Research Article

Study on The Appropriateness of Antimicrobial Therapy in Infectious Diseases in A Tertiary Care Hospital

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Abstract

Background: Antimicrobial resistance is a significant global health issue associated with inappropriate antimicrobial use, including dosing errors or missing data, and can result in treatment failure and increased resistance. This study assessed the appropriateness of antimicrobial prescribing in infectious disease and the need for stewardship interventions in a tertiary care hospital. Methods: A prospective observational study was conducted over 6 months (Jan to June 2025) in the general medicine department of a tertiary care hospital. Data from 132 patients were collected, including demographics, prescribing indicators, microbiological investigation and renal dose adjustment. Appropriateness was evaluated using the World Health Organization guidelines, the Indian Council of Medical Research guidelines, the Gyssens algorithm category, and WHO core indicators. Results: Of the 132 patients, the most frequent age group was 58-67 years. The predominant site of infection in the study population was the urinary system. Ceftriaxone was the most commonly prescribed antimicrobial (16.6%). According to the Gyssens Algorithm (categories 0-VI), 69.6% of antimicrobial prescriptions were appropriate. The study highlights the use of access, watch, and reserve categories, emphasizing the importance of careful antimicrobial selection and monitoring. Conclusion: While a large proportion of antimicrobial therapy was appropriate, gaps remain in assessments, dosing, duration, and other aspects. Adherence to guidelines, dose adjustments, regular prescription review and active involvement of clinical pharmacists are recommended to improve antimicrobial intervention and promote rational use.

Keywords: Rational drug use, antimicrobial therapy, antimicrobial resistance, antimicrobial stewardship, microbiological investigation, Gyssens category.

1. Introduction

Microorganisms (or microbes) are microscopic living organisms that exist almost everywhere in the human body. Their survival and ability to cause infection depend on several factors, including stomach acid, digestive enzymes, and mucus. Microorganisms include bacteria (single-celled organisms such as E. coli and S. aureus), viruses with DNA or RNA (influenza, HIV, SARS-CoV-2), fungi (unicellular or multicellular, such as Candida and Aspergillus), protozoa (single-celled, such as Plasmodium and Entamoeba), algae (photosynthetic, such as Chlorella and Spirogyra), and archaea (single-celled, such as Halobacterium).

Antimicrobials are agents used to kill or prevent the growth of microorganisms. The use of antimicrobials began with the accidental discovery of penicillin by Alexander Fleming in 1928, an event that marked the beginning of antibiotic therapy. The first antimicrobial was Prontosil, a sulfonamide synthesized by the German organic chemist Gerhard Domagk (1). This led to the development of modern medicine and has great importance in the treatment of infectious diseases as well as in preventing infections during surgery in patients. Empirical antibiotic therapy (EAT) is

used, particularly within the first 24 to 48 h, because culture results are not yet available to identify the causative pathogen or its susceptibilities. Consequently, empiric therapy that aligns with antimicrobial guidelines is termed appropriate empiric antimicrobial therapy (AEAT). In contrast, therapy that does not align with the guidelines is termed inappropriate empiric antimicrobial therapy (IEAT) (2). Before beginning treatment with empirical antibiotics, it is necessary to obtain a specimen that is appropriate to identify the causative organism, so that any further adjustments to the empirical antibiotics can be made and definitive therapy administered (3).

The appropriateness of an antimicrobial prescription should be evaluated, including compliance with proper guidelines, appropriate de-escalation or modification of treatment after the microbiological investigation or when there has been clinical improvement, the dose, the route of administration, and the duration (4,5). The Gyssens algorithm should be used to determine whether the antibiotic therapy is appropriate or not. Overuse or overdosing of antimicrobials can cause antimicrobial resistance (AMR), which in turn makes infections more difficult to treat. The most important challenge of antibiotic resistance is worsened by medication abuse and overuse (1).

Therefore, the World Health Organization (WHO) has called for antimicrobial stewardship programs (ASPs). Antimicrobial Stewardship (ASPs) programs are a set of multidisciplinary interventions that aim to ensure the appropriate use of antimicrobials by preventing their unnecessary use and to provide targeted therapy in situations where they are necessary (6–8).

