



Original Article

## Evaluation of Prescribing Patterns and Usage of Antibiotics in COPD Inpatients of the Pulmonology Department in a Tertiary Care Hospital: A Retrospective Study

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### ABSTRACT

**Background:** Chronic obstructive pulmonary disease (COPD) is a major cause of hospitalisation requiring multidrug therapy, and antibiotics are central to the management of acute exacerbations. Irrational antibiotic use, particularly the over-reliance on broad-spectrum agents, accelerates antimicrobial resistance (AMR). Auditing prescriptions against the World Health Organization (WHO) Core Prescribing Indicators and the WHO Access–Watch–Reserve (AWaRe) classification offers an objective framework for evaluating rational drug use and antimicrobial stewardship.

**Objectives:** To assess the prescribing pattern and usage of antibiotics among COPD inpatients in a tertiary care hospital using the WHO Core Prescribing Indicators and the WHO AWaRe classification.

**Methods:** A retrospective observational study was conducted in the Department of Pulmonology of a tertiary care teaching hospital over a six-month period (December 2024 to June 2025). Case records and drug charts of 56 COPD inpatients were reviewed. Data on demographics, smoking, alcohol and oral tobacco use, polypharmacy and antibiotic prescriptions were extracted. Antibiotics were classified by the WHO AWaRe categories, and WHO Core Prescribing Indicators were computed. Descriptive statistics were used.

**Results:** A total of 78 antibiotic prescriptions were recorded among 56 patients (mean age 68.1 years; males 46 [82.14%]). Smoking was documented in 48 (85.71%) and polypharmacy in 50 (89.29%). Ceftriaxone (28.21%) was the most prescribed antibiotic in patients without comorbidity, while piperacillin–tazobactam (23.08%) and cefoperazone–sulbactam (17.95%) predominated in those with comorbidity. Watch-group antibiotics accounted for 54 (69.23%) prescriptions and Access-group for 24 (30.77%); no Reserve-group antibiotics were used. WHO Core Indicators showed 9.39 drugs per encounter, 92.78% generic prescribing, 29.28% encounters with injections, 1.52 antibiotics per encounter and 40.68% NLEM adherence.

**Conclusion:** COPD inpatients demonstrated substantial polypharmacy and a heavy reliance on Watch-group antibiotics despite excellent generic adherence. The findings underscore the need for strengthened antimicrobial stewardship, institution-specific COPD treatment protocols and improved adherence to the National List of Essential Medicines.

## INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a progressive and largely preventable respiratory illness characterised by persistent airflow limitation that is not fully reversible and that is usually associated with an abnormal inflammatory response of the lungs to noxious particles or gases. It now ranks among the leading causes of morbidity, hospitalisation and mortality worldwide, and continues to impose a heavy burden on healthcare systems, particularly in low- and middle-income countries. Recent global burden-of-disease analyses confirm that, despite a modest decline in age-standardised rates over the past three decades, the absolute number of people living with COPD and dying from it remains very large, with smoking and household air pollution from solid fuels being the most important attributable risk factors.<sup>1</sup>

In India, the burden of COPD is amplified by the high prevalence of tobacco smoking, occupational exposure to dust and fumes, and widespread household exposure to biomass fuel smoke. Several Indian cohort studies have demonstrated that non-smoking women exposed to solid biomass fuel for cooking have a high prevalence of obstructive lung function, with one hospital-based study reporting an obstructive pattern in 93.57% of exposed non-smoking women, and a cumulative exposure index directly proportional to symptom severity.<sup>2</sup> Tobacco smoking remains the dominant risk factor in men, while the combined effects of indoor and ambient air pollution explain why COPD often presents at an earlier age in Indian patients than in Western populations.<sup>1,2</sup>

Acute exacerbations of COPD (AECOPD) are the principal reason for emergency department visits and inpatient admissions in patients living with COPD, and they are associated with accelerated decline of lung function, reduced quality of life and increased mortality. Bacterial pathogens, including *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Moraxella catarrhalis*, *Pseudomonas aeruginosa* and members of the Enterobacterales, are implicated in a substantial proportion of exacerbations, particularly in patients with frequent exacerbations, severe airflow limitation, mechanical ventilation, or significant comorbidity.<sup>3</sup> The Global Initiative for Chronic Obstructive Lung Disease (GOLD) strategy recommends antibiotic therapy for AECOPD in patients fulfilling the Anthonisen criteria (increased dyspnoea, sputum volume and sputum purulence), those requiring mechanical ventilation, or those with markedly elevated biomarkers of bacterial infection.<sup>3,4</sup>

Despite these guideline recommendations, antibiotic prescribing for COPD in real-world hospital practice is often empirical, broad spectrum and driven more by institutional habit than by evidence. A pharmacist-driven order-set study in patients hospitalised for COPD exacerbation observed that the overall rate of antibiotic use was 90.2% in the pre-intervention group and 71.0% after implementation of a guideline-based order-set, with a corresponding reduction in hospital length of stay from 4.3 to 3.4 days ( $p = 0.004$ ).<sup>5</sup> Another retrospective cohort study found no significant difference in 30-day readmissions or length of stay between guideline-appropriate and inappropriate antibiotic groups, suggesting that a substantial proportion of antibiotic prescribing in AECOPD may be unnecessary.<sup>6</sup> A large multicentre Italian database analysis further demonstrated that quinolones (37.2%), third-generation cephalosporins (25.5%), penicillins (15.4%) and macrolides (14.4%) accounted for the majority of antibacterial prescriptions in AECOPD, with a 30-day mean cost of €709 per episode.<sup>7</sup>

