

Microbiological Spectrum and Antimicrobial Resistance Patterns of Bloodstream Infection Isolates in a Tertiary Care Hospital

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World Journal of Biology Pharmacy and Health Sciences, 2026, 25(01), 370-378

Publication history: Received on 22 December 2025; revised on 28 January 2026; accepted on 31 January 2026

Article DOI: <https://doi.org/10.30574/wjbphs.2026.25.1.0072>

Abstract

Background: Bloodstream infections are among the most serious infectious conditions, associated with high morbidity and mortality, particularly in low- and middle-income countries. The rising burden of antimicrobial resistance further complicates the management of BSIs and necessitates continuous local surveillance.

Objective: To determine the culture positivity rate, microbiological spectrum, and antimicrobial susceptibility patterns of bloodstream infection isolates in a tertiary care hospital in Bangladesh.

Methods: This cross-sectional study was conducted in the Department of Microbiology of a tertiary care teaching hospital in Savar, Dhaka, from June to December 2024. A total of 600 blood samples from clinically suspected BSI cases were processed using standard culture techniques. Bacterial isolates were identified by conventional microbiological methods, and antimicrobial susceptibility testing was performed using the Kirby-Bauer disc diffusion method following CLSI guidelines. Multidrug resistance (MDR) was defined as resistance to more than two classes of antibiotics.

Results: Out of 600 samples, 162 (27.0%) were culture positive. Culture positivity was significantly higher among males than females (30.1% vs. 23.9%, $p = 0.041$). The highest proportion of positive cases was observed in the 19–40 years age group (30.5%). Gram-negative bacteria predominated among the isolates. *Escherichia coli* (27.8%) was the most frequently isolated organism, followed by *Klebsiella* spp. (21.0%) and *Salmonella* spp. (17.3%). High susceptibility was observed to amikacin (91.0% in Gram-negative isolates) and meropenem (95.0%), although a small proportion of Gram-negative isolates showed meropenem resistance. Multidrug-resistant isolates accounted for 45.7% of all isolates. MDR status showed significant positive correlation with Gram-negative organisms ($r = 0.42$, $p = 0.001$) and meropenem resistance ($r = 0.36$, $p = 0.004$).

Conclusion: Bloodstream infections remain a significant clinical problem in Bangladesh, with a predominance of Gram-negative pathogens and a high burden of antimicrobial resistance.

Keywords: Bloodstream infection; Antimicrobial resistance; Gram-negative bacteria; Multidrug resistance; Bangladesh

1. Introduction

Bloodstream infections (BSIs) represent one of the most severe forms of infectious diseases and remain a major cause of morbidity and mortality worldwide. BSIs range from transient bacteremia to life-threatening sepsis and septic shock, requiring prompt microbiological diagnosis and early initiation of appropriate antimicrobial therapy¹. Globally,

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bloodstream infections are estimated to affect millions of individuals each year and are associated with prolonged hospital stay, increased healthcare costs, and high case-fatality rates, particularly in low- and middle-income countries (LMICs)².

The epidemiology of bloodstream infections varies considerably across regions, healthcare settings, and patient populations. Common causative agents include *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella* species, *Pseudomonas aeruginosa*, and *Salmonella* species, although their relative distribution differs by geographic location³. In Asian and South Asian countries, *Salmonella enterica*—particularly *Salmonella Typhi*—remains a predominant cause of community-acquired bloodstream infections, in contrast to high-income countries where Gram-positive organisms frequently predominate⁴.

South Asia bears a disproportionate burden of bloodstream infections due to high population density, inadequate sanitation, unsafe water supply, and limited infection prevention and control practices⁵. Studies from India⁶, Nepal⁷, Pakistan⁸, and Bangladesh⁹ have consistently reported a high prevalence of Gram-negative bacteremia, accompanied by alarming levels of antimicrobial resistance. In the Indian subcontinent, increasing resistance to fluoroquinolones and third-generation cephalosporins among *Salmonella*, *E. coli*, and *Klebsiella* species has significantly compromised empirical treatment strategies and clinical outcomes¹⁰.

Bangladesh faces unique challenges in the management of bloodstream infections. The widespread availability of antibiotics without prescription, frequent empirical therapy prior to microbiological confirmation, and limited access to advanced diagnostic facilities have contributed to the rapid emergence and spread of multidrug-resistant (MDR) pathogens¹¹. Previous studies conducted in tertiary care hospitals in Bangladesh have demonstrated a high burden of BSIs caused predominantly by Gram-negative bacteria, particularly *Salmonella Typhi*, *Escherichia coli*, and *Klebsiella* species, along with rising resistance to commonly used antimicrobial agents such as ciprofloxacin and cephalosporins¹².

