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Original Research Article

Assessment and evaluation of rational use of antibiotics in pediatric population at a tertiary care hospital

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ABSTRACT

Background: Rational antibiotic use in paediatric patients is essential to optimize treatment outcomes and minimize adverse effects. Inappropriate prescribing may result in treatment failure, toxicity, and antimicrobial resistance.
The objectives are to assess antibiotic prescribing patterns, evaluate appropriateness, describe culture and susceptibility findings, and assess antibiotic optimization among paediatric inpatients in a tertiary care hospital.
Methods: A prospective observational study was conducted among 250 paediatric inpatients aged below 18 years who received at least one systemic antibiotic for suspected or confirmed infection. Data were collected from case notes, medication charts, and laboratory reports. Appropriateness was assessed according to the hospital antibiotic policy, and culture and susceptibility results were reviewed.
Results: Toddlers (39.2%) and children (36.4%) constituted the largest age groups, while males accounted for 53.6% of participants. Respiratory tract infections were the predominant indication (44.7%). Among 414 antibiotics prescribed, ceftriaxone (28.5%), azithromycin (18.8%), and amoxicillin-clavulanate (17.1%) were most frequently used. Intravenous administration accounted for 71.49% of prescriptions. Overall, 98% of prescriptions were appropriate, 0.8% inappropriate, and 1.2% not assessable. Watch antibiotics constituted 64% of use. Four mild, probable adverse drug reactions were reported. Escherichia coli was the most frequently isolated organism, with 91.3% susceptibility to imipenem.
Conclusions: Antibiotic prescribing was generally appropriate; however, the high use of Watch antibiotics emphasizes regular prescription review, culture-guided therapy, adherence to hospital guidelines, and continued antimicrobial stewardship.

Keywords: Antibiotic use, Paediatric inpatients, Antimicrobial stewardship, Antibiotic appropriateness, Antimicrobial resistance

INTRODUCTION

Antibiotics are important medicines in paediatric care and can be lifesaving when used appropriately. However, unnecessary or inappropriate use in hospital and community settings contributes to antimicrobial resistance (AMR), which is a major global public health concern.[1] In 2021, AMR was associated with approximately 1.14 million deaths worldwide, with one in five deaths occurring among children younger than five years.[2] Antimicrobials are frequently prescribed in paediatric emergency settings for conditions such as acute otitis media, tonsillitis, community-acquired pneumonia, preseptal cellulitis, and urinary tract infections (UTIs).[3] Irrational prescribing, including deviation from recommended treatment guidelines, may result in

treatment failure, adverse drug reactions, drug interactions, unnecessary monitoring, increased healthcare costs, prolonged hospitalization, and increased mortality.[4] Many respiratory tract infections are viral and self-limiting; therefore, antibiotic therapy is not required in a substantial proportion of cases.[2,5]

UTIs are among the most common bacterial infections in children and are an important reason for antibiotic prescribing. In high-income countries, up to 2.8% of children experience a UTI annually, and recurrence occurs in approximately 13.6% after the first episode.[6,7] By seven years of age, approximately 8.4% of females and 1.7% of males have experienced at least one symptomatic UTI. Most paediatric UTIs are caused by *Escherichia coli*, while *Klebsiella*, *Proteus mirabilis*, and *Enterococcus* species are less frequently identified.[8,9] The increasing prevalence of infections caused by extended-spectrum beta-lactamase-producing organisms further complicates antibiotic selection.[10] Lower respiratory tract infections also remain an important reason for antibiotic prescribing, although many are viral in origin. Pneumonia, particularly bronchopneumonia, continues to be a major cause of illness and mortality in young children, while vaccination programs such as the 13-valent pneumococcal conjugate vaccine have contributed to reductions in disease burden.[4,11]

AMR occurs when microorganisms become less susceptible or resistant to standard antimicrobial treatment, resulting in prolonged illness, increased complications, and fewer effective therapeutic options.[12] Medication errors may also occur more frequently in paediatric patients because antibiotic doses and regimens often require adjustment according to age and clinical characteristics.[13] Antimicrobial stewardship programs (ASPs) are therefore important for promoting appropriate antibiotic selection, dosing, duration, frequency, and route of administration. Evidence indicates that stewardship interventions can reduce unnecessary antibiotic use without compromising patient safety.[14] Evaluating antibiotic prescribing in paediatric inpatients against hospital guidelines can help identify inappropriate use, support treatment optimization, and strengthen antimicrobial stewardship.[8,14,15]

