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RESEARCH ARTICLE

Evaluation of Antibiotic Utilization Patterns and Therapeutic Indicators in a Pediatric Tertiary Care Inpatient Department

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Abstract: Antimicrobial stewardship in pediatric populations is essential to reduce the progression of multidrug-resistant organisms and ensure the efficacy of life-saving therapies. Rational prescribing remains a challenge in hospitals where infectious diseases account for a high percentage of hospital admissions. Analysis of inpatient data from a tertiary care teaching hospital indicates that respiratory tract infections serve as the primary clinical indication for antibiotic initiation. Among the various classes of antimicrobials, third-generation cephalosporins, specifically ceftriaxone, are utilized with the highest frequency, often administered via the intravenous route. Observations of prescribing habits reveal a significant reliance on injectable formulations and a prevalent trend toward polypharmacy, with a substantial number of patients receiving more than six medications concurrently. While adherence to the National List of Essential Medicines and generic naming conventions is evident, the frequent use of broad-spectrum agents in an empirical capacity highlights a critical area for intervention. Implementation of structured antimicrobial stewardship programs, guided by periodic prescription audits and local sensitivity data, is necessary to optimize therapeutic outcomes. Improving the rational use of antibiotics through early intravenous-to-oral switch therapy and targeted narrow-spectrum selection can significantly reduce the risk of adverse drug reactions and healthcare-associated costs. Continuous monitoring of these patterns serves as a foundation for developing evidence-based guidelines tailored to the unique physiological requirements of the pediatric demographics.

Keywords: Pediatric Pharmacotherapy; Antimicrobial Stewardship; Drug Utilization Evaluation; Rational Prescribing; Polypharmacy Trends

1. Introduction

Antimicrobial agents are vital for primary defense against bacterial pathogens that once caused widespread mortality. However, the efficacy of these agents is currently threatened by the rapid emergence and dissemination of antimicrobial resistance (AMR), a phenomenon driven largely by the irrational use of these drugs in both human and veterinary health sectors [1]. Within pediatric practice, antibiotics are among the most frequently utilized medications, yet they are often initiated without definitive microbiological confirmation. The resulting selective pressure facilitates the survival of resistant strains, leading to therapeutic failure and the necessity for more toxic or expensive alternative treatments [2]. The global burden of AMR is particularly high in developing regions where healthcare infrastructure may lack the robust microbiological support required for targeted therapy, often resulting in prolonged hospital stays and increased healthcare expenditures [3].

The development of resistance is a complex biological process involving multiple adaptive mechanisms. Bacteria may undergo genetic mutations or acquire resistance genes via horizontal gene transfer, leading to the production of enzymes like beta-lactamases that neutralize antibiotic molecules before they reach their targets [4]. Other mechanisms include the modification of penicillin-binding proteins, the activation of multidrug efflux pumps that actively remove the drug from the cell, and the alteration of outer membrane porins to restrict drug entry [5]. These cellular defenses necessitate a strategic approach to antibiotic selection, as the misuse of broad-spectrum agents can inadvertently select for "superbugs" that are resistant to nearly all available therapeutic options [6].

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Prescribing for the pediatric population presents unique challenges that distinguish it from adult medicine. Children are not merely small adults; they undergo rapid physiological changes that influence drug disposition and response [7]. Rational drug use in this demographic requires the right drug to be administered in the right dose, via the right route, and for the right duration, tailored to the specific age and weight of the child. Despite these requirements, a substantial portion of antibiotic prescriptions in pediatric wards is directed toward viral infections, such as the common cold or viral gastroenteritis, where they offer no therapeutic benefit [8]. Such practices not only expose children to unnecessary risks of adverse drug reactions but also disrupt the healthy commensal microflora, potentially leading to secondary complications such as *Clostridioides difficile* infections [9].

The absorption, distribution, metabolism, and excretion (ADME) of antibiotics in children are highly variable and age-dependent. Neonates and infants possess immature hepatic enzyme systems and reduced renal clearance rates, which can significantly prolong the half-life of many antimicrobials [10]. Conversely, older children may exhibit higher metabolic rates for certain drugs compared to adults. These pharmacokinetic differences, combined with a lack of pediatric-specific clinical trial data, often result in off-label use and empirical dosing [11]. The absence of appropriate liquid formulations further complicates administration, leading to dosing inaccuracies when adult solid dosage forms are manipulated for pediatric use [12].

