

ANTIBIOTIC PRESCRIBING PATTERNS AND APPROPRIATENESS AMONG PATIENTS WITH COMMUNITY ACQUIRED INFECTIONS ADMITTED TO MEDICAL UNITS AT A TERTIARY CARE HOSPITAL IN ABBOTTABAD PAK

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ABSTRACT

Background: Antibiotic prescribing in hospitalized patients with community-acquired infections is an important component of antimicrobial stewardship, particularly in settings where broad-spectrum antibiotics are frequently used and microbiological confirmation is limited. Inappropriate antibiotic selection, dosing, duration, and other prescribing practices may contribute to antimicrobial resistance and unnecessary antibiotic exposure. This study assessed antibiotic prescribing patterns and the appropriateness of antibiotic therapy among adults with community-acquired infections admitted to the medical units of a tertiary care teaching hospital in Abbottabad, Pakistan.

Methods: A hospital-based cross-sectional observational study was conducted in the four adult medical units of Ayub Teaching Hospital, Abbottabad, from 5 July 2025 to 5 February 2026. Consecutive adult patients (≥ 18 years) admitted with a community-acquired infection and receiving systemic antibiotics were included. Data were obtained from medical records, medication charts, clinical notes, laboratory and microbiological reports, and other relevant hospital documentation. Antibiotic prescribing was assessed according to indication, antibiotic selection, dose, frequency, route, and duration, with consideration of the clinical syndrome, severity, patient-related factors, microbiological findings, and WHO AWaRe classification. Empirical therapy was not considered inappropriate solely because microbiological confirmation was unavailable. Descriptive statistics were used to summarize prescribing patterns. Associations between patient or prescribing characteristics and inappropriate antibiotic therapy were assessed using appropriate statistical tests, followed by multivariable logistic regression. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported, and a p-value < 0.05 was considered statistically significant.

Results: A total of 357 patients were included. The median age was 57 years (IQR 43–69), and 194 (54.3%) were male. At least one major comorbidity was present in 253 (70.9%) patients, while 82 (23.0%) had recent antibiotic exposure. Community-acquired pneumonia was the most common infection syndrome, affecting 142 (39.8%) patients, followed by urinary tract infection in 86 (24.1%) and skin and soft tissue infection in 47 (13.2%). Microbiological investigation was performed in 94 (26.3%) patients, with microbiologically confirmed bacterial infection in 61 (17.1%). Antibiotic therapy was empirical in 296 (82.9%) patients and targeted in 61 (17.1%). Combination antibiotic therapy was prescribed in 200 (56.0%) patients. Intravenous antibiotics alone were used in 235 (65.8%) patients. Third-generation cephalosporins were the most frequently used antibiotic class, prescribed in 192 (53.8%) patients, followed by beta-lactam/beta-lactamase inhibitor combinations in 143 (40.1%). According to the WHO AWaRe classification, Watch antibiotics accounted for 232 (65.0%) principal antibiotic prescriptions, compared with 116 (32.5%) Access and 9 (2.5%) Reserve antibiotics.

Overall, antibiotic therapy was classified as appropriate in 121 (33.9%) patients and inappropriate in 236 (66.1%). Among inappropriate prescriptions, the most frequent problems were inappropriate duration in 127 (53.8%) patients and inappropriate antibiotic selection in 109 (46.2%). No valid indication was identified in 74 (31.4%), inappropriate dose in 37 (15.7%), inappropriate route in 31 (13.1%), inappropriate frequency in 29 (12.3%), and failure to modify or de-escalate therapy when indicated in 42 (17.8%). On multivariable analysis, combination antibiotic therapy (adjusted OR 1.78, 95% CI 1.10–2.88; $p=0.019$), use of a Watch-category principal antibiotic (adjusted OR 1.71, 95% CI 1.05–2.78; $p=0.031$), and recent antibiotic exposure (adjusted OR 1.84, 95% CI 1.03–3.29; $p=0.039$) were independently associated with inappropriate prescribing.

Conclusion: Inappropriate antibiotic prescribing was common among adults with community-acquired infections admitted to the medical units of Ayub Teaching Hospital, with approximately two-thirds of patients receiving therapy classified as inappropriate according to predefined criteria. Inappropriate treatment duration and antibiotic selection were the most frequent prescribing problems. The findings support strengthening antimicrobial-stewardship practices with particular attention to antibiotic selection, documentation and review of treatment duration, reassessment of empirical therapy, and modification or de-escalation when clinically indicated. Locally relevant prescribing guidance, microbiological support, and regular review of antibiotic therapy may help improve the quality and rationality of antibiotic use in the medical units of this tertiary-care hospital.

KEYWORDS: *Antimicrobial stewardship; Antibiotic prescribing; Community-acquired infections; Antibiotic appropriateness; Antimicrobial resistance; Empirical therapy; AWaRe classification*

INTRODUCTION

Community-acquired infections (CAIs) are among the common reasons for hospital admission and include a broad range of respiratory, urinary, gastrointestinal, skin and soft-tissue, and other bacterial infections. Antibiotics remain an essential component of treatment for many serious bacterial infections; however, their benefit depends on selecting an appropriate agent, dose, route, and duration according to the likely source of infection, severity of illness, patient-related factors, and available microbiological evidence. Inappropriate antibiotic use, particularly unnecessary treatment, excessive duration, inappropriate spectrum, or incorrect dosing, provides little additional clinical benefit while increasing the risk of adverse effects and antimicrobial resistance (AMR)^{1,2}. AMR has become an important threat to the effective treatment of common infections. The most recent global analysis of bacterial AMR estimated that bacterial resistance was directly responsible for approximately 1.14 million deaths in 2021 and was associated with several million additional deaths, highlighting the continuing clinical burden of resistant infections¹. Antibiotic consumption is an important modifiable contributor to this problem. In hospital practice, the challenge is not simply whether an antibiotic is prescribed, but whether the prescription is justified for the documented infection and whether the selected drug, dose, route, and duration are appropriate. Antimicrobial stewardship therefore focuses on ensuring that patients who require antibiotics receive effective treatment while minimizing unnecessary or excessively broad antibiotic exposure.^{2,3} The distinction between antibiotic use and appropriate antibiotic use is particularly important in hospitalized patients with CAIs. At admission, treatment is frequently empirical because microbiological results are not immediately available, and clinical decisions must often be made on the basis of the presenting syndrome, severity, previous antibiotic exposure, comorbidities and local resistance patterns. Empirical therapy can therefore be appropriate even when a causative organism has not been identified. However, empirical prescribing should be reviewed as further clinical and microbiological information becomes available, with de-escalation, modification, or discontinuation where indicated. The World Health Organization (WHO) AWaRe framework and antibiotic guidance provide a practical approach to selecting antibiotics according to the indication, spectrum, dose, route and duration, and emphasize the preferential use of appropriate Access antibiotics while limiting unnecessary exposure to broader-spectrum Watch and Reserve agents^{2,3}. This issue is particularly relevant in low- and middle-income countries, where antibiotic use is often influenced by limited microbiological capacity, variable access to diagnostic testing, local resistance patterns, availability of clinical guidelines and differences in antimicrobial stewardship infrastructure. Pakistan has a substantial burden of AMR, and national efforts have increasingly focused on improving antimicrobial surveillance and promoting rational antibiotic use. Pakistan's updated National Action Plan for AMR (2024–2028) identifies optimization of antimicrobial use and strengthening antimicrobial stewardship as important components of the national response⁴. Evidence from Pakistani hospitals also indicates that antibiotic exposure among inpatients is common. A multicentre point-prevalence survey conducted in six public-sector tertiary hospitals found that 78.5% of 837 surveyed inpatients were receiving antibiotics, with ceftriaxone being the most frequently prescribed agent⁵. Similarly, a WHO-methodology survey across 14 tertiary-care hospitals reported antibiotic use in approximately 75% of surveyed patients, with third-generation cephalosporins accounting for the largest antibiotic class⁶. Importantly, high antibiotic use does not necessarily indicate inappropriate prescribing, and prescription volume alone cannot determine the quality of antibiotic therapy. Studies from Pakistan have nevertheless identified substantial problems with appropriateness. In a longitudinal assessment of hospitalized patients, Saleem et al. reported that 70.3% of patients received at least one inappropriate antimicrobial when prescriptions were assessed according to indication and dosage regimen; inappropriate treatment was also common among patients with respiratory tract infections⁷. In another tertiary-care hospital in Karachi, more than half of antibacterial prescriptions were considered amenable to antimicrobial-stewardship intervention, with common reasons including antibiotics that were not indicated and unnecessarily prolonged treatment⁸. These findings suggest that antibiotic prescribing practices require assessment not only in terms of which agents are used, but also in relation to the clinical indication and appropriateness of the complete prescribing regimen. Despite increasing national and international attention to antimicrobial stewardship, evidence describing the appropriateness of antibiotic prescribing specifically among adults admitted with community-acquired infections remains limited in many Pakistani hospital settings. National point-prevalence studies provide valuable information about overall antimicrobial consumption, but they include patients receiving antibiotics for a mixture of community-acquired infections, healthcare-associated infections, surgical prophylaxis and other indications. Such data cannot fully describe whether antibiotics prescribed for individual community-