METHODS

A prospective observational study was conducted in the paediatric inpatient department of Bangalore Baptist Hospital, Bengaluru, Karnataka, India. The study was conducted during January 2026 to July 2026. A total of 250 paediatric inpatients aged below 18 years who received at least one systemic antibiotic for a suspected or confirmed infection were included.

Patients admitted to the paediatric wards and prescribed at least one systemic antibiotic for a suspected or confirmed infection were eligible for inclusion. Patients aged above 18 years, outpatients, patients admitted to the Paediatric Intensive Care Unit (PICU), patients with non-bacterial infections, and patients who did not provide consent were excluded.

Data were collected prospectively using a structured data collection form. Information was obtained from patient case notes, medication charts, and laboratory reports. Demographic and clinical variables, including age, sex, date of admission, and diagnosis, were recorded. Antibiotic-related information, including antibiotic name, dose, frequency, route of administration, and duration of therapy, was documented. Culture and susceptibility reports were reviewed when available to assess the relationship between the identified organism and the prescribed antibiotic. Antibiotic selection and prescribing appropriateness were evaluated against the hospital antibiotic policy. Antibiotic optimization interventions, including dose correction and intravenous-to-oral or oral-to-intravenous changes when clinically indicated, were also documented. Ethical approval was not required for this study.

Statistical analysis

Data were summarized using descriptive statistics. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation.

RESULTS

The study included 250 paediatric inpatients, with toddlers (1–3 years) representing the largest age group (39.2%), followed by children aged 4–12 years (36.4%) and infants (19.2%). A slight male predominance was observed (53.6%). Most patients had a hospital stay of ≤7 days (77.2%) and received antibiotics for ≤7 days (91.06%). Respiratory tract infections were the most common indication (44.7%), followed by urinary tract infections (21.8%) and gastrointestinal and abdominal infections (12.4%). The table also presents the mean values of selected laboratory parameters, including RBC, WBC, neutrophils, lymphocytes, CRP, serum creatinine, and procalcitonin (Table 1).

A total of 414 antibiotics were prescribed during the study period. Ceftriaxone was the most frequently prescribed antibiotic (28.5%), followed by azithromycin (18.8%) and amoxicillin-clavulanate (17.1%) (Table 2). Amikacin accounted for 12.8% of prescriptions, while cefixime, cefotaxime, vancomycin, piperacillin-tazobactam, meropenem, and other antibiotics were prescribed less frequently.

In terms of dosage form, injections were most frequently prescribed (72.2%), followed by syrups (24.6%) and tablets (2.6%). Capsules and creams each accounted for 0.2%. Intravenous administration was the most common route (71.49%), followed by the oral route (28.26%) and

topical administration (0.24%). No antibiotic was administered by the intramuscular route (Table 3).

Overall, 98% of antibiotic prescriptions were considered appropriate according to the hospital antibiotic policy. Two prescriptions (0.8%) were classified as inappropriate, while three (1.2%) were not assessable. According to the WHO AWaRe classification, Watch antibiotics constituted the largest proportion (64%), followed by Access (34.2%) and Reserve antibiotics (1.69%). Four adverse drug reactions were reported; all were classified as probable and mild. Three ADRs (75%) were considered not preventable, while one (25%) was considered probably preventable (Table 4). Of the prescriptions that were not assessable, three involved diagnoses that were not included in the hospital antibiotic policy. Two prescriptions were considered inappropriate because the selected antibiotic did not correspond to the recommended treatment for the documented diagnosis according to the hospital antibiotic policy. Antibiotic optimization interventions are in Table 5. Intravenous amoxicillin-clavulanate was changed to oral therapy in four clinically stable patients. One patient required a change from oral to intravenous amoxicillin-clavulanate because of a change in clinical status. Dose modifications were made in two patients to correct inappropriate dosing. These interventions demonstrate the role of regular antibiotic review in optimizing therapy.

