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Original Article

Analysis and Promotion of Rational Usage of Drugs to Prevent Antimicrobial Resistance in the Intensive Care Units of a Tertiary Healthcare Centre

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ABSTRACT

Background: Intensive care units use substantial hospital antimicrobials because critically ill patients often require immediate empirical therapy. This urgency can encourage broad-spectrum selection, prolonged intravenous treatment, polypharmacy, and limited de-escalation, increasing adverse effects and antimicrobial resistance. This study was designed to analyse antimicrobial prescribing in the intensive care units of a tertiary teaching hospital and identify practical opportunities for promoting rational drug use.

Methods: This prospective observational drug-utilisation study included 400 adults admitted to the intensive care units of Mahavir Institute of Medical Sciences. Patients receiving at least one antimicrobial were enrolled after ethical approval and informed consent. Demographic, prescribing, adverse-event, duration, modification, and outcome data were recorded. Analysis used IBM SPSS Statistics version 28. Categorical variables were summarised as frequencies and percentages; associations were tested using Pearson's chi-square test.

Results: Patients older than 50 years formed the largest age group (38.0%), and 57.3% were men. Cardiovascular disorders were the leading admission category (19.8%), followed by trauma (13.5%) and poisoning (11.0%). Five or more drugs were prescribed to 76.5% of patients. Antimicrobial monotherapy was used in 68.3%, while 99.25% received intravenous therapy. Cefotaxime was the leading prescribed agent (69.0%), followed by metronidazole (29.0%). The initial regimen remained unchanged in 97.8%; de-escalation occurred in 0.8%. Adverse drug reactions were recorded in 60.2%, most commonly nausea or vomiting (16.5%). Polypharmacy was associated with adverse reactions (χ^2=12.44, $p<0.001$). Clinical improvement occurred in 48.0%, while 13.3% died.

Conclusion: Antimicrobial use was dominated by intravenous broad-spectrum cephalosporins, limited regimen review, and substantial polypharmacy. ICU-specific antibiograms, culture-guided review at 48–72 hours, dose optimisation, early intravenous-to-oral conversion, adverse-event surveillance, and stop dates should be incorporated into a stewardship programme with audit and feedback.

Keywords*: antimicrobial stewardship; intensive care unit; rational drug use; antimicrobial resistance; drug-utilisation study; adverse drug reaction.*

INTRODUCTION

Antimicrobial resistance has become a defining patient-safety problem in modern hospitals. The immediate cause is biological selection under antimicrobial exposure, but the clinical expression of resistance is shaped by prescribing volume, spectrum, duration, infection-control practices, movement of patients, and the local ecology of pathogens. In the intensive care unit (ICU), these forces converge. Patients are severely ill, invasive devices are common, organ function changes

rapidly, and diagnostic uncertainty is often greatest at the moment treatment decisions are most urgent. The result is a setting in which timely antimicrobial therapy can be lifesaving, yet unnecessary or poorly reviewed treatment can create substantial harm [1].

Infection is frequent among critically ill patients and is associated with longer stay, organ dysfunction, and mortality. Large international ICU datasets have shown that infection and antimicrobial exposure are widespread, with resistant organisms contributing appreciably to adverse outcomes [2]. The first therapeutic decision therefore has two competing obligations. It must provide adequate early coverage for a patient who may deteriorate rapidly, and it must avoid exposing patients and the ICU microbial environment to avoidable broad-spectrum treatment. Inadequate empirical therapy has been associated with higher mortality among critically ill patients [3], while delay in effective treatment during septic shock has also been linked to poorer survival [4]. Rational antimicrobial use does not mean withholding treatment when infection is likely. It means selecting, dosing, monitoring, reviewing, narrowing, and stopping therapy with discipline.

Antimicrobial stewardship is the organised expression of rational antimicrobial use. It combines clinical judgment with microbiology, pharmacology, infection control, audit, and feedback. The core objective is to obtain the best possible clinical outcome while minimising toxicity, unnecessary cost, ecological pressure, and the emergence of resistance. Early guidance described stewardship in terms of optimal drug selection, dose, route, and duration [5]. Later implementation guidelines emphasised leadership commitment, prospective audit and feedback, formulary restriction where appropriate, facility-specific treatment guidance, dose optimisation, and systematic measurement of antimicrobial use [6].

The ICU needs a tailored stewardship approach because standard ward-based rules may not fully address altered pharmacokinetics, augmented renal clearance, renal replacement therapy, fluid shifts, vasopressor use, mechanical ventilation, or the consequences of missing early effective treatment. ICU stewardship therefore begins with prompt and adequate empirical therapy when clinically indicated, but it must continue through a structured reassessment once cultures, imaging, biomarkers, organ function, and the clinical trajectory become clearer [7,8]. Broad empirical coverage should be viewed as a temporary bridge to targeted therapy, not as a default regimen to be continued without review.

Drug-utilisation studies provide a practical description of how medicines are actually used in routine care. They can identify polypharmacy, excessive reliance on injectable therapy, dominance of particular antimicrobial classes, limited de-escalation, prolonged treatment, and avoidable adverse effects. Such observations are especially valuable in institutions where electronic prescribing data, defined daily dose metrics, or unit-specific antibiograms are not routinely available. Antibiotic consumption and resistance are positively related at patient and population levels [9], while stewardship interventions can improve guideline adherence, reduce antimicrobial exposure, lower costs, and decrease the incidence of resistant organisms and Clostridioides difficile infection [10-13].

Hospital records Mahavir Institute of Medical Sciences were reviewed to assess antimicrobial prescribing among 400 adults admitted to intensive care units. The analysis covered patient demographics, admission diagnoses, comorbidities, number and class of antimicrobials, route and duration of therapy, drug combinations, suspected adverse reactions, treatment modifications, de-escalation, clinical improvement, referral, discharge against medical advice, and mortality. As culture and susceptibility findings were not available, antimicrobial resistance was not measured directly. The study therefore focused on prescribing practices that may contribute to resistance, with the objectives of evaluating the rationality of antimicrobial use, examining associations between polypharmacy and adverse reactions, identifying gaps in current prescribing, and proposing practical stewardship measures to reduce unnecessary antimicrobial exposure. measures for the ICU.

MATERIALS AND METHODS

Study design and setting

This was a prospective observational and descriptive drug-utilisation study conducted in the intensive care units of Mahavir Institute of Medical Sciences Shivareddypet, Vikarabad, India. The hospital functions as a tertiary teaching centre and receives critically ill medical, surgical, trauma, toxicology, obstetric, and emergency referrals. The study focused on prescribing practice during routine ICU management and did not alter the treating team's therapeutic decisions.