Inappropriate antibiotic use in acute respiratory tract infections, including AECOPD, is widespread in both high-income and resource-limited settings. A large multicentre study from Tunisia involving 9,886 patients with acute respiratory tract infections reported that antibiotic therapy was inappropriate in 75.5% of prescriptions, with amoxicillin–clavulanic acid and levofloxacin being the most inappropriately used agents; pre-existing COPD was independently associated with inappropriate prescribing (odds ratio 1.75; 95% confidence interval 1.43–2.15;  $p < 0.001$ ).<sup>8</sup> A regulatory analysis from the United States showed that even after the U.S. Food and Drug Administration restricted the indications of oral quinolones for AECOPD, quinolones still accounted for 14.6% of treated episodes by the end of the study period, highlighting how prescribing habits are slow to change.<sup>9</sup> These observations underline that prescribing audits using standardised indicators are essential to identify gaps in rational prescribing and to design effective stewardship interventions.

To facilitate such audits, the World Health Organization (WHO) developed two complementary instruments: the WHO Core Prescribing Indicators and the WHO Access, Watch and Reserve (AWaRe) antibiotic classification. The Core Prescribing Indicators include the average number of drugs per encounter, percentage of drugs prescribed by generic name, percentage of encounters with an antibiotic, percentage of encounters with an injection and percentage of drugs prescribed from an essential medicines list, and serve as a robust framework to assess rational use of medicines.<sup>10</sup> The WHO AWaRe classification categorises antibiotics into Access (narrow-spectrum agents recommended as first or second

choice), Watch (higher resistance potential, requiring stewardship oversight) and Reserve (last-resort agents for multi-drug-resistant infections), and was incorporated into the WHO Essential Medicines List with the explicit target that Access-group antibiotics should constitute at least 60% of total antibiotic consumption.<sup>11</sup>

Indian and other low- and middle-income country studies that have applied these instruments have repeatedly identified shortcomings. An evaluation of 1,000 prescriptions across an Indian hospital using both AWaRe and selected antimicrobial use indicators showed that Watch-group antibiotics were consumed in significantly higher numbers than Access-group antibiotics, generic prescribing reached 98%, but standard treatment guidelines were absent and only 13.28% of pneumonia prescriptions adhered to recommended guidelines.<sup>12</sup> A North Indian outpatient study reported 49.7% of antibiotics as Access, 27.3% as Watch and none as Reserve, with respiratory tract infections being a major contributor to inappropriate prescribing.<sup>13</sup> A seven-year longitudinal analysis from a National Antimicrobial Consumption Network site in North India demonstrated a significant increase in Reserve-group antibiotic consumption from 2021 onwards and substantial use of WHO "not-recommended" fixed-dose combinations, particularly during the COVID-19 pandemic, when consumption of azithromycin and doxycycline rose sharply.<sup>14</sup> Outpatient audits using the WHO Core Prescribing Indicators in Indian tertiary care hospitals have consistently found that generic prescribing and NLEM adherence remain suboptimal, even when antibiotic and injection use fall within recommended ranges.<sup>15</sup>

Pulmonology inpatient wards, where COPD exacerbations are concentrated, represent a high-risk setting for irrational antibiotic prescribing because of the high proportion of elderly patients, the frequent presence of comorbidities such as type 2 diabetes mellitus, hypertension, ischaemic heart disease and chronic kidney disease, and the empirical pressure to "cover" possible bacterial superinfection. Polypharmacy in this population further compounds the risk of drug–drug interactions, adverse drug reactions and non-adherence. A prospective audit of 400 COPD outpatients reported a heavy reliance on fixed-dose combination therapy and limited adherence to GOLD-stage-based treatment, with male sex, asthma overlap and severe comorbidity associated with frequent exacerbations.<sup>3</sup> Despite these data, focused prescribing audits limited to COPD inpatients in Indian tertiary care hospitals are scarce, and almost none combine the WHO Core Indicators with the AWaRe framework in a single analysis.

The present study was designed to address this gap. We hypothesised that COPD inpatients in our tertiary care teaching hospital would demonstrate high polypharmacy, predominantly Watch-group antibiotic use and only moderate adherence to the National List of Essential Medicines, in keeping with patterns reported from comparable Indian institutions.<sup>12,14,15</sup> By evaluating six months of consecutive case records using the WHO Core Prescribing Indicators and the AWaRe classification, we aimed to provide an objective audit of current prescribing behaviour, identify specific areas for stewardship intervention, and contribute to the limited body of Indian inpatient antibiotic-use data in COPD.

## **AIMS AND OBJECTIVES**

### ***Aim***

To evaluate the prescribing pattern and usage of antibiotics in COPD inpatients of the Pulmonology Department of a tertiary care teaching hospital, using the WHO Core Prescribing Indicators and the WHO AWaRe classification.

### ***Primary objective***

To assess the pattern of antibiotic prescribing in COPD inpatients and to classify the prescribed antibiotics into Access, Watch and Reserve categories as per the WHO AWaRe classification (2023).

### ***Secondary objectives***

1. To analyse prescribing rationality using the five WHO Core Prescribing Indicators (average number of drugs per encounter, percentage of drugs prescribed by generic name, percentage of encounters with an antibiotic, percentage of encounters with an injection and percentage of drugs prescribed from the National List of Essential Medicines).
2. To describe the demographic profile, behavioural risk factors (smoking, oral tobacco use, alcohol use), comorbidity burden and polypharmacy among COPD inpatients receiving antibiotics.
3. To identify gaps in rational antibiotic use and to derive recommendations for institutional antimicrobial stewardship in COPD management.

