Original Article

Antimicrobial Utilisation Patterns, WHO Aware Classification, and Resistance Profiles in A Tertiary Care Critical Care Unit: A Prospective Observational Study

Mohammed Fareedullah[1]*, Mohammed Haseeb Ahmed[2], Shanmuka Nagaraju Panga[3], Md Atiqh ur Rahman[1], Asra[1], Hasnat Fatima[1], Zunera Fatima[1]
[1]Department of Pharmacy Practice, Deccan School of Pharmacy, Hyderabad, Telangana, India.
[2]Department of Pharmacology, Deccan College of Medical Sciences, Hyderabad, Telangana, India.
[3]Critical Care Unit, Owaisi Hospital and Research Centre, Hyderabad, Telangana, India.
***Corresponding author's E-mail:** fareedullah29@gmail.com

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ABSTRACT

Background: Antimicrobial resistance (AMR) constitutes a critical patient safety threat in intensive care settings, where the convergence of severely ill patients, invasive devices, and extensive broad-spectrum antibiotic use creates conditions that selectively favour resistant pathogens. Systematic evaluation of prescribing patterns, resistance profiles, and alignment with stewardship frameworks is essential to guide rational antimicrobial use.

Methods: A prospective observational study was conducted among 100 CCU patients receiving antimicrobial therapy between February and May 2023. Demographic, microbiological, prescribing, AWaRe classification, therapy modification, and outcome data were collected and analysed descriptively.

Results: The mean patient age was 55.5 years; males comprised 54% of the cohort. Urinary tract infections (24%) and sepsis (22%) were the most common primary diagnoses. Diabetes mellitus (49%) and hypertension (47%) were the predominant comorbidities. Gram-negative organisms accounted for 79.1% of isolates, with Escherichia coli predominating. Among 216 antimicrobial prescriptions, Watch-category antibiotics constituted the majority. Piperacillin–tazobactam (14.9%) and ceftriaxone (11.6%) were most frequently prescribed. Meropenem demonstrated the highest sensitivity (71.4%), while ampicillin showed the greatest resistance (18.1%). Guideline concordance was achieved in 90% of cases, although de-escalation occurred in only 11%. The in-hospital mortality rate was 8%.

Conclusions: Gram-negative pathogens predominated in the CCU. Extensive Watch-category antibiotic use, low de-escalation rates, and increasing resistance to beta-lactams and cephalosporins highlight the need for strengthened antimicrobial stewardship, institutional antibiograms, and culture-guided prescribing.

Keywords: antimicrobial resistance; critical care unit; antibiotic utilisation; WHO AWaRe classification; culture and sensitivity; antimicrobial stewardship; de-escalation.

INTRODUCTION

Antimicrobial resistance (AMR) has emerged as one of the foremost threats to global public health in the 21st century. The World Health Organization (WHO) has designated AMR a challenge that now undermines decades of progress in infectious disease management, contributing to prolonged hospitalisation, escalating healthcare costs, therapeutic failure, and rising mortality [1]. A landmark global analysis published in The Lancet estimated that bacterial AMR was directly responsible for 1.27 million deaths in 2019, with the greatest burden concentrated in low- and middle-income countries (LMICs)[2]. Without effective action, projections warn of catastrophic consequences for global health security in the coming decades.

Critical care units (CCUs) are well-recognised hotspots for the emergence and horizontal dissemination of multidrug-resistant (MDR) organisms. The convergence of severe underlying illness, frequent invasive procedures, prolonged hospitalisation, and intensive exposure to broad-spectrum antimicrobials creates a microbiological environment that powerfully selects for resistance [3]. Global surveillance data consistently demonstrate that resistance rates in intensive care settings substantially exceed those recorded in general wards [4]. Critically ill patients frequently present with life-threatening infections caused by organisms already resistant to first- and second-line agents, narrowing therapeutic options and worsening outcomes.

The AMR burden is particularly pronounced in India, where high infectious disease prevalence, deeply entrenched empirical prescribing practices, limited antimicrobial stewardship infrastructure, and unrestricted over-the-counter antibiotic availability collectively accelerate resistance trajectories [5]. WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) data document increasing resistance among key gram-negative pathogens notably Escherichia coli, Klebsiella pneumoniae, and Acinetobacter baumannii all of which are frequently implicated in ventilator-associated pneumonia, bloodstream infections, urinary tract infections, and sepsis in critical care settings [6,7]. The prevalence of extended-spectrum beta-lactamase (ESBL)- producing Enterobacteriaceae in Indian hospitals further constrains empirical prescribing options and underscores the need for local resistance data to guide therapy.

Inappropriate prescribing remains a principal driver of resistance. Common patterns of misuse include empirical therapy initiated without microbiological guidance, unjustified combination regimens, suboptimal dosing, unnecessarily prolonged treatment courses, and failure to de-escalate therapy once culture and sensitivity data become available [8]. The US Centers for Disease Control and Prevention (CDC) estimates that approximately 30% of antibiotic prescriptions in acute care hospitals are either unnecessary or suboptimal [9], underscoring the urgency of structured stewardship interventions that systematically optimise antimicrobial selection, dosing, route, and duration [10]. The WHO AWaRe (Access, Watch, Reserve) classification system, introduced in 2017 and updated in 2021, provides a globally applicable framework for evaluating prescribing appropriateness, prioritising Access-category agents for common infections while restricting Watch- and Reserve-category agents to situations where they are truly warranted.

