Farmasains: Jurnal Ilmiah Ilmu Kefarmasian
Volume 12, Number 2, 2025, 86-94
ISSN:2621-9816 (Online); 2086-6968 (Print)
Journal homepage: https://journal.uhamka.ac.id/i\ndex.php/farmasains/

Research Article

Application of the ATC/DDD Method in Analysing Inpatient Antibiotic Use at Chasan Boesoirie Ternate Hospital

Penerapan Metode ATC/DDD dalam Analisis Penggunaan Antibiotik Pasien Rawat Inap di RSUD Chasan Boesoirie Ternate

Muhammad Subhan A. Sibadu*, Siti Marita Umaternate, Ismail Rahman

Prodi Farmasi, Fakultas Kedokteran dan Ilmu Kesehatan, Universitas Khairun, Ternate, Maluku Utara, 97719, Indonesia

Received:
February 9, 2025

Reviewed:
July 10, 2025

Accepted:
August 27, 2025

Published:
October 30, 2025

*Corresponding Author:
muhammadsubhan@unkhair.ac.id

ABSTRACT

The irrational use of antibiotics has the potential to increase the risk of bacterial resistance. Quantitative approaches, such as the Defined Daily Dose (DDD) method, can be utilised to evaluate the types and volumes of antibiotics consumed. The purpose of this study was to analyse the use of antibiotics at Dr H. Chasan Boesoirie (RSCB) Ternate Hospital in 2024 using the DDD approach. The research employed an observational approach using medical record data from RSCB, with a population of 1,300 during 2024. The inclusion criteria were inpatients diagnosed with bacterial infections, receiving antibiotic therapy, having clear and complete medical record data, aged over 18 years up to 65 years, and with a discharge status of “permitted” or “improved.” Study showed that the most widely used antibiotics were ceftriaxone, with a value of 45.7 DDD/100 patient-days of care, and ciprofloxacin 0.5 DDD/100 patient-days of care. The total DDD of all antibiotics was 61.7 DDD/100 patient-days of care. The 90% Drug Use (DU) segment was ceftriaxone with a value of 73.6, and the highest 10% DU was metronidazole at 9%. In conclusion, the antibiotic with the highest DDD value was ceftriaxone (45.7 DDD/100 patient-days), while the lowest was ciprofloxacin (0.1 DDD/100 patient-days).

Keywords: Antibiotics, DDD, Evaluation, Usage, 90% DU

ABSTRAK

Penggunaan antibiotik yang tidak rasional berpotensi meningkatkan risiko resistensi bakteri. Pendekatan kuantitatif, seperti metode Defined Daily Dose (DDD), dapat digunakan untuk mengevaluasi jenis dan volume antibiotik yang dikonsumsi. Tujuan penelitian ini untuk menganalisis penggunaan antibiotik di Rumah Sakit Dr H. Chasan Boesoirie (RSCB) Ternate tahun 2024 dengan pendekatan DDD. Penelitian ini menggunakan pendekatan observasional dengan menggunakan data rekam medis RSCB yang berjumlah 1.300 pasien pada tahun 2024. Kriteria inklusi adalah pasien rawat inap yang didiagnosis infeksi bakteri, sedang menjalani terapi antibiotik, memiliki data rekam medis yang jelas dan lengkap, berumur 18->65 tahun, dan berstatus pulang “diizinkan” atau “membaik”. Hasil penelitian menunujukkan antibiotik yang paling banyak digunakan adalah seftriakson dengan nilai 45,7 DDD/100 hari perawatan pasien, dan siprofloksasin 0,5 DDD/100 hari perawatan pasien. Total DDD seluruh antibiotik adalah 61,7 DDD/100 hari perawatan

pasien. Segmen Penggunaan Obat (DU) 90% adalah ceftriaxone dengan nilai 73,6, dan DU 10% tertinggi adalah metronidazol dengan nilai 9%. Kesimpulannya, antibiotik dengan nilai DDD tertinggi adalah seftriakson (45,7 DDD/100 hari perawatan pasien), sedangkan yang terendah adalah siprofloksasin (0,1 DDD/100 hari perawatan pasien).