Prescription Pattern Monitoring Studies (PPMS) serve as essential tools for evaluating the clinical application of drugs and identifying deviations from established guidelines [13]. Researchers can pinpoint specific areas of irrationality [14] by systematically analyzing the types of drugs prescribed, their indications, and the adherence to core prescribing indicators defined by the World Health Organization (WHO). In the context of antibiotics, these audits are vital for assessing the prevalence of polypharmacy and the use of injectable versus oral formulations. Continuous monitoring allows for the detection of shifts in prescribing trends, facilitating the implementation of corrective educational interventions and the refinement of hospital antibiotic policies [15]. Strengthening these stewardship efforts is paramount to preserving the utility of existing antimicrobials for future generations [16].

2. Materials and Methods

2.1. Study Design

The evaluation of antibiotic prescribing habits was structured as a prospective observational study conducted within the inpatient department of a tertiary care teaching hospital. This methodology was selected to capture real-time clinical decisions and therapeutic trends over a defined period of nine months. The study aimed to provide an authentic representation of the current standard of care in the pediatric setting by observing the clinical workflow without intervention. The site was chosen due to its role as a primary referral center, ensuring a diverse range of clinical presentations and a high volume of pediatric admissions.

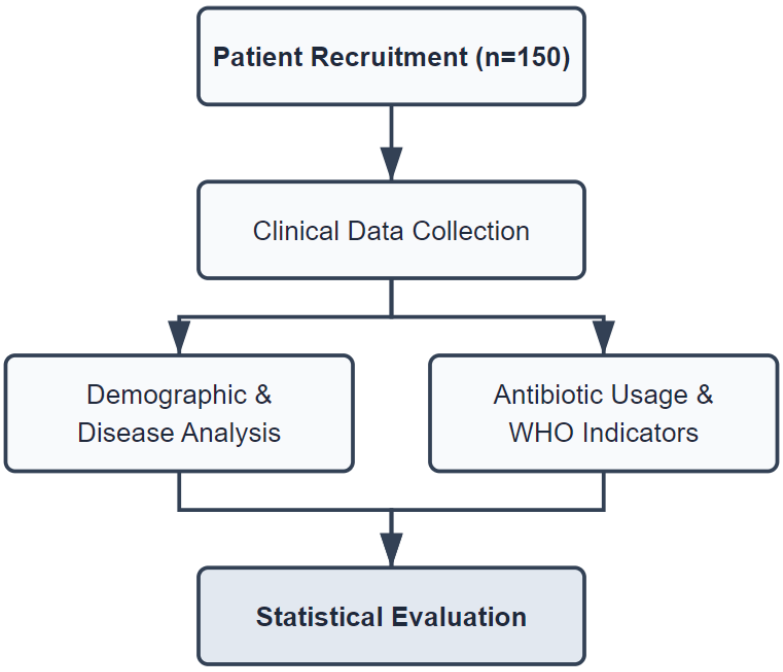

Figure 1. Study Methodology and Data Acquisition

2.1.1. Inclusion and Exclusion Parameters

The study included all pediatric patients aged 18 years and younger who were admitted to the inpatient ward and received at least one systemic antibiotic during their hospitalization. Participation was contingent upon obtaining written informed assent or consent from the parents or legal guardians. To maintain a focus on acute infectious management and general prescribing trends, patients treated exclusively in the outpatient department were excluded. Patients with known chronic conditions requiring long-term, specialized antibiotic prophylaxis were excluded to avoid skewing the data toward non-representative prescribing patterns.

2.2. Data Acquisition and Ethical Safeguards

Data collection was performed using a standardized, pre-tested data collection tool designed to extract comprehensive information from patient case files. The parameters recorded included demographic variables (age, gender), primary and secondary clinical diagnoses, and detailed medication histories. For each antibiotic prescribed, the name (generic or brand), class, dosage regimen, frequency, duration, and route of administration were meticulously documented. The clinical progress and the rationale for any changes in therapy were also noted where available.

2.2.1. Ethical Approval

The study protocol was reviewed and approved by the Institutional Review Board (IRB) and the Ethics Committee (Approval Number. HKES/IRB/150125). Prior to data collection, formal permission was obtained from the Medical Superintendent and the Head of the Department of Pediatrics. All data were anonymized to protect patient confidentiality, and no personal identifiers were included in the final analysis. The study was conducted in strict adherence to the ethical principles outlined in the Declaration of Helsinki.