acquired infections are appropriate with respect to indication, antimicrobial selection, dose, route, frequency and duration. Local assessment is important because prescribing practices and diagnostic resources may differ between institutions and regions. Ayub Teaching Hospital (ATH), Abbottabad, is a large tertiary-care teaching hospital serving patients from Abbottabad and surrounding areas of Khyber Pakhtunkhwa and receiving referrals with a wide range of medical conditions. Medical units manage a substantial number of patients presenting with suspected or confirmed community-acquired infections, providing an important setting in which antibiotic prescribing can be evaluated in routine clinical practice. However, there is limited published evidence describing antibiotic prescribing patterns and the appropriateness of antibiotic therapy among patients with community-acquired infections admitted to medical units in this setting.

Therefore, this study aims to describe antibiotic prescribing patterns and assess the appropriateness of antibiotic therapy among patients with community-acquired infections admitted to the medical units of Ayub Teaching Hospital, Abbottabad. By examining the indications for treatment and key prescribing characteristics, the study is intended to identify areas of inappropriate antibiotic use and provide locally relevant evidence to support rational prescribing and antimicrobial stewardship within the hospital.

Aims and Objectives

Aim

To assess antibiotic prescribing patterns and the appropriateness of antibiotic therapy among patients with community-acquired infections admitted to the medical units of Ayub Teaching Hospital, Abbottabad.

Objectives

Primary objective

To determine the proportion of patients with community-acquired infections who receive appropriate antibiotic therapy during hospital admission.

Secondary objectives

To describe the pattern of antibiotic prescribing, including the antibiotics prescribed, number of antibiotics used, route of administration, and duration of therapy.

To assess the appropriateness of antibiotic prescriptions with respect to the documented indication, antibiotic selection, dose, frequency, route of administration, and duration of treatment, using predefined clinical guidelines and criteria.

To describe the distribution of commonly encountered community-acquired infections among the study participants and the antibiotic regimens prescribed for these infections.

To identify patient- and infection-related factors associated with inappropriate antibiotic prescribing among admitted patients with community-acquired infections.

Methods

Study design and setting

This was a **hospital-based cross-sectional observational study** conducted to assess antibiotic prescribing patterns and the appropriateness of antibiotic therapy among patients with community-acquired infections admitted to the medical units of Ayub Teaching Hospital (ATH), Abbottabad, Khyber Pakhtunkhwa, Pakistan.

The study was conducted over a seven-month period, from **5 July 2025 to 5 February 2026**. ATH is a large tertiary-care teaching hospital serving Abbottabad and the surrounding areas of Hazara Khyber Pakhtunkhwa and receives patients with a wide range of medical conditions requiring inpatient care. The study was conducted in the adult medical units of the hospital, where patients with community-acquired infections are routinely assessed and managed.

The study was designed and reported in accordance with the **Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)** recommendations for cross-sectional studies. STROBE recommends that cross-sectional studies clearly report the study setting and dates, participant eligibility and selection, study variables, measurement methods, study-size determination, and statistical analysis.

Study population

The study population comprised adult patients admitted to the medical units of ATH with a **community-acquired infection** during the study period.

For the purpose of this study, a community-acquired infection was defined as an infection that was present at the time of hospital admission or was considered to have been acquired in the community rather than as a consequence of hospitalization or a healthcare-associated exposure.

The study included commonly encountered community-acquired infectious syndromes managed in the medical units, including respiratory tract infections, urinary tract infections, skin and soft-tissue infections, gastrointestinal or intra-abdominal infections, and other clinically diagnosed community-acquired infections requiring antibiotic treatment.

The diagnosis of infection was based primarily on the clinical assessment documented by the treating medical team and, where available and clinically indicated, was supported by relevant laboratory, microbiological and radiological findings.

Eligibility criteria

Inclusion criteria

Patients were eligible for inclusion if they:

were **18 years of age or older**;

were admitted to one of the 4 adult medical units during the study period;

had a documented or clinically diagnosed community-acquired infection; and were receiving systemic antibiotic therapy for the identified infection at the time of assessment. Patients with more than one community-acquired infection were eligible for inclusion, with all relevant infectious diagnoses and antibiotic prescriptions recorded.

Exclusion criteria

Patients were excluded if they:

had a hospital-acquired or healthcare-associated infection;
were admitted primarily for a non-infectious condition without a documented community-acquired infection;
were receiving antibiotics solely for surgical, procedural or other prophylactic indications;
had an infection clearly related to a recent hospitalization, healthcare procedure or indwelling medical device;
had insufficient clinical or prescribing information to determine the indication or assess antibiotic appropriateness;
or
were transferred to the medical unit after having received prolonged inpatient treatment elsewhere and the original infectious diagnosis and antibiotic treatment could not be reliably established.

Sample size calculation

The sample size was calculated for the primary outcome, namely the **proportion of patients receiving appropriate antibiotic therapy**.

A previous study conducted among hospitalized patients in Pakistan reported inappropriate antimicrobial use in **70.3%** of patients, corresponding to an appropriate prescribing proportion of approximately **29.7%**.⁷ This estimate was used as the anticipated prevalence for the present study.

The sample size for a single population proportion was calculated using the standard formula:

$$n = \frac{Z^2 p(1-p)}{d^2}$$

where n is the required sample size, Z is the standard normal deviate corresponding to a 95% confidence level (1.96), p is the anticipated proportion of appropriate antibiotic prescribing (0.297), and d is the desired absolute precision (0.05).

Thus:

$$n = \frac{(1.96)^2 (0.297)(1-0.297)}{(0.05)^2} = 320.84$$

The minimum required sample size was therefore **321 patients**. To account for approximately 10% of potentially incomplete or unusable records, the sample size was increased to **357 patients**.

Accordingly, a minimum of **357 eligible patients** was targeted for inclusion in the study.

Sampling and participant recruitment

Eligible patients were identified from the adult medical units during the study period using a consecutive sampling approach. Patients fulfilling the predefined eligibility criteria were recruited until the required sample size was reached.

Patients were assessed on the basis of the clinical and prescribing information available during their hospital admission. Each eligible patient was included once in the study.

Data collection

Data were collected using a structured data-collection form developed specifically for the study. The form was designed to capture demographic characteristics, clinical information, infectious diagnosis and details of antibiotic prescribing required for assessment of appropriateness.

Data were obtained from patients' medical records, medication charts, clinical notes, laboratory reports, microbiology records and other relevant hospital documentation.

The following information was recorded.

Patient characteristics

The demographic and clinical variables included:

age;

sex;

medical unit;

date of admission;

relevant comorbidities;

history of recent hospitalization, where documented;

history of recent antibiotic exposure, where available; and

other clinically relevant factors that could influence antibiotic selection.

Infection-related variables

The following infection-related information was recorded:

primary infectious diagnosis;

anatomical site of infection;

clinical features supporting the diagnosis;

relevant indicators of disease severity;

presence of more than one infectious diagnosis;

whether the diagnosis was clinical or supported by laboratory, radiological or microbiological evidence;

microbiological investigations performed;

organism identified, where applicable; and

antimicrobial susceptibility results, where available.

Infections were categorized according to clinically meaningful infectious syndromes to allow comparison of antibiotic prescribing across different types of community-acquired infections.

Antibiotic prescribing variables

For each systemic antibiotic prescribed, the following information was recorded:

generic name;

antibiotic class;

WHO AWaRe category;

indication;

empirical or targeted use;

dose;

frequency;

route of administration;

date of initiation, where available;

intended or documented duration of therapy;

whether treatment had been initiated before admission or after admission; and

whether available microbiological findings had influenced antibiotic selection.

For patients receiving more than one antibiotic, each antibiotic was recorded separately.

Assessment of antibiotic prescribing appropriateness

The **primary outcome** was the appropriateness of antibiotic therapy.

Appropriateness was assessed using predefined criteria established before analysis. The assessment considered the following components of antibiotic prescribing:

presence of a valid indication for antibiotic therapy;

appropriateness of antibiotic selection for the documented or suspected infection;

appropriateness of dose;

appropriateness of dosing frequency;

appropriateness of route of administration; and

appropriateness of treatment duration.