Studies validated the utilization of both microbiological investigation and clinical evaluation in the selection of initial broad-spectrum therapy and further therapeutic conclusions. This study aimed to assess antimicrobial prescribing appropriateness by evaluating the overall quality of antimicrobial prescriptions at a tertiary care hospital.

2. Materials and methods

2.1 Study setting

A prospective study was conducted in the Department of General Medicine in a tertiary care hospital at Salem for a period of six months (from January 2025 to June 2025). The study proposal was presented in a detailed manner to the board members of the institutional ethics committee and was approved (Tracking No. VMKVMC&H/IEC/25/239).

2.2 Sample Size Determination

The sample size was calculated based on a single population proportion formula with the assumption of 50% as a proportion (p) of patients with appropriate antibiotic use, at a 95% confidence level and a margin of error (d) = 5%. The source population (N) = 200.

So, estimated sample (n) = $(Z\alpha/2)^2 \times P(1-P)$, n=384.

d^2

Then, corrected estimated sample size = $N \times n = 200 \times 384 = 132$.

$N \times n \quad 200 \times 384$

The final calculated sample size was 132 samples with 10% contingency; a total of 145 samples were included in the study [3].

2.3 Study participants

Patients were collected over a duration of six months in the medicine inpatient department. All patients ≥18 years of age with a minimum of one prescription including an antibiotic for 24–48 h were included. All patients who had at least one clinical specimen collected for microbiological investigation during hospitalization and tested positive, and who received empirical antibiotic therapy before or within 24 h after pathogenic specimen collection were included in the analysis (2). The study included all intensive care unit (ICU) patients, and all patients receiving postoperative surgical prophylaxis or antibiotic prophylaxis because of prolonged neutropenia were included.

The exclusion criteria for participants involved several factors: Each participant could have more than one visit in the general medicine department, which excluded them from the study. Patients who lacked critical hospitalization information, such as a diagnosis of infectious disease or a lack of discharge pattern excluded from the study (2). Patients in the emergency department and all patients receiving preoperative surgical antimicrobial prophylaxis were excluded from the study. Patients with antiretroviral therapy were excluded because these treatments were outside the scope of antimicrobial therapy assessed in the present study.

2.4 Data collection and procedures

Informed consent was obtained from the patient or their legally agreeable representative. The demographic details, provisional clinical assessment, empirical antibiotic prescription, comorbidities, drug details, culture results,

definitive antibiotic prescription based on the culture report, and total antibiotic consumption were collected using a designed data collection pro forma.

The antibiotic prescription was considered appropriate or rational when it fulfilled the criteria assessed under the Gyssens Algorithm (categories 0-VI) (9). Blood culture and other body fluids like urine/pleural or cerebrospinal fluid cultures taken within 24-48 h of starting antibiotic treatment were considered appropriate. The appropriateness of the empirical prescription for a given indication, appropriate duration and dose was assessed based on the guidelines given by the Indian Council of Medical Research (ICMR), World Health Organization (WHO) guidelines, and the Gyssens Algorithm (10,11)

2.5 Statistical analysis

All collected data were entered into Microsoft Excel (Office 365) and analyzed using SPSS version 28.0. Results were expressed as mean ± standard deviation for continuous variables and as frequencies and percentages for categorical variables. The Chi-square test was used for categorical comparisons, and a P-value <0.05 was considered statistically significant.

3. Results And Discussion

A prospective observational study was conducted among 132 infectious disease patients during the study period from Jan 2025 to Jun 2025 at a tertiary care hospital, Salem, Tamil Nadu. The study aimed to audit antimicrobial prescription patterns in patients, including dose adjustments, treatment duration, and culture investigations.

3.1 Demographic and clinical characteristics of the study population

Table 1. Demographic and clinical characteristics of the study population.

