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Antimicrobial Susceptibility Patterns of Bacterial Isolates among Intensive Care Unit Patients at A Tertiary Care Hospital in Bangladesh

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Abstract

Background: Bloodstream infections (BSIs) that are multi-drug resistant (MDR) represent a significant source of illness and death in intensive care units (ICUs), especially in low- and middle-income nations where antimicrobial resistance is escalating quickly. Ongoing monitoring of causative agents and their resistance patterns is crucial for directing empirical antibiotic treatment and updating hospital antibiotic guidelines. **Objective:** To determine the bacterial profile and antimicrobial susceptibility pattern of bloodstream isolates among ICU patients admitted to Gazi Medical College Hospital, Khulna, Bangladesh. **Methods:** This cross-sectional study was conducted in the ICU of Gazi Medical College Hospital from July 2025 to April 2026. Blood samples from clinically suspected cases of infection were collected and processed using standard microbiological methods, including culture, isolation, identification, and antimicrobial susceptibility testing by the disc diffusion method. Interpretation was performed according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Data were analyzed using SPSS version 26.0 and expressed as frequencies and percentages. **Results:** A total of 200 blood samples were analyzed, of which 81 (40.5%) yielded microbial growth. Gram-negative bacteria predominated, with Escherichia coli being the most common isolate (31, 15.5%), followed by Staphylococcus aureus (24, 12.0%) and Klebsiella spp. (15, 7.5%). Among S. aureus, high resistance to cefoxitin (70.8%) and cloxacillin (66.7%) suggested a high prevalence of MRSA, while linezolid (70.9%) and vancomycin (75.0%) remained the most effective agents. Among Gram-negative isolates, E. coli showed the highest susceptibility to colistin (100.0%), amikacin (83.9%), and gentamicin (80.6%), but high resistance to nalidixic acid (96.8%), ceftazidime (93.5%), and ceftriaxone (83.9%), indicating probable ESBL production. Klebsiella spp. demonstrated 100% resistance to third-generation cephalosporins and low susceptibility to meropenem (20.0%). Colistin remained the most effective drug across Gram-negative organisms. **Conclusion:** The study revealed a high burden of bloodstream infections in ICU patients with predominance of MDR Gram-negative bacteria and a substantial prevalence of MRSA. Due to the startlingly high level of resistance to carbapenems and third-generation cephalosporins, colistin and a small number of other drugs were the only viable treatments. Strict infection control procedures, antimicrobial stewardship, and routine ICU antibiogram updates are desperately needed to stop the spread of resistant microorganisms and enhance clinical results.

Keywords: Bloodstream infection, ICU, Antimicrobial resistance, MRSA, ESBL, Colistin, Bangladesh.

Introduction

Multi-drug-resistant infections are a substantial burden on patients and the public health system of any nation, and they are one of the main causes of morbidity and mortality among hospitalized patients worldwide. Because of the unique risk profile of its patients, the intensive care unit (ICU) is considered the centre of resistance development as it contributes to 20%-25% of all nosocomial infections in a hospital.[1] It has been described as a factory that produces, disseminates, and intensifies antimicrobial resistance.[2]

Because of their higher rates of morbidity, less mobility, and increased usage of intrusive devices, patients admitted to the intensive care unit are more vulnerable to infection.[3] The therapeutic interventions, such as indwelling catheters, advanced life support, intravenous fluid therapy, prosthetic devices, immunosuppressive therapy, and the use of broad-spectrum antibiotics, have resulted in the spread of a variety of multidrug-resistant pathogens. On the other hand, these interventions also helped to evolve the infection problem.[4]

One of the biggest challenges in treating these infections is the emergence of antibiotic resistance. There are now fewer options for treating these infections due to their growing threat. This is because antimicrobial usage is high, particularly in intensive care units.[5] Again, there are significant differences among the patterns of organisms causing infections and their antibiotic resistance pattern from one country to another, as well as from one hospital to another.[6] In addition, there is also variation in the frequency and types of infections among different subsets of patients within the same ICU.[7] So, there is an imperative need to acquire comprehensive data on resistant strains in the ICU along with the susceptibility pattern to help in revising antibiotic policy and guiding clinicians for the better management of patients. Additionally, this observation will help to prevent drug resistance and minimize the needless use of broad-spectrum antibiotics. For infection control initiatives in intensive care units, information on shifting trends in antibiotic susceptibility is crucial.

Keeping this overview in mind, the present study aims to determine the antimicrobial resistance pattern of bacterial isolates from the ICU of Gazi Medical College Hospital, Khulna, Bangladesh. The results of this study will help clinicians to plan antibiotic guidelines as well as antibiotic cycling in ICU settings.