Antimicrobial resistance among bloodstream infection isolates poses a serious threat to effective patient management, especially in resource-limited healthcare settings¹³. Delays in appropriate antimicrobial therapy due to resistant pathogens are strongly associated with increased mortality in septic patients. Therefore, continuous local surveillance of the microbiological spectrum and antimicrobial susceptibility patterns of blood culture isolates is essential to guide empirical therapy, support antimicrobial stewardship programs, and inform infection control policies¹⁴. The present study was undertaken to determine the microbiological spectrum and antimicrobial resistance patterns of bloodstream infection isolates in a tertiary care hospital

2. Materials and methods

This cross-sectional study was conducted in the Department of Microbiology of a tertiary care teaching hospital in Savar, Dhaka, Bangladesh, over a seven-month period from June 2024 to December 2024. The hospital functions as a major referral center, providing diagnostic and treatment services to both inpatient and outpatient populations. During the study period, a total of 600 blood samples were collected from clinically suspected cases of bloodstream infection (BSI) and processed in the microbiology laboratory following standard laboratory protocols. The study population comprised patients of all age groups and both genders whose blood samples were submitted for culture and antimicrobial susceptibility testing during the study period. Samples were obtained consecutively from both inpatient and outpatient departments.

Blood samples were collected aseptically using 70% alcohol and appropriate antiseptic measures. For adult patients, 8–10 mL of venous blood was collected, while 2–3 mL was collected from pediatric patients. Samples were inoculated into appropriate blood culture bottles and incubated according to the laboratory's standard operating procedures (SOPs). Bottles showing no evidence of microbial growth after the recommended incubation period were considered culture negative, whereas bottles indicating positive growth were further processed.

Positive blood culture bottles were subcultured onto blood agar, MacConkey agar, and chocolate agar media. Blood agar and MacConkey agar plates were incubated aerobically at 37°C for 18–24 hours, while chocolate agar plates were incubated in a candle jar to provide 5–10% CO₂. Bacterial isolates were identified based on colony morphology, Gram staining, and standard biochemical tests. Gram-positive organisms were identified using catalase and coagulase tests. Members of the Enterobacteriaceae family were identified by biochemical tests including indole, citrate, urease, hydrogen sulfide production, and triple sugar iron reactions. Non-lactose fermenting Gram-negative bacilli were identified using oxidase, catalase, indole, urease, and triple sugar iron tests.

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disc diffusion method on Mueller–Hinton agar, and results were interpreted according to the Clinical and Laboratory Standards Institute (CLSI) guidelines. The antibiotics tested included ciprofloxacin (CIP), ceftazidime (CAZ), levofloxacin (LEV), amikacin (AK), aztreonam (ATM), gentamicin (CN), piperacillin–tazobactam (TZP), cefepime (FEP), and meropenem (MEM). The diameters of inhibition zones were measured in millimeters and categorized as sensitive, intermediate, or resistant. For analytical purposes, isolates showing intermediate susceptibility were considered resistant.

Demographic and microbiological data, including age, gender, blood culture results, and antimicrobial susceptibility patterns, were collected retrospectively from hospital laboratory registers, data books, and official laboratory reports. Data were entered into a structured database and analyzed using statistical software. Results were expressed as frequencies and percentages.

Quality control procedures were maintained throughout the study. Reference strains of *Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853), and *Staphylococcus aureus* (ATCC 25923) were used for quality assurance of culture media and antimicrobial susceptibility testing. Media sterility was ensured by incubating randomly selected prepared plates. Multidrug resistance (MDR) was defined as resistance to more than two classes of antimicrobial agents. Methicillin resistance among *Staphylococcus aureus* isolates was determined using the cefoxitin disc method in accordance with CLSI guidelines¹⁵.

3. Results

A total of 600 patients clinically suspected of bloodstream infection were included in the study. Overall, 162 patients (27.0%) were blood culture positive, while 438 patients (73.0%) showed no microbial growth. The study population comprised 306 males (51.0%) and 294 females (49.0%). The majority of patients belonged to the 19–40 years age group, followed by the 41–60 years group (Table 1).