Culture results identified a range of Gram-positive and Gram-negative organisms (Table 6). Among Gram-positive isolates, coagulase-negative Staphylococcus and Enterococcus species were the most frequently identified. Among Gram-negative isolates, Escherichia coli was the most frequently isolated organism, followed by Acinetobacter and Klebsiella species. The diversity of organisms identified supports the importance of culture testing, when clinically indicated, in guiding antibiotic selection.

Table 1: The baseline characteristics of the study population.

Demographics	N (%)	Mean±SD
Age (years)		
Infants (0-1)	48 (19.2)	0.577±0.21
Toddlers (1-3)	98 (39.2)	2.269±1.044
Children (4-12)	91 (36.4)	6.927±2.492
Adolescents (13-18)	13 (5.21)	14.333±0.906
Gender	N (%)	
Male	134 (53.6)	
Female	116 (46.4)	
Length of stay		
≤7	193 (77.2)	
>7	57 (22.8)	
Antibiotic treatment days		
≤7	377 (91.06)	
>7	37 (8.937)	
Type of infection		
Respiratory tract infection	119 (44.7)	
Urinary tract infection	58 (21.8)	
Gastrointestinal & Abdominal infections	33 (12.4)	
Acute febrile illness	17 (6.39)	
CNS infection	10 (3.75)	
Sepsis	7 (2.63)	
Hepatology Departments	5 (1.87)	
Other	17(6.39)	
Laboratory parameters	**N**	
Total RBC count (x 10^6/mm^3)	248	4.556±0.665
Total WBC count (x10^3/mm^3)	249	12.824±6.19
Neutrophils (%)	248	55.165±20.011
Lymphocytes (%)	248	35.259±18.786
CRP (mg/L)	231	46.352±75.275
Serum creatinine (mg/L)	237	0.482±0.2400
Procalcitonin (ng/mL)	13	0.640±5.9018

Table 2: Antibiotic prescribed in hospital for pediatric patients.

Class of drugs	Antibiotic prescribed	Number of antibiotics N (%)
Beta-lactam antibiotics		
Penicillin	Amoxicillin	1 (0.2)
	Ampicillin	4 (0.9)
Beta-lactam + Beta-lactamase inhibitors	Amoxycillin + Potassium clavulanate	71 (17.1)
	Piperacillin + Tazobactam	11 (2.6)
Cephalosporins	Ceftriaxone	118 (28.5)
	Cefixime	12 (2.8)
	Cefotaxime	9 (2.1)
Carbapenems	Meropenem	10 (2.4)
Aminoglycosides	Amikacin	53 (12.8)
	Gentamicin	8 (1.9)
Macrolides	Azithromycin	78 (18.8)
Glycopeptides	Vancomycin	12 (2.8)
Tetracyclines	Doxycycline	8 (1.9)
	Tigecycline	1 (0.2)
Lincosamides	Clindamycin	6 (1.4)
Oxazolidinones	Linezolid	5 (1.2)
Sulphonamides	Trimethoprim + Sulphamethoxazole	3 (0.7)
Nitroimidazoles	Metronidazole	2 (0.4)
Rifamycin	Rifaximin	1 (0.2)
Polymyxins	Colistin	1 (0.2)
Grand total		414 (100)

Table 3: Distribution of dosage forms and routes of antibiotic administration.

Category	N (%)
Dosage form	
Injection	299 (72.2)
Syrup	102 (24.6)
Tablet	11 (2.6)
Cream	1 (0.2)
Capsule	1 (0.2)
Route of administration	
Intravenous	296 (71.49)
Per oral	117 (28.26)
Topical	1 (0.24)
Intra muscular	0 (0)

Table 4: Assessment of antibiotic appropriateness, WHO AWaRe categorization and ADR distribution.

Category	Parameters	N (%)
Appropriateness	Appropriate	245 (98)
	Not Appropriate	2 (0.8)
	Not assessable	3 (1.2)
WHO AWaRe categorization	Access	142 (34.2)
	Watch	265 (64)
	Reserve	7 (1.69)
ADR Distribution (n=4)	Causality	
	Probable	4 (100)
	Severity	
	Mild	4 (100)
	Preventability	
	Not preventable	3 (75)

Continued.

