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Original Article

Antimicrobial Resistance Patterns and Clinical Outcomes in Critically Ill Patients

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Abstract

Objective: To determine the antimicrobial resistance patterns among bacterial pathogens isolated from critically ill patients and evaluate their association with clinical outcomes.

Methodology: This longitudinal observational study was conducted in the Department of Medicine at Karachi Teaching Hospital from October 2025 to March 2026. We enrolled 300 critically ill patients admitted to the ICU. We recorded demographic characteristics, comorbidities, previous antibiotic exposure, isolated organisms, antimicrobial susceptibility patterns, multidrug resistance, mechanical ventilation, ICU stay, treatment response, and mortality.

Results: We identified bacterial infection in most clinically suspected cases. The most common bacteria isolated were *Acinetobacter baumannii*, 78 (26.0%), followed by *Klebsiella pneumoniae*, 67 (22.3%), *Pseudomonas aeruginosa*, 49 (16.3%), *E. coli*, 42 (14.0%), *S. aureus*, 31 (10.6%), and *Enterococcus* spp., 15 (5.0%), respectively. Multidrug-resistant organisms constituted a substantial proportion of isolates. Patients with resistant infections had higher mortality, longer ICU stays, and more frequent mechanical ventilation than patients with susceptible infections.

Conclusion: Our study concluded that antimicrobial resistance is a significant issue among critically ill patients and is related to unfavorable clinical outcomes. Consistent ICU-specific antimicrobial surveillance, right empirical treatment, culture-directed treatment, infection-prevention procedures, and antimicrobial stewardship are mandatory to lessen the burden of resistant infections.

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Introduction

Critically ill patients receive advanced medical treatment in specialized departments called Intensive Care Units (ICUs). Because of widespread empirical use of broad-spectrum antibiotics, prolonged hospital stays, and weakened immunity, these patients are highly susceptible to infections[1]. In critically ill patients, the increased prevalence of antibiotic resistance complicates the treatment process and restricts effective empirical therapy choices[2]. In ICUs, multidrug-resistant (MDR) bacteria are a global health problem, where infections lead to higher morbidity and death rates. Gram-negative bacteria *K. pneumoniae* and *E. coli* typically produce ESBLs and carbapenemases, limiting treatment options and requiring last-resort antibiotics such as colistin or tigecycline [3]. AmpC beta-lactamases, both chromosomal and plasmid-mediated, can cause resistance to extended-spectrum cephalosporins, cephamycins, and beta-lactam inhibitor combinations, limiting treatment options in ICU settings [4]. *P. aeruginosa* and *A. baumannii* have significant levels of resistance, especially to carbapenems, making them difficult to eliminate and increasing the chance of severe clinical consequences. MRSA and VRE remain widespread among Gram-positive bacteria in hospital-acquired infections, complicating empirical antibiotic selection [5]. MDR pathogen infections lead to longer ICU stays, greater rates of septic shock, and higher fatality rates, making resistance features crucial for patient outcomes [6]. Continuous tracking of resistance trends and effective antimicrobial stewardship programs are crucial to reducing the incidence of MDR infections in critically ill patients. Sepsis must be diagnosed early and managed appropriately to reduce in-hospital mortality. While improper or insufficient treatment raises the chance of death, very early commencement of successful empirical antibiotic therapy can improve patient prognosis [7]. However, the microorganisms causing infections in ICU patients and their antibiotic susceptibility profiles vary across institutions, even among departments within the same hospital. Bacterial pathogen distribution and antibiotic resistance profiles change over time [8]. To improve antibiotic therapy in ICU patients, hospitals and individual ICUs should study microbiological data and adjust treatment guidelines as needed. Therefore, this study was conducted to determine antimicrobial resistance patterns and clinical outcomes in critically ill patients [9].