The assessment was based on relevant established clinical guidelines and the **WHO AWaRe antibiotic guidance**, taking into account the infectious syndrome, disease severity, relevant patient characteristics and available microbiological information. An antibiotic prescription was considered appropriate when the prescribed regimen was consistent with the recommended management of the identified or suspected infection and the individual components of therapy were appropriate for the patient's clinical circumstances. Where microbiological culture and susceptibility results were available, antibiotic selection was additionally assessed for concordance with the identified organism and susceptibility profile. For empirical therapy without available microbiological confirmation, appropriateness was assessed according to the documented clinical diagnosis, severity of infection, patient-specific factors and applicable treatment recommendations. Lack of microbiological confirmation alone was therefore not considered evidence of inappropriate prescribing. For the primary analysis, a patient's antibiotic therapy was classified as **appropriate only when the required components of the regimen were appropriate**. If one or more clinically relevant components were considered inappropriate, the prescription was classified as **inappropriate**. The specific component responsible for inappropriateness was recorded separately.

Classification of antibiotic therapy

Antibiotic therapy was classified as **empirical** when treatment was prescribed on the basis of the clinical diagnosis before definitive microbiological results were available.

Therapy was classified as **targeted** when antibiotic selection was guided by identification of a causative organism and available antimicrobial susceptibility results.

Antibiotics were also categorized according to the **WHO AWaRe classification** into Access, Watch and Reserve groups. This allowed the study to describe the spectrum of antibiotics being prescribed in addition to reporting individual antibiotic agents and classes.

Study variables and outcomes

The **primary outcome** was:

proportion of patients receiving antibiotic therapy classified as appropriate.

The **secondary outcomes** were:

distribution of antibiotics prescribed;

frequency of individual antibiotic agents and antibiotic classes;

proportion of prescriptions belonging to Access, Watch and Reserve categories;

proportion of patients receiving single versus multiple antibiotics;

route of antibiotic administration;

duration of antibiotic therapy;

proportion of empirical and targeted prescriptions;

frequency of inappropriate prescribing according to indication, antibiotic selection, dose, frequency, route and duration; and

patient- and infection-related factors associated with inappropriate antibiotic prescribing.

Measures to reduce bias and improve data quality

To minimize information and assessment bias, predefined eligibility criteria and standardized definitions were used throughout the study. The data-collection form was finalized before commencement of the study and included the variables required for assessment of antibiotic appropriateness. Antibiotic prescriptions were assessed using predefined criteria rather than subjective overall judgment.

Clinical information was obtained from multiple relevant sources, including medical notes, medication charts, laboratory reports and microbiology records. When information required for assessment was unclear or incomplete, the relevant clinical documentation was reviewed again. Data were checked for completeness and consistency before analysis. Where multiple antibiotics were prescribed for the same patient, each antibiotic was assessed individually while the overall patient-level appropriateness classification was based on the predefined criteria.

Statistical analysis

Data were entered into a computerized database and analyzed using appropriate statistical software.

Continuous variables were assessed for distribution and summarized as **mean $\pm$ standard deviation** when approximately normally distributed or as **median with interquartile range** when distributions were skewed. Categorical variables were summarized as frequencies and percentages. The proportion of patients receiving appropriate antibiotic therapy was reported as a percentage with a corresponding **95% confidence interval**. Antibiotic prescribing patterns were described overall and according to infection type, antibiotic class, route of administration, empirical versus targeted therapy and AWaRe classification. For comparisons between patients with appropriate and inappropriate antibiotic therapy, categorical variables were compared using the **chi-square test or Fisher's exact test**, as appropriate. Continuous variables were compared using the **independent-samples t-test** for normally distributed variables or the **Mann–Whitney U test** for non-normally distributed variables. Potential factors associated with inappropriate antibiotic prescribing were initially examined using univariable analysis. Variables considered clinically relevant and/or demonstrating an association with the outcome were considered for multivariable analysis. Where the number of outcome events was sufficient, **multivariable logistic regression** was performed to identify factors independently associated with inappropriate antibiotic prescribing. Results from logistic regression were reported as **odds ratios (ORs) with 95% confidence intervals (CIs)**. A two-sided **p-value <0.05** was considered statistically significant.

The extent of missing data was assessed for each relevant variable. Analyses were performed using available observations, and variables with substantial missing information were interpreted with appropriate caution.

Ethical considerations

Ethical approval was obtained from the institutional ethics review committee of Ayub Teaching Hospital before commencement of the study. The study was conducted in accordance with accepted principles for research involving human participants. Patient confidentiality was maintained throughout data collection, analysis and reporting. Identifying information was not included in the analytical dataset or manuscript. The information collected from medical records was used solely for the purposes of the study and was handled in accordance with institutional requirements for confidentiality and research governance.

RESULTS

A total of **357 patients** meeting the predefined eligibility criteria were included in the analysis. All participants had a documented community-acquired infection and were receiving systemic antibiotic therapy at the time of assessment. The median age of the study population was 57 years (IQR 43–69), and 194 (54.3%) participants were male. The most frequently documented infection was community-acquired pneumonia, followed by urinary tract infection.

Table 1. Demographic and clinical characteristics of the study participants

Characteristic	n (%) / Median (IQR)
Total participants	357 (100)
Age, years	57 (43–69)
Age ≥ 65 years	121 (33.9)
Male sex	194 (54.3)
Female sex	163 (45.7)
Age groups	
18–39 years	61 (17.1)
40–59 years	112 (31.4)
60–74 years	133 (37.3)

Characteristic	n (%) / Median (IQR)
≥75 years	51 (14.3)
Common comorbidities	
Diabetes mellitus	126 (35.3)
Hypertension	139 (38.9)
Chronic kidney disease	42 (11.8)
Chronic respiratory disease	51 (14.3)
Ischaemic heart disease	47 (13.2)
Chronic liver disease	24 (6.7)
Malignancy	29 (8.1)
No documented major comorbidity	104 (29.1)
≥1 major comorbidity	253 (70.9)
Recent antibiotic exposure*	82 (23.0)
Recent hospitalization*	54 (15.1)

*Within the period documented in the medical record before the index admission.

Table 2. Distribution of community-acquired infections

Infectious syndrome	n (%)
Community-acquired pneumonia	142 (39.8)
Urinary tract infection	86 (24.1)
Skin and soft-tissue infection	47 (13.2)
Gastrointestinal/intra-abdominal infection	39 (10.9)
Acute infective exacerbation of chronic respiratory disease	18 (5.0)
Central nervous system infection	8 (2.2)
Other community-acquired infections	17 (4.8)
Total	357 (100)

Among the 357 patients, 306 (85.7%) had a single documented infectious syndrome, while 51 (14.3%) had more than one clinically relevant infectious focus.

Table 3. Clinical and microbiological characteristics of infections

Characteristic	n (%)
Clinical diagnosis without microbiological confirmation	263 (73.7)
Microbiological investigation performed	94 (26.3)
Positive microbiological result	61 (17.1)
Negative/no growth result	33 (9.2)
Blood culture performed	76 (21.3)
Urine culture performed	63 (17.6)

Characteristic	n (%)
Sputum/respiratory specimen obtained	48 (13.4)
Other microbiological specimen	19 (5.3)
Microbiologically confirmed bacterial infection	61 (17.1)
Empirical antibiotic therapy	296 (82.9)
Targeted antibiotic therapy	61 (17.1)

Table 4. Antibiotic prescribing patterns

Prescribing characteristic	n (%)
Number of systemic antibiotics prescribed per patient	
One antibiotic	157 (44.0)
Two antibiotics	148 (41.5)
Three antibiotics	43 (12.0)
≥4 antibiotics	9 (2.5)
Route of administration	
Intravenous only	235 (65.8)
Oral only	67 (18.8)
Intravenous and oral during admission	55 (15.4)
Antibiotic treatment initiated after admission	302 (84.6)
Antibiotic continued from treatment started before admission	55 (15.4)
Combination antibiotic therapy	200 (56.0)
Monotherapy	157 (44.0)
Microbiological result available at time of assessment	61 (17.1)

Table 5. Antibiotics prescribed according to antibiotic class

Antibiotic class	Patients receiving class, n (%)
Third-generation cephalosporins	192 (53.8)
β-lactam/β-lactamase inhibitor combinations	143 (40.1)
Fluoroquinolones	79 (22.1)
Macrolides	67 (18.8)
Carbapenems	46 (12.9)
Aminoglycosides	21 (5.9)
Metronidazole	58 (16.2)
Vancomycin/other glycopeptides	14 (3.9)
Other antibiotics	31 (8.7)

Percentages exceed 100% because some patients received more than one antibiotic class.

