiotic administration too short) is 16.44%. The administration of ceftriaxone, cefotaxime, and the combination of ampicillin and gentamicin is the appropriate therapy for pediatric bronchopneumonia.

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