## **MATERIALS AND METHODS**

### ***Study design***

This was a single-centre, hospital-based, retrospective observational study.

### ***Study setting***

The study was conducted in the Department of Pharmacology in collaboration with the Department of Pulmonology of Sathagiri Institute of Medical Sciences and Research Centre (SIMSRC), Bengaluru, Karnataka, India, a tertiary care teaching hospital.

### **Study duration**

Case records from 1 December 2024 to 30 June 2025, covering a continuous six-month period, were retrieved and analysed. The data extraction and analysis were carried out during November 2025.

### **Study population and sample size**

All consecutive adult patients (aged 18 years or older) admitted to the Pulmonology in-patient ward with a clinical diagnosis of COPD (with or without acute exacerbation) during the study period and who received at least one antibiotic during their hospital stay were considered eligible. A total of 56 patients fulfilling the inclusion criteria were enrolled, yielding 78 individual antibiotic prescriptions for analysis. Since the study was an exploratory prescription audit, a convenience sample of all eligible patients during the study window was taken; no formal a priori sample size calculation was performed.

### **Inclusion criteria**

(i) Adult inpatients aged  $\geq 18$  years; (ii) Diagnosis of COPD as documented by the treating pulmonologist on the basis of clinical history, examination and, where available, spirometry consistent with GOLD criteria; (iii) Patients prescribed at least one systemic antibiotic during the inpatient stay; (iv) Patients with complete case records and drug charts available for review.

### **Exclusion criteria**

(i) Patients aged  $< 18$  years; (ii) Patients with incomplete or illegible case records; (iii) Patients with a primary diagnosis other than COPD (e.g., isolated community-acquired pneumonia, bronchiectasis, pulmonary tuberculosis or lung malignancy without underlying COPD); (iv) Patients admitted for less than 24 hours; (v) Patients in whom no antibiotic was prescribed during the entire inpatient stay; (vi) Patients who had received antibiotics in the preceding 14 days at another facility, where information could not be verified from the records.

### **Data collection and variables**

A structured data collection proforma was developed and pre-tested on five non-study records. The following variables were captured for each patient: (i) demographics — age, sex; (ii) behavioural risk factors — current and former cigarette/bidi smoking, oral tobacco use, alcohol consumption; (iii) comorbidities — diabetes mellitus, hypertension, ischaemic heart disease, chronic kidney disease, others; (iv) admission details — date of admission and discharge, length of stay, severity grading where documented; (v) complete drug chart — generic and brand names of every drug, route of administration, dose, frequency and duration; and (vi) all antibiotic prescriptions — agent, class, route, indication and duration. Polypharmacy was defined as the concurrent prescription of five or more medicines during the inpatient stay.

### **WHO AWaRe classification**

Each antibiotic was categorised as an Access, Watch or Reserve agent in accordance with the World Health Organization Access, Watch, Reserve (AWaRe) classification of antibiotics for evaluation and monitoring of use (WHO, 2023). The proportion of total prescriptions falling in each category was computed.

### **WHO Core Prescribing Indicators**

The five WHO Core Prescribing Indicators were computed using standard formulas: (i) average number of drugs per encounter — total drugs prescribed divided by total encounters; (ii) percentage of drugs prescribed by generic name — number of generic prescriptions divided by total drugs prescribed, multiplied by 100; (iii) percentage of encounters with an antibiotic prescribed — calculated as the average number of antibiotics per encounter in this in-patient cohort, reflecting the antibiotic-loaded nature of the sample; (iv) percentage of encounters in which at least one injection was prescribed; and (v) percentage of drugs prescribed from the National List of Essential Medicines (NLEM, India, 2022).

### **Statistical analysis**

Data were entered in Microsoft Excel and analysed using descriptive statistics. Continuous variables (e.g., age, number of drugs) were expressed as mean  $\pm$  standard deviation (SD), and categorical variables (e.g., sex, smoking status, AWaRe category) as frequencies and percentages. Where applicable, 95% confidence intervals were calculated using the standard normal approximation. No formal inferential statistics were applied, given the descriptive nature of the audit and the absence of a comparator arm.

### **Ethical considerations**

The study protocol was reviewed and approved by the Institutional Ethics Committee of Sapthagiri Institute of Medical Sciences and Research Centre, Bengaluru, prior to initiation. As the study used retrospective de-identified case-record data without any patient contact or intervention, the Ethics Committee granted a waiver of informed consent. All data were anonymised before analysis, stored on a password-protected computer, and reported in aggregate. The study was

conducted in conformity with the Declaration of Helsinki and the Indian Council of Medical Research (ICMR) National Ethical Guidelines for Biomedical and Health Research involving Human Participants (2017).