Drug utilisation studies are a cornerstone of effective stewardship. By characterising prescribing trends, assessing guideline adherence, evaluating concordance with microbiological findings, classifying antibiotic consumption within frameworks such as WHO AWaRe, and identifying targets for corrective action, such studies generate the institutional evidence base required to implement and refine stewardship strategies [11]. Institution-specific antibiogram data are equally indispensable for guiding empirical therapy, as resistance profiles vary considerably across geographic regions and individual facilities [12,13]. In the absence of continuous surveillance, empirical prescribing risks becoming progressively ineffective, perpetuating resistance cycles that are difficult to reverse.

Despite growing recognition of AMR as a global crisis, institution-specific data on antimicrobial prescribing, WHO AWaRe distribution, and resistance profiles in Indian tertiary care CCUs remain sparse. Many centres lack systematic documentation of antibiotic consumption, de-escalation practices, and guideline adherence, limiting the capacity to design and implement targeted stewardship measures. The present study was therefore conducted to characterise antimicrobial utilisation patterns including WHO AWaRe classification of prescribed agents evaluate bacterial resistance and sensitivity profiles, and assess guideline adherence in the CCU of a tertiary care teaching hospital. By generating local epidemiological and prescribing data, this study aims to inform the optimisation of empirical antimicrobial therapy and strengthen institutional antimicrobial stewardship strategies.

MATERIALS AND METHODS

Study design and setting

This was a prospective observational study conducted in the Critical Care Unit of Owaisi Hospital and Research Centre, a tertiary care teaching hospital in Hyderabad, Telangana, India. Data were collected prospectively over four months from February to May 2023. The CCU is a multidisciplinary unit providing advanced monitoring and intensive therapeutic intervention to critically ill patients requiring organ support or continuous clinical surveillance.

Ethical approval

The study protocol was reviewed and approved by the Institutional Ethics Committee of Deccan School of Pharmacy (Approval No: [APPROVAL NO.]). The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. As this was a non-interventional observational study, patient management was not influenced in any way. All patient data were anonymised throughout data collection and analysis to ensure confidentiality.

Study population

One hundred patients admitted to the CCU during the study period were enrolled on the basis of predefined eligibility criteria. Patients were included if they: (i) were admitted to the CCU during the study period; (ii) received at least one antimicrobial agent; and (iii) underwent microbiological culture and sensitivity testing. Patients were excluded if they were discharged within 24 hours of admission, had incomplete medical records, or did not receive antimicrobial therapy during the observation period.

Data collection

Data were collected prospectively from patient medical records, laboratory reports, and medication charts using a pre-validated, structured data collection instrument. The following information was systematically documented: demographic characteristics (age, sex); primary diagnosis and comorbid conditions; CCU length of stay; type and source of clinical specimens submitted for microbiological analysis; identified microorganisms and corresponding antimicrobial susceptibility patterns; details of antimicrobial therapy (agent name, pharmacological class, dose, frequency, route, and duration); modifications to therapy (dose adjustment, de-escalation, drug withdrawal, or continuation); and clinical outcomes at discharge (discharged, recovered, left against medical advice [LAMA], or death).

All microbiological investigations were performed in the hospital's central microbiology laboratory using standardised procedures. Antimicrobial susceptibility testing was conducted in accordance with the Clinical and Laboratory Standards Institute (CLSI) guidelines, with interpretation of sensitive, intermediate, and resistant categories based on current CLSI breakpoints.

WHO AWaRe classification

Each antimicrobial agent prescribed during the study period was classified according to the WHO AWaRe (Access, Watch, Reserve) framework based on the 2021 WHO AWaRe classification list. Access-category antibiotics are those recommended as first- and second-choice treatments for common infections and associated with a lower resistance risk. Watch-category antibiotics have higher

resistance potential and are recommended for a more limited range of indications. Reserve-category antibiotics are last-resort agents to be used only when all other options have failed. This classification was applied retrospectively to the complete prescribing dataset to characterise the stewardship burden of antimicrobial use in the CCU.

Definitions and outcome measures

The primary outcomes assessed were: the pattern and volume of antimicrobial utilisation; WHO AWaRe category distribution of prescribed agents; the prevalence and distribution of gram-positive and gram-negative isolates; antibiotic sensitivity and resistance profiles; the average number of antimicrobial agents prescribed per patient; concordance of antimicrobial therapy with standard treatment guidelines; and clinical outcomes at end of hospitalisation.

Guideline concordance was defined as use of antimicrobial therapy consistent with both culture and sensitivity findings and established institutional or national treatment guidelines. De-escalation was defined as narrowing of the antimicrobial spectrum or discontinuation of broad-spectrum therapy on the basis of microbiological culture results and evidence of clinical improvement.

Statistical analysis

Data were analysed using descriptive statistics and expressed as frequencies and percentages for categorical variables. Continuous variables are presented as means with standard deviations (SD) where available. Given the observational and descriptive nature of the study, no inferential statistical analysis or hypothesis testing was performed.

RESULTS

Patient demographics and baseline characteristics

One hundred patients admitted to the CCU and receiving antimicrobial therapy were enrolled. The mean age was 55.5 ± years, with the 51–60 year age group comprising the largest proportion of patients (25%), reflecting the predominance of middle-aged and older adults who typically carry the highest burden of infection-associated critical illness. Males constituted a slight majority (54% vs. 46% female), consistent with reported sex-based differences in CCU admission rates across South Asian populations.

Urinary tract infection was the most common primary diagnosis (24%), followed by sepsis (22%) and sepsis with septic shock (18%). The high combined prevalence of sepsis and septic shock (40%) underscores the severity of illness in this cohort and is clinically significant given the association between sepsis and broad-spectrum antimicrobial use. Notably, urinary tract infection as the leading diagnosis is an epidemiologically distinctive finding, differing from the respiratory-infection predominance reported in many international ICU surveillance studies and likely reflecting regional referral patterns and demographics.