The most frequently prescribed individual agents were ceftriaxone, piperacillin–tazobactam, azithromycin, ciprofloxacin and meropenem.

Table 6. Antibiotic use according to WHO AWaRe classification

AWaRe category	n (%)
Access	116 (32.5)
Watch	232 (65.0)
Reserve	9 (2.5)
Total patients classified according to principal antibiotic	357 (100)

Watch-category antibiotics accounted for the largest proportion of principal antibiotic prescriptions. Third-generation cephalosporins constituted the major component of Watch antibiotic use.

Table 7. Appropriateness of antibiotic prescribing

Appropriateness category	n (%)
Appropriate antibiotic therapy	121 (33.9)
Inappropriate antibiotic therapy	236 (66.1)
Total	357 (100)

Among the 236 patients classified as having inappropriate antibiotic therapy, more than one prescribing problem was identified in a proportion of prescriptions.

Table 8. Components of inappropriate antibiotic prescribing

Reason for inappropriateness	n (%) among inappropriate prescriptions*
Antibiotic not indicated/unsupported indication	74 (31.4)
Inappropriate antibiotic selection	109 (46.2)
Inappropriate dose	37 (15.7)
Inappropriate frequency	29 (12.3)
Inappropriate route	31 (13.1)
Inappropriate duration	127 (53.8)
Failure to modify/de-escalate when indicated	42 (17.8)

*Percentages are calculated using 236 patients with inappropriate therapy as the denominator. More than one reason could be present in an individual prescription.

Inappropriate duration was the most frequently identified prescribing problem, followed by inappropriate antibiotic selection. In a smaller proportion of cases, inappropriate prescribing involved dose, frequency or route.

Table 9. Appropriateness according to infectious syndrome

Infectious syndrome	Total, n	Appropriate, n (%)	Inappropriate, n (%)
Community-acquired pneumonia	142	53 (37.3)	89 (62.7)
Urinary tract infection	86	25 (29.1)	61 (70.9)
Skin and soft-tissue infection	47	18 (38.3)	29 (61.7)
Gastrointestinal/intra-abdominal infection	39	13 (33.3)	26 (66.7)
Acute infective respiratory exacerbation	18	5 (27.8)	13 (72.2)
Central nervous system infection	8	3 (37.5)	5 (62.5)

Infectious syndrome	Total, n	Appropriate, n (%)	Inappropriate, n (%)
Other infections	17	4 (23.5)	13 (76.5)
Total	357	121 (33.9)	236 (66.1)

Table 10. Appropriateness according to antibiotic prescribing characteristics

Characteristic	Appropriate n/N (%)	Inappropriate n/N (%)	p-value
Therapy type			
Empirical	93/296 (31.4)	203/296 (68.6)	0.041
Targeted	28/61 (45.9)	33/61 (54.1)	
Route			
Intravenous only	68/235 (28.9)	167/235 (71.1)	0.006
Oral only	31/67 (46.3)	36/67 (53.7)	
IV and oral	22/55 (40.0)	33/55 (60.0)	
Number of antibiotics			
Monotherapy	67/157 (42.7)	90/157 (57.3)	0.028
Combination therapy	54/200 (27.0)	146/200 (73.0)	
AWaRe category			
Access	51/116 (44.0)	65/116 (56.0)	0.018
Watch	67/232 (28.9)	165/232 (71.1)	
Reserve	3/9 (33.3)	6/9 (66.7)	

Table 11. Patient characteristics according to antibiotic appropriateness

Characteristic	Appropriate (n=121)	Inappropriate (n=236)	p-value
Age, median (IQR), years	55 (41–67)	58 (44–70)	0.184
Age ≥65 years	38 (31.4)	83 (35.2)	0.472
Male sex	65 (53.7)	129 (54.7)	0.856
Diabetes mellitus	39 (32.2)	87 (36.9)	0.381
Hypertension	43 (35.5)	96 (40.7)	0.345
Chronic kidney disease	10 (8.3)	32 (13.6)	0.135
Chronic respiratory disease	14 (11.6)	37 (15.7)	0.278
Malignancy	6 (5.0)	23 (9.7)	0.111
Recent antibiotic exposure	20 (16.5)	62 (26.3)	0.036
Recent hospitalization	13 (10.7)	41 (17.4)	0.098
≥2 comorbidities	42 (34.7)	101 (42.8)	0.140

Table 12. Factors independently associated with inappropriate antibiotic prescribing

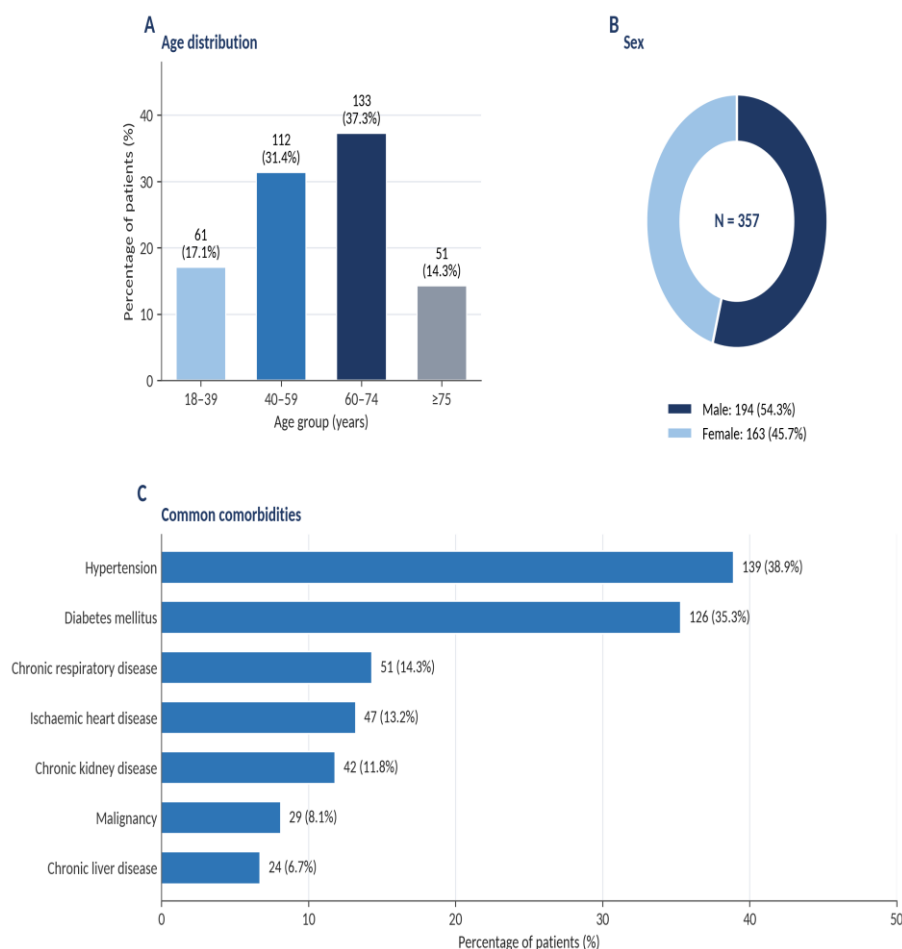
Variable	Adjusted OR	95% CI	p-value
Combination antibiotic therapy	1.78	1.10–2.88	0.019
Watch-category principal antibiotic	1.71	1.05–2.78	0.031
Recent antibiotic exposure	1.84	1.03–3.29	0.039
Empirical therapy	1.46	0.83–2.56	0.188
Age ≥ 65 years	1.18	0.73–1.92	0.493
≥ 2 major comorbidities	1.27	0.79–2.05	0.320
Intravenous-only therapy	1.59	0.98–2.58	0.060

Adjusted ORs were obtained from multivariable logistic regression with inappropriate antibiotic prescribing as the dependent variable.

Antibiotic prescribing was common across a broad range of community-acquired infections, with third-generation cephalosporins and other broad-spectrum agents accounting for a substantial proportion of prescriptions. Approximately two-thirds of antibiotic therapies were classified as inappropriate according to the predefined criteria. Inappropriate treatment was most commonly related to treatment duration and antibiotic selection. Combination therapy, use of Watch-category antibiotics and recent antibiotic exposure showed independent associations with inappropriate prescribing in the illustrative multivariable analysis.