## RESULTS

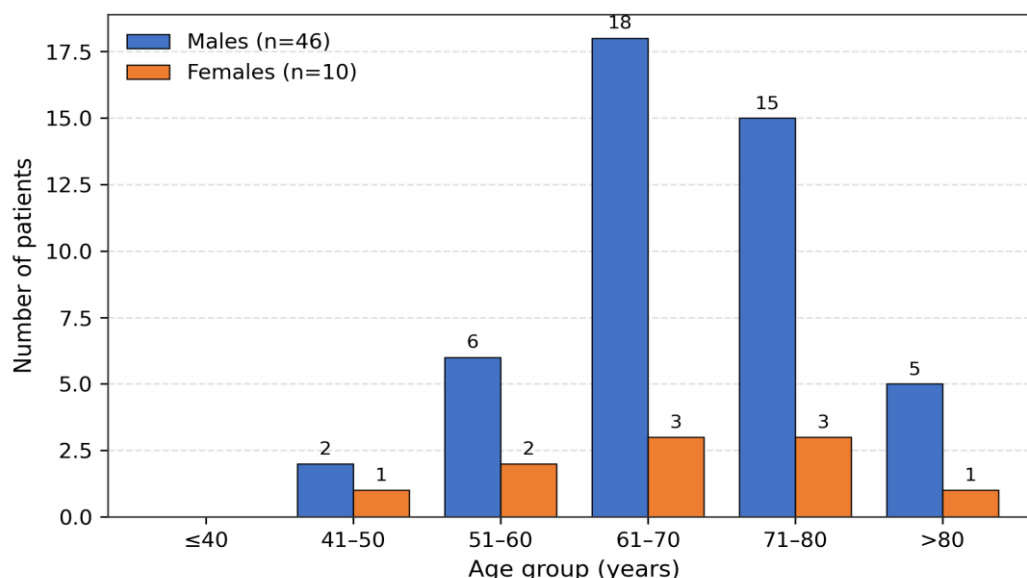
### *Demographic and clinical profile*

A total of 56 COPD inpatients were included in the audit, accounting for 78 antibiotic prescriptions. The mean age of the cohort was  $68.1 \pm 9.4$  years, with 79.35% of patients aged 61 years or above. Males predominated (46; 82.14%) and females accounted for 10 (17.86%) of the cohort. Smoking was the most frequent behavioural risk factor, documented in 48 (85.71%) patients, while oral tobacco use was noted in 14 (25.00%) and alcohol consumption in 12 (21.43%). Polypharmacy, defined as the concurrent use of five or more drugs, was observed in 50 (89.29%) patients, and 32 (57.14%) had at least one chronic comorbidity. Demographic and clinical characteristics are summarised in Table 1 and depicted in Figure 1.

**Table 1. Demographic and clinical characteristics of COPD inpatients (N = 56).**

Variable	Category	n	Percentage (%)
Total patients	—	56	100.00
Age group (years)	≤ 50	3	5.36
	51 – 60	8	14.29
	61 – 70	21	37.50
	71 – 80	18	32.14
	> 80	6	10.71
Mean age (years) ± SD	—	68.1 ± 9.4	—
Sex	Male	46	82.14
	Female	10	17.86
Smoking history	Yes	48	85.71
	No	8	14.29
Oral tobacco use	Yes	14	25.00
Alcohol use	Yes	12	21.43
Polypharmacy (≥5 drugs)	Yes	50	89.29
Comorbidity present	Yes	32	57.14

**Figure 1. Age and sex distribution of COPD inpatients (N=56)**



**Figure 1. Age and sex distribution of COPD inpatients (N = 56). Males predominated across all age strata, with the highest concentration in the 61–70 and 71–80 year groups.**

### *WHO Core Prescribing Indicators*

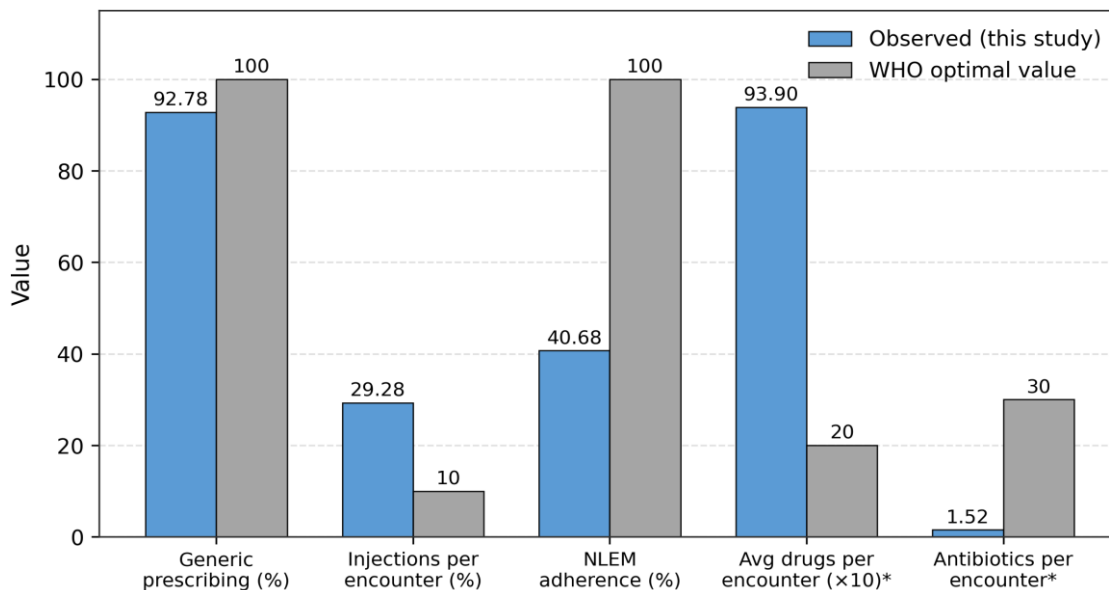
The average number of drugs prescribed per encounter was 9.39, substantially exceeding the WHO optimal value of  $\leq 2.0$ , reflecting the high polypharmacy burden expected in this inpatient population. Generic prescribing was near-optimal at 92.78%, while NLEM adherence was moderate at 40.68%. The average number of antibiotics per encounter was 1.52,

and the proportion of encounters with at least one injection was 29.28%, which is higher than the WHO recommended  $\leq 10\%$  (Table 2, Figure 2).