Materials and methods

Location and duration of study:

This Cross-sectional investigation was carried out in Khulna, Bangladesh, at the Gazi Medical College Hospital. Samples were collected from patients hospitalized in this ICU between July 2025 and April 2026 who had a clinical suspicion of infection.

Data collection:

A structured data collection sheet was used for compiling data for each sample. The data collection sheet included demographic information such as name, age, sex, and laboratory data information, such as the type of samples and results obtained from laboratory methods. All the demographic and laboratory data, sample collection date, and time were recorded and stored in a password-protected file.

Sample collection:

A clinical suspicion regarding the source of infection led to the collection of patient samples (blood). These were forwarded to the department of Microbiology, Gazi Medical College Hospital, for microbial culture, isolation, identification, and antibiotic susceptibility testing.[8]

Sample size calculation:

The sample size was calculated by the following formula,

$n = z2p(1-p)/d^2$,

where z = Z score for 95% confidence interval = 1.96;

p = prevalence (39.68)[9] and d = acceptable error (7%).

n = 187.67

This was rounded up to 200 to provide a conservative estimate and account for any minor variation in data collection.

So, 200 ICU samples have been collected for this study.

Isolation and identification:

Collected specimens were being put on a plate that contained either MacConkey agar (MCA), chocolate agar (CA), or blood agar (BA), and it was then incubated at 37°C for 18 to 24 hours. Blood cultures for favourable growth were processed in an automated blood culture system and then subcultured. Standard microbiological procedures, such as colony morphology, Gram stain, and biochemical reaction, were applied for further identification of suspected pathogenic bacteria.[8]

Antimicrobial susceptibility testing:
The antimicrobial susceptibility test was done using the disc diffusion method. The zone of inhibition was interpreted according to the recommendations of the Clinical Laboratory Standard Institute (CLSI) guideline.

Ethical approval:
This study obtained ethical approval from the Institutional Review Board of Gazi Medical College, Khulna, Bangladesh.

Statistical analysis:
The results were recorded and analyzed systematically using descriptive analysis (frequency and percentage) for the positive culture growth and the resistance towards the antibiotics tested. The SPSS software (IBM SPSS Statistics for Windows, Version 26.0. IBM Corp.: Armonk, New York, NY, USA) has been used to calculate the percentage.

Results

A total of 200 blood samples were taken from patients who were admitted to Gazi Medical College Hospital's Intensive Care Unit (ICU). Of these, 81 (40.5%) samples had microbial growth, whereas 119 (59.5%) had no growth (Figure 01).

Table 01 shows the distribution of organisms; gram-negative organisms predominated in the positive blood cultures. Escherichia coli was the most commonly isolated bacterium (n = 31, 15.5%), followed by Klebsiella spp. (n = 15, 7.5%). Among gram-positive organisms, Staphylococcus aureus (n = 24, 12.0%) was predominant, and Enterobacter spp. were the least prevalent (n = 2, 1.0%), whereas streptococci were detected in 9 instances (4.5%).

A total of 33 Gram-positive isolates (Staphylococcus aureus, n = 24; Streptococci, n = 9) were tested (Table 02).

Among Staphylococcus aureus isolates, the highest susceptibility was observed for linezolid (70.9%) and Vancomycin (75.0%). Aminoglycosides demonstrated 66.7% in amikacin and 66.7% susceptibility in gentamicin. Resistance was notably high against cefoxitin (70.8%) and cloxacillin (66.7%), indicating a high prevalence of methicillin-resistant Staphylococcus aureus (MRSA). Ciprofloxacin also showed reduced susceptibility, with resistance in 45.8% of isolates.

Among Streptococci isolates, linezolid showed the highest susceptibility (77.8%), followed by amikacin (66.7%) and vancomycin (55.6%). However, resistance was high against cloxacillin (77.8%) and ciprofloxacin (77.8%).

A total of 48 Gram-negative isolates (E. coli, n = 31; Klebsiella spp., n = 15; Enterobacter spp., n = 2) were tested (Table 03).

Among E. coli isolates, susceptibility was highest for Colistin (100.0%), amikacin (83.9%), gentamicin (80.6%), and piperacillin–tazobactam (77.4%). Meropenem retained moderate activity (54.8% susceptibility). Resistance was particularly high to nalidixic acid (96.8%), ceftazidime (93.5%), and ceftriaxone (83.9%), suggesting a high burden of extended-spectrum beta-lactamase (ESBL) producing strains.

