



## Original Research Article

# ANALYSIS OF ANTIBIOTIC PRESCRIBING PRACTICES USING A DIGITAL PLATFORM IN A TERTIARY CARE HOSPITAL: IMPLICATIONS IN STEWARDSHIP PLANNING

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**ABSTRACT**

**Background:** Inappropriate antibiotic prescribing is a major contributor for Antimicrobial Resistance (AMR), a global health challenge. This study utilized a novel digital prescription analytical platform VaidyaRx to analyze prescribing trends with reference to essentiality, use of fixed dose combinations (FDC) and pharmacoeconomic analysis. The study aims to provide data-driven insights into antibiotics prescribing practices

**Materials and Methods:** A descriptive observational study was conducted at a tertiary care hospital by analysing 6906 outpatient prescriptions of 5 major antibiotic prescribing departments, over the period of seven months. The Prescriptions were digitized and analyzed to explore the prescribing trends, and classification of antibiotics, completeness of prescriptions and cost distribution by using the digital platform.

**Results:** Out of total 6906 prescriptions, 1783 (25.8%) contained antibiotics. General surgery had the highest antibiotic prescription (67.7%). Empirical prescribing was universal. 93.8% of antibiotics were prescribed by branded name. The most frequently prescribed antibiotic formulations were ofloxacin and ornidazole (28.1%) and amoxicillin and potassium clavulanate (23.9%). According to WHO AWaRe classification the use was 39.7% Access, 17.9% Watch, and 0.02% Reserve antibiotics category reflecting adherence to stewardship guidelines. Analysis of completeness of antibiotic prescribing showed mentions of 55.5% for dose, 75.4% for frequency, and 82.4% for duration. The cost comparison showed less than 2% difference between NLEM & NON NLEM.

**Conclusion:** General surgery was the leading prescriber of antibiotics, with most prescriptions having FDC therapies and were from the essential medicines list. Ofloxacin and ornidazole was the commonest prescribed combination. The cost comparison showed significant cost advantage in antibiotics prescribed from NLEM. The findings suggest gaps in antibiotic prescribing practices that can be improved through the periodic trainings, promotion of generics and complete documentation practice. The use of the VaidyaRx digital analytical platform enabled online prescribing analysis, facilitating targeted interventions that will be useful for strategizing antibiotic stewardship.

**Keywords:** Antibiotic prescribing trend, digital platform, antibiotic stewardship, WHO AWaRe classification, pharmacoeconomics, NLEM.

## INTRODUCTION

AMR is a global health challenge contributing to significant morbidity and mortality. It is estimated that 4.95 million deaths were associated with bacterial AMR worldwide in 2019, with nearly 1.27 million deaths directly attributable to resistant infections. In India, although comprehensive nationwide data on AMR burden remains limited, studies indicate that antibiotic-resistant the burden is substantial, with an estimated 297,000 deaths attributable to AMR and 1,042,500 deaths associated with AMR in 2019.<sup>[1]</sup>

A major contributor to AMR is the inappropriate prescribing of antibiotics, including over prescription, empirical treatment, incorrect dosing and/or duration. Empirical prescribing is prevalent due to factors such as limited diagnostic facilities, delayed test results, and, in some cases, a lack of trust in results from non-accredited laboratories. Additionally, the unregulated availability of antibiotics in certain regions promotes irrational prescribing practices.

Multiple studies have reported an increase in antibiotic consumption among humans in India, with Antimicrobial Consumption (AMC) being the primary driver of AMR. Recent data from 2019 revealed that humans consumed a total of 5,071 million Defined Daily Doses (DDD), with "Watch category" drugs accounting for 54.9% of DDIs, and "Access category" drugs accounting for 27.0%.<sup>[2]</sup>

Given the increasing threat of AMR, it is essential to evaluate prescribing patterns in medical disciplines with high antibiotic utilization. The present study analyzes prescription trends in a tertiary care hospital using a digital analytical platform, VaidyaRx, to assess antibiotic prescribing behavior across five major outpatient departments (OPDs). The use of customized digital analytics allows for rapid evaluation of antibiotic use, which can facilitate strategic interventions to enhance rational prescribing and optimize antimicrobial stewardship. VaidyaRx digital platforms showcase the potential of digital tools to improve healthcare efficiency. By enabling swift prescription data capture and retrieval in tertiary care settings, it enhances clinical decision-making and promotes better patient outcomes and also streamline the patient-physician-pharmacy loop, improving adherence and compliance by offering features that simplify prescription details, especially for handwritten prescriptions. Their ability to improve clarity, accessibility, and communication underscores their potential to transform prescription management and make healthcare more patient-centric.