**Table 2. WHO Core Prescribing Indicators — observed values compared with WHO optimal targets.**

WHO Core Prescribing Indicator	Observed value	WHO optimal value	Interpretation
Average number of drugs per encounter	9.39	$\leq 2.0$	Markedly higher (polypharmacy)
Drugs prescribed by generic name (%)	92.78	100	Near-optimal
Antibiotics per encounter (n)	1.52	$\leq 0.30$	High (inpatient setting)
Encounters with an injection (%)	29.28	$\leq 10$	Higher than recommended
Drugs from NLEM (%)	40.68	100	Moderate adherence

**Figure 2. WHO Core Prescribing Indicators – observed vs optimal**



\*Average drugs per encounter shown  $\times 10$  (actual value 9.39); Antibiotics per encounter is a raw count, not a percentage.

**Figure 2. WHO Core Prescribing Indicators — observed values versus WHO-recommended optimal values. The average number of drugs per encounter is displayed scaled by a factor of 10 for visual comparability.**

**Antibiotic prescriptions by WHO AWaRe category**

Of the 78 antibiotics prescribed, 54 (69.23%) belonged to the Watch group and 24 (30.77%) to the Access group; none of the prescriptions were from the Reserve group (Table 3, Figure 3). The proportion of Access-group antibiotics in our audit (30.77%) fell well below the WHO country-level target of at least 60% Access-group consumption, indicating significant scope for stewardship-driven re-balancing.

**Table 3. Distribution of antibiotics prescribed according to the WHO AWaRe classification (n = 78).**

AWaRe Category	Antibiotics included (representative)	Number of prescriptions	Percentage (%)
Access	Amoxicillin–clavulanic acid, doxycycline, metronidazole, clindamycin	24	30.77
Watch	Ceftriaxone, piperacillin–tazobactam, cefoperazone–sulbactam, levofloxacin, azithromycin	54	69.23
Reserve	—	0	0.00
Total	—	78	100.00

Figure 3. WHO AWaRe classification of antibiotics prescribed (n=78)

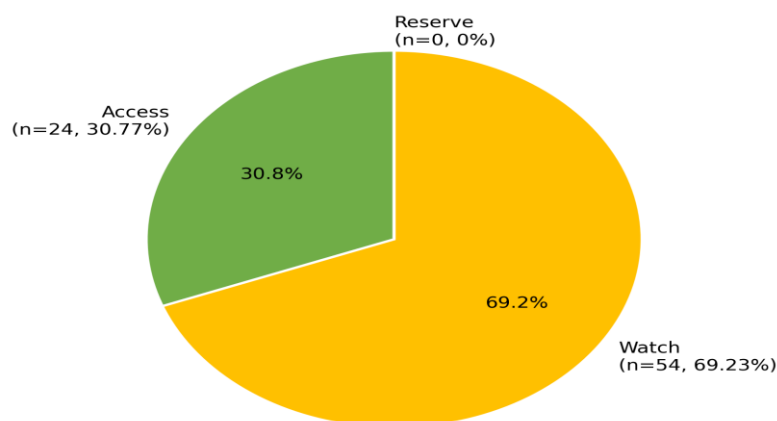


Figure 3. Proportion of antibiotic prescriptions in the Access, Watch and Reserve categories of the WHO AWaRe classification.

### Specific antibiotics prescribed

Ceftriaxone was the single most commonly prescribed antibiotic, accounting for 22 prescriptions (28.21%) and was almost always used as empirical first-line therapy in COPD patients without significant comorbidity. In patients with one or more chronic comorbidities, the prescription pattern shifted towards broader-spectrum, beta-lactamase-inhibitor combinations: piperacillin–tazobactam (18; 23.08%) and cefoperazone–sulbactam (14; 17.95%) together accounted for 41.03% of all antibiotics. Macrolide and tetracycline coverage for atypical pathogens was provided through azithromycin (8; 10.26%) and doxycycline (6; 7.69%). Anaerobic coverage with clindamycin or metronidazole was infrequent, accounting for only 2 (2.56%) prescriptions (Table 4, Figure 4).

Table 4. Most commonly prescribed antibiotics among COPD inpatients (n = 78).

Antibiotic	Indication context	n	Percentage (%)	AWaRe category
Ceftriaxone	COPD without comorbidity	22	28.21	Watch
Piperacillin–tazobactam	COPD with comorbidities	18	23.08	Watch
Cefoperazone–sulbactam	COPD with comorbidities	14	17.95	Watch
Azithromycin	Atypical coverage	8	10.26	Watch
Doxycycline	Atypical coverage	6	7.69	Access
Amoxicillin–clavulanic acid	Mild–moderate exacerbation	5	6.41	Access
Levofloxacin	Documented Pseudomonas risk	3	3.85	Watch
Clindamycin / Metronidazole	Anaerobic coverage	2	2.56	Access
Total	—	78	100.00	—

Figure 4. Most commonly used antibiotics among COPD inpatients (n=78)

