

Pharmacoeconomic Evaluation of Oral Antibiotic Utilization Using Cost Per Defined Daily Dose in a Hospital-Based Study in North Kerala

Nithish Shyamlal V K¹ and Ankit Singh²

¹Faculty of Pharmacy

^{1,2}Shri Jagdishprasad Jhabarmal Tibrewala University (Shri JYT University), Rajasthan, India

Abstract: Background: Irrational antibiotic prescribing can increase treatment expenditure and contribute to antimicrobial resistance. Simple utilization measures do not fully describe the economic implications of antibiotic selection. This study evaluated the cost of commonly prescribed oral antibiotics using cost per Defined Daily Dose (cost/DDD) and interpreted the findings alongside antibiotic utilization.

Methods: Antibiotic utilization data were assessed using the WHO Anatomical Therapeutic Chemical/Defined Daily Dose (ATC/DDD) methodology. Twelve commonly prescribed oral antibiotics were included in the cost analysis. The percentage of prescriptions, ATC classification, WHO DDD, strength per unit and cost/DDD were recorded. Unit prices were obtained from average generic retail prices reported in CIMS, PharmEasy and 1mg and accessed in 2025. Cost/DDD was calculated by standardizing the unit price to the WHO-assigned DDD. Descriptive statistics, including mean, median, standard deviation, coefficient of variation, range and weighted mean cost, were calculated.

Results: Amoxicillin–clavulanic acid represented the largest proportion of prescriptions (25%) and had the highest cost/DDD (₹54). Azithromycin accounted for 15% of prescriptions and had a cost/DDD of ₹7.80. Cefpodoxime and cefixime accounted for 9% and 8% of prescriptions, with cost/DDD values of ₹28 and ₹32, respectively. Amoxicillin accounted for 7% of prescriptions and had a cost/DDD of ₹18. Doxycycline had the lowest cost/DDD (₹2) but represented only 1% of prescriptions. Across the 12 antibiotics, the mean prescription share was 6.83%, the mean cost/DDD was ₹16.61, the median cost/DDD was ₹11.00, the coefficient of variation for cost/DDD was 91.4%, and the weighted mean cost was ₹27.65. The observed cost/DDD ranged from ₹2 to ₹54.

Conclusion: There was substantial variation in the economic burden associated with commonly prescribed oral antibiotics. Amoxicillin–clavulanic acid combined high prescribing frequency with the highest cost/DDD, making it an important target for prescription review and cost-conscious antimicrobial stewardship. Cost/DDD should be interpreted together with utilization and clinical appropriateness rather than used as an independent criterion for antibiotic selection.

Keywords: pharmacoeconomics; antibiotic utilization; antimicrobial stewardship; defined daily dose; cost per DDD; amoxicillin–clavulanic acid; antibiotic prescribing.

I. INTRODUCTION

Antibiotics are essential medicines, but inappropriate selection, excessive use of broad-spectrum agents and prolonged or unnecessary treatment can increase direct medicine expenditure and contribute to antimicrobial resistance. In settings where patients bear substantial out-of-pocket costs, the economic consequences of antibiotic selection are particularly relevant.



The WHO ATC/DDD methodology provides a standardized approach for comparing medicine utilization across drugs and settings. Expressing antibiotic expenditure as cost per DDD allows the cost associated with a standardized daily dose to be compared across agents with different strengths and dosing schedules. However, a lower-cost antibiotic is not necessarily clinically preferable; economic interpretation must remain subordinate to indication, local resistance patterns, guideline recommendations, patient characteristics and safety.

The present study therefore focused on the pharmaco-economic dimension of oral antibiotic use. The analysis retained the principal utilization findings from the thesis and concentrated on the cost/DDD results, prescription frequency and their combined implications for antimicrobial stewardship.

II. AIM

To evaluate the economic burden of commonly prescribed oral antibiotics by estimating cost per Defined Daily Dose and examining cost in relation to prescribing frequency and antibiotic utilization.