Materials and method

This longitudinal observational study was conducted at the Department of Medicine, Karachi Teaching Hospital, from 7th October 2025 to 7th March 2026, after obtaining permission from the hospital's ethics committee. This study included 300 critically ill individuals of both genders and different age groups (above 18 years) admitted to the ICU who had clinical evidence of suspected bacterial infection, had an appropriate clinical specimen submitted for microbiological examination, and had sufficient clinical information available for outcome assessment. We excluded individuals with incomplete clinical records and those transferred before clinical outcome assessment. Based on the infection site and the treating physician's request, we collected samples using standard aseptic precautions and transported them immediately to the microbiology laboratory. These samples included wound/pus, urine, endotracheal aspirates, blood, and other relevant samples. When clinically feasible, we obtained blood cultures in adequate blood culture bottles before administering antibiotics. We processed specimens using conventional microbiological methods. We selected the appropriate culture medium based on the specimen type. After incubation, we assessed bacterial growth by colony morphology, Gram staining, and standard biochemical testing. We confirmed results using automatic identification systems where available. We conducted antimicrobial susceptibility testing on clinically relevant bacterial isolates. We performed antimicrobial susceptibility screening using the Kirby-Bauer disk diffusion technique. According to widely accepted worldwide criteria, multidrug resistance (MDR) is recognized as non-susceptibility to at least one antimicrobial agent in more than three antimicrobial categories. We recorded demographic and clinical data using a standardized data-collection proforma. We documented demographic and clinical data, including gender, age, ICU stay duration, hypertension, chronic renal disease, chronic obstructive pulmonary disease, diabetes, antibiotic exposure, ICU admission, antimicrobial susceptibility pattern, MDR status, identified bacterial species, and presence of sepsis/septic shock. We evaluated clinical outcomes by reviewing individual clinical records from the time the bacterial infection was identified until ICU discharge, admission to another ward, or death. We analyzed data using SPSS version 16. We expressed categorical data as frequencies and percentages, and summarized continuous variables as mean $\pm$ standard deviation. We used the chi-square test or Fisher's exact test to investigate associations between antibiotic

resistance/MDR status and pertinent demographic or clinical factors, as needed. We considered $p < 0.05$ statistically significant.

Results

This study included 300 critically ill patients admitted to the ICU: 178 (59.3%) male and 122 (40.7%) female. Of the participants, 214 (71.3%) were under 60 years old, and 86 (28.7%) were over 60. Hypertension was seen in 112 (37.3%) patients, while diabetes mellitus was found in 96 (32.0%) patients. Mechanical ventilation was necessary for 174 (58.0%) individuals. Chronic renal disease was detected in 48 (16%) people, while COPD was investigated in 39 (13.0%). Sepsis or septic shock was found in 139 (46.3%) cases, whereas acute renal damage occurred in 87 (29.0%). Table 1 shows that 108 (36.0%) had a previous hospitalization, and 126 (42.0%) had been prescribed antibiotics before ICU admission. The most common bacteria isolated were *Acinetobacter baumannii*, 78 (26.0%), followed by *Klebsiella pneumoniae*, 67 (22.3%); *Pseudomonas aeruginosa*, 49 (16.3%); *E. coli*, 42 (14.0%); *S. aureus*, 31 (10.6%); and *Enterococcus* spp., 15 (5.0), respectively. In total, 174 isolates (58.0%) met the multidrug resistance criterion. *A. baumannii* had the greatest MDR percentage (73.1%), followed by *K. pneumoniae* (68.7%) and *P. aeruginosa* (55.1%). Carbapenem resistance was especially common among the main Gram-negative bacteria. Table 2 shows that about 74.4% of *A. baumannii* and 62.7% of *K. pneumoniae* strains were carbapenem-resistant. Clinical outcomes were evaluated. Mechanical ventilation was necessary in 71.3% of individuals with MDR infections, compared to 39.7% of non-MDR patients. Septic shock and acute renal damage were substantially more common in the MDR group. Similarly, the MDR group had more than double the ICU mortality rate. Participants with MDR infections had an average ICU stay of 10.6 ± 6.4 days, versus 7.7 ± 4.5 days for non-MDR infections. Individuals with MDR infections had a considerably higher in-hospital death rate (44.8%) compared to those without (21.4%, $p < 0.001$). About 55.2% of MDR participants showed clinical improvement, compared to 78.6% of individuals with non-MDR illnesses. Likewise, MDR infections had worse microbiological clearance rates, as shown in Table 3.