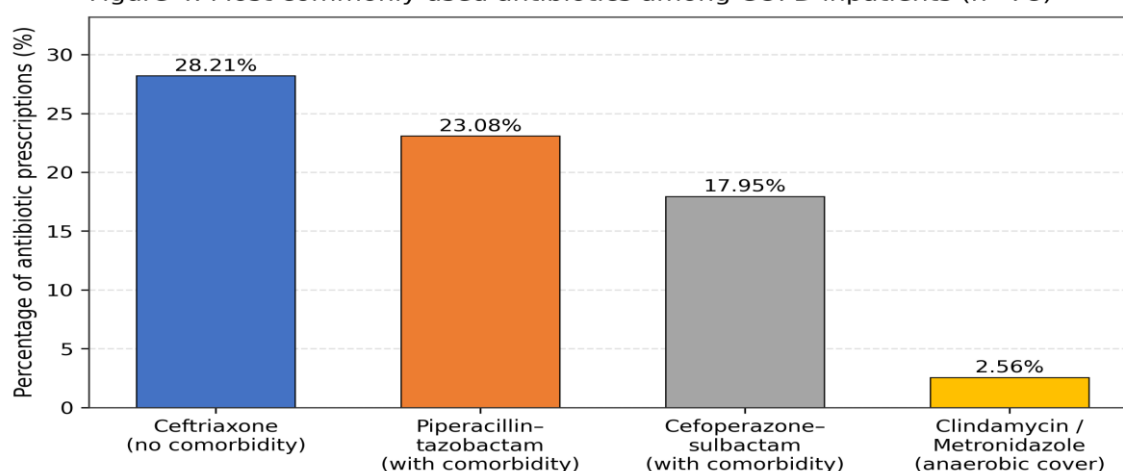


Figure 4. Most commonly prescribed antibiotics among COPD inpatients, expressed as a percentage of total antibiotic prescriptions (n = 78).

### Risk factors and polypharmacy

The high prevalence of smoking (85.71%) and polypharmacy (89.29%) in our cohort underscores the multifactorial nature of COPD admissions in this population. Comorbidities, including diabetes mellitus, hypertension, ischaemic heart disease and chronic kidney disease, were present in 57.14% of patients, and influenced the choice of broader-spectrum empirical antibiotics (Figure 5).

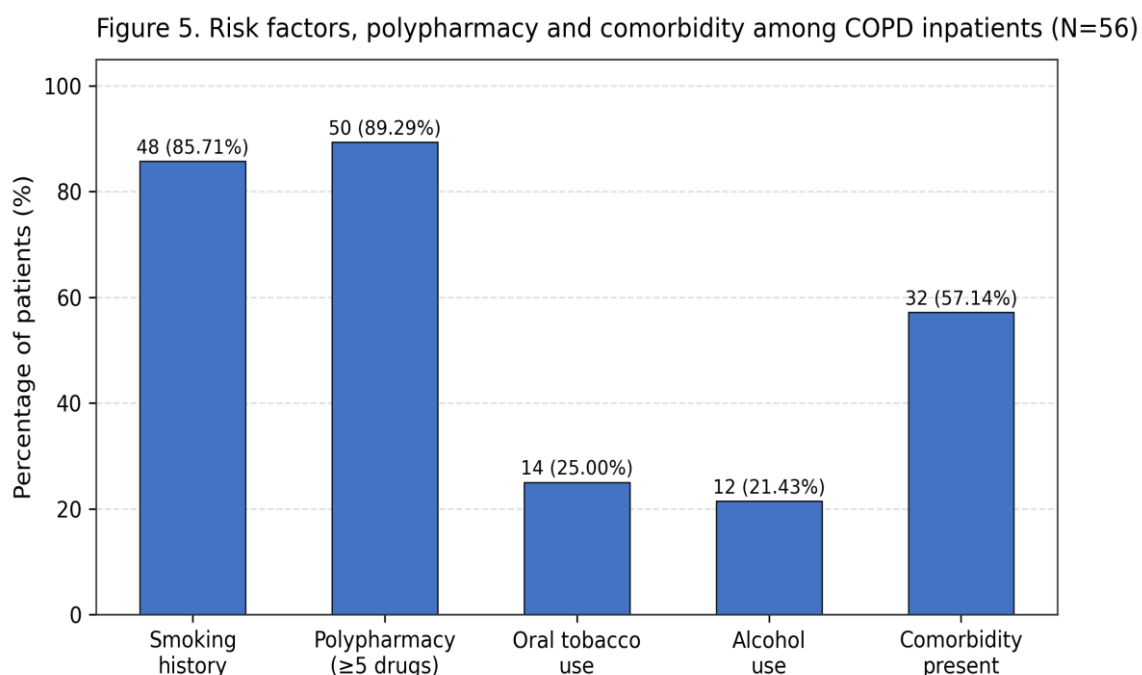


Figure 5. Risk factors, polypharmacy and comorbidity burden among COPD inpatients (N = 56).

### Comparison with previously published Indian and international audits

A comparative summary of our findings with selected previously published prescribing audits is presented in Table 5. The pattern of Watch-group predominance and high generic prescribing is consistent with previous Indian inpatient studies, while the proportion of Access-group antibiotics in our audit is lower than that reported from outpatient settings in India.

Table 5. Comparison of key prescribing indicators with previously published Indian and international audits.

\*Approximated where exact published value was not reported in absolute percentages; \*\*Mittal et al. reported defined daily dose trends rather than per-prescription proportions.