This study was conducted in a tertiary care center in South India, and aims to provide data-driven insights into antibiotics prescribing practices. Such evaluations are crucial, particularly in developing

countries like India, where the high burden of infectious diseases, unrestricted antibiotic access, and lack of stringent prescription regulations contribute to excessive antibiotic use. By leveraging digital prescription analysis, this study aims to inform policy changes and strengthen antimicrobial stewardship efforts to combat the rising threat of antibiotic resistance.

## MATERIALS AND METHODS

A descriptive observational study was conducted at SVS Medical College and Hospital, Mahabubnagar, Telangana, over a seven-month period (June to December 2024) following approval from the institutional ethics committee.

A total of 6906 prescriptions were collected from the departments of general medicine, general surgery, pediatrics, orthopaedics, and pulmonology OPDs. These prescriptions were scanned, digitized, and stored using the VaidyaRx platform. Prescriptions containing one or more antibiotics were included in the study. Prescriptions that did not include any medications or those from patients who declined to share their prescriptions were excluded. Additionally, physicians who consented to onboard onto the VaidyaRx platform and share their prescriptions were included in the study.

Informed consent was obtained from all participating patients and physicians before data collection.

Prescription data were collected via trained pharmacy interns and nurses, who uploaded scanned copies of prescriptions to the secure, encrypted VaidyaRx cloud database. A two-tier transcription and verification process ensured accuracy, with random samples reviewed by prescribing doctors for quality assurance. The extracted data included patient demographics, vitals, complaints, diagnosis, and prescription details (drug name, dose, frequency, duration, strength, and formulation).

The collected prescription data were systematically analyzed to evaluate antibiotic prescribing trends across multiple parameters. Antibiotics were categorized based on their pharmacological classification, and their distribution across departments was assessed. Prescriptions were further classified using the WHO AWaRe classification to determine adherence to antimicrobial stewardship principles. The proportion of antibiotics prescribed from the National List of Essential Medicines (NLEM) versus non-NLEM was examined, along with department-wise variations. A comparative analysis was performed to distinguish between fixed-dose combination (FDC) antibiotics and single-drug formulations, identifying trends in combination therapy usage. Use of irrational antimicrobial FDC was also studied. Additionally, antibiotic completeness was assessed,

documenting any missing details such as dose, frequency, duration, strength, or formulation. The study also evaluated cases where antibiotics were prescribed or modified based on microbiological culture and sensitivity reports. A cost comparison analysis was conducted to assess price differentials between NLEM and non-NLEM antibiotics. The collected data were tabulated in Microsoft Excel and analyzed by VaidyaRx digital platform. Descriptive statistics were used to represent data as mean  $\pm$  SD or as number and percentages, wherever applicable.

## RESULTS

Around 6906 prescriptions were analyzed during the study period of which 1783 prescriptions consisted of antibiotics. 52.27 % were male and 47.73% were female, with a mean age of  $13.0 \pm 4.8$  years for

pediatrics age group,  $38.8 \pm 12.9$  for adult age group and  $71.9 \pm 2.5$  for geriatric age group. The highest proportion of prescriptions was for the 19–65 years age group (73.75 %), followed by the 0–18 years age group (21.65%) and the 65+ years age group (4.60 %).

The distribution of prescriptions across different departments revealed notable variations in antibiotic usage. General medicine had the highest number of total prescriptions (2635; 38.2%), but only 21.5% included antibiotics, with most containing a single antibiotic (90.3%). General surgery accounted for 36.3% of total prescriptions, with the highest proportion of antibiotic use (67.7%), and 91.5% of these contained a single antibiotic. Pediatrics had 13.6% of total prescriptions, with antibiotics prescribed in only 4.4% of cases, predominantly as monotherapy (92.4%) as shown in table 1.