Variables	Subgroups	No. of Patients	(%)
Age (Yrs)	18 – 27	12	9.0%
	28 - 37	28	21.2%
	38 - 47	24	18.1%
	48 - 57	23	17.4%
	58 - 67	30	22.7%
	68 - 77	12	9.0%
	> 77	3	2.2%
Gender	Male	65	49.2%
	Female	67	50.7%
BMI	Underweight (<18.5)	12	9.0%
	Normal weight (18 .5-24.9)	43	32.5%
	Overweight (25.0-29.9)	46	34.5%
	Obese (>30.0)	31	23.4%
Education level	No formal schooling	27	20.4%
	primary school	20	15.1%
	Secondary school	55	41.6%
	Graduated and postgraduate	30	22.7%
Marital status	Single	22	16.6%
	Married	110	83.3%
Charlson comorbidity index (IQR)	0	26	19.6%
	1	33	25%
	2	35	26.5%
	3	23	17.4%
	>4	15	11.3%
Duration of treatment (days)	1-3	28	21.2%
	4-6	29	21.9%
	7-9	32	24.2%
	9-12	30	22.7%

	12<	13	9.8%

The patients were categorized into different age groups, and the maximum number of patients fell in the age group of 58–67 yrs (n = 30, 22.7%), followed by 28–37 yrs (n = 28, 21.2%). The demographic study had a mean age of 47.8 ± 15.1 years, with the female population (n = 67, 50.7%) being predominant, whereas the male population (n=65,49.2%). Based on the mean body mass index, the high prevalence of overweight in the study population (n = 46, 34.5 %), followed by Normal weight (n = 43, 32.5%). The most frequent level of education was secondary schooling (n = 55, 41.6%), whereas the least prevalent was no formal schooling (n = 27, 20.4%). Assessment of co-morbid conditions has been categorized using the Charlson comorbidity index (IQR) and had a mean range of (1.80 ± 1.36). Among patients who received definitive therapy, treatment duration was most frequently between 7-9 days (24.2%), followed by 9-12 days (22.7%) and 4-6 days (21.9%). The results are shown in Table 1.

3.2 Distribution of specimen types, infection sites and identified pathogen

Table 2. Distribution of specimen types, infection sites and identified pathogen

Specimens and treatment indications	Subgroups	No. of patients (n=121)	%
Types of specimens	Blood	36	29.7%
	Urine	34	28.0%
	Sputum	23	19.0%
	Pus	24	19.8%
	Csf	4	3.3%
Treatment indication	Respiratory system	22	18.1%
	Gastrointestinal system	18	14.8%
	Reproductive system	5	4.1%
	Urinary system	65	53.7%
	Nervous system	6	4.9%
	Immune system	4	3.3%
	Integumentary system	3	2.4%
	Circulatory system	2	1.6%
	Microvascular system	4	3.3%
	Biliary system	3	2.4%
Culture obtained: blood culture	Escherichia coli	11	9.0%
	Methicillin-resistant Staphylococcus aureus	3	2.4%
	Klebsiella pneumoniae	5	4.1%
	Pseudomonas aeruginosa	7	5.7%
	Enterococcus species	1	0.8%
Urine culture	Escherichia coli	14	11.5%
	Proteus mirabilis	13	10.7%
	Klebsiella oxytoca	5	4.1%
	Enterobacter cloacae	1	0.8%
	Enterococcus species	4	3.3%
	Candida albicans	2	1.6%
Spectrum culture	Mycobacterium tuberculosis	11	9.0%
	Klebsiella pneumoniae	7	5.7%
	Pseudomonas aeruginosa	8	6.6%
	Methicillin-resistant Staphylococcus aureus	6	4.9%

Pus	Methicillin-resistant Staphylococcus aureus	3	2.4%
	Pseudomonas aeruginosa	5	4.1%
	. Escherichia coli	10	8.2%
	Klebsiella pneumoniae	6	4.9%
	Proteus mirabilis	8	6.6%
	Klebsiella oxytoca	6	4.9%
	Enterococcus species	2	1.6%
Csf	. Escherichia coli	2	1.6%
	Klebsiella pneumoniae	2	1.6%
	Mycobacterium tuberculosis	4	3.3%