Kata Kunci: *Antibiotik, DDD, DU 90%, Evaluasi, Penggunaan*

INTRODUCTION

Indonesia is a country with a relatively high prevalence of infectious diseases. The increasing number of infection cases has consequently led to a rise in the use of antibiotic (1). Infection is defined as the process by which an infectious agent (bacteria, viruses, fungi, or parasites) enters and multiplies within the human body (2). In managing infectious diseases, antibiotic therapy is often the primary treatment option (3). Antibiotics are antimicrobial agents specifically used to treat bacterial infections. Their mechanisms of action can be classified as either bactericidal, which kills bacteria, or bacteriostatic, which inhibit bacterial growth. In Indonesia, as in many other countries, the prevalence of antibiotic use without a medical prescription continues to rise, thereby contributing to the increased risk of antimicrobial resistance (4,5).

Antibiotic resistance is a condition in which bacteria can no longer be killed or inhibited by antibiotics (6). The World Health Organization (WHO) has undertaken various efforts to address antibiotic resistance at the global level by formulating a Global Action Plan, one of whose main focuses is to promote the prudent use of antibiotics and to evaluate their utilisation (7).

One of the ways to assess the rationality of antibiotic use is by evaluating the appropriateness of antibiotic administration (8). Drug Use Evaluation (DUE) is part of the pharmaceutical care standards in hospitals, as stipulated in the Regulation of the Minister of Health of the Republic of Indonesia No. 72 of 2016 concerning Standards for Pharmaceutical Services in Hospitals (9). The evaluation of antibiotic use can be conducted through two main approaches: a quantitative evaluation using the Anatomical Therapeutic Chemical/Defined Daily Dose (ATC/DDD) method, and a qualitative evaluation employing the Gyssens method. The quantitative approach can also be carried out using the Drug Use (DU) 90% method, which is based on drug classification according to the ATC system and DDD. The DDD is defined as the estimated average maintenance dose per day for a drug used for its main indication in adults (10). The ATC/DDD and DU 90% methods are standardised methodologies developed by the WHO (11). These methods allow the identification of the types and quantities of antibiotics used, thereby serving as a basis for assessing the rationality of their utilisation (12,13).

A similar study was conducted by Sitepu *et al.,* (2020) in Sampang Regency, aiming to evaluate the pattern of antibiotic use through the ATC/DDD, Prescribed Daily Dose (PDD), and Drug Use (DU) 90% approaches. The results of the study showed that, in cases of non-pneumonia Acute Respiratory Infections (ARI), amoxicillin 500 mg had the highest DDD value, at 2.063 DDD per 1,000 inhabitants, followed by ciprofloxacin 500 mg with 2.061 DDD per 1,000 inhabitants. Meanwhile, based on the PDD evaluation, the consumption of amoxicillin 500 mg was recorded at 1.358 grams, and cefadroxil 500 mg at 1.167 grams.

Based on the aforementioned explanation, the quantitative evaluation approach using the DDD method is considered an important initial step in assessing and improving the rational use of antibiotics. However, the application of this method remains limited at Dr H. Chasan Boesoirie Hospital (RSCB) in Ternate. Therefore, this study aimed to quantitatively evaluate the use of antibiotics among inpatients at RSCB. The findings are expected to provide an overview of antibiotic use patterns to support efforts to prevent antibiotic resistance.

METHODS

Study Period and Location

This study was conducted from January to February 2025 at the Medical Records Department of Dr H. Chasan Boesoirie Hospital (RSCB) in Ternate.

Type and Design of Study

This study employed an observational design with a retrospective approach, whereby data were collected through a review of medical records of inpatients diagnosed with bacterial infections at RSCB Ternate in 2024. Ethical approval for this study was obtained from the Research Ethics Committee of the Faculty of Medicine and Health Sciences, Khairun University, Ternate, under approval No. 019/UN44/C.9/KEP/2025.