**Table 1: Department-Wise distribution of prescriptions and antibiotic utilization pattern**

DEPARTMENTS	TOTAL NUMBER OF PRESCRIPTIONS (%)	TOTAL NUMBER OF PRESCRIPTIONS WITH ANTIBIOTICS (%)	NO.OF PRESCRIPTIONS WITH NO ANTIBIOTICS (%)	NO.OF PRESCRIPTIONS WITH 1 ANTIBIOTICS (%)	NO.OF PRESCRIPTIONS WITH 2 ANTIBIOTICS (%)
GENERAL MEDICINE	2635 (38.2)	383 (21.5)	2252 (43.9)	346 (90.3)	35 (9.1)
GENERAL SURGERY	2506 (36.3)	1207 (67.7)	1299 (25.4)	1104 (91.5)	100 (8.3)
PEDIATRICS	942 (13.6)	79 (4.4)	863 (16.8)	73 (92.4)	6 (7.6)
PULMONOLOGY	793 (11.5)	107 (6)	686 (13.4)	90 (84.1)	16 (15.0)
ORTHOPEDIC	30 (0.4)	7 (0.4)	23 (0.4)	6 (85.7)	1 (14.3)

A total of 1835 (93.8%) antibiotics were prescribed using brand names, while only 122 (6.2%) were prescribed as generics. General surgery had the highest proportion of branded antibiotic prescriptions 1279 (97.4%), followed by general medicine 371(19.0%) and pulmonology 113 (5.8%). Pediatrics, pulmonology, and orthopedics exhibited lower antibiotic prescription rates.

The majority of prescriptions 1619 (90.8%) included a single antibiotic, while a smaller portion 164 (9.2%) involved two antibiotics. Oral administration was the most common route (98.51%), with intravenous (0.9%) and topical (0.56%) prescriptions being significantly lower.

Additionally, all antibiotics were prescribed empirically in the outpatient department across multiple specialties.

Among the 1957 antibiotics analyzed, the most prescribed therapeutic category was quinolone + nitroimidazole, accounting for 28.2% of the total, followed by penicillin + beta-lactamase inhibitors at 24.0%. Third-generation cephalosporins constituted 9.3%, while their combinations with beta-lactamase inhibitors made up 8.7%. The high prevalence of combination antibiotics, particularly beta-lactamase inhibitors and third-generation cephalosporins, highlights their critical role in empirical therapy and resistance management. [Table 2]

**Table 2: Distribution of antibiotics based on therapeutic classification**

ANTIBIOTIC CLASSIFICATION	n= 1957	%
QUINOLONE + NITROIMIDAZOLE	552	28.2
PENICILLIN + BETA LACTAMASE INHIBITOR	470	24.0
3RD GENERATION CEPHALOSPORIN	182	9.3
3RD GENERATION CEPHALOSPORIN + BETA LACTAMASE INHIBITOR	170	8.7
NITROFURAN	116	5.9
MACROLIDE	103	5.3
NITROIMIDAZOLE	88	4.5
TETRACYCLINE	47	2.4
FLUROQUINOLONE + NITROIMIDAZOLE	38	2.0
FLUROQUINOLONE	37	1.9
OXAZOLIDONES	36	1.9
LINCOSAMIDE	36	1.8
QUINOLONE	15	0.8

Antibiotic prescriptions were categorized using the WHO AWaRe classification, with Access antibiotics comprising 39.7%, Watch 17.9%, and Reserve only 0.02%, reflecting adherence to stewardship guidelines. Amoxicillin + potassium clavulanate (60.2%) was the most prescribed Access antibiotic, while cefixime (42.0%) led in the Watch category. Linezolid was the primary Reserve antibiotic, with minimal use of faropenem and

colistin. Around 39.3% of prescriptions involved WHO "Not Recommended" combinations, mainly ofloxacin + ornidazole (75.3%) and cefpodoxime + potassium clavulanate (21.9%), with 0.6% of antibiotics unlisted. General surgery had the highest use of Access (62.0%) and Watch category antibiotics, while Reserve antibiotics were primarily used in surgical cases.

