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Original Article

Predictors of Mortality in ICU Patients with Multidrug-Resistant Bacterial Infections

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Abstract

Objective: To identify clinical, microbiological, and treatment-related predictors of mortality among ICU patients with multidrug-resistant (MDR) Bacterial Infections.

Methodology: This longitudinal observational study was conducted in the Department of Medicine at Karachi Teaching Hospital from December 2025 to May 2026. We enrolled 250 ICU patients with culture-confirmed MDR bacterial infections. We assessed demographic characteristics, comorbidities, prior antibiotic exposure, mechanical ventilation, septic shock, acute kidney injury (AKI), MDR pathogen, carbapenem resistance, and appropriateness of empirical antimicrobial therapy. The primary outcome was in-hospital mortality. We compared categorical variables using the Chi-square test and used multivariable logistic regression to identify independent predictors of mortality.

Results: Among 250 patients, 105 (42.0%) died, and 145 (58.0%) survived. The most frequently isolated organisms were *Acinetobacter baumannii* (72, 28.8%), *Klebsiella pneumoniae* (61, 24.4%), and *Pseudomonas aeruginosa* (39, 15.6%). Mortality was higher among patients with septic shock, mechanical ventilation, AKI, carbapenem-resistant infection, previous antibiotic exposure, and inappropriate empirical antimicrobial therapy. In multivariable logistic regression, septic shock was the highest independent predictor of mortality. Other independent predictors were inappropriate empirical therapy, mechanical ventilation, carbapenem-resistant infection, AKI, previous antibiotic exposure, and age >60 years.

Conclusion: Mortality among ICU patients with MDR bacterial infections was high. Septic shock, inappropriate empirical antimicrobial therapy, mechanical ventilation, carbapenem resistance, AKI, previous antibiotic exposure, and older age were important independent predictors of mortality.

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Introduction

Intensive care units (ICUs) are specialized places that deliver innovative medical management to critically ill patients. Individuals admitted to these facilities are especially susceptible to infections due to many reasons such as immunosuppression, lengthy hospital stays, invasive surgeries, and the extensive empirical use of broad-spectrum antibiotics[1]. Infections resulting from multidrug-resistant (MDR) bacteria are among the most prevalent causes of hospital-acquired infections, contributing to higher morbidity and death rates in ICU patients[2]. The increased frequency of antibiotic resistance in critically sick patients nowadays restricts effective empirical therapy choices and complicates the treatment process[3]. Multidrug-resistant (MDR) bacteria are a major global health concern, particularly in ICUs, where infections caused by these pathogens contribute to higher morbidity and mortality rates. *K. pneumoniae* and *E. coli* are two Gram-negative bacteria that are commonly linked to the synthesis of carbapenemase and extended-spectrum beta-lactamase (ESBL), which restricts treatment choices and usually necessitates the use of last-resort medicines[4]. There are numerous independent risk factors for the occurrence of MDR bacterial infections within ICU patients, including central venous access, pulmonary artery catheterization, stress ulcer prophylaxis, urinary catheterization, mechanical ventilation, trauma, ICU length of stay, and, most importantly, a previous history of infection or colonization by MDR microorganisms[5]. According to one research, the severity of infection, underlying illness, MDR status, and inadequate antibiotic therapy were all significant predictors of death in ICU patients. Septic shock, pneumonia, and inadequate empirical or final therapy were significantly related to poor outcomes[6]. A 2026 study on carbapenem-resistant Gram-negative bloodstream infections reported notably high mortality and identified mechanical ventilation, prior carbapenem exposure, and prolonged hospitalization as significant risk factors for resistance infection [7]. Thus, identifying independent predictors of death among intensive care unit patients with MDR infections is critical for risk stratification and therapeutic decision-making. Therefore, the present study was conducted to determine predictors of mortality among critically ill ICU patients with microbiologically confirmed multidrug-resistant bacterial infections [8,9].

Materials and Method

This longitudinal observational study was conducted at the Department of Medicine, Karachi Teaching Hospital, from December 2025 to May 2026, after approval from the hospital's ethics committee. A total of 250 individuals of both genders and different age groups (≥ 18 years) admitted to the ICU with confirmed MDR bacterial infections and stayed in hospital till the outcome assessment were included. We excluded individuals with incomplete clinical records or age below 18 years. We collected several specimens from each participant (pus/wound, endotracheal aspirates, blood, sputum, and other clinically relevant samples) from the suspected site of infection aseptically and sent them to the microbiology lab for further processing. Each sample was inoculated on a specified medium and incubated for growth. After incubation, we measured bacterial growth using colony morphology, Gram staining, and standard biochemical testing. We confirmed identification 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 for each participant. We followed each individual to identify predictors of mortality. We classified participants into survivor and non-survivor groups. We analyzed data using SPSS version 16. Continuous variables were presented as mean $\pm$ standard deviation, and Categorical variables were presented as frequencies and percentages. To assess associations between mortality and different variables, we used the chi-square test or Fisher's exact test. P-value of <0.05 was considered statistically significant.