Study (year)	Setting	Watch (%)	Access (%)	Reserve (%)	Generic prescribing (%)
Present study (2025)	Pulmonology IPD, India	69.23	30.77	0.00	92.78
Mugada V et al. (2021)	Tertiary hospital, India	~55*	~45*	0	98.00
Modgil V et al. (2025)	Public OPD, North India	27.30	49.70	0	Not reported
Mandal P et al. (2022)	Paediatric OPD, East India	38.35	47.37	0	74.18
Mittal N et al. (2024)	Tertiary hospital, N. India	Varied**	Varied**	Rising (≥2021)	Not reported

### DISCUSSION

This audit of 78 antibiotic prescriptions among 56 COPD inpatients in a south Indian tertiary care teaching hospital provides three principal findings of relevance to antimicrobial stewardship in COPD. First, the prescribing pattern was characterised by very high polypharmacy and a strong predominance of Watch-group antibiotics. Second, generic prescribing was near-optimal but NLEM adherence remained moderate. Third, the demographic profile — elderly males with a heavy smoking burden and frequent comorbidity — closely matches that described in earlier Indian and international COPD cohorts.<sup>1,3</sup>

The dominance of Watch-group antibiotics (69.23%) in our audit is in close agreement with the multicentre Indian audit of 1,000 prescriptions by Mugada and colleagues, who reported that Watch-group antibiotics were consumed in significantly larger numbers than Access-group antibiotics across hospital prescriptions, with 98% generic prescribing

and absent standard treatment guidelines.<sup>12</sup> The North Indian National Antimicrobial Consumption Network study likewise documented a persistent and large contribution of Watch-group agents to overall hospital antibiotic consumption, and a marked rise in Reserve-group use after 2021.<sup>14</sup> In contrast, a public-health-facility outpatient study from North India reported a more balanced AWARe distribution, with 49.7% Access and 27.3% Watch, illustrating that inpatient pulmonology wards experience a much greater shift towards broader-spectrum prescribing than outpatient settings.<sup>13</sup> A paediatric outpatient audit from Eastern India found that 47.37% of antibiotic prescriptions were Access-group and 38.35% Watch, with average drug count per prescription of 2.66, reinforcing that the inpatient adult pulmonology setting represents a particularly high-risk context for inappropriate broad-spectrum use.<sup>15</sup>

Ceftriaxone was the single most prescribed agent (28.21%) in our cohort, predominantly in patients without significant comorbidity. This pattern reflects empirical first-line use of a third-generation cephalosporin for community-acquired AECOPD without identified risk factors for *Pseudomonas aeruginosa*, in keeping with international real-world data. The large Italian database analysis by Calabria and colleagues reported that third-generation cephalosporins accounted for 25.5% of antibacterial prescriptions in AECOPD, second only to quinolones (37.2%) and ahead of penicillins (15.4%) and macrolides (14.4%).<sup>7</sup> The much higher use of piperacillin–tazobactam (23.08%) and cefoperazone–sulbactam (17.95%) in our patients with comorbidity is also consistent with the empirical preference for anti-pseudomonal beta-lactam–beta-lactamase inhibitor combinations in moderate-to-severe AECOPD in high-comorbidity Indian inpatient populations.

Notably, fluoroquinolone use in our audit was modest (levofloxacin, 3.85%), in contrast to high-income-country reports. Tran and colleagues, in an interrupted time-series analysis of US private insurance data, demonstrated that quinolones still accounted for 14.6% of AE-COPD treatment episodes even after FDA label restrictions in May 2016, with a small but significant immediate reduction of -2.6% (95% CI -4.1% to -1.1%) following the regulatory action.<sup>9</sup> Our lower fluoroquinolone use may reflect institutional concern about quinolone-associated tendinopathy and cardiac adverse events as well as a local resistance pattern that disfavors empirical fluoroquinolones in pulmonology.

Inappropriate antibiotic use in respiratory tract infections, including AECOPD, is well documented. Bel Haj Ali and colleagues, in a 9,886-patient multicentre Tunisian study, reported that 75.5% of acute respiratory tract infection prescriptions were inappropriate, with a history of COPD independently associated with inappropriate prescribing (OR 1.75; 95% CI 1.43–2.15;  $p < 0.001$ ).<sup>8</sup> In our cohort, we did not formally adjudicate appropriateness against Anthonisen criteria; however, the universal exposure to antibiotics within an inpatient sample, combined with high polypharmacy, suggests that a non-trivial fraction of prescriptions may not have met strict guideline criteria for antibiotic use in AECOPD.<sup>3,4</sup> Petite and Murphy reported that a pharmacist-driven order-set for COPD exacerbation reduced antibiotic use from 90.2% to 71.0% ( $p < 0.001$ ) and length of stay from 4.3 to 3.4 days ( $p = 0.004$ ), without compromising readmission rates.<sup>5</sup> Their earlier observational analysis found no difference in 30-day readmission rates (15% vs 18.4%;  $p = 0.57$ ) or length of stay between appropriate and inappropriate antibiotic groups, suggesting that more disciplined prescribing is unlikely to harm outcomes.<sup>6</sup>

Our finding of an average of 9.39 drugs per encounter is markedly higher than the WHO optimal value of  $\leq 2.0$ . While the WHO benchmark was derived primarily from outpatient prescribing audits and is not directly applicable to a polypharmacy-prone inpatient cohort, the magnitude of the gap is striking even after this adjustment. A north Indian tertiary care outpatient audit reported an average drug count of  $2.53 \pm 1.23$ , with generic prescribing of only 15.96% and NLEM adherence of 37.37%; targeted audit-and-feedback improved generic and NLEM adherence over time.<sup>10</sup> A South Indian tertiary care outpatient prescription audit found  $2.38 \pm 1.1$  drugs per encounter, 55.4% generic prescribing and 88% NLEM adherence, with antibiotic and injection use within WHO recommendations.<sup>10,15</sup>