Study period and study population

The study was conducted over 12 months, from April 2025 to March 2026. The study population consisted of adult patients admitted to the ICUs who received one or more antimicrobial agents during their stay. A total of 400 consecutive eligible patients were included. Each patient was observed from enrolment until discharge, referral, discharge against medical advice, or death, according to the information available in the source record.

Eligibility criteria

Patients older than 18 years of either sex who were admitted to an ICU and prescribed at least one antimicrobial were eligible. Pregnant or lactating women, patients younger than 18 years, individuals who declined participation, cases with

insufficient clinical or prescribing information, and patients with systemic or local malignancy were excluded. These criteria were retained from the original study protocol.

Sampling and sample size

Purposive consecutive sampling was used. The prespecified sample size was 400 cases. All consecutive patients meeting the eligibility criteria during the study period were recruited until the required sample was achieved. The available source document did not provide a formal prevalence-based sample size calculation, and no retrospective power calculation was undertaken because the study was primarily descriptive.

Data collection procedure

Data were collected personally from ICU case records and entered in a preapproved case-record form. The variables included age, sex, admission diagnosis, inpatient number, admission and exit dates, comorbid conditions, laboratory information recorded in the case sheet, antimicrobial name, drug class, dose, frequency, route, duration, use of generic or trade names, monotherapy or combination therapy, reason for change, suspected adverse drug reactions, drug interactions when documented, and clinical disposition. Written informed consent was obtained from the patient or an authorised relative after the purpose and procedures had been explained.

Operational definitions and study outcomes

Polypharmacy was operationally classified as prescription of five or more total drugs during ICU care, matching the categorisation used in the source results. Antimicrobial monotherapy indicated use of one antimicrobial agent, while multitherapy indicated concurrent use of two or more agents. De-escalation referred to documented narrowing of therapy or conversion to an oral regimen. Suspected adverse drug reactions were recorded as documented by the treating team; the available source data did not include formal causality, severity, or preventability assessment. The main descriptive outcomes were antimicrobial selection, route, duration, regimen modification, adverse reactions, and final clinical disposition.

Ethical considerations

Institutional Ethics Committee clearance and administrative permission were obtained before recruitment. Written informed consent was obtained from patients or relatives.

Statistical analysis

Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, New York, USA). Categorical variables were summarised using frequencies and percentages. Pearson's chi-square test was used to examine associations between admission category and sex, total number of drugs and suspected adverse drug reactions, sex and clinical outcome, and adverse drug reactions and clinical outcome. A two-sided p value below 0.05 was considered statistically significant. Because age was available only in categories, no mean age was estimated. The median duration of therapy and interquartile range were derived from the recorded day-wise frequency distribution.

Data verification and handling of source inconsistencies

The numerical tables in the attached results were checked arithmetically before manuscript preparation. The adverse-reaction-by-outcome table listed the total number of patients with adverse reactions as 66, although its component cells summed to 241; the reconstructed analysis therefore used 241 and yielded $\chi^2=6.12$ with $p=0.106$. The antimicrobial table listed piperacillin-tazobactam use as 32 men and 17 women, but gave a total of 43. The sex-specific counts sum to 49, and the reconstructed table reports 49 with an explanatory footnote. These corrections are transparent arithmetic reconciliations rather than new observations. No culture, susceptibility, defined daily dose, days-of-therapy, severity-score, or infection-source data were added because they were not present in the supplied files.

RESULTS

Demographic characteristics

All 400 enrolled patients were included in the descriptive analysis. The largest age group comprised patients older than 50 years, accounting for 152 cases (38.0%). Patients aged 21-30 years formed the next largest group, with 90 cases (22.5%). There were 229 men (57.3%) and 171 women (42.8%). The complete age and sex profile is shown in Table 1, and the age distribution is illustrated in Figure 1.

Table 1: Demographic profile of the study population (n=400)

Characteristic	n	Percent
Age: <21 years	39	9.8
Age: 21-30 years	90	22.5
Age: 31-40 years	65	16.3
Age: 41-50 years	54	13.5

Age: >50 years	152	38.0
Sex: Female	171	42.8
Sex: Male	229	57.3

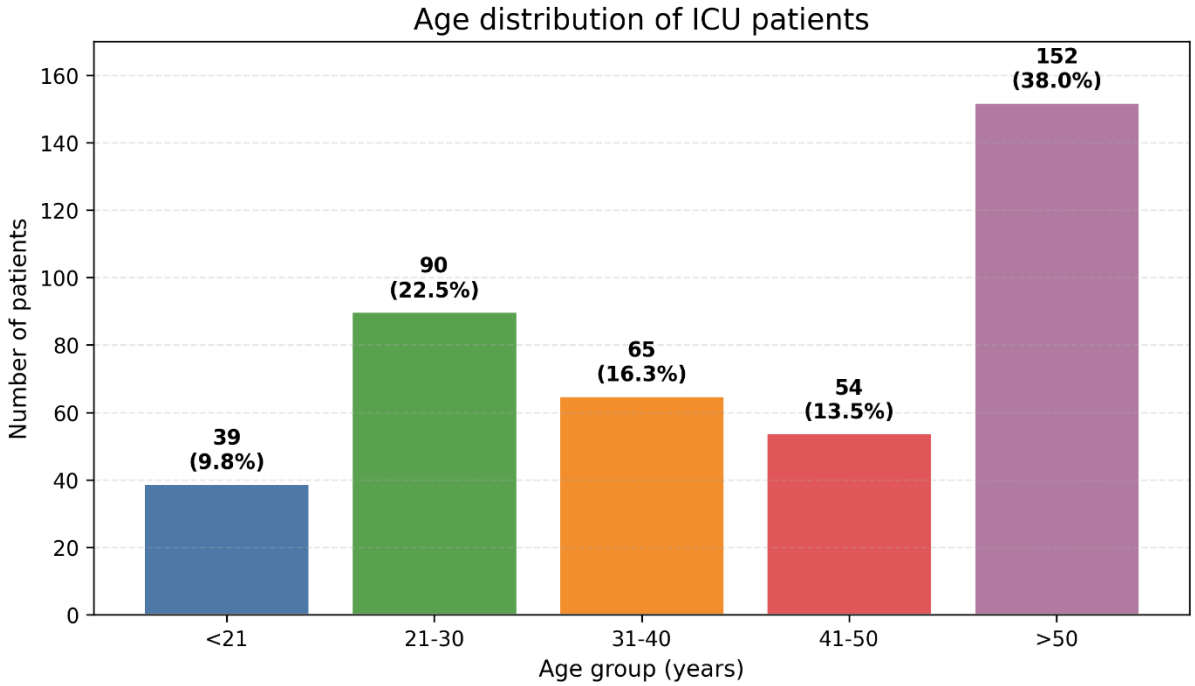

Figure 1: Age distribution of adult ICU patients receiving antimicrobial therapy. The oldest category contained the largest proportion of participants.