Among Klebsiella spp., colistin showed the highest susceptibility (93.3%), while piperacillin–tazobactam and meropenem showed low susceptibility (40.0% and 20.0%, respectively). Resistance to third-generation cephalosporins was universal, as ceftriaxone and ceftazidime demonstrated 100% resistance. Netilmicin and gentamicin were also largely ineffective, with resistance in 93.3% of isolates.

Enterobacter spp. isolates were fully susceptible to piperacillin–tazobactam (100.0%) and colistin (100.0%), but exhibited complete resistance to meropenem, nalidixic acid, cefepime, and ceftriaxone. Due to the low number of isolates (n = 2), interpretation should be made cautiously.

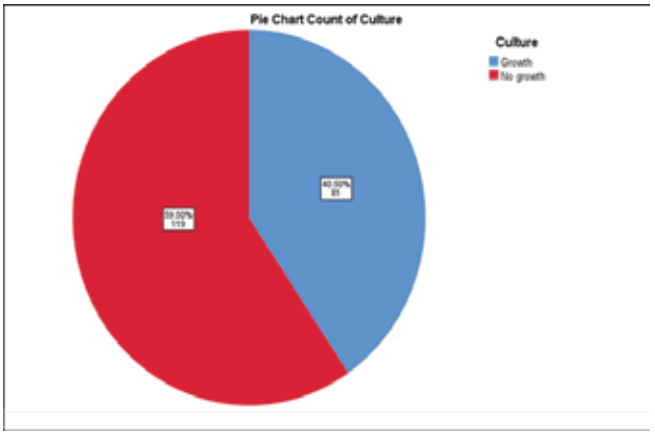

Figure 01: Pie chart indicating the proportion of growth of microbes in blood samples

Table 01: The distribution of microbes isolated from blood samples of ICU patients

Organisms	Number	Percentage
E. coli	31	15.5
Klebsiella	15	7.5
S. aureus	24	12.0
Streptococci	9	4.5
Enterobacter	2	1.0
No growth	119	59.5
Total	200	100.0

Table 02: Antibiotic susceptibility pattern of Gram-positive organisms (n=33)
[Values are expressed as n (%) within each organism]

Antibiotic	Staphylococcus aureus (n=24)			Streptococci (n=9)		
	S n (%)	**R** n (%)	**I** n (%)	**S** n (%)	**R** n (%)	**I** n (%)
Amikacin	16 (66.7)	5 (20.8)	3 (12.5)	6 (66.7)	2 (22.2)	1 (11.1)
Gentamicin	16 (66.7)	7 (29.2)	1 (4.2)	5 (55.6)	2 (22.2)	2 (22.2)
Vancomycin	18 (75.0)	2 (8.3)	4 (16.7)	5 (55.6)	4 (44.4)	0 (0.0)
Cloxacillin	4 (16.7)	16 (66.7)	4 (16.7)	1 (11.1)	7 (77.8)	1 (11.1)
Cefoxitin	4 (16.7)	17 (70.8)	3 (12.5)	1 (11.1)	6 (66.7)	2 (22.2)
Ciprofloxacin	5 (20.8)	11 (45.8)	8 (33.3)	1 (11.1)	7 (77.8)	1 (11.1)
Linezolid	17 (70.9)	1 (4.2)	6 (25.0)	7 (77.8)	0 (0.0)	2 (22.2)
Clindamycin	10 (41.7)	7 (29.2)	7 (29.2)	4 (44.4)	5 (55.6)	0 (0.0)
Meropenem	9 (37.5)	8 (33.3)	7 (29.2)	6 (66.7)	0 (0.0)	3 (33.3)

Footnote: S = Sensitive, R = Resistant, I = Intermediate

Table 03: Antibiotic susceptibility pattern of Gram-negative organisms (n=48)
[Values are expressed as n (%) within each organism]

Antibiotic	E. coli (n=31)			Klebsiella spp. (n=15)			Enterobacter spp. (n=2)		
	S n (%)	**R** n (%)	**I** n (%)	**S** n (%)	**R** n (%)	**I** n (%)	**S** n (%)	**R** n (%)	**I** n (%)
Piperacillin–Tazobactam	24 (77.4)	7 (22.6)	0 (0.0)	6 (40.0)	9 (60.0)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)
Meropenem	17 (54.8)	13 (41.9)	1 (3.2)	3 (20.0)	12 (80.0)	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)
Colistin	31 (100.0)	0 (0.0)	1 (3.2)	14 (93.3)	1 (6.7)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)
Nalidixic Acid	1 (3.2)	30 (96.8)	0 (0.0)	0 (0.0)	13 (86.7)	2 (13.3)	0 (0.0)	2 (100.0)	0 (0.0)
Netilmicin	19 (61.3)	11 (35.5)	0 (0.0)	1 (6.7)	14 (93.3)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)
Gentamicin	25 (80.6)	6 (19.4)	0 (0.0)	1 (6.7)	14 (93.3)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)