Clinical specimens were collected from 121 patients for microbiological results to identify the causative organism. The specimens' results show a high prevalence in blood samples (n = 36, 29.7%), followed by urine samples (n=34,28.0%). The predominant infection sites in the study population were the urinary system (53.7%), while the least affected infection sites were the Integumentary system (2.4%), followed by the biliary system (2.4%) and circulatory system (1.6%). Based on the identified pathogen in culture, the high prevalence of E. coli was observed in the study population (30.5%), while the least observed pathogens were Enterobacter cloacae (0.8%), followed by Candida albicans (1.6%). However, in the infection sites and identified pathogens sample collection, a total of 11 patients had no culture results available. The results are shown in Table 2.

3.3 Pattern of antimicrobial utilization and therapeutic strategies

Table 3. Pattern of antimicrobial utilization and therapeutic strategies

S.no	Category according to drug class	Name of antimicrobials	No. of prescriptions (N=132)	%
1.	Cephalosporin	Ceftriaxone	22	16.6%
		Cefixime	2	1.5%
2.	Macrolide antibiotic	Erythromycin	2	1.5%
		Azithromycin	7	5.3%
		Metronidazole	3	2.2%
3.	Rifamycin	Rifampicin	4	3.0%
4.	Tetracycline	Doxycycline	8	6.0%
5.	Amino penicillin	Amoxicillin	2	1.5%
6.	Carbapenem	Meropenem	3	2.2%
7.	Fluoroquinolones	Ciprofloxacin	3	2.2%
8.	Lincosamide	Clindamycin	1	0.7%
9.	Anti-tubular therapy	ATT	11	8.3%
10.	Nitrofuran	Nitrofurantoin	6	4.5%
11.	Macrolide, cephalosporin	Metronidazole, cefixime	1	0.7%
		Metronidazole, ceftriaxone	6	4.5%
12.	Macrolide, cephalosporin+ beta lactamase inhibitor	Metronidazole, cefoperazone + sulbactam	6	4.5%
13.	Cephalosporin + beta-lactamase inhibitor	Cefoperazone + sulbactam	18	13.6%
14.	Ureidopenicillins+ beta lactamase inhibitor	Piperacillin + tazobactams	7	5.3%
15.	Ureidopenicillins+ beta lactamase inhibitor+ macrolides	Piperacillin + tazobactam, metronidazole	8	6.0%

16.	Fluoroquinolones+ cephalosporin	Ciprofloxacin, ceftriaxone	2	1.5%
		Ceftriaxone, levofloxacin	1	0.7
17.	Carbapenem, aminoglycosides	Meropenem, gentamicin	4	3.0%
18.	Macrolides, ATT	Azithromycin, ATT	1	0.7%
19.	Cephalosporin + beta lactamase inhibitor, aminoglycosides, Tetracycline	Cefoperazone + sulbactam, amikacin, doxycycline	1	0.7%
20.	Aminopenicillin + beta-lactamase inhibitor, cephalosporin	Amoxicillin + potassium clavulanate, ceftriaxone	1	0.7%
21.	Carbapenem, short-acting beta-2 antagonist	Meropenem, Levo salbutamol	2	1.5%

A prospective study was conducted among 132 patients for whom medication was prescribed for infectious diseases with or without culture results. In the study, the most frequently used antimicrobials were ceftriaxone (n = 22, 16.6%), followed by Cefoperazone + sulbactam (n = 18, 13.6%), however least antimicrobials prescribed Erythromycin (n = 2, 1.5%), Cefixime (n = 2, 1.5%), Fluoroquinolones+ cephalosporin antibiotics Ciprofloxacin, ceftriaxone (n = 2, 1.5%), followed by the Aminopenicillin + beta-lactamase inhibitor, cephalosporin combination (n= 1, 0.7%), and Ceftriaxone, levofloxacin combination (n = 1, 0.7%).

The WHO AWaRe classification is a system made by the World Health Organization to group antibiotics based on how they are used, their risk of resistance, and importance. They are divided into three groups: access, watch, and reserve. In total, 132 antimicrobials were prescribed. Access represents antibiotics preferred for common infections and low-resistance drugs (38.8%), watch antibiotics are higher-risk antibiotics that cause high resistance and are carefully monitored (55.5%), and reserve antibiotics are saved as a last option for serious resistant infections. The results are shown in Table 3.