Reasons for ICU admission and comorbid conditions

Cardiovascular disorders were the most frequent admission category, affecting 79 patients (19.8%), followed by trauma in 54 (13.5%), poisoning in 44 (11.0%), central nervous system disorders in 35 (8.8%), and both respiratory and abdominal or gastrointestinal disorders in 34 patients each (8.5%). Obstetric and gynaecological conditions accounted for 32 admissions and occurred exclusively among women. Trauma and snake bite were predominantly recorded among men. The distribution of admission categories differed significantly by sex (χ^2=65.06, df=9, p<0.001), as presented in Table 2 and Figure 2.

No comorbid illness was documented in 276 patients (69.1%). Hypertension alone was present in 49 (12.3%), hypertension with diabetes in 29 (7.3%), and diabetes alone in 20 (5.0%). Overall, 124 patients (30.9% as reported in the source discussion) had at least one recorded comorbid condition. The comorbidity profile is included in Table 2.

Table 2: Clinical profile, admission category by sex, and comorbidity status

Category	Female n	Male n	Total n	Percent / test
Abdominal/GIT	8	26	34	8.5
CNS	15	20	35	8.8
CVS	35	44	79	19.8
Obstetrics and gynaecology	32	0	32	8.0
Poisoning	21	23	44	11.0
Respiratory	11	23	34	8.5
Sepsis	6	7	13	3.2
Snake bite	3	12	15	3.8
Trauma	11	43	54	13.5
Others	29	31	60	15.0
Admission category: overall test				χ^2=65.06; df=9; p<0.001
Comorbidity: None			276	69.1
Comorbidity: Hypertension			49	12.3

Comorbidity: Hypertension and diabetes			29	7.3
Comorbidity: Hypertension, diabetes and others			2	0.5
Comorbidity: Hypertension and others			1	0.3
Comorbidity: Diabetes			20	5.0
Comorbidity: Diabetes and others			1	0.3
Comorbidity: Other conditions			22	5.5

GIT, gastrointestinal; CNS, central nervous system; CVS, cardiovascular system. The chi-square test compares the full 10 x 2 admission-category-by-sex table. Comorbidity percentages reproduce the source table and may differ slightly from direct recalculation because of source rounding. No inferential test was applied to the comorbidity distribution.

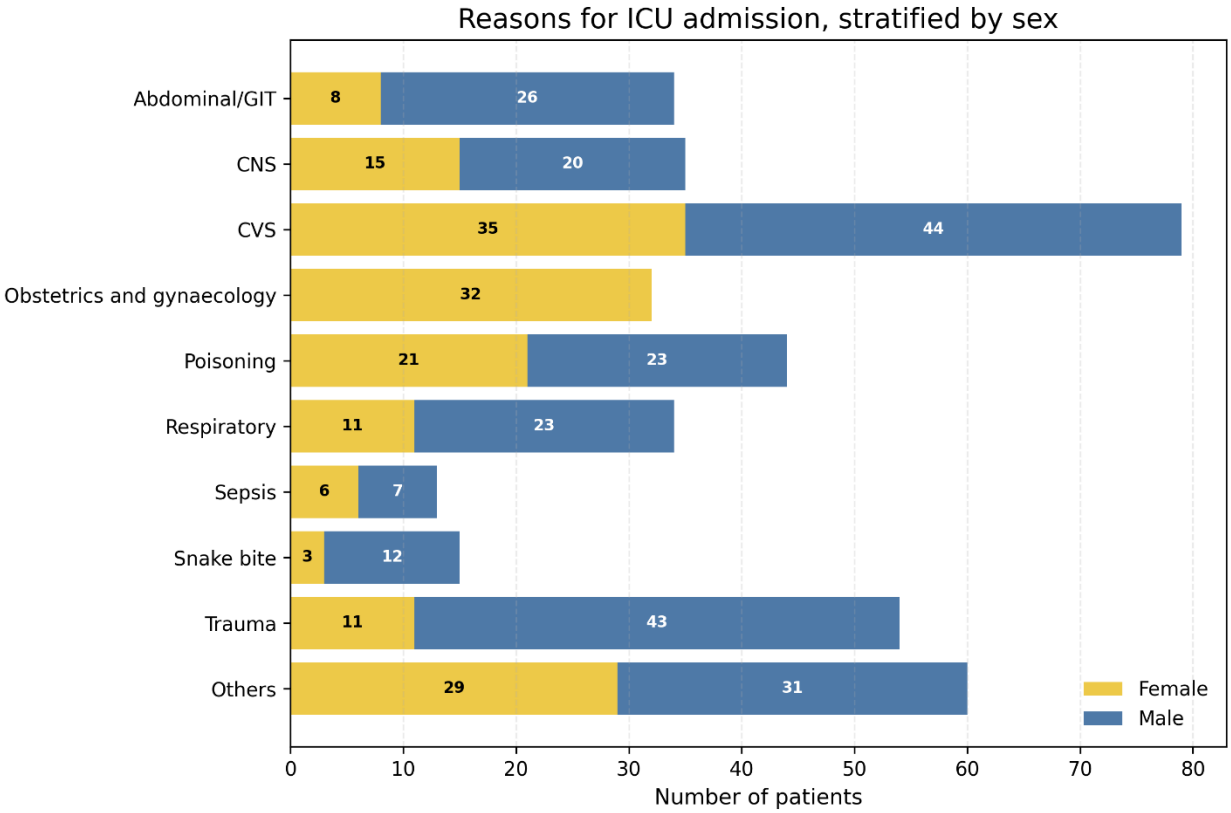

Figure 2: Reasons for admission to the ICU stratified by sex. The significant overall association reflects the female-only obstetric and gynaecological category and the male predominance in trauma and snake bite admissions

Overall prescribing burden and antimicrobial strategy

Five or more total drugs were prescribed to 306 patients (76.5%), indicating a high burden of concurrent pharmacotherapy in the ICU. Ninety-four patients (23.5%) received fewer than five drugs. Antimicrobial monotherapy was used in 273 cases (68.3%), while 127 patients (31.8%) received two or more antimicrobial agents. These combinations were generally used to broaden empirical coverage or address suspected mixed aerobic and anaerobic infection. The core prescribing indicators are summarised in Table 3 and Figure 3.