Category	Parameters	N (%)
	Probably preventable	1 (25)

Table 5: Action taken for optimization of antibiotics in the study population.

Reason	Action taken	Frequency
Reduced infection risk, improved patient comfort and convenience and feasibility and clinical stability	Intravenous Amoxycillin + potassium clavulanate Is step-down to oral Amoxycillin + potassium clavulanate	4
Empirical therapy to treatment course based on clinical status	Oral Amoxycillin + potassium clavulanate is switched to Intravenous Amoxycillin + potassium clavulanate	1
Incorrect dose	Oral Azithromycin Subtherapeutic dose changed to prescribed daily dose	1
	Injection Amoxycillin + potassium clavulanate Overdose changed to prescribed daily dose	1

Table 6: Organism observed in pediatric patients.

Type of bacteria	Organism	Number of organisms N (%)
Gram positive	Coagulase Negative *Staphylococcus*	10 (13.7)
	Enterococcus sp.	10 (13.7)
	Beta Haemolytic *Streptococcus* Likely Non-Group A	3 (4.2)
	Staphylococcus aureus (MRSA)	3 (4.2)
	Streptococcus pneumoniae	3 (4.2)
	Vancomycin Resistant Enterococcus sp. (VRE)	1 (1.3)
	Viridians group streptococcus	1 (1.3)
Gram negative	*Escherichia coli*	23 (31.6)
	Acinetobacter sp.	3 (4.2)
	Klebsiella oxytoca	2 (2.8)
	Klebsiella sp.	2 (2.8)
	Non fermenting gram-negative bacilli	2 (2.8)
	Pseudomonas aeruginosa	2 (2.8)
	Non Typhoidal Salmonella	1 (1.3)
	Proteus vulgaris	1 (1.3)
	Pseudomonas sp.	1 (1.3)
	Salmonella enterica serotype Typhi	1 (1.3)
	Salmonella sp.	1 (1.3)
	Shigella sp.	1 (1.3)
	Sphingomonas sp.	1 (1.3)
	Citrobacter koseri	1 (1.3)

The culture susceptibility matrix presents the susceptibility of bacterial isolates to the antibiotics tested (Figure 1). Green, yellow, and red cells represent high, intermediate, and low susceptibility, respectively. The percentage shown for each organism-antibiotic combination was calculated as the number of susceptible isolates divided by the total number of isolates of that organism, multiplied by 100. Among Gram-positive organisms, MRSA showed 100% susceptibility to vancomycin (2/2). Among Gram-negative organisms, Escherichia coli showed 91.3% susceptibility to imipenem (21/23), whereas susceptibility to ampicillin was 21.7% (5/23). These findings demonstrate variation in antimicrobial susceptibility and support the use of culture and susceptibility results when selecting or optimizing antibiotic therapy.

The culture resistance matrix illustrates the resistance patterns of the bacterial isolates (Figure 2). Green, yellow, and red cells represent low, intermediate, and high

resistance, respectively. Resistance percentages were calculated as the number of resistant isolates divided by the total number of isolates of the respective organism, multiplied by 100. Among Gram-positive organisms, one Enterococcus isolate showed 100% resistance to vancomycin. MRSA also demonstrated resistance to several antibiotics. Among Gram-negative organisms, higher resistance was observed to some first-line agents, including ampicillin, cefazolin, and co-trimoxazole, whereas lower resistance was observed with carbapenems such as imipenem and meropenem and with colistin. These findings highlight the importance of continued antimicrobial resistance surveillance and culture-guided antibiotic selection.