Table 1. Clinical and demographic features of the study populations, $n = 300$

Features	(n)	(%)
Sex		
Male	178	59.3
Female	122	40.6
Age in years		
≤60 years	214	71.3
>60 years	86	28.7
Diabetes mellitus	96	32.0
Hypertension	112	37.3
Chronic kidney disease	48	16.0
Chronic obstructive pulmonary disease	39	13.0
Previous hospitalization	108	36.0
Previous antibiotic exposure	126	42.0
Mechanical ventilation	174	58.0
Sepsis/septic shock	139	46.3
Acute kidney injury	87	29.0

Values are presented as frequency (n) and percentage (%), based on the total study population ($n = 300$).

Table 2. Isolated bacteria and their antibiogram, $n = 300$

Bacterial pathogen	Isolates n (%)	MDR n (%)	Carbapenem-resistant n (%)
<i>Acinetobacter baumannii</i>	78(26.0)	57 (73.1)	58 (74.4)
<i>Klebsiella pneumoniae</i>	67 (22.3)	46 (68.7)	42 (62.7)
<i>Pseudomonas aeruginosa</i>	49 (16.3)	27 (55.1)	25 (51.0)
<i>Escherichia coli</i>	42 (14.0)	21 (50.0)	16 (38.1)
<i>Staphylococcus aureus</i>	31 (10.3)	13 (41.9)	—
<i>Enterococcus</i> spp.	15 (5.0)	5 (33.3)	—
Other bacteria	18 (6.0)	5 (27.8)	—
Total	300 (100)	174 (58.0)	—

Values are presented as frequency (n) and percentage (%). MDR, multidrug-resistant.

Table 3. Based on MDR status, clinical outcomes in the study population

Clinical outcome	MDR infection n=174	Non-MDR infection n=126	p-value
In-hospital mortality	78 (44.8%)	27 (21.4%)	<0.001
ICU mortality	69 (39.7%)	23 (18.3%)	<0.001
Mean ICU stay (days)	10.6 ± 6.4	7.7 ± 4.5	<0.001

Mechanical ventilation	124 (71.3%)	50 (39.7%)	<0.001
Septic shock	94 (54.0%)	45 (35.7%)	0.002
Acute kidney injury	65 (37.4%)	22 (17.5%)	<0.001
Clinical improvement	96 (55.2%)	99 (78.6%)	<0.001
Microbiological clearance	02 (58.6%)	12 (73.0%)	0.012

Categorical variables are presented as n (%), and continuous variables as mean $\pm$ standard deviation (SD). We used chi-square or Fisher's exact test, as appropriate. We considered $p < 0.05$ statistically significant. MDR, multidrug-resistant.

Discussion

This study included 300 critically ill patients admitted to the ICU: 178 (59.3%) male and 122 (40.7%) female. Hypertension was seen in 112 (37.3%) patients, while diabetes mellitus was found in 96 (32.0%). Mechanical ventilation was necessary for 174 (58.0%) individuals [10]. Chronic renal disease was detected in 48 (16%) people, while COPD was investigated in 39 (13.0%). Sepsis or septic shock was found in 139 (46.3%) cases, whereas acute renal damage occurred in 87 (29.0%) Previous hospitalization was documented in 108 (36.0%) of individuals, whereas 126 (42.0%) had been prescribed antibiotics prior to ICU admission. Our study's clinical and demographic features are similar to those in a systematic review and meta-analysis of prediction models for multidrug-resistant organism infections in comprehensive intensive care units conducted in 2025, which supports our findings.¹⁰ The high prevalence of mechanical ventilation in our study is especially significant since mechanically ventilated patients are more exposed to healthcare-associated infections, particularly MDR Gram-negative bacteria. In a recent ICU investigation of carbapenem-resistant Gram-negative bacteremia, invasive mechanical ventilation before bacteremia was a major risk factor for resistant infection [11]. In our study, the most common bacteria isolated were *Acinetobacter baumannii*, 78 (26.0%), followed by *Klebsiella pneumoniae*, 67 (22.3%); *Pseudomonas aeruginosa*, 49 (16.3%); *E. coli*, 42 (14.0%); *S. aureus*, 31 (10.6%); and *Enterococcus* spp., 15 (5.0), respectively. The prevalence of these Gram-negative infections aligns with research on critically ill individuals admitted to the intensive care unit (Paramythiotou et al. [12]). The high prevalence of *A. baumannii* in our study is most worrying because this organism can persist in the hospital setting and quickly acquire resistance mechanisms. In our study, 58% of isolates were multidrug-resistant; *A. baumannii* had the highest MDR percentage (73.1%), followed