Results

We studied 250 individuals admitted to the ICU with multi-drug bacterial infections. We classified participants as survivors or non-survivors. During the study period, 145 (58.0%) survived, and 105 (42.0%) died during hospitalization. Non-survivors were substantially more likely to have had previous antibiotic exposure (56.2% vs. 37.2%, $p=0.002$). Mechanical ventilation was strongly associated with mortality. It was needed in 77.1% of non-survivors when compared to 52.4% of survivors ($p<0.001$). Acute kidney injury was also substantially more

common among non-survivors (44.8% compared with 24.1%, $p=0.001$). Septic shock showed the most clinically significant difference. It affected 63.8% of non-survivors and just 21.4% of survivors ($p < 0.001$). Survivors and non-survivors did not differ significantly in terms of gender, hypertension, chronic renal disease, diabetes, or previous hospitalization, as presented in Table 1. Among multidrug-resistant bacteria, *A. baumannii* was most prevalent (72, 28.8), followed by *K. pneumoniae* (61, 24.4) and *P. aeruginosa* (39, 15.6). The death rate was greatest among individuals infected with *A. baumannii*, with 38 of 72 (52.8%) dying, followed by *K. pneumoniae* (45.9%). Carbapenem-resistant infections were found in 129 (51.6%) individuals. The death rate in individuals with carbapenem-resistant infections was 57.4%, which was significantly higher than the general mortality rate of 42.0%. Inadequate empirical treatment occurred in 32.8% of individuals, with non-survivors having a significantly higher rate (47.6% versus 22.1% among survivors), as shown in Table 2. Multivariable logistic regression revealed that the most common predictors of mortality in ICU patients with MDR infections were septic shock, mechanical ventilation, and acute kidney injury. Similarly, incorrect empirical antibiotic medication was linked with a 2.5-fold increased risk of mortality, and Carbapenem- After adjusting for prior antibiotic exposure and age >60 years, these effects remained statistically significant, although reduced, as shown in Table 3.

Table 1. Clinical and demographic features by survival outcome.

Variable	Total n=250	Survivors n=145	Non- survivors n=105	p- value
Age >60 years	86 (34.4%)	50 (34.5%)	36 (34.3%)	0.037
Male gender	151 (60.4%)	89 (61.4%)	62 (59.0%)	0.695
Diabetes mellitus	83 (33.2%)	44 (30.3%)	39 (37.1%)	0.263
Hypertension	94 (37.6%)	50 (34.5%)	44 (41.9%)	0.231
Chronic kidney disease	42 (16.8%)	21 (14.5%)	21 (20.0%)	0.262
Previous hospitalization	91 (36.4%)	48 (33.1%)	43 (41.0%)	0.202
Previous antibiotic exposure	113 (45.2%)	54 (37.2%)	59 (56.2%)	0.002
Mechanical ventilation	157 (62.8%)	76 (52.4%)	81 (77.1%)	<0.001
Septic shock	98 (39.2%)	31 (21.4%)	67 (63.8%)	<0.001

Acute kidney injury	82 (32.8%)	35 (24.1%)	47 (44.8%)	0.001
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Table 2. Multidrug-resistant bacteria and their resistance features

Bacterial pathogen	Total n (%)	Survivors n(%) (%)	Non- survivors n (%)	Mortality within pathogen group
<i>Acinetobacter baumannii</i>	72 (28.8)	34 (23.4)	38 (36.2)	52.8%
<i>Klebsiella pneumoniae</i>	61 (24.4)	33 (22.8)	28 (26.7)	45.9%
<i>Pseudomonas aeruginosa</i>	39 (15.6)	24 (16.6)	15 (14.3)	38.5%
<i>Escherichia coli</i>	31 (12.4)	21 (14.5)	10 (9.5)	32.3%
<i>Staphylococcus aureus</i>	24 (9.6)	16 (11.0)	8 (7.6)	33.3%
<i>Enterococcus spp.</i>	11 (4.4)	7 (4.8)	4 (3.8)	36.4%
Other organisms	12 (4.8)	10 (6.9)	2 (1.9)	16.7%
Total	250 (100)	145 (100)	105 (100)	42.0%
Carbapenem-resistant infection	129 (51.6)	55 (37.9)	74 (70.5)	57.4%
Inappropriate empirical therapy	82 (32.8)	32 (22.1)	50 (47.6)	61.0%

Table 3. Predictors of Motility among the study population applying multivariable logistic regression