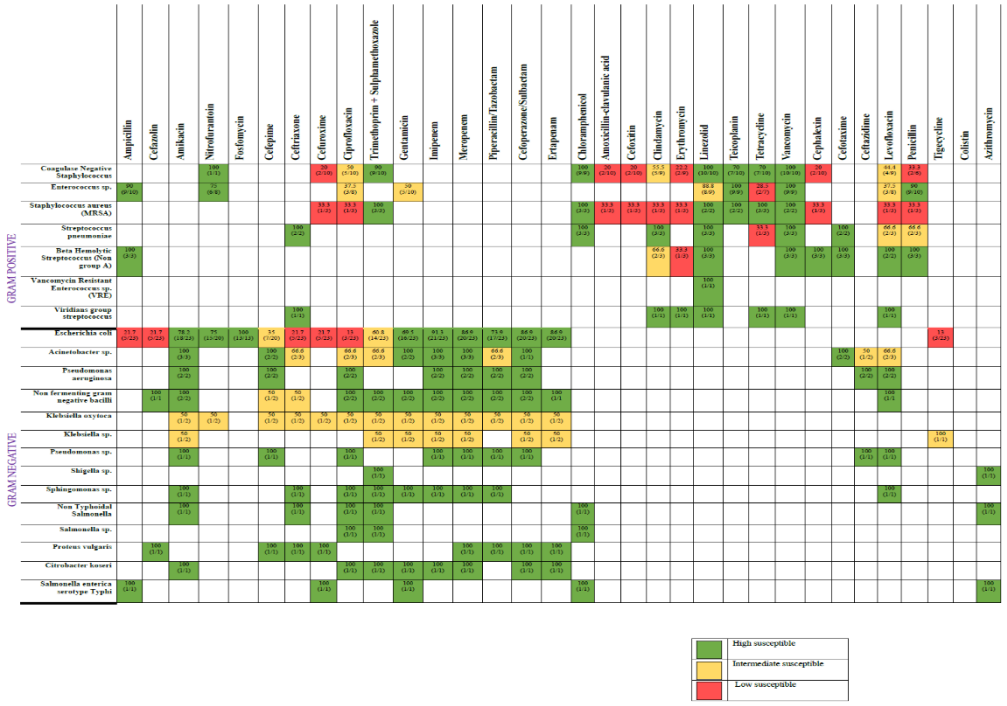


Figure 1: Culture sensitivity matrix grid.

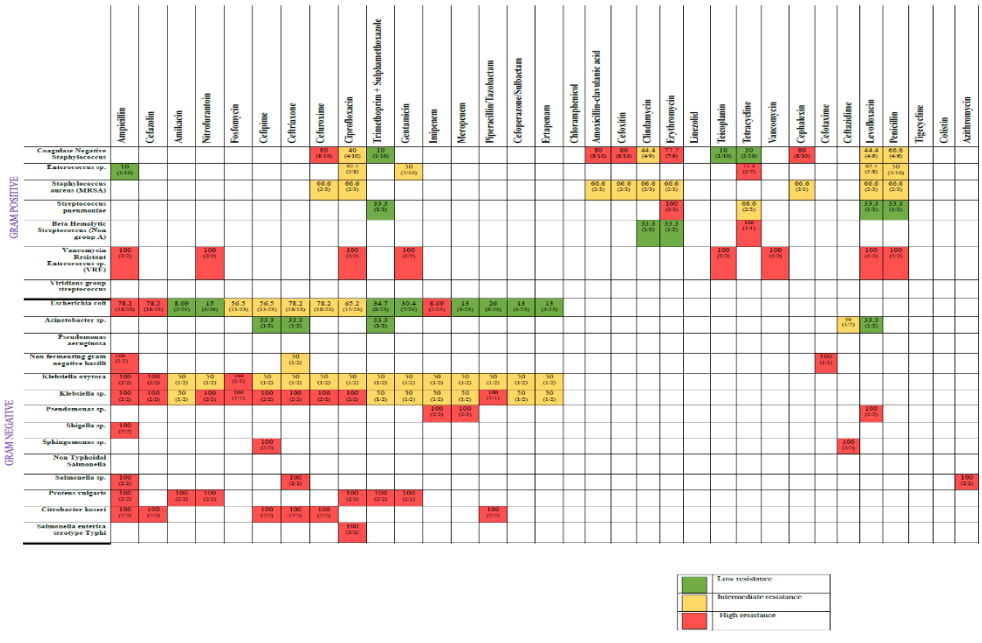


Figure 2: Culture resistance matrix grid.