Table 3: Drug-utilisation and antimicrobial prescribing indicators

Indicator	n	Percent
Fewer than 5 total drugs	94	23.5
5 or more total drugs	306	76.5
Antimicrobial monotherapy	273	68.3

Antimicrobial multitherapy	127	31.8
Intravenous route only	397	99.25
Intravenous and oral	1	0.25
Oral route only	2	0.50
No antimicrobial change	391	97.8
Changed for inadequate response	6	1.5
De-escalation / oral switch	3	0.8

Descriptive categories are not mutually exclusive across sections. No inferential test was applied to these single-variable distributions. IV, intravenous.

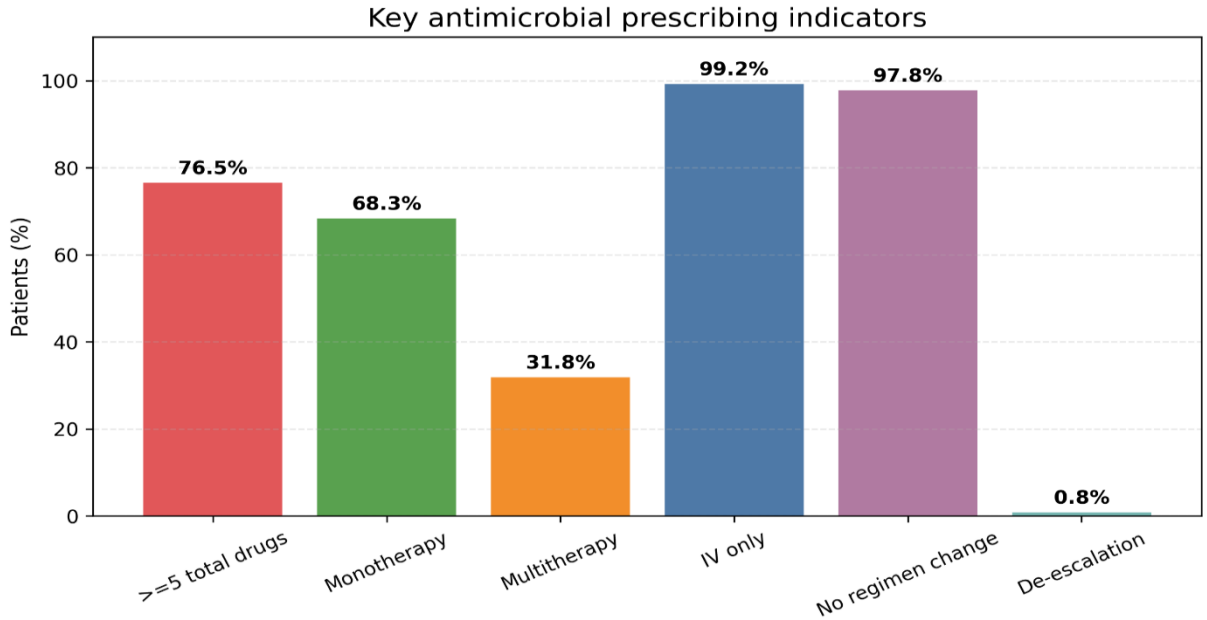

Figure 3: Selected prescribing indicators. Near-universal intravenous use and the very low documented de-escalation rate identify major opportunities for structured antimicrobial review

Route, duration, and modification of antimicrobial therapy

The intravenous route was used exclusively in 397 patients (99.25%). Two patients received oral treatment alone, and one received both intravenous and oral therapy. The median recorded treatment duration was 3 days, with an interquartile range of 2-5 days. A total of 384 patients (96.0%) received antimicrobials for seven days or less, while 16 (4.0%) had treatment extending beyond seven days. The short recorded duration in many cases reflected early referral, discharge against medical advice, or termination of observation rather than necessarily planned completion of an antimicrobial course.

The original antimicrobial regimen was continued without change in 391 patients (97.8%). Six regimens (1.5%) were modified because of inadequate clinical response, and three (0.8%) were documented as de-escalation or oral switch. No change was attributed to allergy or a severe adverse reaction in the available records. The detailed duration distribution is shown in Table 4.

Table 4: Duration of antimicrobial treatment

Duration	n	Percent / summary
1	86	21.75
2	72	18.00
3	78	19.50
4	15	3.75
5	87	21.75
6	4	1.00
7	42	10.50
8	4	1.00
9	2	0.50
10	5	1.25
13	2	0.50
14	1	0.25

30	1	0.25
Median (IQR)	3 days	2-5 days
Up to 7 days	384	96.0
More than 7 days	16	4.0

Duration represents observed antimicrobial exposure in the source record. The source table reports 86 one-day courses as 21.75%, although direct calculation gives 21.50%; the reported percentage has been retained transparently

Antimicrobial classes and individual agents

Cephalosporins dominated prescribing. Cefotaxime was recorded in 276 patients (69.0%), making it the most frequently used agent by a wide margin. Metronidazole was used in 116 (29.0%), piperacillin-tazobactam in 49 (12.3%) after arithmetic reconstruction of the sex-specific counts, ceftriaxone and gentamicin in 28 patients each (7.0%), amoxicillin-clavulanate and ciprofloxacin in 20 each (5.0%), and cefoperazone-sulbactam in seven (1.8%). Meropenem and amikacin were each used in three patients, while azithromycin was used in two. Levofloxacin and fluconazole were each recorded once. Table 5 presents the individual agents, and Figure 4 displays the ten most frequently prescribed drugs.

Table 5: Class and individual antimicrobial agents used

Class	Agent and recorded regimen	Male	Female	Total	Percent
Penicillins/beta-lactamase inhibitor combinations	Amoxicillin-clavulanate 1.2 g IV twice daily	12	8	20	5.0
Penicillins/beta-lactamase inhibitor combinations	Piperacillin-tazobactam 4.5 g IV three times daily	32	17	49	12.3
Carbapenem	Meropenem 1 g IV twice daily	3	0	3	0.8
Cephalosporin	Cefotaxime 1 g IV twice daily	154	122	276	69.0
Cephalosporin	Ceftriaxone 1 g IV twice daily	15	13	28	7.0
Cephalosporin/beta-lactamase inhibitor combination	Cefoperazone-sulbactam 1.5 g IV twice daily	6	1	7	1.8
Macrolide	Azithromycin 500 mg orally once daily	2	0	2	0.5
Aminoglycoside	Amikacin 500 mg IV twice daily	3	0	3	0.8
Aminoglycoside	Gentamicin 80 mg IV twice daily	5	23	28	7.0
Nitroimidazole	Metronidazole 500 mg IV twice daily	58	58	116	29.0
Fluoroquinolone	Ciprofloxacin 200 mg IV twice daily	8	12	20	5.0
Fluoroquinolone	Levofloxacin 500 mg IV once daily	0	1	1	0.3
Antifungal	Fluconazole 150 mg once weekly	0	1	1	0.3

Percentages use 400 patients as the denominator and may sum to more than 100 because patients receiving combination therapy could appear under more than one agent. The source table reported piperacillin-tazobactam as 32 men and 17 women but gave a total of 43; the arithmetically correct total of 49 is shown.