Table 1 Baseline demographic and culture profile of study patients (n = 600)

Characteristics	Number (n)	Percentage (%)
Culture status		
Culture positive	162	27.0
Culture negative	438	73.0
Gender		
Male	306	51.0
Female	294	49.0
Age group (years)		
≤18	110	18.3
19–40	210	35.0
41–60	165	27.5
>60	115	19.2

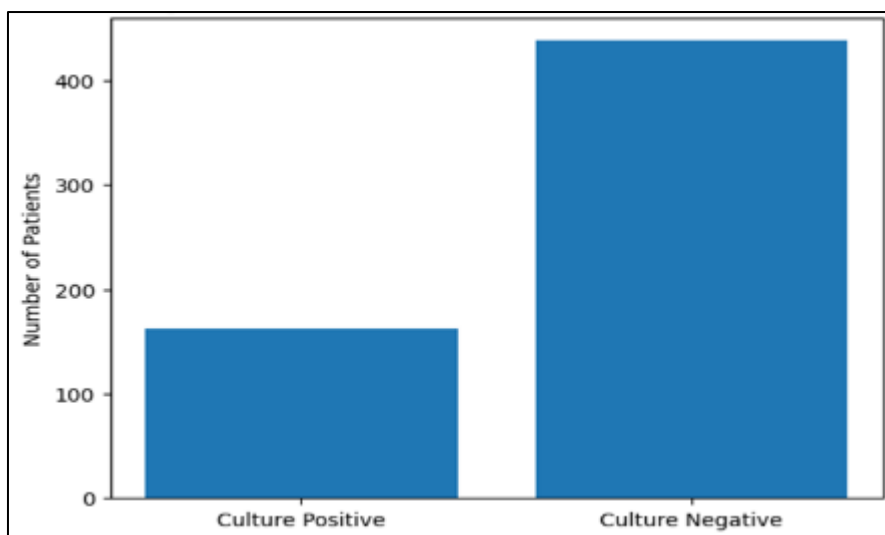


Figure 1 Distribution of Blood Culture Results (n=600)

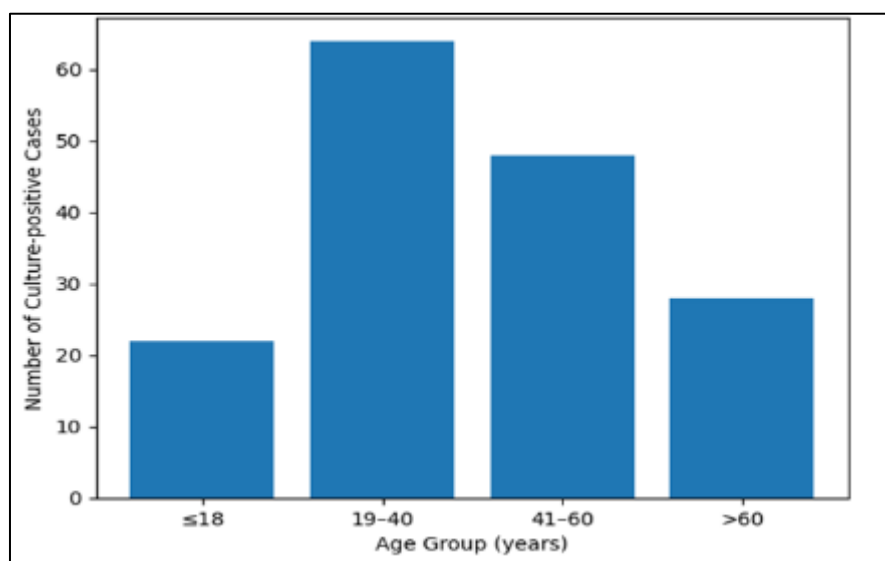


Figure 2 Age-wise Distribution of Culture-positive Cases (n=162)

Among the 162 culture-positive patients, 92 (56.8%) were male and 70 (43.2%) were female. Gender-wise distribution of culture-positive cases is presented in Table 2.

Table 2 Gender distribution of culture-positive cases (n = 162)

Gender	Number (n)	Percentage (%)
Male	92	56.8
Female	70	43.2

Gender-wise comparison of blood culture results among the total study population showed a statistically significant association between gender and culture positivity (χ^2 test, $p = 0.041$). Detailed findings are shown in Table 3.