Diabetes mellitus (49%) and hypertension (47%) were the most prevalent comorbid conditions, both of which are well-established risk factors for infectious complications and impaired immune response, potentially contributing to the observed severity of presentation and duration of CCU stay. The majority of patients (60%) had a CCU stay of 5–8 days, with a mean of 6.5 ± days. Full baseline characteristics are presented in Table 1.

Table 1: Baseline demographic and clinical characteristics of study participants (n = 100)

Characteristic	Category	n (%)
Age group (years)	≤30	13 (13%)
	31–40	18 (18%)
	41–50	20 (20%)
	51–60	25 (25%)
	>60	24 (24%)
Sex	Male	54 (54%)
	Female	46 (46%)
Primary diagnosis	Urinary tract infection	24 (24%)
	Sepsis	22 (22%)
	Sepsis with septic shock	18 (18%)
	Respiratory illness	10 (10%)
	Encephalopathy	9 (9%)
	Renal disease	7 (7%)
	Diabetic foot	4 (4%)
	Gastritis	3 (3%)
	Coronary artery disease	2 (2%)
	Cerebrovascular accident	1 (1%)
Comorbid conditions	Diabetes mellitus	49 (49%)
	Hypertension	47 (47%)
	Renal disease	13 (13%)
	Cardiovascular illness	7 (7%)
	Epilepsy	6 (6%)
	Hypothyroidism	6 (6%)
	Parkinson's disease	3 (3%)
	Benign prostatic hyperplasia	2 (2%)
	Ischaemic stroke	2 (2%)
	Other	11 (11%)
CCU length of stay (days)	1–4	22 (22%)
	5–8	60 (60%)
	9–12	14 (14%)
	13–16	3 (3%)
	17–20	1 (1%)

Microbiological profile

All 100 patients underwent microbiological culture and sensitivity testing prior to initiation of antimicrobial therapy, yielding a total of 105 isolates — indicating polymicrobial infection in a subset of patients. The microbiological distribution was markedly skewed towards

gram-negative organisms, which accounted for 79.1% (n = 83) of all isolates, while gram-positive organisms comprised the remaining 20.9% (n = 22). This near four-to-one gram-negative predominance is consistent with the ecological pressure of broad-spectrum antibiotic use, widespread device use, and prolonged hospitalisation characteristic of CCU environments[17].

Escherichia coli was the most frequently isolated pathogen, followed by *Klebsiella* species. This gram-negative preponderance, with *E. coli* and *Klebsiella* as leading pathogens, is consistent with the ESBL-producing phenotypes that are disproportionately represented in Indian hospital microbiomes [20]. *Enterobacter* species demonstrated the highest overall resistance profile among gram-negative isolates, followed by *Citrobacter* and *Klebsiella* species, a finding that reflects the intrinsic and acquired beta-lactamase repertoire of these genera. *Proteus* species and *Micrococcus* species were least commonly isolated.

Urine was the most common specimen source (45.53%), a finding commensurate with the high prevalence of urinary tract infections in the cohort. Blood cultures accounted for 14.28% of specimens, consistent with the substantial burden of sepsis and bacteraemia.