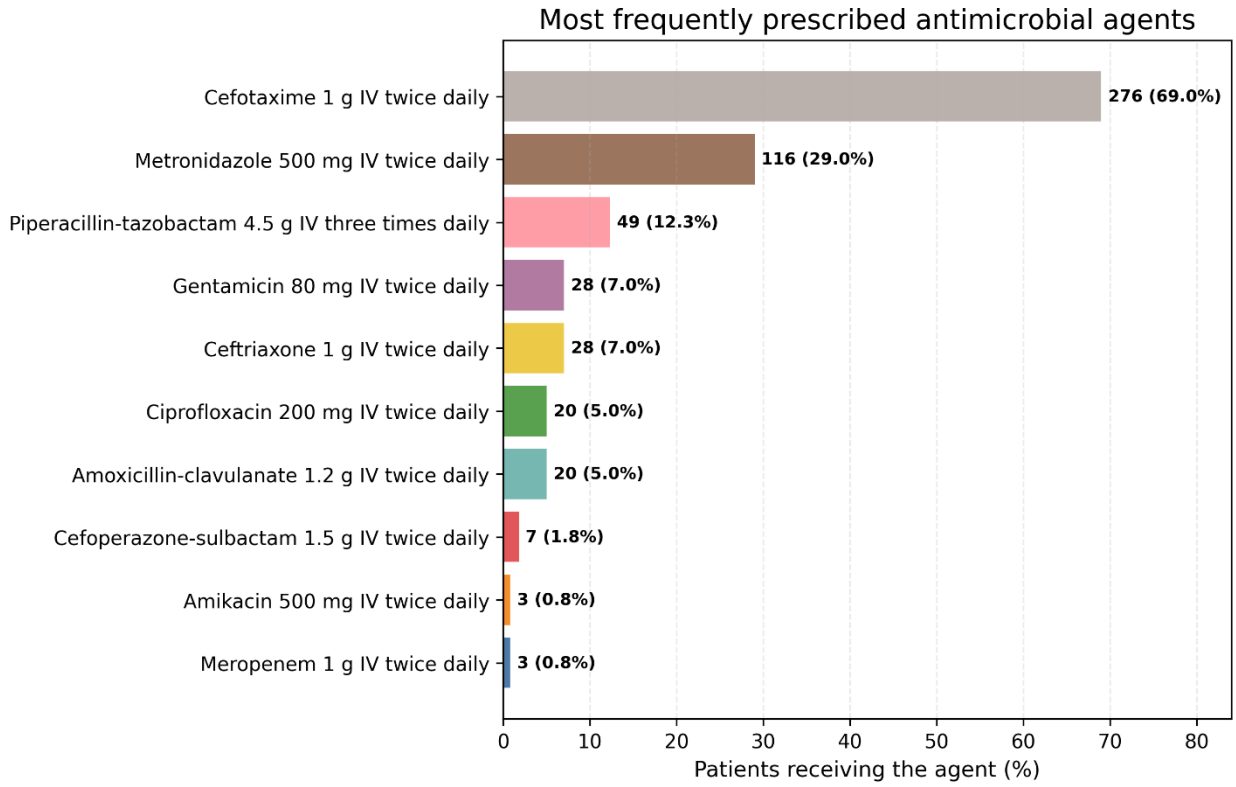

Figure 4: Most frequently prescribed antimicrobial agents. Cefotaxime accounted for the greatest exposure, followed by metronidazole

Suspected adverse drug reactions

At least one suspected adverse drug reaction was documented in 241 patients (60.2%), while 159 (39.8%) had no recorded reaction. Nausea or vomiting was the most frequent reaction, occurring in 66 patients (16.5%). Headache was recorded in 51 (12.8%), diarrhoea in 48 (12.0%), and altered taste sensation in 46 (11.5%). Less frequent events included pruritus or rash, thrombophlebitis, urticaria, anorexia, and photosensitivity. The reaction profile is presented in Table 6 and Figure 5. The available records did not include a formal causality scale, severity grading, or preventability assessment, so these events should be interpreted as documented suspected reactions rather than confirmed antimicrobial-related events.

Table 6: Documented suspected adverse drug reactions

Reaction	n	Percent
No documented ADR	159	39.8
Nausea/vomiting	66	16.5
Headache	51	12.8
Diarrhoea	48	12.0
Pruritus/rash	6	1.5
Thrombophlebitis	6	1.5
Altered taste sensation	46	11.5
Urticaria	1	0.3
Other: anorexia/photosensitivity	17	4.3

The categories sum to 400 because one principal reaction category was recorded for each patient in the source table. No causality, severity, or preventability assessment was available