Amikacin	26 (83.9)	4(13.0)	1 (3.2)	1 (6.7)	13 (86.7)	1 (6.7)	0 (0.0)	0 (0.0)	2 (100.0)
Cefuroxime	5 (16.1)	20 (64.5)	6(19.3)	1 (6.7)	13 (86.7)	1 (6.7)	0 (0.0)	0 (0.0)	2 (100.0)
Ceftriaxone	5 (16.1)	26 (83.9)	0 (0.0)	0 (0.0)	15 (100.0)	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)
Ceftazidime	2 (6.5)	29 (93.5)	0 (0.0)	0 (0.0)	15 (100.0)	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)
Cefepime	19 (61.3)	11 (35.5)	0 (0.0)	1 (6.7)	14 (93.3)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)

Footnote: S = Sensitive, R = Resistant, I = Intermediate

Discussion

This study assessed the bacterial isolate and antimicrobial susceptibility pattern of bloodstream isolates among ICU patients in Gazi Medical College Hospital, Khulna, Bangladesh. The findings demonstrated a rising burden of bloodstream infections (BSIs), with microbial growth detected in 40.5% of blood samples. This relatively high positivity rate may reflect the critical illness status of ICU patients, frequent use of invasive devices, prolonged hospitalization, and prior exposure to broad-spectrum antibiotics, all of which are well-established risk factors for nosocomial bloodstream infections.[10,11]

In this study, Gram-negative bacteria were the predominant isolates, accounting for the majority of positive cultures. Escherichia coli (15.5%) was the most frequently isolated organism, followed by Staphylococcus aureus (12.0%) and Klebsiella spp. (7.5%). Similar predominance of Gram-negative organisms has been reported in ICU-based bloodstream infection studies from South Asia and other low- and middle-income countries (LMICs), where Enterobacterales are common causes of sepsis and hospital-acquired bacteremia.[12,10] The higher prevalence of Gram-negative isolates may be explained by colonization of the gastrointestinal tract, and selective pressure from frequent cephalosporin and carbapenem exposure in ICU settings. [13]

Among Gram-positive organisms, Staphylococcus aureus is the leading pathogen. The susceptibility patterns revealed markedly high resistance to cefoxitin (70.8%) and cloxacillin (66.7%), indicating a substantial burden of methicillin-resistant Staphylococcus aureus (MRSA) in the ICU. This finding is concerning, as MRSA is associated with increased morbidity, prolonged hospital stay, higher treatment cost, and increased mortality compared to methicillin-sensitive strains (MSSA) (Turner et al., 2019).[14] The high MRSA prevalence observed in the present study aligns with reports from hospital ICUs in Bangladesh and neighbouring regions.[11,15]

Linezolid (70.9%) and vancomycin (75.0%) showed the highest susceptibility among Staphylococcus aureus isolates, indicating that these remain reliable therapeutic options. These findings are consistent with global surveillance data showing that glycopeptides and oxazolidinones continue to be effective against MRSA strains in many settings.[12] However, the reduced susceptibility and intermediate resistance rates observed in vancomycin should be monitored carefully, as vancomycin-intermediate S. aureus (VISA) has been increasing worldwide and may jeopardize future treatment outcomes.[14]

For Streptococci isolates, linezolid remained the most effective drug (77.8%), while resistance was high against ciprofloxacin (77.8%) and cloxacillin (77.8%). Although the sample size for streptococci was small (n=9), the observed resistance trend suggests limited usefulness of fluoroquinolones for empiric coverage of Gram-positive bloodstream infections in this ICU population.

The antimicrobial resistance pattern of Gram-negative isolates is ominous. E. coli exhibited very high resistance to nalidixic acid (96.8%), ceftazidime (93.5%), and

ceftriaxone (83.9%). This strongly suggests a high prevalence of extended-spectrum beta-lactamase (ESBL)-producing Enterobacterales. ESBL-producing organisms are considered a major cause of treatment failure and increased mortality in bloodstream infections marked by reduced efficacy of third-generation cephalosporins.[16,13]

Similarly, Klebsiella spp. showed universal resistance (100%) to ceftriaxone and ceftazidime, further supporting widespread ESBL-mediated resistance. This is consistent with the global rise of ESBL-producing Klebsiella pneumoniae in ICUs, particularly where antibiotic stewardship programs may be limited, and antibiotics are frequently used empirically.[11,13]