Population, Sample, and Inclusion–Exclusion Criteria

This study involved all inpatients diagnosed with bacterial infections at RSCB Ternate in 2024, with a total population of 1,300 patients. The research sample comprised inpatients who met the inclusion criteria, namely those diagnosed with bacterial infections and possessing complete medical records of antibiotic use during the 2024 period. The inclusion criteria were as follows: inpatients diagnosed with bacterial infectious diseases, receiving antibiotic therapy classified under the ATC system, having clear and complete medical record data (including name, age, sex, date of admission, date of discharge, Length of Stay (LoS), duration of antibiotic use, antibiotic dosage, and quantity), adults (aged 18-65 years), and discharged in an improvement or recovered condition. The exclusion criteria were patients who left the hospital against medical advice or who died during treatment.

Sampling Technique

A purposive sampling technique was employed, which is a non-probability method where sample selection is based on specific criteria or considerations determined by the researcher to achieve the study objectives more accurately (14). The number of samples was then calculated using the Slovin formula, as follows:

$$n = \frac{N}{1+N\,(e)^2}$$

$$n = \frac{1{,}300}{1+1{,}300\,(0.1)^2}$$

$$n = \frac{1{,}300}{14} = 92.9 \approx 93 \text{ samples}$$

Description:

n : Number of samples
N : Total population
e : Margin of error (e = 0.1 or 10%)

Data Analysis

DDD

DDD refers to the assumed average maintenance dose per day for a drug used for its main therapeutic indication in adults. The DDD system is applicable only to medicines that have been classified and assigned an ATC code (15).

Data were collected from patient medical records and processed using Microsoft Excel software. Study subjects were identified based on the predetermined inclusion criteria. The collected data were then analysed using the DDD calculation method. Information regarding ATC codes and DDD values for each antibiotic was obtained from the official WHO website (https://www.whocc.no/atc_ddd_index/). Antibiotic consumption among patients was calculated using the following formula (1,16):

$$\text{DDD/100 patient-days} = \frac{\text{Total amount of antibiotic used (g)}}{\text{WHO DDD (g)}} \times \frac{100}{\text{(Total LoS)}}$$

DU 90%

The DU 90% method is applied to determine the group of antibiotics most frequently utilised by ranking antibiotics from the highest to the lowest DDD value and cumulatively summing the percentages

until a 90% threshold is achieved. The combination of DDD and DU 90% methods enables the identification of antibiotic groups with the highest frequency of use in the hospital. Moreover, this method serves as a benchmark for assessing the rationality of prescribing practices and compliance with the hospital formulary and treatment guidelines (17). The calculation formula is as follows:

$$\text{DU 90\%} = \frac{\text{DDD/100 patient-days}}{\text{Total DDD/100 patient-days}} \times 100$$

RESULTS

Patient Demographics

The characteristics of the study population were categorised according to sex, age, and length of hospital stay. The age variable was grouped into six age ranges (18). For the length of hospital stay, the variable was divided into four categories (12). The details of each characteristic are presented in **Table 1**.

Table 1. Patient Demographic Data

Patient Demographics	Frequency (n=93)	Percentage (%)
Sex		
Male	37	40
Female	56	60
Age (Years)		
18-26	19	20
27-35	11	12
36-45	14	15
46-55	17	18
56-65	21	23
>65	11	12
Length of Hospital Stay (Days)		
≤3	15	19
4-6	50	54
7-14	28	28
≥15	2	2

Characteristics of Bacterial Infectious Disease Patterns

The characteristics based on bacterial infectious disease patterns among inpatients at RSCB are presented in **Table 2**.