3.4 Indicators used for assessment of appropriateness

Table 4. Indicators used for assessment of appropriateness

Indicators used for assessment of appropriateness	Samples	Indicator characteristic	No. of prescriptions	%
Appropriate renal function and dose calculation per prescription	N=53	Total no. of antimicrobials requiring renal adjustment	53	100%
		No renal impairment/ adjustment not required	5	9.4%
		Renal impairment/adjustment required	48	90.5%
		Appropriately adjusted	43	32.5%
		Not appropriately adjusted	5	3.7%
Appropriate and inappropriate use of antibiotics per prescription (Gyssens Algorithm)	N=132	0-Appropriate antibiotic use	92	69.6%
		I-Incorrect timing	2	1.5%
		IIa-Incorrect dose	7	5.3%
		IIb-Incorrect dosing interval	2	1.5%
		IIc-Incorrect route	5	3.7%
		IIIa-Duration too long	6	4.5%
		IIIb-Duration too short	3	3.2%
		IV-Alternative antibiotic available	6	4.5%
		V-No indication	2	1.5%
		VI-Insufficient information	7	5.3%

Renal dose adjustment of antimicrobials was assessed to evaluate appropriateness of dosing in relation to the patient's renal function. Total no. of antimicrobials requiring renal adjustment (n =53, 100%); some drugs did not require renal dose adjustment or no renal impairment based on patient renal function (9.4%), some drugs require renal dose adjustment or renal impairment based on patient renal function (90.5%), among the renal dose adjustments based on patient renal function, the prescribed doses were appropriately adjusted (32.5%), the renal dose adjustments based on patient renal function, the prescribed doses were inappropriately adjusted (3.7%).
In the study, the Gyssens algorithm was used to assess the appropriateness of antibiotics prescribed and identify areas of inappropriate use. The predominant antimicrobials prescribed were as per guidelines (n = 92, 69.6%), followed by inappropriate use of antimicrobials, which was non-adherence to guidelines; it includes incorrect doses and insufficient information (5.3%), followed by the long duration of drug prescribed without necessity (4.5%). Indicators used for assessment of appropriateness are presented in Table 4.

3.5 Evaluation of prescribing practices using WHO core prescribing indicators

Table 5. Evaluation of prescribing practices using WHO core prescribing indicators

WHO prescribing indicators	**%**
Average no. of drugs per encounter	6.96%
% of antibiotics prescribed by generic name	13.38%
% of encounters with an antibiotic prescribed	20.5%
% of encounters with an injection prescribed	5.0%
% of drugs prescribed from the essential drug list	16.1%

The prescribing pattern of antimicrobial therapy was evaluated using the WHO core indicators to assess the rational use of medicines among the study population. The average was (6.96 ±1.26) drugs per encounter. Antibiotics were prescribed in (0.93±0.63) of encounters. Only (1.43±0.06) of antibiotics were given by generic name. Antibiotic encounters with an injectable form were (0.34 ± 0.47). The quantity of drugs prescribed from the essential drug list was (1.12 ± 0.64), representing reasonable adherence. Evaluation of prescribing practices using WHO core indicators is presented in Table 5.