Table 3 Association between gender and blood culture positivity (n = 600)

Gender	Culture positive (n)	Culture positive (%)	Culture negative (n)	Culture negative (%)	p-value
Male	92	30.1	214	69.9	
Female	70	23.9	224	76.1	0.041

Age-wise analysis of culture-positive cases demonstrated that the highest proportion of positivity was observed in the 19–40 years age group. Distribution of culture-positive cases across different age groups is summarized in Table 4.

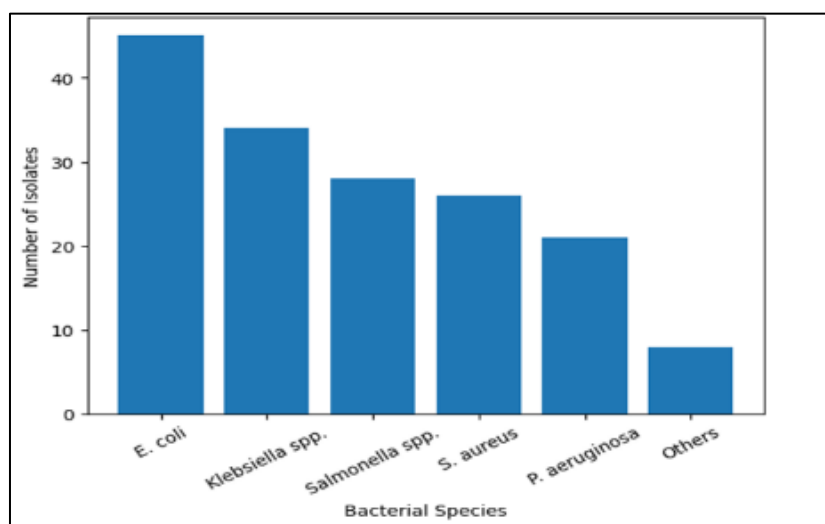
Table 4 Age-wise distribution of culture-positive cases (n = 162)

Age group (years)	Total samples (n)	Culture positive (n)	Culture positive (%)
≤18	110	22	20.0
19–40	210	64	30.5
41–60	165	48	29.1
>60	115	28	24.3

A total of **162 bacterial isolates** were recovered from positive blood cultures. Gram-negative bacteria predominated among the isolates. *Escherichia coli* was the most frequently isolated organism, followed by *Klebsiella* spp. and *Salmonella* spp. The distribution of bacterial isolates is shown in Table 5.

Table 5 Distribution of bacterial isolates recovered from blood cultures (n = 162)

Organism	Number (n)	Percentage (%)
<i>Escherichia coli</i>	45	27.8
<i>Klebsiella</i> spp.	34	21.0
<i>Salmonella</i> spp.	28	17.3
<i>Staphylococcus aureus</i>	26	16.0
<i>Pseudomonas aeruginosa</i>	21	13.0
Others	8	4.9

**Figure 3** Distribution of Bacterial Isolates from Blood Cultures (n=162)

The antimicrobial susceptibility profiles of Gram-positive and Gram-negative isolates against commonly used antibiotics are presented in Table 6.

Table 6 Antimicrobial susceptibility pattern of bloodstream infection isolates

Antibiotic	Gram-positive Sensitive (n)	Gram-positive (%)	Gram-negative Sensitive (n)	Gram-negative (%)
Ciprofloxacin	16	62.0	52	38.0
Gentamicin	20	78.0	98	72.0
Amikacin	22	85.0	124	91.0
Levofloxacin	—	—	57	42.0
Ceftazidime	14	54.0	76	56.0
Cefepime	—	—	75	55.0
Piperacillin-tazobactam	—	—	98	72.0
Meropenem	26	100	129	95.0

Comparison of meropenem susceptibility between Gram-positive and Gram-negative isolates revealed a statistically significant difference ($p = 0.032$). The comparison is summarized in Table 7.

Table 7 Comparison of meropenem susceptibility by organism group

Organism group	Sensitive (n)	Sensitive (%)	Resistant (n)	Resistant (%)	p-value
Gram-positive	26	100	0	0	
Gram-negative	129	95.0	7	5.0	0.032

Among the 162 bacterial isolates, 74 isolates (45.7%) were identified as multidrug-resistant (MDR), while 88 isolates (54.3%) were non-MDR. The distribution of MDR isolates is shown in Table 8.

Table 8 Distribution of multidrug-resistant (MDR) isolates (n = 162)

Category	Number (n)	Percentage (%)
MDR isolates	74	45.7
Non-MDR isolates	88	54.3

Correlation analysis demonstrated significant associations between MDR status and selected microbiological characteristics. Results of the correlation analysis are presented in Table 9.