Figure 1. Distribution of Microbiological Isolates by Organism

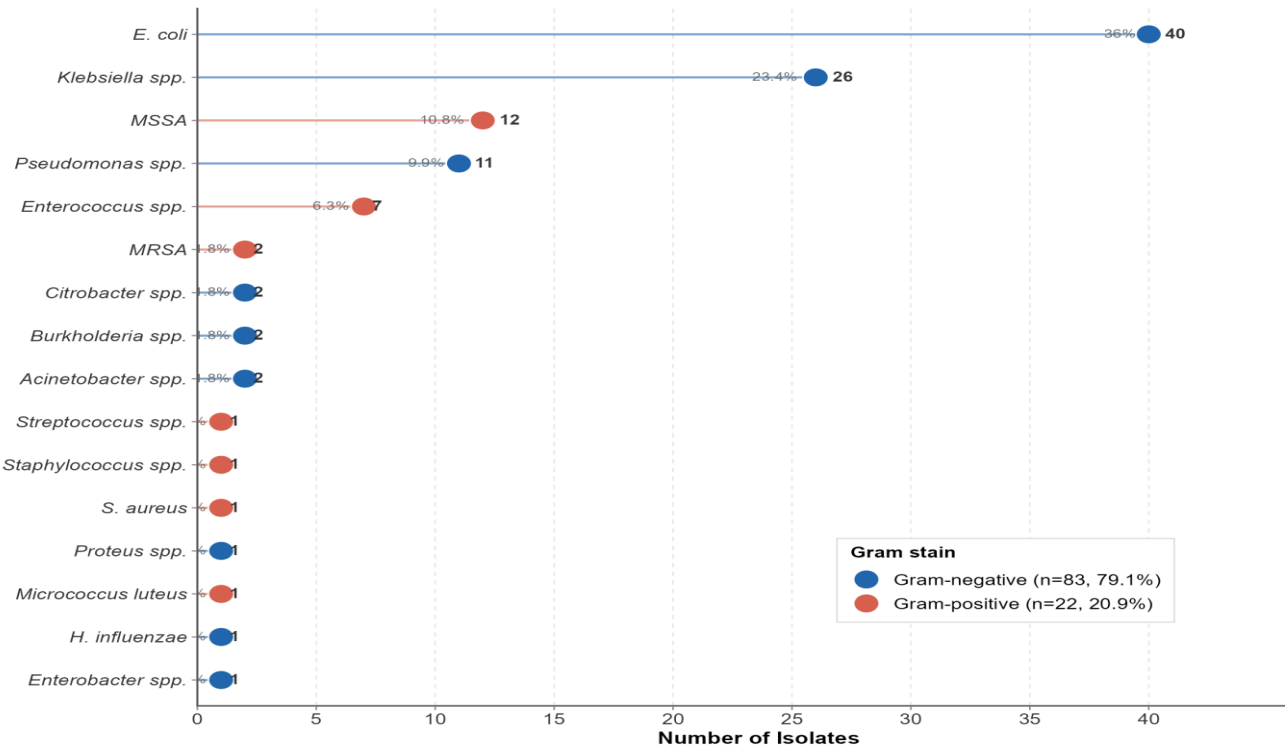
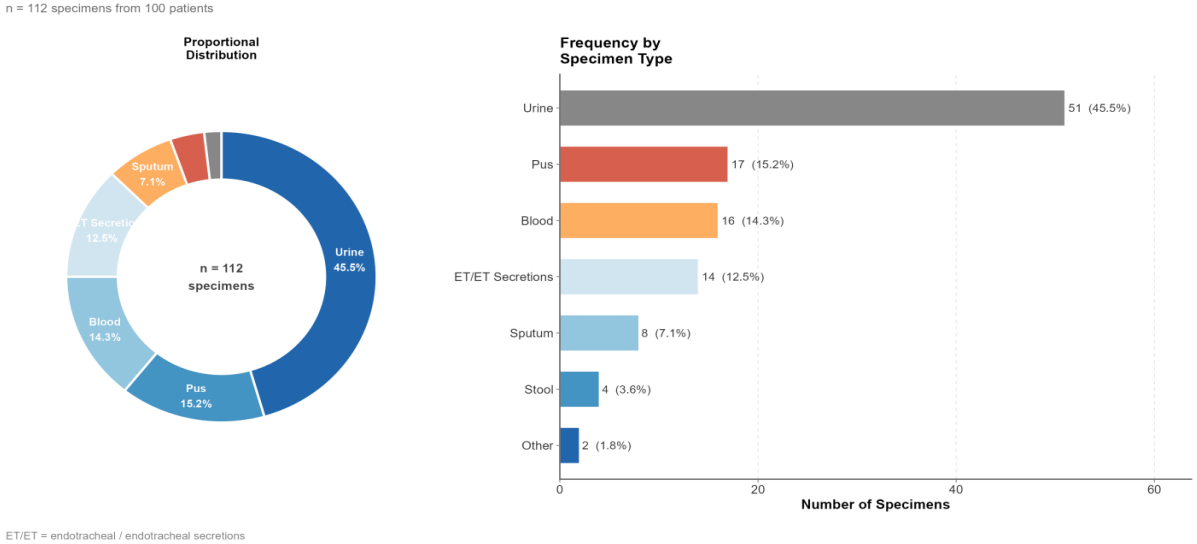


Figure 2. Distribution of Clinical Specimen Sources for Microbiological Culture



Antimicrobial utilisation and WHO AWaRe classification

A total of 216 antimicrobial agents were prescribed across the 100 study patients, yielding a mean of 3.56 ± [SD] agents per patient. This level of polypharmacy reflects the clinical complexity inherent to critical care: 76% of patients received one to four agents, 22% received five to eight, and 2% received nine to twelve. The parenteral route accounted for 74.7% of administrations, consistent with the severity of illness and the requirement for reliable drug exposure in haemodynamically unstable patients.

Application of the WHO AWaRe classification revealed that Watch-category antibiotics constituted the largest proportion of prescribed agents, a finding with significant stewardship implications. Piperacillin–tazobactam was the most frequently prescribed agent overall (14.9%), followed by clindamycin (12.6%), meropenem (12.2%), and ceftriaxone (11.6%). Beta-lactam antibiotics as a class accounted for 23.43% of all prescriptions. The predominance of Watch-category agents — rather than the Access-category antibiotics recommended by the WHO for most common infections — indicates a prescribing pattern weighted towards broader-spectrum therapy than may be strictly necessary in all cases, and is a priority target for stewardship optimisation[30]. The WHO AWaRe classification of key prescribed antimicrobials is detailed in Table 2.

Table 2: WHO AWaRe classification of prescribed antimicrobial agents and stewardship comments

Antimicrobial Agent	Class	WHO AWaRe	Prescribing Comment
Piperacillin–tazobactam	Beta-lactam	Watch	Most frequently prescribed agent (14.9%); Watch-category use warrants ongoing stewardship review
Ceftriaxone	Cephalosporin	Watch	Second most prescribed (11.6%); rising resistance (17.1%) limits empirical utility
Meropenem	Carbapenem	Watch	High utilisation (12.2%) despite Reserve-adjacent status; preserving activity is a stewardship priority
Clindamycin	Lincosamide	Watch	Commonly prescribed (12.6%); requires justification in gram-negative predominant settings
Amikacin	Aminoglycoside	Watch	Appropriate for MDR gram-negative cover; monitor nephrotoxicity
Gentamicin	Aminoglycoside	Watch	Moderate sensitivity (45.7%); therapeutic drug monitoring advised
Amoxicillin–clavulanate	Beta-lactam	Access	Access-category; moderate resistance (14.3%) may reflect community-acquired resistance carryover
Ciprofloxacin	Fluoroquinolone	Watch	Variable sensitivity (32.4%); restrict empirical use given resistance trends
Ampicillin	Beta-lactam	Access	Highest resistance rate (18.1%); empirical use in CCU not recommended
Cotrimoxazole	Sulfonamide	Access	Limited empirical utility (26.7% sensitivity); reserve for culture-directed therapy