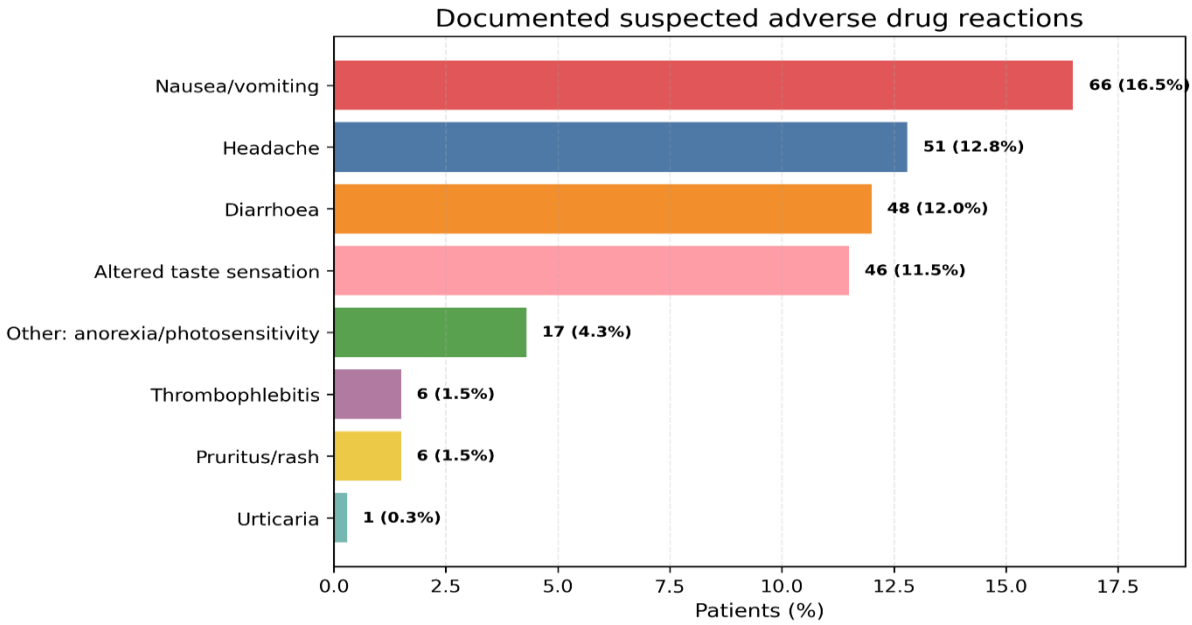

Figure 5: Distribution of documented suspected adverse drug reactions among patients receiving antimicrobial therapy

Clinical disposition

Clinical improvement with subsequent discharge after stabilisation was documented in 192 patients (48.0%). Eighty-nine patients (22.3%) were discharged against medical advice, and 66 (16.5%) were referred to a higher centre because the required facilities were unavailable locally. Fifty-three patients died, giving an observed mortality of 13.3%. Since 155 patients were either referred or discharged against medical advice, the final efficacy of antimicrobial treatment could not be determined for a substantial proportion of the cohort. Table 7 and Figure 6 show the clinical disposition.

Table 7: Clinical disposition at the end of observation

Outcome	n	Percent	χ^2 / p value
Improved	192	48.0	Not applicable
Discharged against medical advice	89	22.3	Not applicable
Referred to a higher centre	66	16.5	Not applicable
Death	53	13.3	Not applicable

Disposition is not equivalent to antimicrobial efficacy. Outcomes were influenced by underlying illness, referral, availability of facilities, and discharge against medical advice

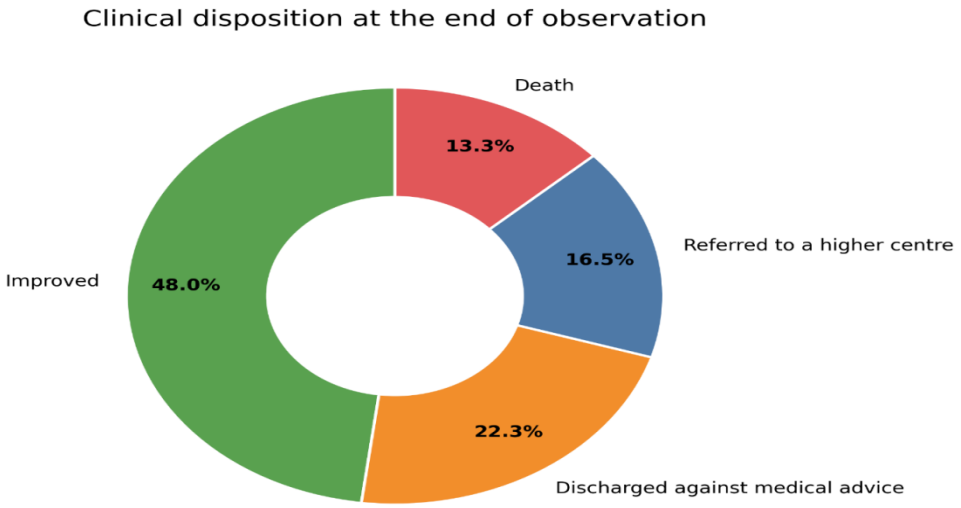

Figure 6: Clinical disposition at the end of observation. Almost two-fifths of the cohort had incomplete local follow-up because of referral or discharge against medical advice

Association analyses

Suspected adverse reactions were more frequent among patients prescribed five or more total drugs. Among patients receiving fewer than five drugs, 42 of 94 (44.7%) had a documented reaction, compared with 199 of 306 (65.0%) among those receiving five or more drugs. The association was statistically significant (χ^2=12.44, df=1, p<0.001). This finding supports medication review as an important safety component of rational ICU prescribing.

Clinical outcome did not differ significantly by sex (χ^2=2.30, df=3, p=0.513). The association between adverse-reaction status and outcome was also not statistically significant (χ^2=6.12, df=3, p=0.106). These analyses are summarised in Table 8.

Table 8: Inferential analyses of prescribing safety and clinical outcome

Comparison	Cell counts	Total	Pearson chi-square
Total drugs <5: No ADR / ADR	52 / 42	94	χ^2=12.44; df=1; p<0.001
Total drugs >=5: No ADR / ADR	107 / 199	306	
Sex versus outcome	Female 171; Male 229	400	χ^2=2.30; df=3; p=0.513
No ADR: Death / DAMA / referral / improved	15 / 33 / 33 / 78	159	χ^2=6.12; df=3; p=0.106
ADR present: Death / DAMA / referral / improved	38 / 56 / 33 / 114	241	

ADR, suspected adverse drug reaction; DAMA, discharged against medical advice. The ADR-present total was reconstructed as 241 from the component cells. Pearson chi-square tests were two-sided; p<0.05 was considered significant.

DISCUSSION

This prospective ICU drug-utilisation study identified a prescribing pattern characterised by extensive polypharmacy, near-universal intravenous antimicrobial use, dominance of broad-spectrum cephalosporins, and very limited documented de-escalation. Cefotaxime was used in more than two-thirds of patients, while metronidazole was the second most frequent agent. Although most patients received one antimicrobial, almost one-third received combinations. The majority of observed courses lasted seven days or less, but the short durations must be interpreted in the context of referral and discharge against medical advice. Suspected adverse reactions were common in the record and were significantly associated with the total number of drugs prescribed. These findings point to clear opportunities for rationalisation, but they do not establish the prevalence or microbiological pattern of antimicrobial resistance because culture and susceptibility data were not available.

Patients older than 50 years formed the largest age category. This is clinically plausible because ageing is accompanied by greater cardiovascular, respiratory, neurological, and metabolic vulnerability, as well as reduced physiological reserve. Cardiovascular disease was the most common reason for ICU admission, followed by trauma and poisoning. The admission profile shows that antimicrobial therapy was prescribed not only for established infection but also in clinical contexts where prophylaxis or concern for secondary infection may have influenced treatment. This distinction is important. Antimicrobial need in perforation, sepsis, or severe respiratory infection is different from routine prophylaxis after trauma, poisoning, stroke, or monitoring admissions. A rational-use programme should therefore require a clearly documented indication for every antimicrobial order.