Table 2. Characteristics of Disease Patterns

Disease	Frequency (n=93)	Percentage (%)
Pneumonia	34	37
Urinary Tract Infection (UTI)	17	18
Pulmonary Tuberculosis (TB)	16	17
Acute Gastritis (AG)	14	15
Septicaemia	12	13

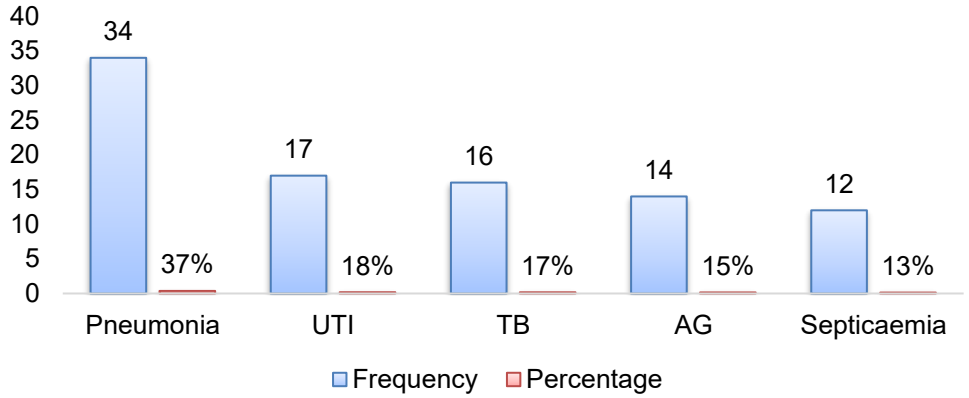

Figure 1. Diagram of bacterial infectious disease pattern characteristics

Characteristics of Antibiotic Prescription Patterns

The characteristics based on antibiotic prescription patterns among inpatients at RSCB are presented in **Table 3**.

Table 3. Characteristics Based on Antibiotic Prescription Patterns

ATC Code	Antibiotic Class	Type of Antibiotic	Frequency (n=93)	Percentage (%)
J01DD04	Cephalosporins	Ceftriaxone	61	66
J01MA12	Quinolones	Levofloxacin	12	13
J01XD01	Imidazole Derivatives	Metronidazole	6	7
J01DD08	Cephalosporins	Cefixime	4	4
J01MA14	Quinolones	Moxifloxacin	4	4
J01EE04	Sulphonamides	Cotrimoxazole	3	3
J01MA02	Quinolones	Ciprofloxacin	2	2
J01DH02	Carbapenems	Meropenem	1	1