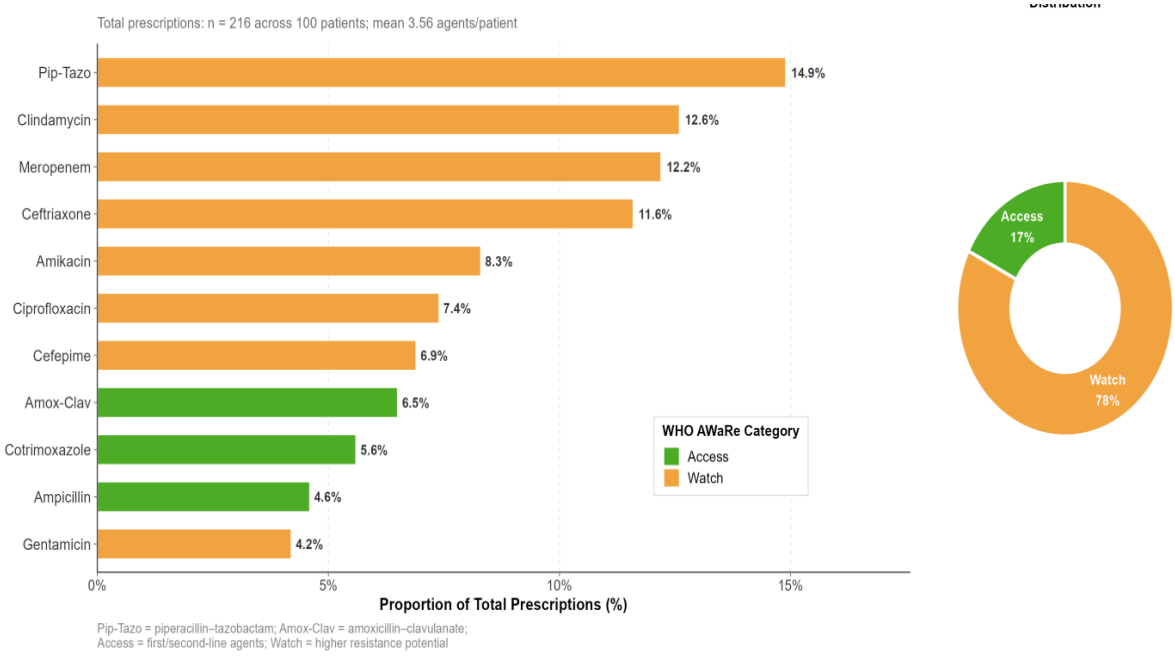


Figure 3: WHO AWaRe Classification of Prescribed Antimicrobial Agents

Antimicrobial sensitivity and resistance profiles

Among antimicrobial agents tested against the 105 clinical isolates, meropenem demonstrated the highest susceptibility rate (75 isolates; 71.4%), affirming preserved carbapenem activity against the predominantly gram-negative microbiological landscape. However, the high utilisation rate of meropenem (12.2% of all prescriptions) in the context of its Watch-category status warrants careful stewardship scrutiny, as indiscriminate carbapenem use risks accelerating the emergence of carbapenem-resistant Enterobacteriaceae (CRE), currently among the most clinically feared resistance phenotypes globally[19].

Resistance patterns were most pronounced for ampicillin (18.1%), ceftriaxone (17.1%), and cefepime (16.2%), with the latter two findings particularly suggestive of ESBL-producing phenotypes among gram-negative isolates. ESBL production renders third-generation and fourth-generation cephalosporins clinically unreliable despite in vitro intermediate susceptibility in some isolates, and likely explains the reduced sensitivity observed for piperacillin–tazobactam in ESBL-producing strains[20]. Resistance to cotrimoxazole (15.2%) and amoxicillin–clavulanate (14.3%) further limits oral step-down and outpatient treatment options. Gram-negative organisms demonstrated uniformly higher resistance rates compared to gram-positive isolates across all tested agents, a pattern reflective of the broader epidemiological context of gram-negative AMR in South Asian tertiary care hospitals. Detailed sensitivity and resistance data are presented in Table 3.

Table 3: Antimicrobial sensitivity and resistance profiles of clinical isolates (n = 105)

Antimicrobial Agent	Sensitive, n (%)	Resistant, n (%)	Clinical Interpretation
Meropenem	75 (71.4%)	8 (7.6%)	Highest sensitivity; preserved activity against MDR gram-negatives; rising use risks CRE emergence
Piperacillin–tazobactam	58 (55.2%)	14 (13.3%)	Moderate-to-high sensitivity; ESBL-producing isolates may show in vitro susceptibility but clinical failures reported
Amikacin	52 (49.5%)	12 (11.4%)	Effective aminoglycoside; preferred over gentamicin based on susceptibility data
Gentamicin	48 (45.7%)	11 (10.5%)	Moderate sensitivity; second-line aminoglycoside option
Amoxicillin–clavulanate	42 (40.0%)	15 (14.3%)	Moderate resistance; suitable for culture-directed use in susceptible isolates
Ceftriaxone	36 (34.3%)	18 (17.1%)	Rising resistance trend likely reflecting ESBL prevalence; caution in empirical use
Ciprofloxacin	34 (32.4%)	13 (12.4%)	Variable sensitivity; restrict empirical fluoroquinolone use in CCU
Cefepime	30 (28.6%)	17 (16.2%)	Reduced effectiveness; cephalosporin resistance consistent with ESBL/AmpC phenotypes
Cotrimoxazole	28 (26.7%)	16 (15.2%)	Limited utility; reserve for culture-confirmed susceptibility
Ampicillin	10 (9.5%)	19 (18.1%)	Highest resistance rate; beta-lactamase production likely; empirical CCU use not recommended