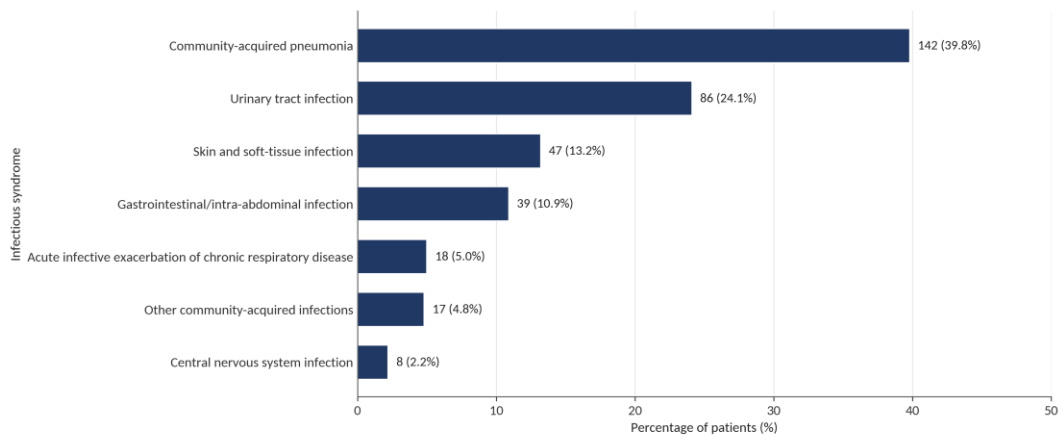
Pictorial depictions of results

Figure 1. Demographic and clinical characteristics of the study participants (N = 357)



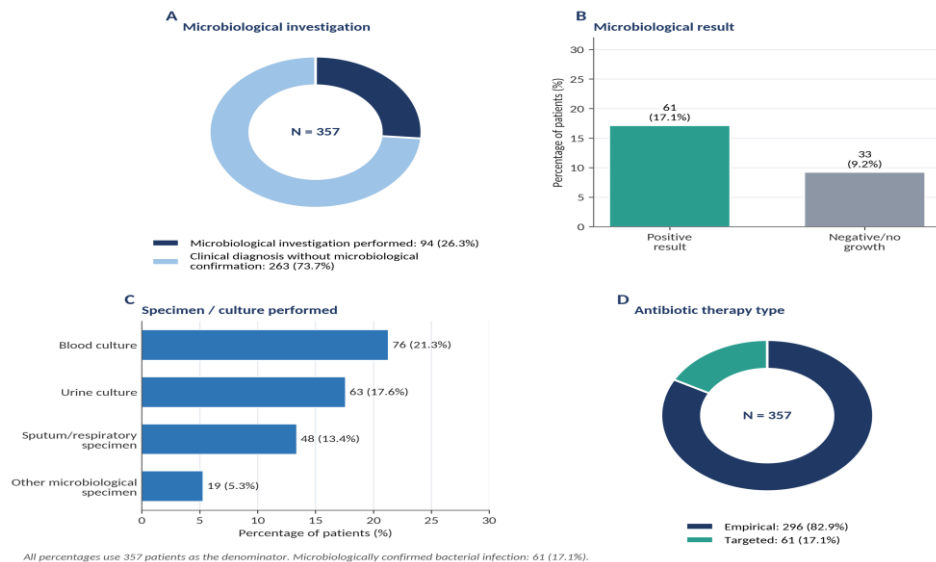
Percentages are calculated with 357 participants as the denominator. Median age 57 years (IQR 43–69); age ≥ 65 years: 121 (33.9%).

Figure 2. Distribution of community-acquired infections (N = 357)



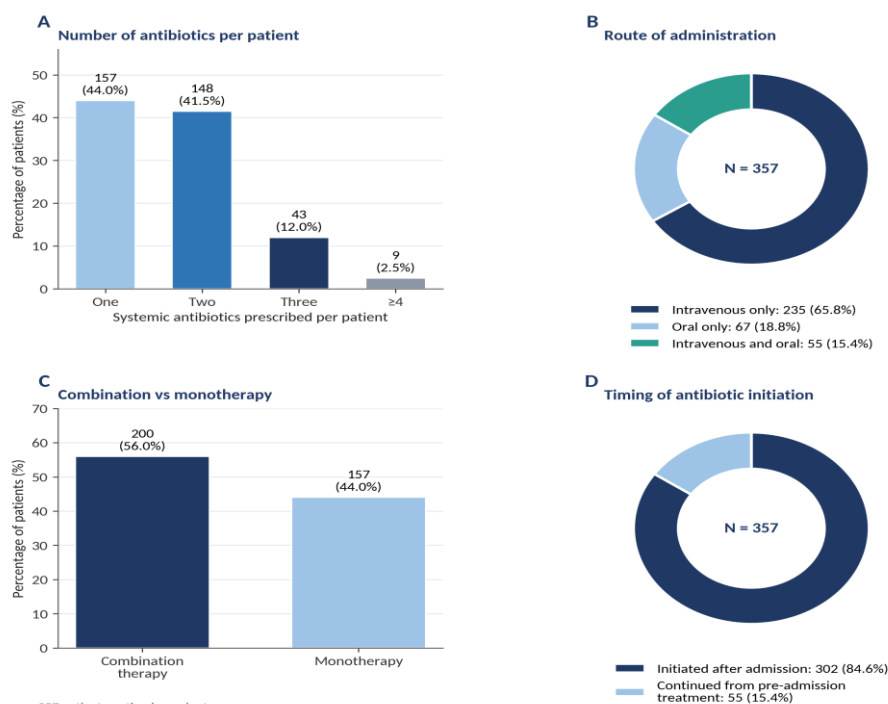
Single documented infectious syndrome: 306 (85.7%); more than one clinically relevant infectious focus: 51 (14.3%).

Figure 3. Clinical and microbiological characteristics of infections



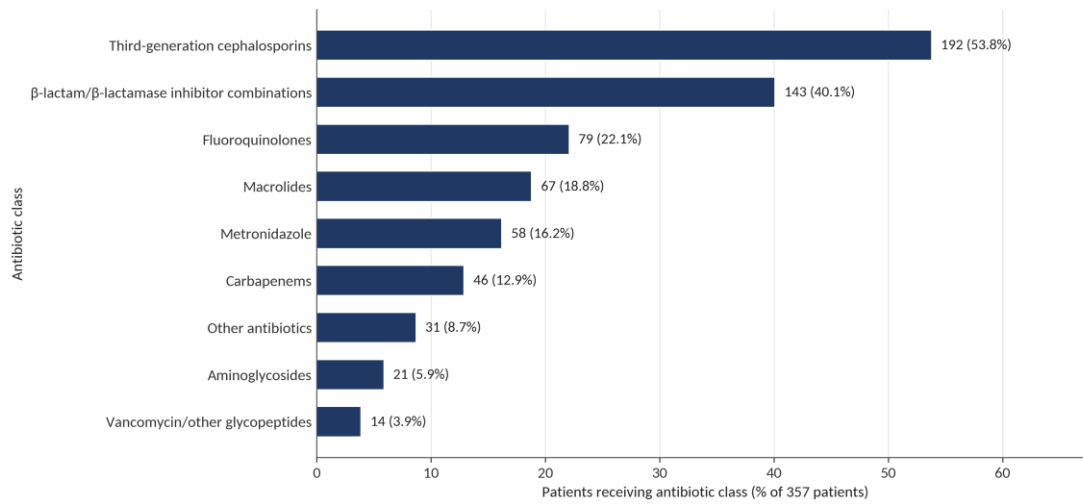
All percentages use 357 patients as the denominator. Microbiologically confirmed bacterial infection: 61 (17.1%).

Figure 4. Antibiotic prescribing patterns



All percentages use 357 patients as the denominator.

Figure 5. Antibiotics prescribed according to antibiotic class



Percentages exceed 100% because some patients received more than one antibiotic class.