III. OBJECTIVES

1. To determine the prescription frequency of commonly used oral antibiotics.
2. To calculate the cost per WHO-defined daily dose for each selected oral antibiotic.
3. To describe the variability in antibiotic cost/DDD and identify antibiotics with comparatively high or low standardized daily costs.
4. To interpret cost/DDD together with antibiotic utilization to identify potential areas for cost-conscious antimicrobial stewardship.

IV. MATERIALS AND METHODS

4.1 Study design and setting

The parent research was a prospective hospital-based study involving antibiotic prescribing and utilization assessment in North Kerala. For this article, the cost-analysis component of the thesis was extracted and presented as a focused pharmaco-economic analysis of commonly prescribed oral antibiotics.

4.2 Antibiotics included

Twelve commonly prescribed oral antibiotics were included in the cost analysis: amoxicillin-clavulanic acid, azithromycin, cefixime, cefpodoxime, amoxicillin, metronidazole, ciprofloxacin, ofloxacin, doxycycline, nitrofurantoin, erythromycin and levofloxacin.

4.3 Cost data

Unit prices were sourced from average generic retail prices listed in CIMS, PharmEasy and 1mg, with the source data accessed in 2025. The analysis therefore represents medicine acquisition/retail price estimates available during the stated period and should not be interpreted as actual patient-level expenditure unless confirmed from dispensing or billing records.

4.4 Cost/DDD calculation

Cost per DDD was standardized using the WHO-assigned DDD for each antibiotic. The calculation used in the thesis was: $\text{Cost/DDD} = (\text{unit price} \div \text{strength per unit in grams}) \times \text{WHO DDD}$. This approach permits comparison of standardized daily antibiotic costs despite differences in dosage strength.

4.5 Utilization measures

Prescription percentage and antibiotic utilization were considered alongside cost/DDD. The parent thesis also assessed total DDDs and DDD/1000 patient-days using the WHO ATC/DDD methodology and evaluated antibiotic utilization using the Antimicrobial Utilization Ratio (AUR). These measures were used in this article to provide contextual interpretation of the cost findings.



4.6 Statistical analysis

Descriptive statistics included mean, median, standard deviation, coefficient of variation, minimum, maximum and range for prescription percentage and cost/DDD. A weighted mean cost/DDD was also reported in the thesis.

V. RESULTS

5.1 Prescription frequency and cost per DDD

Amoxicillin–clavulanic acid had the highest prescription frequency (25%) and the highest cost/DDD (₹54). Azithromycin was the second most frequently prescribed agent (15%) but had a substantially lower cost/DDD of ₹7.80. Cefpodoxime (9%) and cefixime (8%) had cost/DDD values of ₹28 and ₹32, respectively. Amoxicillin represented 7% of prescriptions and had a cost/DDD of ₹18.

The lowest prescription frequencies were observed for doxycycline and levofloxacin (1% each). Doxycycline had the lowest cost/DDD among the 12 antibiotics (₹2). Nitrofurantoin and erythromycin had cost/DDD values of ₹12 and ₹8, respectively. Metronidazole had a cost/DDD of ₹7.50.

Antibiotic	Prescription %	ATC code	WHO DDD	Strength (g)	Cost/DDD (₹)
Amoxicillin–clavulanic acid	25%	J01CR02	1.5 g	0.625	54
Azithromycin	15%	J01FA10	0.3 g	0.5	7.8
Cefixime	8%	J01DD08	0.4 g	0.2	32
Cefpodoxime	9%	J01DD13	0.4 g	0.2	28
Amoxicillin	7%	J01CA04	1.5 g	0.5	18
Metronidazole	4%	J01XD01	1.5 g	0.4	7.5
Ciprofloxacin	3%	J01MA02	1 g	0.5	8
Ofloxacin	4%	J01MA01	0.4 g	0.2	12
Doxycycline	1%	J01AA02	0.1 g	0.1	2
Nitrofurantoin	3%	J01XE01	0.2 g	0.1	12
Erythromycin	2%	J01FA01	1 g	0.5	8
Levofloxacin	1%	J01MA12	0.5 g	0.5	10