**Table 3: Department wise distribution of AWaRe classification**

DEPARTMENT (total antibiotics)	ACCESS (n=777) (%)	WATCH (n= 351) (%)	RESERVE (n=49) (%)
General Medicine (426)	25.5	30.5	16.3
General Surgery (1313)	62.0	51.0	69.4
Paediatrics (85)	6.9	5.1	4.1
Pulmonary Medicine (125)	5.1	12.5	10.2
Orthopedics (8)	0.4	0.9	0.0

The age-wise distribution of antibiotics revealed distinct prescribing patterns across pediatric, adult, and geriatric groups. In the pediatric group (399), the most frequently prescribed antibiotic combination was ofloxacin + ornidazole (38.4%), followed by amoxicillin + potassium clavulanate (27.1%) and cefixime (8.3%). For adults (1402), ofloxacin + ornidazole (26.3%) was most commonly prescribed, with amoxicillin + potassium clavulanate (23.1%) and cefpodoxime + potassium clavulanate (9.3%) also being prominent choices. In the geriatric group (92), amoxicillin + potassium clavulanate was most commonly prescribed (21.7%), followed by cefixime (13%) and cefpodoxime + potassium clavulanate (13%). The use of nitrofurantoin and metronidazole showed a notable presence in the adult and geriatric groups, while pediatric prescriptions exhibited a lower diversity in antibiotic choice.

The department-wise distribution of antibiotics based on NLEM and FDCs showed significant variation. General surgery had the highest proportion of NLEM prescriptions (59.2%), followed by general medicine (27.0%), with lower

usage in pediatrics, pulmonology, and orthopedics, reflecting adherence to essential medicine protocols. Among NLEM antibiotics (1062), amoxicillin + potassium clavulanate (44.3%) was the most prescribed, followed by cefixime (13.8%), nitrofurantoin (10.9%), metronidazole (8.3%), and azithromycin (8.2%). For non-NLEM antibiotics (895), ofloxacin + ornidazole (61.3%) was the most common, followed by cefpodoxime + potassium clavulanate (17.9%), ciprofloxacin + ornidazole (4.5%), clindamycin (4.0%), and cefuroxime (1.7%). Table 4

General surgery (71.3%) had the highest usage of FDC antibiotics, followed by general medicine (19.3%) and pulmonology (5.0%), reflecting the preference for combination therapies. Among FDC antibiotics (1249), ofloxacin + ornidazole (44.0%) was the most prescribed, followed by amoxicillin + potassium clavulanate (37.6%) and cefpodoxime + potassium clavulanate (12.8%). Cefixime (20.8%) was the most prescribed single-molecule antibiotic, followed by nitrofurantoin and metronidazole. [Table 4]

**Table 4: Department wise distribution of NLEM and FDC antibiotics**

DEPARTMENT	NLEM Medicines (n (%))	FDC Medicines (n (%))
General Medicine (426)	287 (27.0)	241 (19.3)
General Surgery (1313)	629 (59.2)	890 (71.3)
Paediatrics (85)	63 (5.9)	51 (4.1)
Pulmonary Medicine (125)	78 (1.3)	63 (5.0)
Orthopedics (8)	5 (0.5)	4 (0.3)

The evaluation of antibiotic prescription completeness showed high adherence to key parameters. Dose was documented in 55.5% of prescriptions, while frequency was recorded in 75.4% of cases. Duration was specified in 82.4% of prescriptions, reflecting strong compliance. Notably, route of administration and dosage form were nearly documented, with 99.7% completeness. The assessment of antibiotic prescription completeness across departments revealed that general surgery had the highest percentage of antibiotics, with

46.8% specifying dose, 75.6% frequency, and 85.3% duration. General Medicine showed moderate adherence, with 70.7% dose, 77.9% frequency, and 80.5% duration documented. Pediatrics and Pulmonology demonstrated relatively high completeness, with 71.8% and 80.8% dose specification, respectively. The route of administration was consistently recorded across all departments (97.6–100%), indicating strong adherence to antibiotic prescribing guidelines. [Table 5]