2.3. Evaluation of WHO Core Prescribing Indicators

The assessment utilized the World Health Organization (WHO) core prescribing indicators to provide a standardized measure of drug utilization quality. These indicators include:

- Average number of drugs per encounter: To measure the degree of polypharmacy.
- Percentage of drugs prescribed by generic name: To evaluate adherence to cost-effective prescribing practices.
- Percentage of encounters with an antibiotic prescribed: To determine the frequency of antimicrobial use.
- Percentage of encounters with an injection prescribed: To assess the reliance on parenteral therapy.
- Percentage of drugs prescribed from the National Essential Medicines List (NEML): To determine the alignment with national therapeutic standards.

3. Results

3.1. Patient Demographics and Clinical Presentations

The clinical investigation involved a cohort of 150 pediatric inpatients, where a slight predominance of male patients (53.33%) was observed compared to female patients (46.67%). Age-based stratification revealed that adolescents between 12 and 18 years accounted for the largest segment of the study population, representing 44% of total admissions. In contrast, neonates and infants constituted a smaller proportion, at 5.33% and 10% respectively. The distribution of toddlers and preschool-aged children remained consistent at 10.67% each, while school-aged children (6–12 years) made up 19.33% of the cohort.

Respiratory tract infections were identified as the primary driver for antibiotic initiation, affecting 36.66% of the patients. This was followed by gastrointestinal infections, which were diagnosed in 23.33% of the cases. Hematological disorders accounted for 15.33% of the indications, while urinary tract infections and viral infections represented 10.66% and 4% of the population, respectively. Central nervous system infections and liver-related pathologies were less frequent, collectively accounting for approximately 3.32% of the admissions. A miscellaneous group of conditions comprised the remaining 6.66% of the disease patterns observed during the study period.

Table 1. Demographic Profile and Clinical Diagnosis Patterns (n = 150)

Category	Variable	Number of Patients (n=150)	Percentage (%)
Gender	Male	80	53.33%
	Female	70	46.67%
Age Group	Newborn (Birth–1 Month)	8	5.33%
	Infant (1 Month–1 Year)	15	10.00%
	Toddler (1–3 Years)	16	10.67%
	Preschool (3–6 Years)	16	10.67%
	School Age (6–12 Years)	29	19.33%
	Adolescent (12–18 Years)	66	44.00%
Clinical Indication	Respiratory Tract Infection	55	36.66%
	Gastrointestinal Infection	35	23.33%
	Haematological Disorder	23	15.33%
	Urinary Tract Infection	16	10.66%
	Viral Infection	6	4.00%
	CNS Infection/Disorder	4	2.66%
	Liver Infection	1	0.66%
	Others	10	6.66%

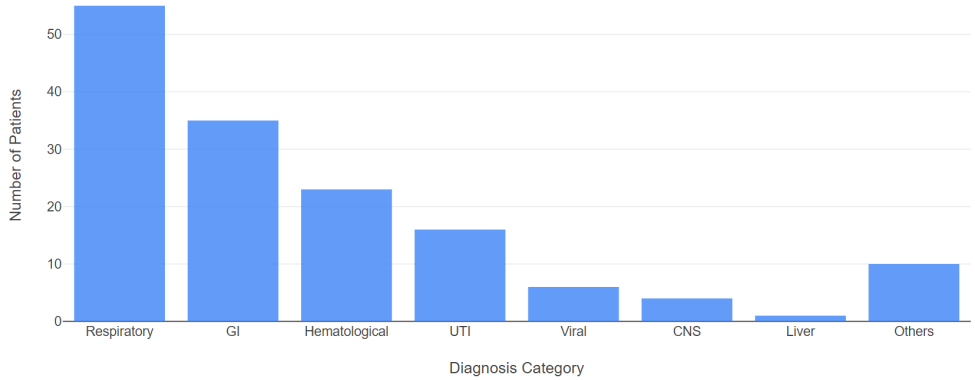

Figure 2. Quantitative Distribution of Clinical Indications

3.2. Characterization of Antibiotic Utilization and Administration

A total of 290 antibiotic prescriptions were documented across the 150-patient cohort. Regarding the route of administration, there was a pronounced reliance on parenteral therapy, with 77.69% of antibiotics being administered intravenously. Oral formulations were utilized in 22.31% of the cases. Among the individual agents prescribed, ceftriaxone emerged as the most frequently utilized antibiotic, representing 34% of all prescriptions. Other significant agents included amikacin (10.53%), ampicillin (8.61%), and meropenem (7.66%). Narrower-spectrum agents and specialized antimicrobials such as vancomycin, linezolid, and faropenem were utilized in smaller frequencies, typically reserved for specific clinical presentations or suspected resistant infections.