The significant association between sex and admission category was mainly structural. Obstetric and gynaecological admissions occurred only among women, while trauma and snake bite were predominantly male. Sex itself was not associated with clinical outcome. The finding should therefore not be interpreted as a biological difference in antimicrobial response. It reflects the case mix of a tertiary centre serving medical, surgical, obstetric, and emergency populations.

More than three-quarters of patients received at least five drugs. Polypharmacy is expected in intensive care because organ support, analgesia, sedation, thromboprophylaxis, fluid and electrolyte correction, glycaemic control, and treatment of comorbid illness are often required simultaneously. Nevertheless, every additional medicine increases the possibility of drug-drug interactions, duplicated therapy, administration error, renal or hepatic accumulation, and difficulty attributing an adverse event to a specific agent. In the present dataset, suspected adverse reactions occurred in 65.0% of patients receiving five or more drugs compared with 44.7% among those receiving fewer medicines. The significant association does not prove causality, but it supports daily multidisciplinary medication review.

Antibiotic exposure itself is associated with gastrointestinal, dermatological, renal, neurological, haematological, and other adverse events. A hospital cohort reported that longer antibiotic exposure increased the risk of antibiotic-associated adverse drug events [14]. The present record showed nausea or vomiting, headache, diarrhoea, and altered taste as the most common reactions. Because the source files did not contain causality assessment, some events may have arisen from critical illness

or concomitant drugs. Future pharmacovigilance should use a standard causality tool, severity classification, preventability assessment, and details of management and outcome.

Cephalosporin predominance was the most striking prescribing feature. Cefotaxime alone was recorded in 69.0% of patients. Such heavy reliance on one broad-spectrum class may be understandable when rapid empirical coverage is required and microbiology support is delayed, but it can also produce strong ecological pressure. Third-generation cephalosporin exposure has implications for selection of extended-spectrum beta-lactamase-producing organisms and Clostridioides difficile. Stewardship programmes have been associated with reductions in resistant Gram-negative bacteria, methicillin-resistant Staphylococcus aureus, and C. difficile infection [11,15]. The local objective should not be to prohibit cephalosporins, but to reserve them for documented indications, align empirical choices with a current ICU antibiogram, and narrow treatment when culture results permit.

Metronidazole use in 29.0% suggests frequent empirical anaerobic coverage, particularly in abdominal, surgical, trauma, and obstetric settings. Combination treatment can be rational when polymicrobial infection is likely, but routine addition without a defined source may duplicate coverage or extend treatment unnecessarily. Piperacillin-tazobactam, amoxicillin-clavulanate, cefoperazone-sulbactam, aminoglycosides, and fluoroquinolones were also used. Each class carries distinct dose, toxicity, and resistance considerations. Renal function, body weight, infection site, organ support, and local susceptibility should guide dosing rather than fixed regimens alone.

Almost every patient received intravenous therapy. The intravenous route is often appropriate at the start of ICU treatment because of shock, altered gastrointestinal absorption, mechanical ventilation, reduced consciousness, and the need for reliable tissue exposure. However, continuing intravenous treatment after haemodynamic and gastrointestinal recovery exposes patients to line-related complications, nursing workload, and avoidable cost. Evidence syntheses identify intravenous-to-oral conversion as a stewardship objective associated with clinical and resource benefits [10]. A daily switch assessment should therefore be incorporated once the patient is stable, an active oral agent is available, and absorption is reliable.

Most observed courses lasted no more than seven days, and the median recorded duration was three days. A short course can be an indicator of rational use when it represents an intentional evidence-based stop decision. In this dataset, however, many one- to five-day observations were interrupted by referral or discharge against medical advice. Duration should therefore be interpreted as observed exposure rather than a completed course. Biomarker-guided discontinuation has reduced antibiotic exposure in critically ill patients without compromising safety in large randomised trials [18,19]. Biomarkers cannot replace clinical assessment or microbiology, but when available they can support a structured decision to stop therapy.

Only 0.8% of patients had documented de-escalation or oral switch, and 97.8% continued the initial regimen. This is the clearest stewardship gap in the study. An empirical regimen that is reasonable during the first hour of sepsis may become unnecessarily broad after 48 to 72 hours. At that point, the team should review cultures, susceptibility, imaging, source control, clinical response, organ function, and the probability of a non-infectious diagnosis. Observational evidence has associated de-escalation with lower mortality in severe sepsis and septic shock [16], while a randomised trial found that formal de-escalation was feasible but did not automatically shorten total exposure, highlighting the need for careful implementation [17].

The source records did not include culture positivity, organisms isolated, susceptibility patterns, time to culture collection, or the proportion of cultures obtained before antimicrobial administration. This limitation prevents assessment of concordance between empirical and definitive treatment. It also prevents construction of an ICU antibiogram, which is essential for rational empirical selection. Future audits should record the indication, infection source, culture timing, empirical regimen, microbiological result, definitive regimen, and reason for continuation or discontinuation. De-escalation should be documented as a clinical decision even when cultures are negative and treatment is stopped.

Improvement was documented in 48.0%, and mortality was 13.3%. These figures should not be interpreted as the efficacy or failure rate of antimicrobial therapy. Outcome in the ICU depends on illness severity, timeliness of source control, organ support, comorbidity, poisoning or trauma severity, referral decisions, and availability of higher-level services. Moreover, 38.8% of patients were referred or discharged against medical advice, so final outcomes were not available locally. The lack of APACHE II, SOFA, infection severity, and microbiological adequacy data also prevents adjusted outcome analysis.

The clinical imperative remains to avoid both undertreatment and overtreatment. Sepsis guidelines support prompt antimicrobials when infection is likely or septic shock is present, followed by daily assessment for de-escalation and appropriate duration [20]. For hospital-acquired and ventilator-associated pneumonia, guideline-based selection and seven-day treatment for many patients are recommended, with adaptation to clinical response and local susceptibility patterns [21]. These principles reconcile the need for early effective therapy with the need to limit unnecessary exposure.

The findings support a practical ICU stewardship programme centred on the prescribing event and a mandatory reassessment. At initiation, the prescriber should document the suspected source, severity, reason for empirical coverage, cultures obtained, planned duration, and dose adjustment. The antimicrobial order should carry a review or stop date. At 48 to 72 hours, a structured antibiotic timeout should classify the regimen as stop, continue unchanged with justification, narrow, broaden, change for toxicity, or convert from intravenous to oral therapy. The review should be visible in the case record and discussed during rounds.