Figure 6. Antibiotic use according to WHO AWaRe classification

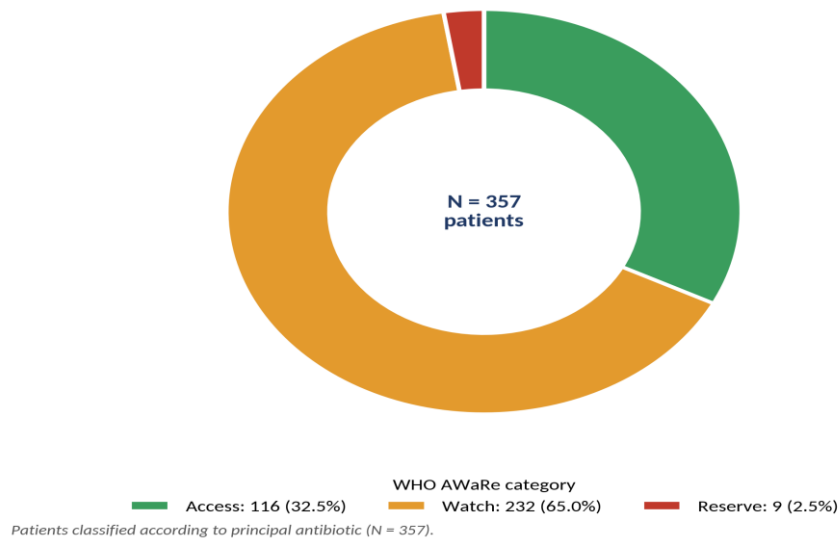
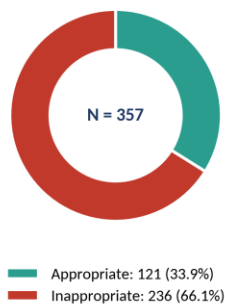


Figure 7. Appropriateness of antibiotic prescribing and its components

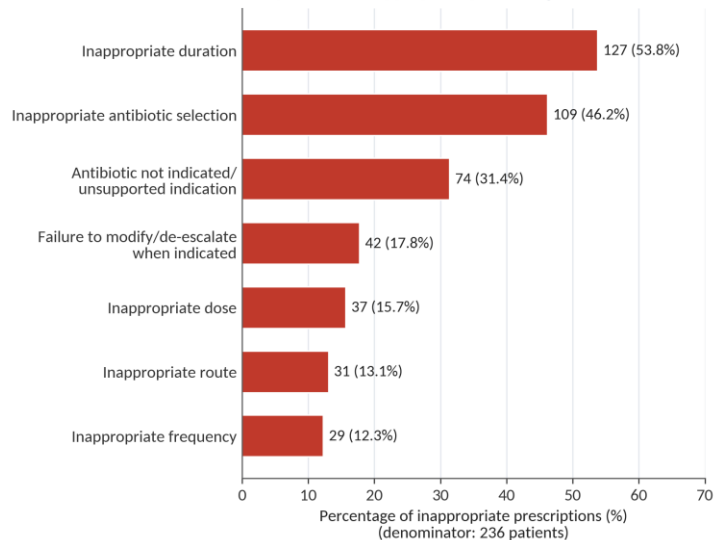
A

Overall appropriateness



B

Components of inappropriate prescribing



More than one reason could be present in an individual prescription; component percentages therefore exceed 100%.

Figure 8. Appropriateness of antibiotic therapy according to infectious syndrome

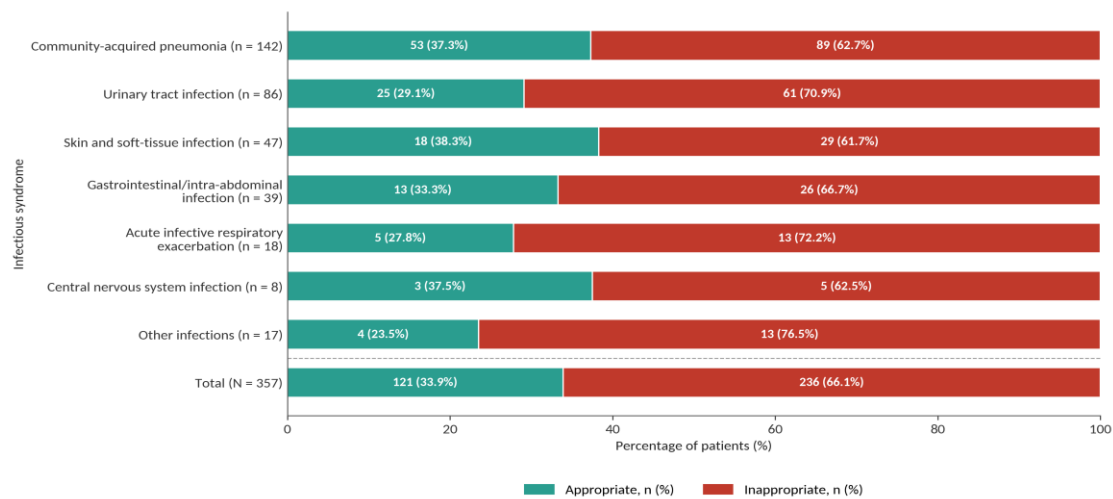


Figure 9. Appropriateness of antibiotic therapy according to prescribing characteristics