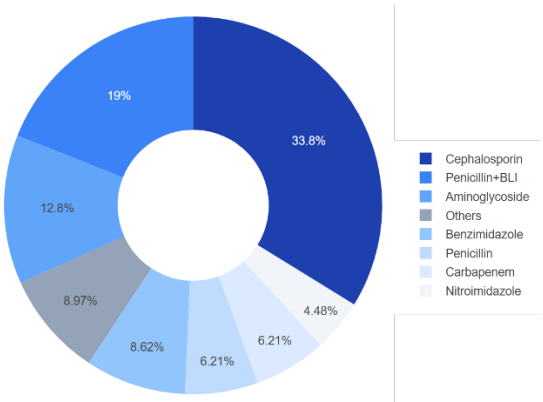

Figure 3. Relative Proportions of Prescribed Antibiotic Classes

Table 2. Distribution of Antibiotic Classes and Individual Agents (n = 290)

Category	Variable	Count	Percentage (%)
Antibiotic Class	Cephalosporin	98	33.79%
	Penicillin + Beta-lactamase Inhibitor	55	18.97%
	Aminoglycoside	37	12.76%
	Benzimidazole	25	8.62%
	Penicillin	18	6.21%
	Carbapenem	18	6.21%
	Nitroimidazole	13	4.48%
	Others (Oxazolidinone, Macrolide, etc.)	26	8.96%
Top Individual Agents (n = 209 Monotherapies)	Ceftriaxone	71	34.00%*
	Amikacin	22	10.53%
	Ampicillin	18	8.61%
	Meropenem	16	7.66%
Fixed Dose Combinations (n = 81 FDCs)	Amoxycillin + Clavulanic Acid	52	64.20%**
	Albendazole + Ivermectin	16	19.75%

**Percentage of individual agents; **Percentage of FDCs*

Fixed-dose combinations (FDCs) were integrated into the therapeutic regimens of several patients, with 81 instances recorded. The combination of amoxycillin and clavulanic acid was the most prevalent FDC, accounting for 64.20% of all combination therapies. Anthelmintic combinations, specifically albendazole and ivermectin, were documented in 19.75% of the FDC instances. Other combinations such as cefoperazone/sulbactam and piperacillin/tazobactam were utilized in 7.40% and 3.70% of the cases, respectively, reflecting a strategy to broaden the spectrum of activity against beta-lactamase-producing organisms.

Table 3. Route of Administration and Therapy Classification

Parameter	Variable	Frequency	Percentage (%)
Route of Delivery (n = 278)	Intravenous (IV)	216	77.69%
	Oral	62	22.31%
Therapy Type	Monotherapy	209	72.00%
(n = 290 antibiotics)	Combination Therapy	81	28.00%
Antibiotics per Case (n = 150 patients)	One Antibiotic	73	48.67%
	Two Antibiotics	36	24.00%
	Three or More Antibiotics	41	27.33%

3.3. WHO Prescribing Indicators and Polypharmacy Trends

The quantitative assessment of prescribing habits through WHO indicators revealed an average of 1.93 antibiotics per patient. Monotherapy was the dominant strategy, applied in 72% of the prescriptions, while combination therapy was utilized in 28%. When considering the entirety of the pharmacological regimen, the average number of drugs per patient reached 6.33. Generic name prescribing was observed in 56.55% of antibiotic instances and 52% across all drug classes. Notably, 100% of the antibiotics utilized were included in the National List of Essential Medicines (NLEM), although overall drug adherence to the NLEM across all categories was 80%.

Table 4. Analysis of World Health Organization (WHO) Core Prescribing Indicators

WHO Prescribing Indicator	Observed Value
Average number of drugs per encounter	6.33
Percentage of drugs prescribed by generic name	52.00%
Percentage of encounters with an antibiotic prescribed	30.52%
Percentage of encounters with an injection prescribed	45.57%
Percentage of antibiotics from National Essential Medicine List (NLEM)	100.00%
Average number of antibiotics per patient	1.93

Analysis of the total medication burden indicated a high prevalence of polypharmacy within the pediatric ward. Mild polypharmacy (2–4 drugs) and moderate polypharmacy (5–7 drugs) were distributed almost equally, at 34.67% and 34%, respectively. However, a

significant portion of the population (31.33%) was subject to severe polypharmacy, defined as the concurrent administration of eight or more medications. This elevated medication count often included a mix of antimicrobials, analgesics, vitamins, and fluids, increasing the complexity of the therapeutic management and the potential for drug-drug interactions