A multidisciplinary stewardship team should include an intensivist, microbiologist, clinical pharmacologist or infectious-disease physician where available, pharmacist, infection-control nurse, and hospital administrator. The team should prepare an ICU-specific antibiogram at least annually, audit high-use agents such as cefotaxime, monitor days of therapy per 1,000 patient-days, review prolonged or duplicate anaerobic coverage, and provide feedback to prescribers. Education should be linked to actual local prescribing data rather than delivered as isolated lectures. The proposed cycle is summarised in Table 9 and Figure 7.

Table 9. Proposed ICU antimicrobial stewardship actions based on the observed prescribing pattern

Observed gap	Recommended action	Suggested audit indicator
High use of empirical broad-spectrum cephalosporins	Develop an annual ICU antibiogram; create syndrome-specific empirical guidance; require indication documentation	Cefotaxime days of therapy per 1,000 ICU patient-days; guideline concordance
Near-universal intravenous use	Daily assessment for intravenous-to-oral conversion after haemodynamic and gastrointestinal recovery	Eligible patients converted within 24 hours of meeting criteria
Initial regimen unchanged in 97.8%	Mandatory antibiotic timeout at 48-72 hours with stop, narrow, continue, broaden, or switch decision	Percentage with documented 48-72-hour review; de-escalation and discontinuation rates
Polypharmacy associated with suspected ADRs	Daily pharmacist-led medication reconciliation, renal-dose review, interaction screening, and therapeutic drug monitoring where appropriate	Potential interactions resolved; renal-dose concordance; confirmed ADR rate
Culture and susceptibility data absent from audit	Collect cultures before antibiotics when feasible and link microbiology to definitive therapy	Culture-before-antibiotic rate; time to effective therapy; culture-directed modification
Uncertain treatment completion after referral or DAMA	Document intended duration, stop date, referral regimen, and follow-up plan	Orders with stop/review date; complete antimicrobial handover rate
Limited outcome adjustment	Record SOFA/APACHE II, infection source, source control, and organ support	Risk-adjusted mortality, ICU length of stay, and antimicrobial-free days

These are evidence-informed recommendations generated from the observed prescribing gaps. They were not tested as an intervention in the present observational study. DAMA, discharge against medical advice

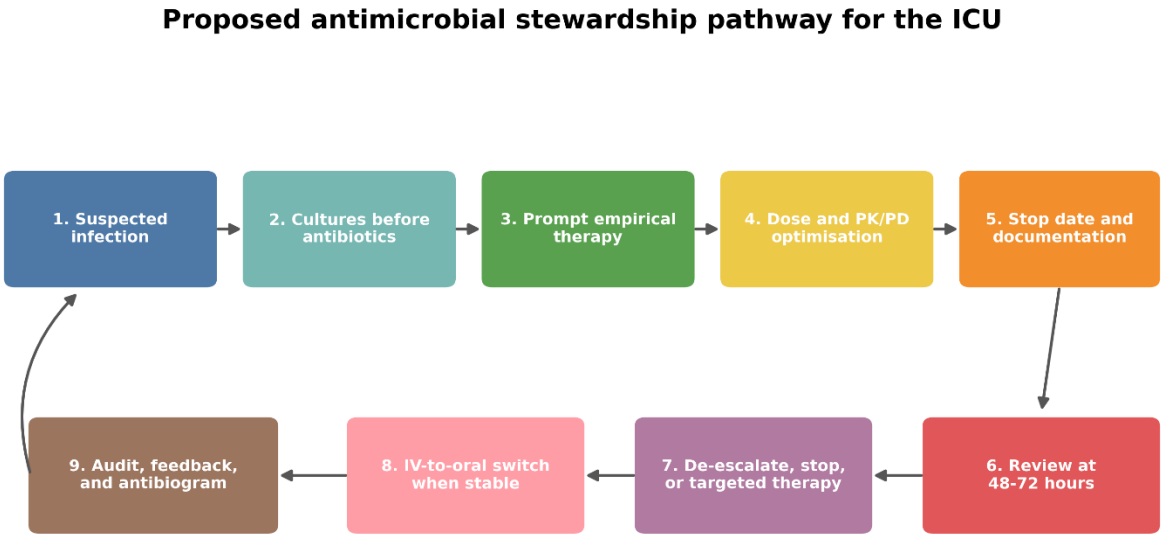

Figure 7: Proposed antimicrobial stewardship pathway for the ICU. The cycle preserves prompt empirical treatment while creating explicit checkpoints for microbiology, dose optimisation, de-escalation, route conversion, and audit.

The study included a relatively large consecutive cohort of 400 adult ICU patients and captured routine prescribing across diverse medical, surgical, trauma, toxicology, respiratory, cardiovascular, and obstetric presentations. It described the complete medication burden, antimicrobial route, duration, individual agents, treatment modification, suspected adverse reactions, and disposition. The significant association between polypharmacy and documented adverse reactions provides a clinically relevant safety signal. The manuscript also transparently reconciles arithmetic inconsistencies in the source tables instead of silently reproducing them.

The study was conducted at a single centre and used purposive consecutive sampling. The source files did not include culture and susceptibility results, organism distribution, infection source confirmation, timing of antimicrobial administration, surgical prophylaxis duration, defined daily doses, days of therapy, cost, generic-prescribing indicators, or adherence to a local guideline. The study therefore cannot directly quantify antimicrobial resistance or determine the appropriateness of each individual prescription.

Severity scores, renal and hepatic function at the time of dosing, mechanical ventilation, invasive-device exposure, source-control procedures, ICU length of stay, and adjusted mortality predictors were not available. Suspected adverse reactions were not assessed with a formal causality or severity scale. Many patients were referred or discharged against medical advice, which limited outcome ascertainment. Finally, the study was observational and did not include a pre-post stewardship intervention, so the proposed promotion strategy requires prospective implementation and evaluation.

CONCLUSION

Antimicrobial prescribing in the ICUs of BRIMS Teaching Hospital was characterised by a high overall drug burden, extensive use of intravenous therapy, marked reliance on cefotaxime, and minimal documented de-escalation. Most patients received one antimicrobial and had an observed treatment duration of seven days or less, but interruption by referral or discharge against medical advice limited assessment of completed courses. Suspected adverse reactions were common and were significantly associated with prescription of five or more total drugs. The data support introduction of a structured ICU antimicrobial stewardship programme built around clear indications, cultures before treatment when feasible, local antibiogram-guided empirical choices, dose optimisation, a mandatory 48-72-hour review, early intravenous-to-oral conversion, documented stop dates, pharmacovigilance, and regular audit with feedback. Because resistance and microbiological adequacy were not measured in the available dataset, future evaluation should link antimicrobial use to culture results, days of therapy, resistance trends, clinical severity, and risk-adjusted outcomes.

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