5.2 Descriptive statistics of cost

Across the 12 oral antibiotics, the mean prescription share was 6.83% and the mean cost/DDD was ₹16.61. The median cost/DDD was ₹11.00, with a standard deviation of ₹15.18. The coefficient of variation for cost/DDD was 91.4%, indicating substantial relative variability. Cost/DDD ranged from ₹2 to ₹54, giving an absolute range of ₹52. The weighted mean cost reported in the thesis was ₹27.65.

Parameter	Cost/DDD
Mean	₹16.61
Median	₹11.00
Standard deviation	₹15.18
Coefficient of variation	91.4%
Minimum	₹2
Maximum	₹54
Range	₹52
Weighted mean	₹27.65

5.3 Cost ranking

The antibiotics ranked from lowest to highest cost/DDD were doxycycline (₹2), metronidazole (₹7.50), azithromycin (₹7.80), ciprofloxacin (₹8), erythromycin (₹8), levofloxacin (₹10), nitrofurantoin (₹12), ofloxacin (₹12), amoxicillin (₹18), cefpodoxime (₹28), cefixime (₹32) and amoxicillin–clavulanic acid (₹54).



5.4 Cost in relation to utilization

The parent utilization analysis showed that amoxicillin–clavulanic acid had 229.5 total DDDs and 218.57 DDD/1000 patient-days, the highest utilization among the listed agents. Azithromycin had 150 total DDDs and 142.85 DDD/1000 patient-days, while cefixime had 72.5 total DDDs and 69.04 DDD/1000 patient-days. Thus, amoxicillin–clavulanic acid combined high prescribing frequency, high standardized cost and high utilization in the study dataset.

VI. DISCUSSION

The principal finding of this pharmacoeconomic analysis was the wide variation in standardized antibiotic cost. Cost/DDD varied 27-fold between doxycycline (□2) and amoxicillin–clavulanic acid (□54). The high coefficient of variation further indicates that the economic burden was not uniform across the antibiotics evaluated.

Amoxicillin–clavulanic acid is particularly relevant because it combined the highest prescription frequency with the highest cost/DDD. In the parent study it also had the highest total DDD and DDD/1000 patient-days and an AUR of 109.28%. Taken together, these findings identify this agent as an important candidate for prescription audit, duration review and assessment of indication. This does not imply that amoxicillin–clavulanic acid should be replaced whenever it is prescribed; clinical appropriateness and local susceptibility information must determine antibiotic selection.

Third-generation cephalosporins showed another economically relevant pattern. Cefixime and cefpodoxime accounted for 8% and 9% of prescriptions, respectively, with cost/DDD values of □32 and □28. Their standardized costs were considerably higher than those of several commonly available alternatives. Stewardship review should therefore assess whether their use is supported by indication, microbiological information and applicable treatment guidelines.

Azithromycin illustrates why cost alone should not determine prescribing. Although it accounted for 15% of prescriptions, its cost/DDD was only □7.80. A low medicine price does not establish clinical appropriateness, and inexpensive antibiotics can still contribute to resistance when used unnecessarily or incorrectly.

Doxycycline had the lowest cost/DDD at □2 but only 1% of prescriptions. The finding demonstrates that prescribing frequency is not determined solely by medicine price. Clinician preference, indication, local resistance patterns, patient factors and guideline recommendations can all influence selection.

The combined interpretation of cost/DDD and utilization provides more useful stewardship information than either measure alone. A high-cost antibiotic with very low utilization may have less aggregate economic impact than a moderately or highly utilized antibiotic with a high standardized cost. In the present dataset, amoxicillin–clavulanic acid is the clearest example of the high-utilization/high-cost combination.