Predictor	Adjusted OR	95% CI	p- value
Age >60 years	1.71	1.01–2.92	0.045
Previous antibiotic exposure	1.85	1.08–3.21	0.025
Mechanical ventilation	2.37	1.34–4.21	0.003
Septic shock	4.30	2.42–7.66	<0.001
Acute kidney injury	1.92	1.11–3.35	0.020
Carbapenem-resistant infection	2.16	1.25–3.76	0.006
Inappropriate empirical therapy	2.53	1.43–4.49	0.002

Discussion

MDR has emerged as a major concern, particularly in the hospital's ICU. In 2019, MD illnesses caused around 4.95 million fatalities worldwide, including 1.27 million of them mainly attributed to medication resistance.⁷ ICUs are frequently regarded as the epicenter of drug-resistant microbe growth, amplification, and spread[10]. Patients with severe illnesses are especially susceptible to infections due to being exposed to multiple invasive procedures compromising the anatomical barriers' defenses, impairment of protective mechanisms such as the cough reflex or acid gastric environment by sedative drugs or stress-ulcer prophylaxis, and the continual impairment of the immune response induced by trauma, surgery, and sepsis[11,12]. Previous studies revealed that the most common predictors of mortality in patients with MDR infections are trauma, ICU length of stay, mechanical ventilation, urinary catheterization, pulmonary artery catheterization, stress ulcer prophylaxis, or previous history of infection or colonization by MDR microorganisms[13]. Therefore, this study aimed to identify predictors of mortality among critically ill ICU patients with microbiologically confirmed multidrug-resistant bacterial infections. We studied 250 individuals admitted to the ICU with multidrug-resistant bacterial infections[14]. In our study, 42% of the individuals admitted to the ICU died during the study period. Non-survivors were substantially more likely to have had previous antibiotic exposure[15]. These findings are similar to the study by Vardakas et al.¹⁰ Our findings differ from those of Fatima et al.; they reported a 14-day mortality of 26.8%, which is lower than in our study[16]. The slightly greater mortality observed in our study might be explained by including critically ill individuals with a wider spectrum of serious infections rather than just bloodstream infections. Mortality rates vary because of differences in infection type, pathogen, resistance mechanisms, disease severity, and access to treatment. In our study, *A. baumannii* was the most prevalent among multidrug-resistant bacteria, followed by *K. pneumoniae* and *P. aeruginosa* [17]. The death rate was greatest among individuals infected with *A. baumannii*, with 38 of 72 (52.8%) dying, followed by *K. pneumoniae* (45.9%). The death rate in individuals with carbapenem-resistant infections was 57.4%, which was significantly higher than the general mortality rate. These findings are similar to the study by Vardakas et al., which further supports these findings[18]. In our study, septic shock was a robust predictor of mortality. This result is consistent with prior reports. In a review of MDR Gram-negative infections, septic

shock was revealed as one of the highest death predictors[19]. Septic shock was also found to be an independent risk factor related to in-hospital death in a current ICU study of Gram-negative bloodstream infections[19]. Septic shock causes severe circulatory and cellular dysfunction and can lead to multiple organ failure. As a result, its link to mortality is physiologically plausible, underscoring the importance of early detection and prompt sepsis treatment[20]. Mechanical ventilation was independently associated with death in our study. A recent ICU study found invasive mechanical ventilation to be a major factor associated with resistant Gram-negative infection and death[21]. Mechanical ventilation may signal illness severity rather than directly causing mortality. Patients who need invasive ventilation often have multiple organ dysfunction, respiratory failure, septic shock, or severe pneumonia. Our study also revealed that Incorrect empirical antibiotic medication was linked with a 2.5-fold increased risk of mortality, and Carbapenem-resistant illness raised the risk of death by around 2.2-fold[22]. After adjusting for previous antibiotic exposure and age >60 years, their effects remained statistically significant. These findings are similar to those of the previous study [23]. The results highlight that host factors, disease severity, resistance traits, and antimicrobial therapy effectiveness all influence mortality in MDR infections; early identification of high-risk patients, appropriate empirical treatment, rapid microbiological diagnosis, prompt definitive therapy, and efficient source control could improve outcomes.

Conclusion

Our study concluded that mortality among ICU patients with MDR bacterial infections was high. Septic shock, inappropriate empirical antimicrobial therapy, mechanical ventilation, carbapenem resistance, AKI, previous antibiotic exposure, and older age were important independent predictors of mortality.

Ethical Approval

Ethical approval for this study was obtained from the Institutional Review Board/Ethics Committee under approval number ERB-372/11/2024 prior to the study's commencement.

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This study received no external funding. The research was conducted using available institutional resources.

Conflict of Interest

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

Authors' Contributions

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

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

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

Sellal Ahmed: 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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