DISCUSSION

In the present study, antibiotic prescribing was most common among toddlers and children, with smaller proportions among infants and adolescents. This distribution differs from reports from Ethiopia and Chinese studies, where infants and younger children represented larger proportions of the study populations.[12,13] Differences in study setting, hospital admission patterns, healthcare resources, and inclusion criteria may account for these variations. The present study included paediatric ward inpatients, whereas some comparative studies included larger numbers of younger or neonatal admissions. In the present study, males represented 53.6% and females 46.4% of participants. Similar male predominance has been reported in Ethiopia and Oman.[3,12]

The Benin birth cohort study reported an approximately equal distribution of males and females.[14] Differences in sex distribution across studies may reflect variations in population characteristics, healthcare-seeking patterns, and study design.

Most children in the present study had a hospital stay of ≤7 days. This was shorter than the mean hospital stay reported in the Ethiopian study (11.24±6.9 days) and broadly comparable with the Chinese cross-sectional study, in which nearly 80% of patients stayed ≤10 days and the mean stay was 8.96±9.6 days.[12,13] Differences may be related to illness severity, healthcare systems, discharge practices, and availability of outpatient follow-up.

Most antibiotic treatment durations in the present study lasted ≤7 days, which was shorter than the mean duration reported in the Ethiopian study (10.6±6.9 days).[12] This difference may be associated with the characteristics of the study population and prescribing practices in the study setting. In the present study, ceftriaxone (28.5%) and azithromycin (18.8%) were the most frequently prescribed antibiotics, followed by amoxicillin-clavulanate and amikacin. The high use of Watch antibiotics, particularly ceftriaxone, highlights the importance of monitoring broad-spectrum antibiotic use.

The present study showed a high proportion of appropriate antibiotic therapy. This finding was higher than the 71.7% appropriateness reported in an Ethiopian study.[21] Differences may be related to adherence to hospital antibiotic policies, availability of diagnostic support, patient characteristics, and antimicrobial stewardship practices.

The adverse drug reactions identified in the present study were mild and classified as probable. Antibiotics are an important contributor to ADRs in hospitalized children. Similar findings have been reported in paediatric studies, although the frequency and severity of ADRs vary across settings.[23,28] Differences may reflect variations in patient populations, monitoring practices, and reporting systems.

WHO AWaRe categorization showed that Watch antibiotics accounted for the largest proportion of antibiotic use in the present study, followed by Access antibiotics, while Reserve antibiotics were used infrequently. In contrast, a study from Sierra Leone reported higher use of Access antibiotics (63.5%).[26] The greater proportion of Watch antibiotics in the present study may be related to the characteristics of patients managed in a tertiary care setting and the types of infections encountered. These findings support continued monitoring of antibiotic use, adherence to hospital guidelines, and strengthening of antimicrobial stewardship activities.

Limitations

This study was conducted at a single tertiary care hospital and included 250 paediatric inpatients; therefore, the findings may not be generalizable to other healthcare settings. Only paediatric ward inpatients were included, and antibiotic use among outpatients and PICU patients was not assessed. The study period was limited and may not capture seasonal variation in infections or prescribing patterns. Culture and susceptibility testing were not available for all patients, limiting microbiological assessment of antibiotic selection. Only four ADRs were reported, which may underestimate the frequency of adverse drug reactions in the study population.

CONCLUSION

The present study found that antibiotic prescribing among paediatric inpatients was generally appropriate, with 98% of prescriptions consistent with the hospital antibiotic policy. Ceftriaxone was the most frequently prescribed antibiotic, and Watch antibiotics represented the largest AWaRe category. Despite the high level of appropriateness, the substantial use of broad-spectrum antibiotics emphasizes the need for regular review and careful antibiotic selection. Culture and susceptibility testing provided useful information for antibiotic selection and optimization where available. Dose correction and appropriate switching between intravenous and oral therapy were among the optimization interventions identified. Continued monitoring of prescribing practices, adherence to hospital guidelines, culture-guided therapy, and antimicrobial stewardship activities are important for promoting safe and rational antibiotic use and for limiting antimicrobial resistance in paediatric patients.

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