4. Discussion

The observation of a male-dominated patient distribution (53.33%) aligns with several regional studies, which consistently report higher hospitalization rates for male children in South Asian contexts [17, 18, 19]. This trend may be attributed to a combination of biological susceptibility and socio-cultural factors influencing healthcare-seeking behavior. The high percentage of adolescents (44%) in this cohort diverges from earlier studies where younger children under the age of five typically constituted the majority of pediatric admissions [20-23]. This shift suggests a local variation in disease burden or perhaps a specific referral pattern within the teaching hospital setting.

Respiratory tract infections remain the most significant clinical challenge in pediatric medicine, a finding corroborated by the 36.66% prevalence in this study. This data is consistent with global literature identifying respiratory ailments as the primary reason for both outpatient visits and inpatient antibiotic initiation [24, 25]. The frequent diagnosis of gastrointestinal infections (23.33%) further emphasizes the burden of infectious diseases in areas with varying levels of sanitation and emphasizes the need for targeted antimicrobial strategies that address both enteric and respiratory pathogens.

The heavy reliance on intravenous administration (77.69%) reflects the common clinical practice in inpatient settings where rapid therapeutic onset is prioritized for acute infections. Similar parenteral preferences have been documented in tertiary care audits, where the severity of illness often necessitates bypassing the oral route [26, 27]. However, the high rate of injectable use warrants a review of "IV-to-oral switch" protocols, which are essential for reducing catheter-related infections and hospital costs.

The dominance of ceftriaxone (34%) and the cephalosporin class (33.79%) highlights their role as the preferred empirical choice for many clinicians due to their broad-spectrum activity and favorable safety profile in children [28-30]. This utilization pattern mirrors findings in other institutional audits where third-generation cephalosporins have largely replaced older penicillins as first-line empirical agents [31, 32]. While effective, the widespread use of these agents without culture-guided specificity may contribute to the selection of extended-spectrum beta-lactamase (ESBL) producing organisms, necessitating strict adherence to stewardship guidelines.

The average of 6.33 drugs per prescription exceeds the WHO recommendation, indicating a high degree of polypharmacy. This finding is consistent with other inpatient studies where multiple supportive therapies are often co-administered with antibiotics [33-35]. The antibiotic-specific average of 1.93 drugs per patient suggests that while clinicians generally avoid excessive antibiotic combinations, the overall therapeutic burden remains high. Adherence to the National List of Essential Medicines (NLEM) was high (100% for antibiotics), which is a positive indicator of rational selection according to national standards.

Generic prescribing at 56.55% for antibiotics represents a moderate level of compliance with international recommendations aimed at reducing healthcare costs [32]. However, the prevalence of severe polypharmacy in 31.33% of patients is a significant concern. The concurrent use of multiple medications increases the risk of adverse drug reactions (ADRs) and potential drug-drug interactions, which are particularly difficult to monitor in the pediatric population due to limited pharmacokinetic data [21, 23]. This highlights the necessity for clinical pharmacists to actively participate in ward rounds to optimize drug regimens and ensure patient safety.

5. Conclusion

This work revealed that while antibiotic selection aligns with national essential medicine lists, there is a clear trend toward the use of broad-spectrum parenteral agents and significant polypharmacy. These patterns reflect an empirical approach to pediatric infectious disease management that could be optimized through the integration of microbiological data and structured stewardship interventions. Efforts should be made to reduce unnecessary injectable use and promote targeted, narrow-spectrum therapy as soon as clinical stability and culture results allow. Implementing regular prescription audits and providing feedback to healthcare providers will be essential steps in rational prescribing and mitigating the long-term impact of antimicrobial resistance in the pediatric population.

Compliance with ethical standards

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Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript. No funding, consultancy, or institutional affiliations exist that pose a conflict of interest regarding the outcomes of this study.

Statement of ethical approval

The protocol for this clinical study was reviewed and approved by the Institutional Ethics Committee (IEC) of HKES's Matoshree Taradevi Rampure Institute of Pharmaceutical Sciences and Basaveshwar Teaching and General Hospital (Approval Number: HKES/IRB/150125). All procedures involving human participants were conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study. In the case of pediatric subjects, written informed consent and assent were obtained from the parents or legal guardians prior to their inclusion in the research

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