The economic analysis in this article is a cost-of-utilization analysis rather than a formal cost-effectiveness or cost-benefit analysis. The available thesis data do not establish incremental clinical outcomes, quality-adjusted life-years, total patient expenditure, hospitalization costs attributable to each antibiotic, or the cost of implementing the pharmacist intervention. Consequently, the results should not be interpreted as proving that one antibiotic is more cost-effective than another.

VII. IMPLICATIONS FOR ANTIMICROBIAL STEWARDSHIP

Cost information can be incorporated into antimicrobial stewardship as a secondary decision-support variable. Routine antibiotic audits can identify agents with high utilization and comparatively high cost/DDD. For such agents, pharmacists and prescribers can review indication, dose, duration, route, opportunities for de-escalation and availability of clinically appropriate alternatives.

The findings also support routine monitoring of antibiotic consumption using ATC/DDD methodology. Integrating prescription frequency, DDD/1000 patient-days, AUR, AWaRe category and cost/DDD can provide a broader institutional picture of antibiotic use. Such an approach can help identify areas for further audit without replacing clinical judgment.



VIII. STRENGTHS AND LIMITATIONS

The main strength is the use of WHO-standardized DDD methodology, allowing comparison of antibiotic costs across different strengths and dosage forms. The analysis also combines economic information with prescribing frequency and utilization measures.

The analysis has limitations. Prices were based on retail/generic price sources accessed in 2025 rather than patient-specific dispensing or hospital procurement invoices. Only selected oral antibiotics were included in the cost table. The study did not calculate total treatment cost per patient, indirect costs, hospitalization costs, adverse-event costs or the cost of pharmacist intervention. No formal cost-effectiveness, cost-utility or cost-benefit analysis was performed. Prices may also vary by manufacturer, formulation, location, procurement source and time.

IX. CONCLUSION

The study demonstrated substantial variation in the standardized cost of commonly prescribed oral antibiotics, with cost/DDD ranging from ₹2 for doxycycline to ₹54 for amoxicillin–clavulanic acid. Amoxicillin–clavulanic acid was notable for combining the highest prescription frequency with the highest cost/DDD and the highest utilization in the parent study. Cost/DDD analysis, when combined with antibiotic utilization measures, can help antimicrobial stewardship teams identify priorities for prescription review and cost containment. However, cost should remain a secondary consideration after clinical indication, guideline concordance, microbiological evidence, safety and patient-specific factors. Future studies should incorporate patient-level treatment costs, clinical outcomes and intervention costs to establish formal cost-effectiveness.

X. DECLARATIONS

Ethics approval: The parent thesis reports Institutional Human Ethics Committee approval dated 15 February 2025 (approval no. 005/2025/CCOPS/IEC).

Funding: Not stated in the supplied thesis; complete according to the target journal.

Conflict of interest: Not stated in the supplied thesis; complete according to the target journal.

Data availability: To be completed according to institutional and journal requirements.

REFERENCES

1. World Health Organization Collaborating Centre for Drug Statistics Methodology. Guidelines for ATC classification and DDD assignment 2024. Oslo: Norwegian Institute of Public Health; 2024.
2. World Health Organization. AWaRe classification of antibiotics for evaluation and monitoring of use, 2023. Geneva: WHO; 2023.
3. Laxminarayan R, Chaudhury RR. Antibiotic resistance in India. Lancet. 2016;387(10014):168–170.
4. Smith R, Coast J. The true cost of antimicrobial resistance. BMJ. 2013;346:f1493.
5. Shrestha P, Cooper BS, Coast J, et al. Enumerating the economic cost of antimicrobial resistance per antibiotic consumed to inform the evaluation of interventions affecting their use. Antimicrob Resist Infect Control. 2018;7:98.
6. Davey P, Marwick CA, Scott CL, et al. Interventions to improve antibiotic prescribing practices for hospital inpatients. Cochrane Database Syst Rev. 2017;2:CD003543.
7. Rawson TM, Moore LSP, Castro-Sánchez E, et al. A systematic review of clinical pharmacy interventions in antimicrobial stewardship. Clin Microbiol Infect. 2017;23(11):854–863.