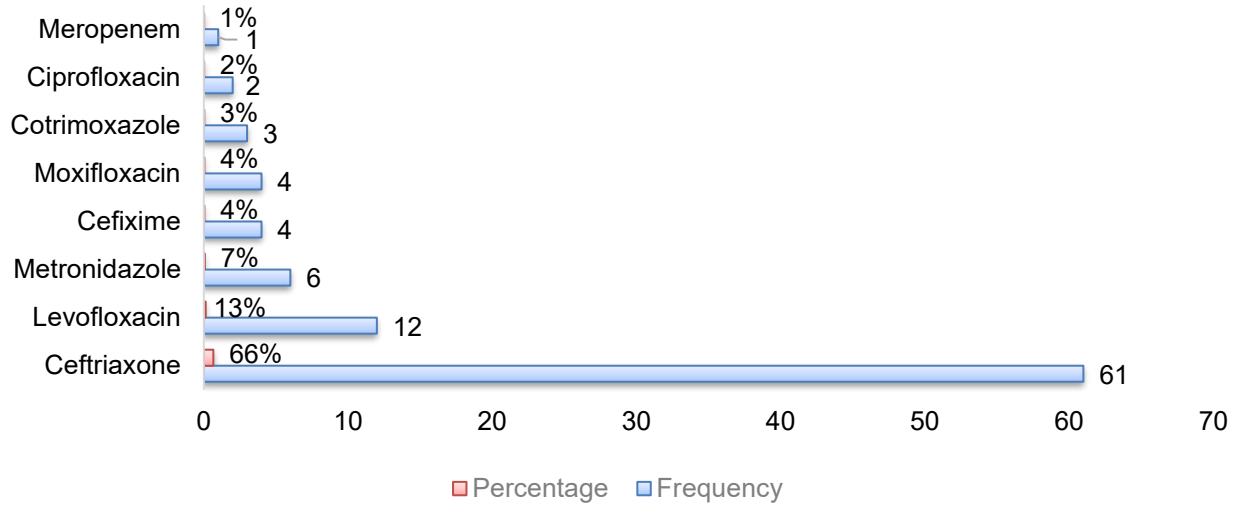

Figure 2. Diagram of characteristics based on antibiotic prescription pattern

Results of DDD Method Analysis

The data obtained were analysed using the WHO Collaborating Centre-recommended formula to calculate antibiotic use. The quantification results are expressed in units of DDD/100 patient-days and are presented in **Table 4**. After calculating the DDD values, the antibiotics were ranked from highest to lowest use and classified into DU 90% segments, as shown in **Table 5**.

Table 4. DDD/100 Patient-Days Values for Antibiotic Use

ATC Code	Type of Antibiotic	Route of Administration	WHO DDD	Total Amount of Antibiotic (g)	Total LoS	DDD/100 Patient-days
J01DD04	Ceftriaxone	IV	2	512	560	45.7
J01MA14	Moxifloxacin	IV	0.4	9.2		4.1
J01MA12	Levofloxacin	IV	0.5	12.5		4.4
J01XD01	Metronidazole	IV	1.5	47.7		5.6
J01DH02	Meropenem	IV	3	6		0.3
J01DD08	Cefixime	O	0.4	2.4		1.1
J01EE04	Cotrimoxazole	O	4	9.6		0.4
J01MA02	Ciprofloxacin	O	1	1		0.1
Total						**61.7**

Note: IV = Intravenous; O = Oral

Table 5. DU 90% Segmentation

ATC Code	Type of Antibiotic	Route of Administration	DDD/100 Patient-days	% DU	DU 90% Segment
J01DD04	Ceftriaxone	IV	45.7	74	90
J01XD01	Metronidazole	IV	5.6	9	
J01MA12	Levofloxacin	IV	4.4	7.1	
J01MA14	Moxifloxacin	IV	4.1	6.6	
J01DD08	Cefixime	O	1.1	1.7	10
J01EE04	Cotrimoxazole	O	0.4	0.6	
J01DH02	Meropenem	IV	0.3	0.4	
J01MA02	Ciprofloxacin	O	0.1	0.1	

Note: IV = Intravenous; O = Oral

DISCUSSION

Patient Characteristics

The characteristics of patients based on sex showed that the female group was predominant, with 56 patients (60%), while the male group comprised 37 patients (40%). Based on age distribution, patients were classified into six groups: 56-65 years (21 patients; 23%), followed by 18-26 years (19 patients; 20%), 46-55 years (17 patients; 18%), 36-45 years (14 patients; 15%), and both 27-35 years and >65 years with 11 patients each (12%). Meanwhile, the length of hospital stay was divided into four categories: <3 days (15 patients; 19%), 4-6 days (50 patients; 54%), 7-14 days (26 patients; 28%), and >15 days (2 patients; 2%) (**Table 1**).

Based on the demographic characteristics of the patients, the sex distribution in this study was consistent with the findings reported by Hanifah *et al.,* (2022) at a private hospital in Bandung, which also showed a higher proportion of female patients, namely 300 patients (57.47%) compared to 222 male patients (42.53%). Women are known to be at greater risk of developing health problems, such as acute gastritis, which was the most prevalent case in this study. This may be associated with women's greater concern for body image, which can lead to dietary behaviours that deviate from balanced nutrition principles, thereby adversely affecting gastric health. Other contributing factors more commonly found among women include the consumption of unhealthy foods and beverages, meal skipping habits, and relatively higher stress levels (20). Furthermore, the prevalence of Urinary Tract Infection (UTI) is also higher among women, due to the anatomical characteristics of the urogenital tract, which increase susceptibility to contamination by pathogenic microorganisms, particularly during menstruation, when the risk of infection is elevated (21).