Table 9 Correlation between MDR status and isolate characteristics

Variables	Correlation coefficient (r)	p-value
MDR status vs Gram-negative isolates	0.42	0.001
MDR status vs Meropenem resistance	0.36	0.004

4. Discussion

Bloodstream infections (BSIs) remain a major cause of morbidity and mortality worldwide, particularly in low- and middle-income countries such as Bangladesh. The present study provides updated insights into the culture positivity

rate, demographic characteristics, microbiological spectrum, and antimicrobial resistance patterns of bloodstream infection isolates in a tertiary care hospital setting.

In this study, the overall blood culture positivity rate was 27.0%, which is comparable to reports from other tertiary care hospitals in Bangladesh and neighboring South Asian countries, where positivity rates ranging from 20% to 35% have been documented. Variations in culture positivity may be influenced by factors such as prior empirical antibiotic use, volume of blood collected, timing of sample collection, and differences in laboratory methodologies¹⁶.

Male patients constituted a slightly higher proportion of culture-positive cases (56.8%) compared to females (43.2%), and a statistically significant association was observed between gender and blood culture positivity. Similar male predominance has been reported in studies from Bangladesh, India, and Nepal. This finding may reflect increased exposure of males to community-acquired infections, occupational risk factors, and healthcare-seeking behaviors, although biological factors cannot be excluded¹⁷.

Age-wise analysis demonstrated that the highest proportion of culture-positive cases occurred in the 19–40 years age group, followed by the 41–60 years group. This observation is consistent with previous regional studies and may be attributed to higher mobility, occupational exposure, and increased risk of community-acquired bloodstream infections among economically active adults. The presence of culture-positive cases across all age groups highlights the broad clinical burden of BSIs in the hospital setting¹⁸.

Analysis of the microbiological spectrum revealed a predominance of Gram-negative bacteria, with *Escherichia coli* being the most frequently isolated organism, followed by *Klebsiella* spp. and *Salmonella* spp. This pattern aligns with reports from Bangladesh and other South Asian countries, where Gram-negative organisms remain the leading causes of bloodstream infections. In contrast, studies from high-income countries often report a higher prevalence of Gram-positive organisms, reflecting differences in healthcare practices, device use, and infection control measures¹⁹.

Antimicrobial susceptibility testing demonstrated variable resistance patterns among the isolates. High susceptibility rates were observed for amikacin and meropenem, whereas reduced susceptibility to fluoroquinolones and third- and fourth-generation cephalosporins was noted, particularly among Gram-negative organisms. These findings are consistent with regional trends indicating widespread resistance to commonly used empirical antibiotics, likely driven by inappropriate antibiotic use and limited antimicrobial stewardship²⁰.

Meropenem showed high effectiveness against both Gram-positive and Gram-negative isolates, although a small proportion of Gram-negative organisms exhibited resistance. The statistically significant difference in meropenem susceptibility between organism groups underscores the importance of continuous surveillance of carbapenem resistance, as the emergence of carbapenem-resistant pathogens poses a serious threat to effective management of severe bloodstream infections²¹.

The prevalence of multidrug-resistant (MDR) isolates in this study was 45.7%, which is alarmingly high and comparable to reports from other tertiary care hospitals in the region. The significant positive correlation between MDR status and Gram-negative isolates further emphasizes the role of Gram-negative bacteria as key drivers of antimicrobial resistance in bloodstream infections. Additionally, the observed association between MDR status and meropenem resistance highlights the potential risk of losing last-line therapeutic options if resistance continues to rise.

5. Conclusion

This study highlights a substantial burden of bloodstream infections in a tertiary care hospital in Bangladesh, with a clear predominance of Gram-negative bacterial pathogens. *Escherichia coli*, *Klebsiella* spp., and *Salmonella* spp. emerged as the most common causative organisms. A high level of antimicrobial resistance, including multidrug-resistant isolates, was observed among bloodstream infection pathogens. Although meropenem remains an effective therapeutic option, the presence of resistant isolates emphasizes the need for its judicious use. Continuous surveillance of bloodstream infection pathogens and their antimicrobial susceptibility patterns is crucial to guide empirical treatment, support antimicrobial stewardship initiatives, and improve patient outcomes in resource-limited healthcare settings.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no potential conflicts of interest.

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