**Table 5: Distribution based on antibiotic parameter completeness**

SL.NO	DEPARTMENTS	DOSE n(%)	FREQUENCY n(%)	DURATION n(%)	ROUTE OF ADMINISTRATION n(%)	DOSAGE FORM n(%)
1	GENERAL MEDICINE	301 (70.7)	332 (77.9)	343 (80.5)	426 (100)	426 (100)
2	GENERAL SURGERY	615 (46.8)	992 (75.6)	1120 (85.3)	1311 (99.8)	1311 (99.8)
3	PEDIATRICS	61 (71.8)	49 (57.6)	63 (74.1)	83 (97.6)	83 (97.6)
4	PULMONOLOGY	101 (80.8)	95 (76)	81 (64.8)	123 (98.4)	123 (98.4)
5	ORTHOPEDIC	8 (100)	8 (100)	6 (75)	8 (100)	8 (100)

An analysis of antibiotic expenditure across the given departments revealed that general surgery had the highest reliance on NLEM antibiotics (65.2%), followed by general medicine (24.6%) and orthopedics (6.6%). Conversely, non-NLEM

antibiotic expenditure was also highest in general surgery (67.37%), followed by general medicine (22.09%) and pediatrics (0.53%) having the lowest as shown in table 6.

**Table 6: Percentage cost distribution of NLEM and Non-NLEM Antibiotics**

DEPARTMENT	COST OF NLEM MEDICINE (%)	COST OF NON NLEM MEDICINE (%)
GENERAL MEDICINE	24.6	22.1
GENERAL SURGERY	65.2	67.4
PEADIATRICS	0.3	0.5
PULMOLOGY	3.3	1.1
ORTHOPEDICS	6.6	9.0

## DISCUSSIONS

Antibiotic prescribing practices vary across clinical settings, with trends indicating significant overuse, particularly in tertiary care centers in India. The WHO has emphasized rational antibiotic use to combat antimicrobial resistance (AMR), a growing global health threat.<sup>[3]</sup> Studies in Indian hospitals reveal a heavy reliance on empirical prescribing, leading to excessive broad-spectrum antibiotic use.<sup>[4]</sup> Prescription monitoring studies highlight inappropriate antibiotic usage and non-adherence to standard treatment guidelines (Sharma et al., 2020). In the United States, research suggests that overprescription for viral infections can be mitigated by extending patient consultation times.<sup>[5]</sup> Improving diagnostic tool availability, adherence to evidence-based guidelines, and increasing consultation time are key strategies to enhance rational antibiotic usage. Between 2000 and 2015, India experienced a 103% rise in antibiotic consumption, driven by factors such as high disease burden, rising incomes, unregulated prescription sales, and insufficient vaccine coverage.<sup>[6]</sup> Similar trends have been observed in other lower- and middle-income countries, contributing to antibiotic misuse and resistance.

The integration of digital platforms has significantly improved the monitoring and analysis of antibiotic prescribing patterns. Digital healthcare exchange platforms allow real-time tracking of prescription trends, linking clinical diagnoses with treatment data for more accurate assessments.<sup>[7]</sup> These

interventions have been effective in reducing antimicrobial use and enhancing prescribing appropriateness in hospital settings. Rational antibiotic use is essential not only for effective infection management but also for minimizing the emergence and spread of resistant pathogens.