4. Discussion

This prospective observational study took place in the general medicine department at a tertiary care hospital in Salem. A total of 132 patients were prospectively selected according to the study's inclusion and exclusion criteria.
In the present study, the mean age of participants was 47.8 ±15.1 yrs. A similar study was performed by Khalawi et al. (12), with a mean age of 45.98 ± 16.35 yrs. The female predominance in this study mirrors the well-established fact of UTI susceptibility because of their anatomy. A comprehensive review by Khalawi et al.. shows that the high prevalence of female predominance in UTI aligns with the study (12). Assessment of comorbid conditions has been categorized using the Charlson comorbidity index (CCI) and had a mean range of 1.80±1.36 that correlates with their findings Charlson et al., (13,14). where a similar mean range of 1.68 ± 1.94 is shown, the simplest and most obvious tactic for estimating the overall burden of comorbid diseases in each patient.
Analysis of treatment indication for respiratory tract and urinary tract has the most frequently monitored indication; slightly similar findings are shown in van den Bosch CMA et al. and Luo et al. (2,15,16). Urogenital and respiratory indications were mostly monitored. In our study, E. coli was the most common organism in culture reports in IPD due to predominance of urinary tract infection. This is similar to studies from other tertiary care centers Singhal et al.,(17).
Prescription of antimicrobials was monitored for 132 individuals; the predominant drug was ceftriaxone 16.6%, cefoperazone + beta-lactamase inhibitor and, in the least order, ciprofloxacin and cefixime. These findings are slightly similar to those reported by Pathak et al. (4,18–21). The work focused on prescription patterns. WHO-AWaRe

classification is a system used to classify antibiotics based on their use, resistance risk and importance. They are classified into three types: access, watch and reserve. Access represents antibiotics preferred for common infections and low-resistance drugs; watch antibiotics are higher-risk antibiotics that cause high resistance; reserve is kept only for serious infections. Based on the WHO AWaRe classification, our study was driven by the treatment chart and division into access, watch, and reserve categories (22).

Assessment of appropriateness was conducted using two indicators: appropriate renal dose calculation per prescription and Gyssens Algorithm Category. In our study, the predominance of renal doses appropriately adjusted was high 32.5% and inappropriate adjustment was the lowest count, at the same time as van den Bosch CMA et al. (15). There were 138 antimicrobial prescriptions for which dosage adjustment was recommended because of renal impairment; only 9.6% were adjusted. The antimicrobial prescribing pattern was evaluated using WHO indicators; a similar study was performed by Prasad et al. (23,24).

5. Limitations

This was a prospective observational study conducted in a single healthcare setting; the results may not be generalizable to all healthcare settings. Only the general medicine department was included. Incomplete microbiological data for some patients limited the assessment of antimicrobial appropriateness. The study emphasizes antimicrobial prescribing utilization patterns and did not evaluate long-term clinical outcomes, follow-up visit and, large sample size or recurrence.

6. Conclusion

This prospective observational study demonstrated that the majority of antimicrobial prescriptions in the general medicine ward were appropriate. With an average of 69.6%, Gyssens' algorithm categorized most prescriptions as adequate, while a high percentage of inappropriate prescriptions were due to dosing errors or missing data. Ceftriaxone was the most commonly prescribed antimicrobial, while E. coli was the most frequently identified organism. coli was the most frequently identified organism. This ward exhibited a high prevalence of gram-negative infections, as reflected in the high percentage of urinary tract infections and the frequent use of watch-category antibiotics. The study's results confirm the necessity for appropriate intervention in terms of antimicrobial prescriptions. The antimicrobial stewardship program's key elements that should be integrated into the hospitals' treatment policies include regular audits, culture-guided antibiotic use, de-escalation when applicable, and synergistic collaboration between pharmacists and physicians. The results of the study contribute to the growing body of literature concerning the importance of antimicrobial stewardship programs. Aiming at improving the appropriateness of medication use, such programs ultimately impact morbidity, mortality, and overall healthcare system expenditures. As a result, a wider range of research conducted across different facilities and settings is required to produce more data on the matter.

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- **Conflict Of Interest**

The authors have none to declare

- **Author Contributions**

Conceptualisation, study design, drafting of the manuscript, Kothai Ramalingam; Statistical analysis, critical review of the manuscript, Arul Balasubramanian; Data acquisition, patient interaction, preparation of results, manuscript editing, Literature review, Devaakshayah Shreenithee Ragunathan; Methodology support, data tabulation, interpretation of results, and manuscript proofreading, Evan Vanya Thiruvenkadam; Data analysis, Bavusika. Supervision, guidance, and final approval of the manuscript, Arul Balasubramanian. All authors have read and agreed to the published version of the manuscript.

- **Data Availability Statement**

The data are not publicly available due to privacy or ethical restrictions.

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