In this study, colistin retained the highest activity against Gram-negative organisms, showing 100% susceptibility in E. coli and Enterobacter spp. and 93.3% susceptibility in Klebsiella spp. This is consistent with the role of colistin, which can still be used as a last-resort drug for multidrug-resistant Gram-negative infections, especially carbapenem-resistant Enterobacterales (CRE).[17] However, reliance on colistin is clinically challenging due to its nephrotoxicity and neurotoxicity, and emerging plasmid-mediated resistance mechanisms (mcr genes) are increasingly being reported globally.[13] Therefore, the high dependence on colistin cannot be encouraged in the ICU; rather, it can be considered as an indication of an urgent need for antimicrobial stewardship and enhanced infection control interventions.

Carbapenem susceptibility patterns in this study warrant special attention. Meropenem susceptibility was only 54.8% in E. coli and 20.0% in Klebsiella spp., while Enterobacter spp. showed complete resistance (100%). Recent ICU studies mirror this finding, highlighting the rising carbapenem resistance in Enterobacterales. A multicenter study in Korea reported increasing CRE bacteremia in ICUs with carbapenemase-producing strains and linked to higher mortality.[19] This finding is particularly concerning because carbapenem-resistant Enterobacterales (CRE) are recognized by the World Health Organization as critical priority pathogens due to their limited therapeutic options and high mortality rates.[20] Carbapenem resistance in ICU settings often emerges from excessive carbapenem use, horizontal gene transfer of carbapenemase-producing plasmids, as well as poor infection prevention measures.[13]

Piperacillin–tazobactam demonstrated relatively good susceptibility against E. coli (77.4%) and Enterobacter spp. (100%), but poor susceptibility against Klebsiella spp. (40.0%). This variability is consistent with the global trends where piperacillin-tazobactam (TZP) shows 77-97% susceptibility for E. coli (often boosted by tazobactam against some ESBLs) but lower rates (60-96%) for Klebsiella spp., varying by region, ESBL prevalence, and CLSI/EUCAST breakpoints.[21] This can be explained by complex resistance mechanisms in Klebsiella, including ESBLs combined with porin loss and carbapenemase production, which significantly reduce the effectiveness of beta-lactam/beta-lactamase inhibitor combinations. [16]

Aminoglycosides such as amikacin and gentamicin retained moderate effectiveness against E. coli (83.9% and 80.6% susceptibility, respectively) but were largely ineffective against Klebsiella spp. (only 6.7% susceptibility). A three-year study also demonstrated that the susceptibility of E. coli isolates to aminoglycoside exceeding 80%, whereas that of Klebsiella spp. generally had lower susceptibility levels.[17] This suggests that aminoglycosides may remain useful for empiric coverage in suspected E. coli sepsis but should be avoided as monotherapy, particularly given toxicity risks and poor effectiveness against Klebsiella. Combination therapy guided by susceptibility testing is therefore essential.[18]

The observed resistance patterns highlight a serious therapeutic challenge in ICU bloodstream infections. High resistance to widely used antibiotics, including fluoroquinolones, carbapenems, and third-generation cephalosporins, suggests that empirical regimens may often be insufficient, delaying effective therapy and leading to worse clinical outcomes. Early initiation of appropriate antibiotics is crucial in sepsis management, where inappropriate empiric therapy is strongly associated with increased mortality.[22]

The predominance of multidrug-resistant Gram-negative organisms, combined with high MRSA rates, emphasizes the need for hospital-specific antibiograms to guide empiric antibiotic policies. ICU antibiograms should be updated regularly, as resistance patterns evolve rapidly in high-antibiotic-pressure environments.[23] To lessen the spread of MDROs, antibiotic cycling and de-escalation techniques are also essential, along with stringent infection prevention and control measures like hand hygiene, device-care bundles, and isolation precautions.[11,13]

Conclusion

Overall, the findings of this study indicate a high burden of antimicrobial resistance in bloodstream infections

among ICU patients at Gazi Medical College Hospital. Gram-negative organisms, particularly E. coli and Klebsiella spp., were the predominant pathogens and exhibited high resistance to cephalosporins and fluoroquinolones, strongly suggesting widespread ESBL production. The reduced susceptibility to meropenem is alarming and suggests possible carbapenem resistance. Among Gram-positive organisms, MRSA prevalence was high, though linezolid and vancomycin remained effective. These results underscore the urgent need for strengthened antimicrobial stewardship programs, routine antibiogram updates, and rigorous infection prevention strategies to limit the spread of MDROs in ICU settings.

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