by *K. pneumoniae* (68.7%) and *P. aeruginosa* (55.1%). Carbapenem resistance was especially common among the Gram-negative bacteria. About 74.4% of *A. baumannii* and 62.7% of *K. pneumoniae* strains were carbapenem-resistant. A similar resistance pattern was seen in a retrospective study by Kilinc in critically ill patients, which supports our findings [13]. A current study of carbapenem-resistant Gram-negative bacteremia in a medical intensive care unit showed extraordinarily high resistance rates among resistant isolates and found that carbapenem-resistant infections were linked to considerably higher 30-day mortality [14]. In our study, the MDR group had more than double the ICU mortality rate. Participants with MDR infections had an average ICU stay of 10.6 ± 6.4 days, versus 7.7 ± 4.5 days for non-MDR infections. Individuals with MDR infections had a considerably higher in-hospital death rate (44.8%) compared to those without (21.4%). These findings are similar to the study conducted by Kilinc, in which individuals with MDR infections had a higher death rate, longer ICU stay, and double the ICU mortality rate[13]. In the present study, mechanical ventilation was necessary in 71.3% of individuals with MDR infections, compared to 39.7% of non-MDR patients. Septic shock and acute renal damage were substantially more common in the MDR group. These results support the fact that individuals with more severe systemic disease often have severe MDR infections[15]. Our study found that 55.2% of MDR participants showed clinical improvement, compared to 78.6% of individuals with non-MDR illnesses. Likewise, MDR infections had worse microbiological clearance rates. MDR organisms lower the likelihood of successful first-line antimicrobial treatment, which may be one factor. A comprehensive review and meta-analysis of more than 73,000 individuals found that rising multidrug-resistant organism frequency was associated with higher rates of inappropriate empirical antibiotic treatment. In contrast, MDRO frequency was independently associated with death [16,17]. The findings emphasize the importance of continual antibiotic resistance surveillance in ICUs. The prevalence of MDR pathogens, especially *A. baumannii*, *K. pneumoniae*, and *P. aeruginosa*, suggests that empirical antibiotic policy should be based on recent local susceptibility data rather than relying entirely on generic guidelines. Prompt specimen collection, early microbiological diagnosis, effective empirical therapy followed by culture-directed therapy, antibiotic stewardship, and stringent infection-prevention procedures are critical components of controlling MDR infections.

Conclusion

Our study concluded that antimicrobial resistance is a significant issue among critically ill patients and is associated with unfavorable clinical outcomes. Consistent ICU-specific antimicrobial surveillance, appropriate empirical treatment, culture-directed treatment, infection-prevention procedures, and antimicrobial stewardship are mandatory to lessen the burden of resistant infections.

Ethical Approval

The Institutional Review Board/Ethics Committee approved this study under approval number ERB-346/08/2024 before the study began.

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This study received no external funding. The research used available institutional resources.

Conflict of Interest

The authors declare that they have no competing interests or conflicts of interest related to this study.

Authors' Contributions

Ajmaal Jami: Conceptualization, study design, supervision, data interpretation, manuscript drafting, critical revision, final approval, and accountability for all aspects of the work.

Sellal Ahmed: Methodology, data collection, data curation, statistical analysis, data interpretation, manuscript drafting and revision, final approval, and accountability for all aspects of the work.

Arshad Ali: Study supervision, methodology, interpretation of findings, critical review of the manuscript, final approval, and accountability for all aspects of the work.

Mahnoor Khan: Data collection, literature review, data curation, manuscript revision, final approval, and accountability for all aspects of the work.

All authors: Reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work in accordance with ICMJE authorship criteria.

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