In our study, general surgery exhibited the highest antibiotic prescription rate (67.7%), compared to general medicine (21.5%) and pediatrics (4.4%). This finding aligns with a study conducted in a South Indian tertiary care setting, where 65% of surgical cases involved prophylactic antibiotic administration. However, the prevalent empirical use without microbiological confirmation underscores the need for a transition toward culture-guided therapy. A strong preference for branded antibiotics (93.8%), particularly in general surgery (97.4%), with only 6.2% prescribed as generics was seen and underscore the need for policies promoting generic prescribing to optimize healthcare expenditures without compromising treatment quality. Most prescriptions (90.8%) involved a single antibiotic, predominantly administered orally (98.51%), while intravenous and topical routes were minimal. Empirical prescribing was universal across outpatient specialties, raising concerns about antimicrobial resistance. The preference for oral antibiotics in the outpatient department reflects the general feasibility, cost-effectiveness, and patient adherence advantages of this route. Previous studies have demonstrated that oral antibiotic overuse, especially without microbiological confirmation, contributes to rising antimicrobial resistance rates.<sup>[8]</sup>

Encouraging generic drug use, promoting culture-based prescribing, and enhancing antimicrobial stewardship are crucial for optimizing antibiotic use. The selection of antibiotic combinations, particularly quinolone + nitroimidazole (28.1%) and penicillin + beta-lactamase inhibitors (23.9%), aligns with global trends favoring broad-spectrum agents in empirical treatment. The frequent use of third-generation cephalosporins (9.4%) and their beta-lactamase inhibitor combinations (8.7%) reflects an increasing reliance on extended-spectrum agents, which, if unchecked, may accelerate resistance patterns. A similar trend was seen in a study conducted among outpatients setting which revealed that cephalosporins and fluoroquinolones were the most prescribed antibiotic classes indicating that such prescribing behaviors necessitate regular surveillance to promote rational antibiotic use and curb the spread of resistance highlighting a preference for broad-spectrum antibiotics.<sup>[9]</sup>

According to the WHO AWaRe classification, antibiotics are categorized to promote rational prescribing. In our study, 39.7% of prescriptions comprised Access group antibiotics, while Watch antibiotics accounted for 17.9%. This distribution of AWaRe category has similar findings to a study conducted in a tertiary care center in North India, where Access antibiotics accounted for 57.6% of prescriptions, Watch for 38.3%, and Reserve for 4.1%.<sup>[10]</sup> More concerning is the prescription of "Not Recommended" antibiotic combinations (39.3%), such as ofloxacin + ornidazole which has been mostly prescribed (75.3%). This excessive use of irrational combinations highlights a need for stricter regulatory policies and prescriber education to align with WHO recommendations.

Complete antibiotic information in prescriptions is essential for ensuring accurate dosing, reducing medication errors, and optimizing treatment outcomes. Proper documentation of drug name, dose, frequency, duration, and route of administration enhances patient safety, prevents under or overdosing, and minimizes the risk of antimicrobial resistance. In our study, dose specification was documented in 55.5% of prescriptions, frequency in 75.4%, and duration in 82.4%. The discrepancies underscore the importance of standardizing digital prescription formats to enhance adherence to best practices.

The economic burden of antibiotic prescribing remains a concern, especially in resource-limited settings. Our cost analysis indicated that general surgery had the highest expenditure on both NLEM (65.15%) and non-NLEM (67.37%) antibiotics. Cost-effective prescribing interventions can be initiated.

A key limitation of this study was the absence of follow-up on therapeutic responses, as it was structured as a time-point prevalence study. This design constrained our ability to evaluate the clinical effectiveness of prescribed antibiotics, identify

potential treatment failures, and monitor the emergence of resistance over time. Additionally, the study only included prescriptions from five clinical departments, providing a limited, cross-sectional view of antibiotic prescribing patterns which cannot be generalized in all settings.

## CONCLUSION

Antibiotic prescribing practices play a crucial role in infection management, and optimizing their use is essential for improving patient outcomes, reducing healthcare costs, and mitigating antimicrobial resistance. Our study found ofloxacin + ornidazole as the most prescribed antibiotic, followed by amoxicillin + potassium clavulanate, with limited generic prescribing and mostly empirical use. Surgery had the highest antibiotic use, predominantly access-class and combination therapies. The evaluation of antibiotic prescription completeness showed high adherence to key parameters. Enhancing prescribing practices through improved documentation, culture-based selection, and increased generic use is crucial. Digital integration, antimicrobial stewardship, and clinician training can further rationalize antibiotic usage. Future studies with longitudinal follow-up will offer deeper insights into the impact of these interventions on patient outcomes and antibiotic resistance trends.

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