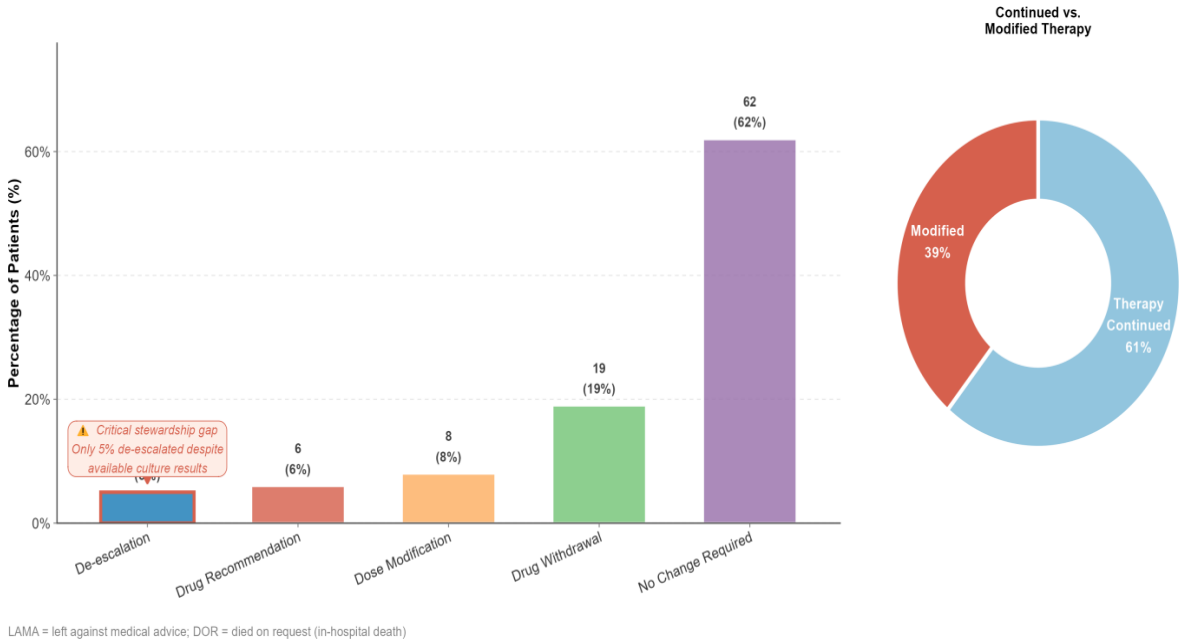


Figure 4: Distribution of Antimicrobial Therapy Modifications Following Culture Results

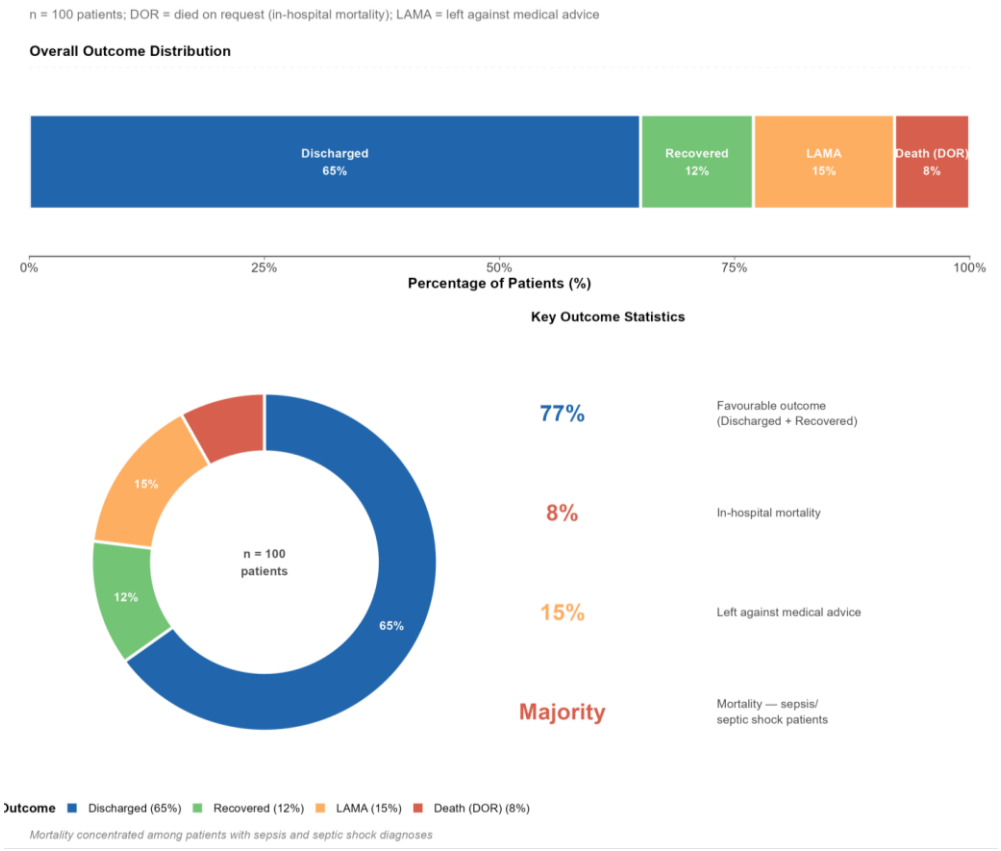


Figure 5: Distribution of Clinical Outcomes at Hospital Discharge

Modification of antimicrobial therapy

Following receipt of culture and sensitivity results, antimicrobial therapy was modified in 38% of patients. The most common modification was withdrawal of an agent (19%), followed by de-escalation to a narrower-spectrum antibiotic (11%), and dose adjustment (8%). In the remaining 62% of patients, empirical therapy was continued without modification on the grounds of microbiological concordance and clinical improvement. The overall de-escalation rate of 11% is notably low relative to the proportion of patients with available microbiological data, suggesting a substantial missed opportunity for antimicrobial stewardship — a finding that is critically examined in the Discussion.