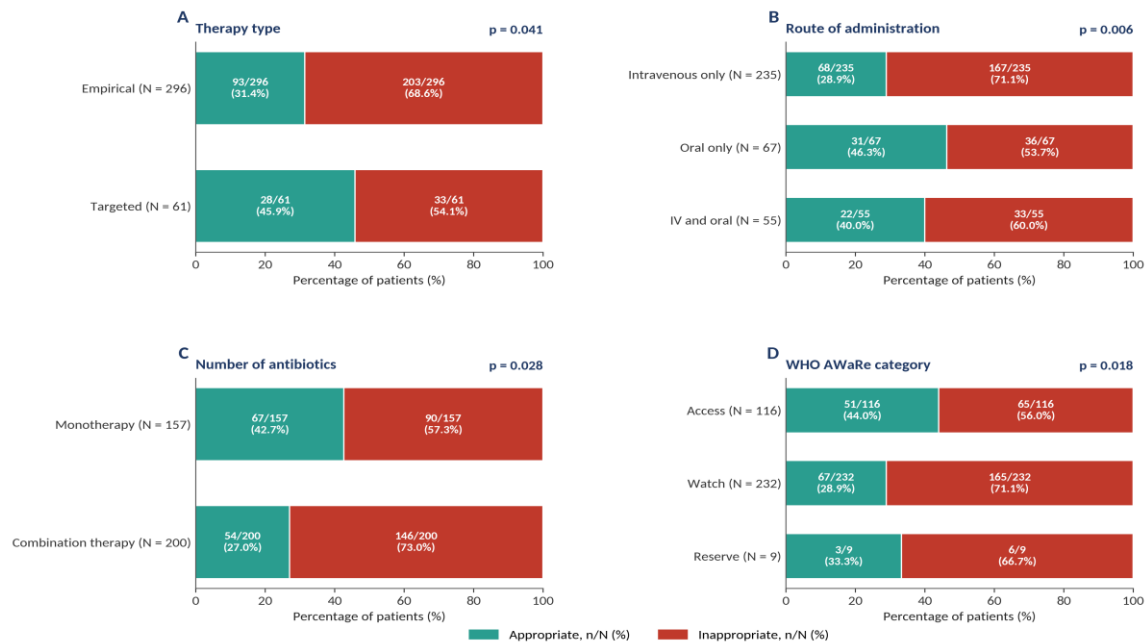


Figure 10. Patient characteristics according to antibiotic appropriateness

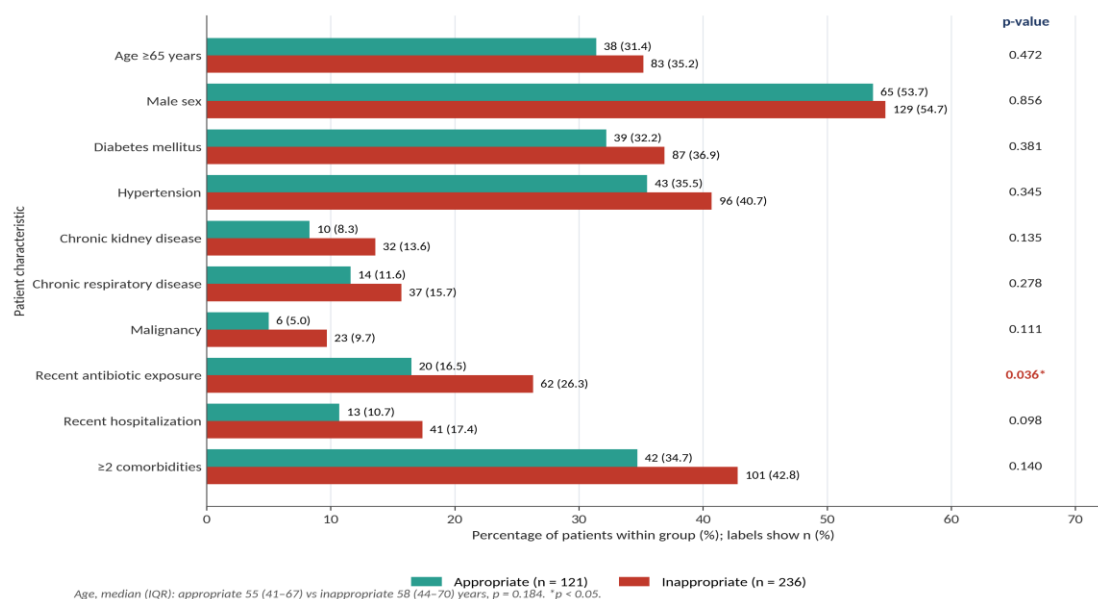
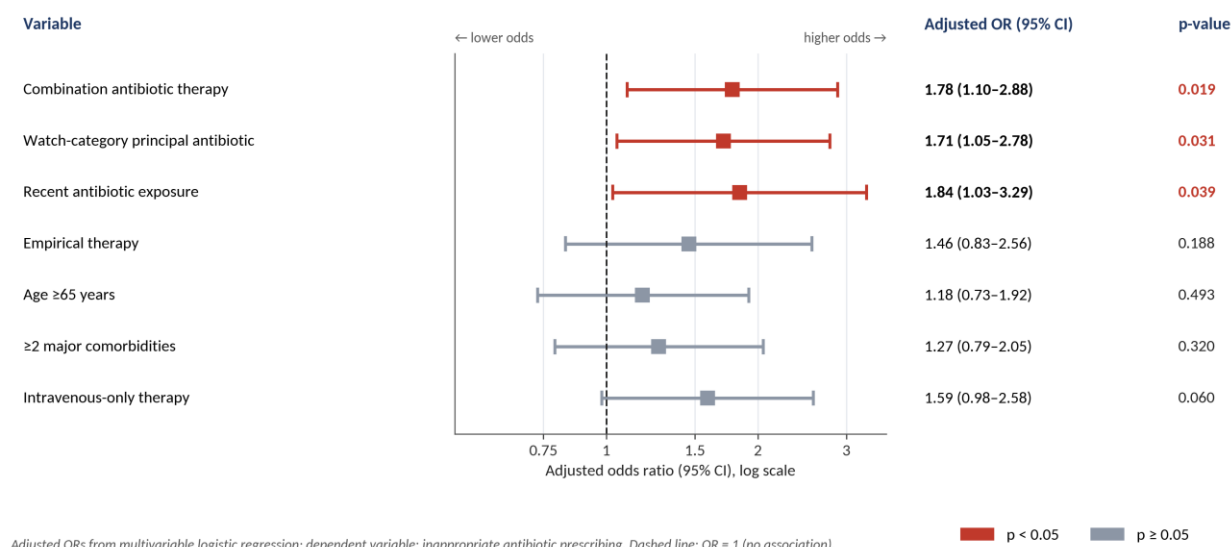


Figure 11. Factors independently associated with inappropriate antibiotic prescribing



DISCUSSION

This study assessed antibiotic prescribing patterns and the appropriateness of antibiotic therapy among 357 adults with community-acquired infections admitted to the medical units of Ayub Teaching Hospital, Abbottabad. The principal finding was that only 121 (33.9%) patients received antibiotic therapy classified as appropriate according to the predefined criteria, whereas 236 (66.1%) had at least one clinically relevant prescribing problem. Inappropriate prescribing was most frequently related to treatment duration and antibiotic selection, while dose, frequency and route were less frequent contributors. The findings therefore indicate that the main challenge in this setting is not simply the use of antibiotics, but the optimization of the complete antibiotic regimen after treatment has been initiated. The overall level of inappropriate prescribing observed in the present study is consistent with previous evidence from Pakistan, although direct comparison should be made cautiously because the populations, clinical conditions and definitions of appropriateness were not identical. Saleem et al. reported that 70.3% of hospitalized patients in Pakistan received at least one inappropriate antimicrobial when indication and dosage regimen were assessed, with respiratory tract infections also showing a substantial burden of inappropriate treatment.⁷ The present study found a somewhat lower proportion of inappropriate therapy (66.1%), but the findings remain broadly consistent in demonstrating that inappropriate antibiotic use is common among hospitalized patients in Pakistan. The difference may partly reflect the more specific population in the present study, which included adults with community-acquired infections admitted to medical units, as well as the broader appropriateness criteria used here, which incorporated selection, dose, frequency, route and duration.

The prescribing pattern observed in this study also reflects the broader pattern reported from Pakistani hospitals. Third-generation cephalosporins were the most frequently used antibiotic class, prescribed in 53.8% of patients, followed by β -lactam/ β -lactamase inhibitor combinations (40.1%) and fluoroquinolones (22.1%). Ceftriaxone, piperacillin–tazobactam, azithromycin, ciprofloxacin and meropenem were the most frequently used individual agents. Similar reliance on broad-spectrum agents, particularly ceftriaxone, has been documented in multicentre Pakistani studies. In a point-prevalence survey involving 837 inpatients from six public-sector tertiary hospitals, ceftriaxone was the most frequently prescribed antimicrobial, accounting for 21.7% of prescriptions.⁹ Another national survey across 14 tertiary-care hospitals found third-generation cephalosporins to be the most frequently prescribed antibiotic class, accounting for 38.5% of antimicrobial use.¹⁰ These findings suggest that the prominent use of third-generation cephalosporins observed at ATH is not an isolated institutional phenomenon but forms part of a wider prescribing pattern in Pakistani tertiary-care hospitals.

The AWARe distribution in the present study provides an additional perspective on antibiotic selection. Watch-category antibiotics accounted for 65.0% of the principal antibiotics, compared with 32.5% for Access and 2.5% for Reserve antibiotics. Although Watch antibiotics have important indications and their use should not automatically be interpreted as inappropriate, their predominance indicates substantial exposure to broader-spectrum agents. This is particularly relevant because the AWARe framework is intended to encourage appropriate use of Access antibiotics where suitable while limiting unnecessary exposure to broader-spectrum Watch and Reserve agents.^{2,3} Similar patterns have been reported in Pakistan. The multicentre survey of 14 tertiary hospitals found extensive use of third-generation cephalosporins, while more recent national surveillance has continued to demonstrate a substantial contribution from Watch-category antibiotics.^{10,11} Importantly, the present study assessed appropriateness independently of AWARe classification; therefore, a Watch antibiotic was not automatically considered inappropriate. This distinction is important because antibiotic spectrum must be interpreted in relation to the infection, severity, patient characteristics and microbiological findings.

Another important finding was the high proportion of empirical therapy. Overall, 296 (82.9%) patients were receiving empirical antibiotics, while only 61 (17.1%) had targeted therapy based on microbiological

identification and susceptibility results. The predominance of empirical treatment is understandable in hospitalized patients with suspected community-acquired infections because treatment decisions often have to be made before microbiological results become available. In the present study, 73.7% of patients had a clinical diagnosis without microbiological confirmation. Lack of culture confirmation alone was not considered evidence of inappropriate prescribing, consistent with the predefined methodology of the study. Nevertheless, the relatively small proportion of patients with microbiologically confirmed infections highlights the importance of improving diagnostic support where clinically appropriate. Recent multicentre surveillance from Pakistani public hospitals similarly found that more than 95% of antibiotic prescribing remained empirical despite improvements in institutional antimicrobial stewardship capacity.¹¹ This suggests that strengthening microbiological services and linking diagnostic information to prescribing review may be an important component of stewardship in tertiary-care hospitals.

The finding that inappropriate duration was the most common prescribing problem deserves particular attention. Among patients classified as having inappropriate antibiotic therapy, 127 (53.8%) had an inappropriate treatment duration. This was followed by inappropriate antibiotic selection in 109 (46.2%). The importance of treatment duration has also been demonstrated in Pakistani hospital studies. At a tertiary-care hospital in Karachi, unjustified prolonged antibacterial treatment was one of the major reasons prescriptions were considered amenable to antimicrobial-stewardship intervention.⁸ Similarly, a national point-prevalence survey identified prolonged antibiotic exposure as an important prescribing concern.¹⁰ Excessive duration may occur when an antibiotic started empirically is continued without timely reassessment, when treatment is not shortened after clinical improvement, or when there is no clearly documented stop or review point. The present cross-sectional design cannot determine which of these mechanisms was responsible in individual cases. However, the high frequency of duration-related problems indicates that antibiotic review during admission may represent an important practical target for stewardship at ATH.