The analysis of age characteristics showed that the 56-65-year age group was the most dominant, with 21 patients (23%). This finding is consistent with the study by Basuki & Mayasari (2024) at Yogyakarta City General Hospital, which reported that the 56-65-year age group had the highest number of patients, namely 1,558 (48.5%). This trend can be explained by the physiological decline that occurs with ageing, as individuals tend to experience reduced physical function and become more

susceptible to various infectious diseases due to a weakened immune system. In addition, older adults generally engage in lower levels of physical activity, which further decreases endurance and overall immunity as age advances (18).

The characteristic analysis based on the length of hospital stay showed that the most common duration was within the 4-6 day category, with 50 patients (56%). This result is in line with the findings of Putri *et al.*, (2023) at the University of Mataram Hospital in 2021, where the majority of patients (59 patients, 46.28%) were also hospitalised for 4-6 days. The LoS parameter is an important indicator used to evaluate antibiotic utilisation, expressed in DDD/100 patient-days (12). According to the Indonesian Ministry of Health (2011), analysing hospital stay duration provides valuable information on operational efficiency and the quality of healthcare services, with the optimal average LoS typically ranging between 6-9 days (24).

Characteristics Based on Disease Patterns

Based on the disease pattern characteristics, this study observed bacterial infectious diseases at RSCB Ternate, which included pneumonia, UTI, pulmonary tuberculosis, acute gastritis, and septicaemia. The analysis revealed that pneumonia ranked the highest, affecting 34 patients (37%), followed by UTI in 17 patients (18%), pulmonary tuberculosis in 16 patients (17%), acute gastritis in 14 patients (15%), and septicaemia in 12 patients (13%). This finding is consistent with that of Armal *et al.,* (2023) at Ibnu Sina Islamic Hospital in Bukittinggi, which reported pneumonia as the most common diagnosis, affecting 72 patients (38.5%). Pneumonia is generally caused by the bacterium *Klebsiella pneumoniae* (25). According to Riskesdas 2018 data, the prevalence of pneumonia in Indonesia across all age groups was recorded at 2.21%. The highest distribution of cases occurred among those aged 44-64 years (2.5%), 64-74 years (3.0%), and 75 years and above (2.9%). The high incidence of pneumonia at RSCB Ternate is in line with the National Health Insurance (JKN) statistical report from 2014 to 2018, which identified pneumonia as one of the top ten leading causes of hospitalisation (4).

Characteristics Based on Antibiotic Prescription Patterns

The characteristics based on antibiotic prescription patterns at RSCB Ternate indicated that the most frequently used antibiotic was ceftriaxone, a third-generation cephalosporin, prescribed to 61 patients (66%), followed by levofloxacin for 12 patients (13%), metronidazole for 6 patients (7%), cefixime for 4 patients (4%), moxifloxacin for 4 patients (4%), cotrimoxazole for 3 patients (3%), and the least prescribed antibiotic was meropenem, a carbapenem, prescribed for 1 patient (1%). The findings of this study are consistent with those of Rahmatillah *et al.,* (2023) at Hospital X, which also reported ceftriaxone as the most frequently prescribed antibiotic, used in 92 patients (40.35%). In Indonesia, third-generation cephalosporins are among the most commonly used therapies in the management of bacterial infections (1). Third-generation cephalosporins, such as ceftriaxone, are broad-spectrum antibiotics widely used as empirical therapy for bacterial infections. This antibiotic class is recognised for its high efficacy in eliminating bacteria and its general safety in humans. The antimicrobial activity of cephalosporins is particularly strong against Gram-negative bacteria, including pathogens responsible for UTI and pneumonia. The efficacy of ceftriaxone has been extensively documented across various regions, including Europe and the Americas (17).