Clinical outcomes

At the conclusion of the study period, 65% of patients were discharged following clinical improvement, and a further 12% demonstrated recovery during the observation period, yielding a combined favourable outcome rate of 77%. Fifteen percent of patients left against medical advice (LAMA), a finding that may reflect socioeconomic factors, perceived clinical improvement, or care-related concerns, and which warrants further institutional attention. The in-hospital mortality rate was 8%, with fatal outcomes concentrated among patients presenting with sepsis or septic shock — diagnoses associated with the highest severity scores and most complex antimicrobial management requirements in this cohort.

DISCUSSION

This prospective study characterises antimicrobial utilisation patterns, WHO AWaRe prescribing distribution, and resistance profiles in a tertiary care CCU in Hyderabad, India. The findings reveal a microbiological landscape dominated by gram-negative pathogens, a prescribing pattern weighted heavily towards Watch-category agents, meaningful resistance to beta-lactams and third-generation cephalosporins, and a strikingly low formal de-escalation rate — each representing a distinct and actionable target for antimicrobial stewardship intervention.

The near four-to-one preponderance of gram-negative isolates (79.1%) is consistent with international ICU surveillance data. The landmark EPIC II study, which enrolled over 14,000 patients across 1,265 ICUs in 75 countries, reported a comparable dominance of gram-negative organisms in ICU infections globally, with E. coli, Klebsiella species, and Pseudomonas aeruginosa as the most frequently identified pathogens [14]. In the Indian context, comparable gram-negative predominance has been documented in CCU-based studies from multiple tertiary centres, with E. coli and Klebsiella species consistently identified as the leading isolates [15,16]. The selective pressure exerted by broad-spectrum antibiotics — particularly the Watch-category agents that dominated prescribing in our cohort — combined with structural risk factors inherent to critical care (mechanical ventilation, central venous and urinary catheterisation, and prolonged

hospitalisation) plausibly drives this gram-negative microbiological predominance [17].

The WHO AWaRe analysis adds an important and previously underreported dimension to the prescribing profile of this CCU. The predominance of Watch-category prescriptions — including piperacillin–tazobactam, ceftriaxone, meropenem, and clindamycin as the four most commonly prescribed agents — reveals a systemic tendency towards broader-spectrum empirical coverage than guidelines advocate for most common infections. The WHO's target is for at least 60% of antibiotic consumption to consist of Access-category agents at national and institutional level. The prescribing pattern observed in this study falls considerably short of that benchmark, driven by the clinical complexity of critical care patients but also, potentially, by prescriber habit and the absence of structured stewardship protocols. This AWaRe lens provides a new framework through which stewardship teams at this institution can benchmark and monitor progress over time.

Meropenem retained the highest susceptibility rate in our cohort (71.4%), affirming its activity against MDR gram-negative organisms and consistent with findings by Girish et al. in comparable Indian ICU populations [18]. However, this observation demands careful contextualisation: carbapenem use accounted for 12.2% of all prescriptions, a proportion that warrants close monitoring given the global escalation of carbapenem-resistant Enterobacteriaceae (CRE). The WHO has listed CRE as a critical-priority pathogen requiring urgent research and new therapeutic development [19]. Furthermore, carbapenems occupy a borderline position within the AWaRe framework — classified as Watch agents — yet are functionally equivalent to Reserve agents in clinical practice at many institutions, given the absence of reliable alternatives for CRE infections. Any further erosion of carbapenem susceptibility in this CCU would have immediate and severe consequences for the management of critically ill patients.

The elevated resistance rates for ampicillin (18.1%) and third-generation cephalosporins — ceftriaxone (17.1%) and cefepime (16.2%) — are strongly suggestive of ESBL production among gram-negative isolates, an increasingly prevalent phenotype in Indian hospital settings [20]. The clinical significance of this finding is compounded by the fact that ceftriaxone and piperacillin–tazobactam were simultaneously the most commonly prescribed agents: prescribing empirically with agents to which nearly one-fifth of isolates are resistant implies an unacceptably high probability of inappropriate initial therapy. Several Indian CCU studies have reported similar cephalosporin resistance rates, with ESBL prevalence in E. coli and Klebsiella isolates ranging from 40% to over 70% in tertiary care settings [15,20]. These data collectively argue against empirical cephalosporin use in this CCU without microbiological confirmation of susceptibility.

The average prescription of 3.56 antimicrobial agents per patient represents a level of antibiotic polypharmacy that is both clinically understandable and epidemiologically concerning. This figure falls within the 2.5 to 4 agents per patient range documented in comparable Indian and international ICU drug utilisation studies [21,22]. While combination therapy is clinically justified in septic shock, suspected polymicrobial infection, or empirical coverage pending culture results, it concurrently increases the risks of nephrotoxicity, hepatotoxicity, Clostridioides difficile superinfection, and resistance selection. The 90% guideline concordance rate observed in this cohort is commendable and compares favourably with inappropriate antibiotic use rates of 30–50% reported in some ICU settings [23], suggesting a relatively strong baseline standard of empirical prescribing. However, guideline concordance alone does not capture the full stewardship picture — particularly given the de-escalation findings discussed below.