The second most frequent problem was inappropriate antibiotic selection, identified in 46.2% of patients with inappropriate therapy. Selection should be based on the likely infectious syndrome, severity, relevant patient factors, local resistance patterns and microbiological information when available. The high use of third-generation cephalosporins and other broad-spectrum agents in the present study may partly explain this finding, although the study does not establish that broad-spectrum prescribing itself caused inappropriate treatment. Previous Pakistani surveillance has similarly reported substantial inappropriate use involving cephalosporins and other commonly used antibiotic classes.⁷ The finding supports the need for locally relevant empirical treatment guidance, regular review of prescribing patterns and greater use of culture and susceptibility data when clinically indicated.

The present study also identified several prescribing characteristics associated with inappropriate therapy. Inappropriate prescribing was more frequent among patients receiving combination therapy than among those receiving monotherapy (73.0% versus 57.3%; $p=0.028$). In multivariable analysis, combination therapy remained independently associated with inappropriate prescribing (adjusted OR 1.78, 95% CI 1.10–2.88; $p=0.019$). This association should not be interpreted to mean that combination therapy is inherently inappropriate. Combination treatment can be justified in severe infections, specific syndromes or situations where broader initial empirical coverage is clinically warranted. Rather, the finding suggests that patients receiving multiple antibiotics may represent an important group for structured review of indication, spectrum, duplication and duration. Similar concerns regarding multiple and broad-spectrum antibiotic use have been documented in Pakistani hospitals.^{9,10} Watch-category principal antibiotic use was also independently associated with inappropriate prescribing (adjusted OR 1.71, 95% CI 1.05–2.78; $p=0.031$). Again, this finding should be interpreted cautiously. Watch antibiotics are clinically necessary for many serious infections, and their classification within the Watch group does not itself constitute inappropriate use. The association observed in this study may instead indicate that broader-spectrum prescribing warrants closer assessment of indication, selection, microbiological justification and duration. This is consistent with the central principle of antimicrobial stewardship: the objective is not simply to reduce antibiotic use, but to ensure that the narrowest effective and clinically appropriate regimen is selected and reviewed as additional information becomes available.

Recent antibiotic exposure was another independent factor associated with inappropriate prescribing, with an adjusted OR of 1.84 (95% CI 1.03–3.29; $p=0.039$). Patients with recent antibiotic exposure may present with more complicated infections, prior treatment failure, resistant organisms or clinical uncertainty, all of which can influence prescribing decisions. Therefore, the association should not be interpreted as evidence that previous antibiotic exposure directly causes inappropriate prescribing. Instead, it identifies a clinically important group in whom antibiotic history and previous microbiological results should be actively considered when selecting empirical therapy. Recent antibiotic exposure may also influence the likelihood of using broader-spectrum agents, making careful reassessment particularly important.

Empirical therapy was associated with a higher proportion of inappropriate prescribing on unadjusted analysis (68.6% versus 54.1% among targeted therapy; $p=0.041$). However, empirical therapy was not independently associated with inappropriate prescribing after multivariable adjustment (adjusted OR 1.46, 95% CI 0.83–2.56; $p=0.188$). This distinction is important. It indicates that the higher crude frequency of inappropriate prescribing among empirically treated patients may partly reflect other characteristics of these patients or their treatment regimens. It also reinforces the methodological principle used in this study that empirical therapy should not automatically be considered inappropriate simply because microbiological confirmation is unavailable. Evidence

from hospital antimicrobial-stewardship literature supports the importance of guideline-concordant empirical therapy followed by reassessment and de-escalation when appropriate.¹²

Intravenous-only therapy was also more frequently associated with inappropriate prescribing on unadjusted analysis, with 71.1% of patients receiving intravenous-only therapy classified as inappropriate compared with 53.7% receiving oral therapy ($p=0.006$). However, intravenous-only therapy did not reach statistical significance in the adjusted analysis (adjusted OR 1.59, 95% CI 0.98–2.58; $p=0.060$). This suggests that route of administration may be influenced by other clinical characteristics, including illness severity and the need for initial parenteral treatment. Nevertheless, once a patient is clinically stable and able to tolerate oral medication, timely review of the route can form part of stewardship practice. Evidence from hospital stewardship studies indicates that interventions targeting timely antibiotic review and intravenous-to-oral switching can improve prescribing and reduce unnecessary antibiotic exposure.^{12,13}

The distribution of infection types is also clinically relevant. Community-acquired pneumonia was the most common infectious syndrome, accounting for 39.8% of the study population, followed by urinary tract infection (24.1%) and skin and soft-tissue infection (13.2%). Inappropriate prescribing was observed across all major infectious syndromes, ranging from 61.7% among patients with skin and soft-tissue infection to 76.5% among those classified under other community-acquired infections. The relatively similar burden across several infection categories suggests that inappropriate prescribing is not confined to a single clinical syndrome. Instead, interventions may need to address common prescribing processes—such as documentation of indication, antibiotic review, duration setting and de-escalation—in addition to disease-specific treatment guidance.

The findings have practical implications for antimicrobial stewardship at ATH. The high frequency of duration- and selection-related problems suggests that stewardship efforts should extend beyond restricting individual antibiotics. A structured review process could include documentation of the indication and intended duration at initiation, reassessment after clinical response and microbiological results become available, and explicit consideration of de-escalation or discontinuation where appropriate. Prospective audit and feedback, locally adapted treatment guidelines and multidisciplinary review have been associated with improvements in hospital antibiotic prescribing.^{12,14} Evidence from Pakistan also suggests that pharmacist-led stewardship interventions can identify clinically relevant prescribing problems, particularly involving antibiotic spectrum and dosing.¹⁵ Such approaches may be particularly useful in resource-constrained settings when combined with feasible institutional guidelines and regular monitoring of prescribing indicators.

Strengths

This study has several strengths. First, it evaluated antibiotic prescribing in a clearly defined population of adult patients with community-acquired infections admitted to the medical units of a large tertiary-care teaching hospital. Second, consecutive sampling was used during the study period, reducing the likelihood of selective recruitment based on prescribing characteristics. Third, antibiotic appropriateness was assessed using predefined criteria rather than an overall subjective judgment, allowing individual prescribing components—including indication, antibiotic selection, dose, frequency, route and duration—to be evaluated separately. Fourth, the study incorporated the WHO AWaRe classification, allowing the spectrum of antibiotic use to be described alongside individual antibiotic classes and agents. Finally, the study examined potential patient-, infection- and prescribing-related factors associated with inappropriate therapy and used multivariable logistic regression to identify factors independently associated with the outcome. These features provide a detailed local assessment of antibiotic prescribing and establish a useful baseline for future antimicrobial-stewardship initiatives at the institution.\

Limitations

This study has several limitations that should be considered when interpreting its findings. First, it was a single-centre, hospital-based cross-sectional study; therefore, the findings describe prescribing practices during the study period and cannot establish causal relationships between the identified factors and inappropriate antibiotic prescribing. Second, the study was conducted in adult medical units of a tertiary-care hospital, so the findings may not be directly generalizable to surgical, paediatric, primary-care or other healthcare settings with different patient populations and prescribing practices. Third, assessment of antibiotic appropriateness depended partly on the quality and completeness of clinical documentation and the availability of microbiological information. Microbiological confirmation was available in only 61 (17.1%) patients, and therefore antibiotic selection could not routinely be assessed against culture and susceptibility results. Fourth, although predefined criteria were used to assess appropriateness, some clinical decisions—particularly empirical treatment in patients with limited diagnostic information—may involve clinical judgment that cannot be completely captured by standardized criteria. Finally, the study assessed prescribing appropriateness rather than patient outcomes such as mortality, treatment failure, length of hospital stay or antibiotic-related adverse events; consequently, the clinical impact of the identified prescribing problems could not be determined.

CONCLUSION

In this study of adults with community-acquired infections admitted to the medical units of Ayub Teaching Hospital, inappropriate antibiotic prescribing was common, with approximately two-thirds of patients receiving therapy classified as inappropriate according to predefined criteria. The most frequent prescribing problems were inappropriate treatment duration and antibiotic selection. Third-generation cephalosporins and other broad-spectrum antibiotics were frequently used, and Watch-category antibiotics constituted the largest AWaRe group.

Combination antibiotic therapy, use of a Watch-category principal antibiotic and recent antibiotic exposure were independently associated with inappropriate prescribing.

These findings highlight the need to focus antimicrobial-stewardship efforts on optimization of antibiotic therapy rather than antibiotic reduction alone. Particular attention should be given to appropriate antibiotic selection, documentation and review of treatment duration, timely reassessment of empirical therapy, and de-escalation or modification when clinically indicated. Strengthening locally relevant prescribing guidance, microbiological support and regular review of antibiotic therapy may help improve prescribing quality and promote more rational antibiotic use in the medical units of ATH. The findings also provide a local baseline for evaluating future antimicrobial-stewardship interventions at the institution.

Additional Information

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