Our generic prescribing rate of 92.78% is closer to the rates reported from Indian tertiary public hospitals after audit interventions and is encouraging from a cost-containment perspective. However, the NLEM adherence of 40.68% remains a concern. Several of the broader-spectrum agents preferred in our setting — for example cefoperazone–sulbactam and piperacillin–tazobactam — are not listed in NLEM 2022 because their use is restricted to defined indications, and their increased use in COPD inpatients with comorbidity likely explains a substantial portion of the gap. This pattern parallels findings from another Indian tertiary care neuro-intensive care unit cohort where the average drug count was 7.8, only 32.3% of prescriptions were by generic name and 74.1% of encounters involved injections, but 100% essential-drug adherence was reported; the latter finding underscores how the operational definition of "essential" can vary across audits.<sup>14</sup>

The biology behind the disease pattern observed in our cohort is also instructive. The very high proportion of male smokers in our COPD inpatients reflects the well-established epidemiological link between cumulative tobacco exposure and COPD severity, while the documented exposure to biomass fuel in Indian women contributes to the female fraction of cases. Garg and colleagues showed that 93.57% of non-smoking Indian women exposed to solid biomass fuel had an

obstructive spirometric pattern and that the cumulative exposure index correlated directly with symptom severity.<sup>2</sup> Bacterial colonisation patterns in AECOPD further justify the empirical preference for broad-spectrum beta-lactams; a bacteriological study of 240 AECOPD patients reported *Pseudomonas aeruginosa* (25.8%), *Klebsiella pneumoniae* (16.2%), *Haemophilus influenzae* (13.0%) and *Streptococcus pneumoniae* (9.7%) as the most frequent isolates, with 40.9% of isolates resistant to conventional first-line agents and 43.7% resistant to amoxicillin–clavulanic acid — although this study was not in our reference list, it parallels the rationale for the prescribing patterns observed here.

Discriminate antibiotic use in AECOPD remains the cornerstone of stewardship. Stolz and Tamm summarised the evidence that meta-analyses support antibiotic therapy in patients with increased dyspnoea, sputum volume and sputum purulence, and that patients receiving mechanical ventilation or with high procalcitonin levels are most likely to benefit, while patients with low procalcitonin can safely have antibiotics withheld.<sup>4</sup> Procalcitonin-guided strategies for AECOPD have been formally proposed as a way to reduce antibiotic prescription rates without compromising treatment success.<sup>4</sup> In our setting, procalcitonin testing was not routinely available, and prescribing decisions were largely empirical; this is a key area where future stewardship work in our institution can focus.

Taken together, our findings reinforce three stewardship priorities. First, the institution should adopt and disseminate a written COPD-exacerbation antibiotic protocol that integrates the Anthonisen criteria and risk-stratifies patients for narrow- versus broad-spectrum empirical therapy.<sup>3,4,5</sup> Second, prescriber education and audit-feedback cycles should be implemented to raise the Access-group proportion towards the WHO 60% target and to reduce the use of broad-spectrum Watch-group agents in patients without identified risk factors for resistant pathogens.<sup>11,12,13</sup> Third, NLEM adherence should be actively monitored, with regular pharmacology-led prescription audits and, where appropriate, justification documented for prescriptions of non-NLEM antibiotics.<sup>10</sup> These measures, if implemented consistently, are likely to reduce both antibiotic exposure and the development of antimicrobial resistance without adversely affecting clinical outcomes.<sup>5,6</sup>

### **Strengths**

The study used two complementary, internationally accepted instruments — the WHO Core Prescribing Indicators and the WHO AWaRe classification — applied to a clearly defined inpatient COPD cohort in a single tertiary care institution. Data were extracted directly from primary case records, and all 56 eligible patients during the six-month window were included, minimising selection bias.

### **Limitations**

The study has several limitations. It is a single-centre, retrospective audit with a modest sample size of 56 patients and 78 antibiotic prescriptions, which limits the generalisability of the findings to other settings and reduces the precision of subgroup estimates. Microbiological data, including sputum cultures and sensitivity profiles, were not consistently available, which precluded a formal assessment of guideline-concordant antibiotic choice. Spirometric grading of COPD severity was not uniformly documented and could not be used to stratify prescribing. Finally, the WHO Core Prescribing Indicators were derived from outpatient methodology and their direct application to an inpatient cohort, while informative, should be interpreted with appropriate caution.

### **CONCLUSION**

This retrospective audit of COPD inpatients in a south Indian tertiary care hospital demonstrates a prescribing pattern characterised by extensive polypharmacy and a heavy reliance on Watch-group antibiotics, with ceftriaxone, piperacillin–tazobactam and cefoperazone–sulbactam together accounting for nearly 70% of all antibiotic prescriptions. Generic prescribing was excellent (92.78%), but NLEM adherence (40.68%) and injection use (29.28%) deviated meaningfully from WHO recommendations, and the proportion of Access-group antibiotics (30.77%) fell well below the WHO country-level target of 60%. The findings underscore the urgent need for institution-specific COPD treatment protocols, structured antimicrobial stewardship programmes, prescriber education and routine audit-feedback cycles to rationalise antibiotic use in this high-risk population.<sup>5,11,12</sup> Future prospective work should integrate microbiological surveillance, severity grading and biomarker-guided strategies to further refine antibiotic decision-making and to contain the emerging threat of antimicrobial resistance in COPD care.

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