The de-escalation rate of 11% represents perhaps the most critical finding of this study from a stewardship perspective. Antibiotic de-escalation — defined as narrowing of antimicrobial spectrum or discontinuation of broad-spectrum therapy on the basis of culture and sensitivity results — is a cornerstone of effective antimicrobial stewardship, and is endorsed by the IDSA/SHEA guidelines as a core programme element. Multiple randomised and cohort studies have demonstrated that de-escalation reduces antibiotic exposure, lowers selective pressure for resistance, and does not adversely affect mortality in appropriately selected patients [24]. Yet in this cohort, despite 38% of patients having therapy modified post-culture, only 11% underwent formal de-escalation — meaning the majority of modifications involved dose adjustment or antibiotic withdrawal rather than spectrum narrowing. Garnacho-Montero et al. demonstrated that de-escalation in severe sepsis is independently associated with reduced 28-day mortality [25], making the low de-escalation rate in our study not merely a stewardship concern but a potential patient safety issue. The barriers to de-escalation — clinician inertia, therapeutic uncertainty in haemodynamically unstable patients, and the absence of structured antibiotic review rounds — must be directly addressed through institutional stewardship programmes.

The in-hospital mortality rate of 8% was notably lower than the 15–30% rates commonly reported in ICU cohorts with predominantly infectious diagnoses [26]. This difference may reflect favourable case-mix characteristics, the relatively high guideline concordance observed, or selection bias inherent to the 15% LAMA rate — patients who left against medical advice may have included individuals with poor prognosis whose outcomes are not captured in the institutional mortality figure. Mortality was concentrated among patients with sepsis and septic shock, consistent with global data demonstrating that delayed appropriate antimicrobial therapy and MDR infections are independent predictors of mortality in septic patients [27]. The importance of rapid, appropriate empirical therapy in sepsis — ideally guided by a regularly updated institutional antibiogram — cannot be overstated.

The predominance of urinary tract infections as the primary diagnosis in our cohort diverges from the respiratory-infection predominance reported in international CCU surveillance studies likely reflecting regional epidemiological trends, patient demographics, and the referral profile of this institution. This divergence has direct practical implications: it means that antibiogram-guided empirical therapy for urinary pathogens — particularly E. coli — should be a focal priority for stewardship at this hospital, and that blanket application of international or national empirical guidelines may not optimally serve this patient population.

From a stewardship intervention standpoint, the composite picture emerging from this study — Watch-category antibiotic dominance, low de-escalation, ESBL-associated resistance, and carbapenem dependency — points to several specific, actionable priorities. First, implementing prospective audit and feedback, in which pharmacist or stewardship physician review of antibiotic prescriptions triggers culture-guided de-escalation, has the strongest evidence base for improving de-escalation rates in ICU settings [28]. Second, developing and regularly updating an institution-specific antibiogram for this CCU, stratified by specimen source and organism, would provide prescribers with locally validated guidance for empirical therapy — reducing both inappropriate cephalosporin use and unnecessary carbapenem initiation. Third, adopting AWaRe monitoring as a standard institutional metric would enable the hospital to track its prescribing profile against the WHO 60% Access target and incentivise progressive improvement. Fourth, structured antimicrobial time-outs at 48–72 hours, aligned with culture result availability, could systematically close the gap between the 38% modification rate and the 11% de-escalation rate [29,30].

Several limitations of this study warrant acknowledgement. The single-centre design limits the generalisability of findings to other institutions, patient populations, and geographic settings. The four-month observation period may not capture seasonal variation in infection patterns or resistance trends. The sample size of 100 patients, while appropriate for a descriptive study, precludes inferential statistical analysis of associations between prescribing patterns, resistance profiles, and clinical outcomes. The absence of denominator-based consumption metrics — such as defined daily doses (DDDs) per 100 bed-days — prevents direct comparison with international antibiotic consumption benchmarks. Additionally, ESBL status was not formally reported for all isolates, precluding a precise enumeration of the ESBL burden. Future studies employing multi-centre designs, longer observation periods, phenotypic and genotypic resistance characterisation, and standardised consumption metrics would substantially strengthen the evidence base for stewardship programme planning in this setting.

CONCLUSIONS

This prospective study demonstrates a clear predominance of gram-negative pathogens in the CCU microbiological landscape, with E. coli and Klebsiella species as the leading isolates. Significant resistance to beta-lactams and third-generation cephalosporins — consistent with ESBL-producing phenotypes — signals an evolving and clinically impactful resistance profile that renders these agents unreliable for empirical use without microbiological support. The application of WHO AWaRe classification reveals that Watch-category antibiotics dominated prescribing, with the most commonly used agents representing broader-spectrum choices than Access-category alternatives would allow for many indications.

Although guideline concordance was high at 90%, the formal de-escalation rate of only 11% represents the most critically modifiable gap identified by this study. Bridging the distance between culture-result availability and culture-guided de-escalation must be a central objective of any stewardship initiative at this institution. The retention of meropenem activity reinforces its current clinical utility, but its preservation for future patients demands prudent, indication-specific use. Together, these findings constitute a clear, evidence-based argument for formalised antimicrobial stewardship programmes, prospective audit and feedback mechanisms, institution-specific antibiogram development, and regular AWaRe-based monitoring of antimicrobial consumption in this CCU.

DECLARATIONS

Conflict of interest: The authors declare no conflicts of interest.

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Ethical approval: Approved by the Institutional Ethics Committee of Deccan School of Pharmacy. Conducted in accordance with the Declaration of Helsinki.

Author contributions: MF: conceptualisation, study supervision, and critical manuscript review. SNP and MHA: clinical data acquisition and patient follow-up. MAR, A, HF, and ZF: data collection, analysis, and manuscript drafting. All authors reviewed and approved the final version of the manuscript.

Data availability: The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

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