Results of DDD Method Analysis

Quantification of antibiotic use was expressed in units of DDD/100 patient-days. Following the DDD calculation, antibiotics were classified into DU 90% segments based on the order of percentage of use from highest to lowest. Ceftriaxone was recorded as the most frequently used antibiotic, with 45.7 DDD/100 patient-days, followed by metronidazole (5.6), levofloxacin (4.4), moxifloxacin (4.1), cefixime (1.1), cotrimoxazole (0.4), meropenem (0.3), and ciprofloxacin as the lowest, with 0.1 DDD/100 patient-days. The DU 90% classification indicated that ceftriaxone belonged to the DU 90% segment with a proportion of 74%. In contrast, other antibiotics falling within the DU 10% segment included metronidazole (9%), levofloxacin (7.1%), moxifloxacin (6.6%), cefixime (1.7%), cotrimoxazole (0.6%), meropenem (0.4%), and ciprofloxacin (0.1%).

Based on the findings of this study, ceftriaxone was recorded as the antibiotic with the highest level of use, at 45.7 DDD/100 patient-days. At the same time, ciprofloxacin had the lowest utilisation, with a value of 0.1 DDD/100 patient-days. These results are consistent with the study conducted by

Armal *et al.,* (2023) at RSI Ibnu Sina Bukittinggi, where ceftriaxone was also identified as the most frequently used antibiotic among fifteen other types, with a value of 42.75 DDD/100 patient-days. This indicates that, for every 100 hospitalised patients, approximately 43 patients received ceftriaxone at the standard DDD dosage of 2 grams. A similar study by Rachmawati *et al.,* (2020) at RSUD Bangil, Pasuruan Regency, also demonstrated that ceftriaxone had the highest DDD/100 patient-days value, at 27.79 DDD/100 patient-days. Based on the results from RSCB Ternate, it can be interpreted that out of every 100 patients, approximately 46 patients were administered ceftriaxone with a DDD of 2 grams. In general, the DDD value reflects the extent of antibiotic use — the higher the DDD, the greater the utilisation — which may indicate a potential for irrational drug use (12).

Meanwhile, as shown in **Table 5**, after classification into the DU 90% segment, the antibiotic ceftriaxone accounted for 74%, while antibiotics included in the DU 10% segment comprised metronidazole (9%), levofloxacin (7.1%), moxifloxacin (6.6%), cefixime (1.7%), cotrimoxazole (0.6%), meropenem (0.4%), and ciprofloxacin (0.1%). The DU 90% value serves as a reference for assessing the quality of antibiotic prescribing and adherence to treatment guidelines and formularies (17). This finding aligns with the study conducted by Azyenela *et al.,* (2022) at RSUD M. Natsir, Solok City, which demonstrated that ceftriaxone was the antibiotic included in the DU 90% segment (18.39%). Based on the findings at RSCB Ternate, the high utilisation of ceftriaxone within the DU 90% segment indicates a potential risk of resistance and non-selective antibiotic prescribing. This lack of selectivity arises from the frequent use of ceftriaxone as the first-line antibiotic choice, regardless of patients' clinical conditions, and without sufficient reference to national or hospital formularies and treatment guidelines. Thus, it can be concluded that the principle of rational antibiotic use has not yet been fully implemented at RSCB Ternate.

CONCLUSION

Based on the research findings, the antibiotic with the highest DDD value was ceftriaxone, at 45.7 DDD/100 patient-days, while the lowest value was observed for ciprofloxacin, at 0.1 DDD/100 patient-days. In the DU 90% segment analysis, ceftriaxone accounted for the largest proportion (74%). Meanwhile, antibiotics included in the DU 10% group were metronidazole (9%), levofloxacin (7.1%), moxifloxacin (6.6%), cefixime (1.7%), cotrimoxazole (0.6%), meropenem (0.4%), and ciprofloxacin (0.1%).

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