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Microbiological Profile and Antimicrobial Resistance Patterns of Bloodstream Infections in a Tertiary Care Hospital in South India: A Cross-Sectional Study

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ABSTRACT

Background: Bloodstream infections (BSIs) are a major cause of morbidity and mortality, particularly among hospitalized and critically ill patients. The increasing prevalence of multidrug-resistant (MDR) organisms has significantly compromised empirical antimicrobial therapy, especially in resource-limited settings.

Objectives: To evaluate the microbiological profile of bloodstream infections and analyse antimicrobial susceptibility patterns, with emphasis on resistance trends, hospital distribution, and associated clinical risk factors.

Methods: A cross-sectional study was conducted over six months in a tertiary care teaching hospital. A total of 505 patients with suspected BSIs were included, and 521 blood culture samples were processed. Only the first clinically significant isolate per patient was considered. Blood cultures were processed using BACTEC automated blood culture system, and antimicrobial susceptibility testing was performed using the VITEK 2 Compact system as per CLSI 2023 guidelines. Statistical analysis was performed using chi-square test and odds ratios with 95% confidence intervals. Inclusion and exclusion criteria were predefined.

Results: Out of 505 patients, 214 (42.4%) had culture-confirmed BSIs. Gram-negative organisms predominated (85.0%) ($p < 0.001$), with *Klebsiella pneumoniae* (29.9%) and *Acinetobacter* spp. (24.8%) being the most common isolates. Carbapenem resistance was observed in 62.1% of Gram-negative isolates. The overall prevalence of MDR organisms was 56.5%, significantly higher in ICU patients ($p = 0.0004$). Patients with comorbidities had a significantly higher MDR rate ($p = 0.001$). Odds ratios with 95% confidence intervals confirmed significant association of MDR with ICU stay and comorbidities. Colistin and tigecycline showed the highest susceptibility (>90%).

Conclusion: A high burden of Gram-negative BSIs with significant antimicrobial resistance was observed, particularly in intensive care settings. Continuous surveillance and antimicrobial stewardship are essential to optimize empirical therapy and improve clinical outcomes.

Keywords*: Bloodstream infections, antimicrobial resistance, multidrug resistance, Gram-negative bacteria.*

INTRODUCTION

Bloodstream infections are among the most serious infectious diseases encountered in clinical practice and are associated with considerable morbidity, mortality, prolonged hospitalization, and increased healthcare expenditure. Early diagnosis and timely administration of appropriate antimicrobial therapy are critical for improving survival rates in affected patients. However, the growing prevalence of antimicrobial resistance has emerged as a major obstacle in the management of bloodstream infections worldwide.

Recent epidemiological studies have demonstrated a shift toward Gram-negative organisms as the predominant causative agents of bloodstream infections in tertiary care hospitals. Organisms such as Klebsiella pneumoniae, Acinetobacter

species, Pseudomonas aeruginosa, and Escherichia coli have become increasingly important due to their capacity to acquire multiple resistance mechanisms, including extended-spectrum beta-lactamase production and carbapenem resistance (Gandra et al., 2017; Veeraraghavan et al., 2017).

India has reported particularly high rates of antimicrobial resistance because of widespread antibiotic usage, prolonged hospitalization, inadequate infection control practices, and increasing utilization of invasive medical procedures. Surveillance studies conducted across Indian tertiary care centres have highlighted the increasing prevalence of multidrug-resistant organisms in intensive care settings (Datta et al., 2019; Wattal et al., 2010).

The emergence of multidrug-resistant bloodstream pathogens significantly complicates empirical treatment strategies and contributes to poor clinical outcomes. Therefore, periodic evaluation of the local bacteriological profile and resistance trends is essential for guiding clinicians in selecting effective empirical antimicrobial therapy and formulating antibiotic policies.

The present study was conducted to evaluate the microbiological profile of bloodstream infections in a tertiary care hospital in South India and to analyse the associated antimicrobial susceptibility patterns and multidrug resistance trends.

MATERIALS AND METHODS

Study Design and Setting

This cross-sectional study was conducted over a period of six months in the Department of Microbiology at a tertiary care teaching hospital in Karnataka, India.

Study Population

A total of 505 patients of all age groups with clinical suspicion of bloodstream infection were included.

Sample Collection and Processing

A total of 521 blood culture samples were collected under strict aseptic precautions.

- Adults: 8–10 mL blood per sample
- Paediatric patients: 1–3 mL

Blood culture samples were processed using the BACTEC automated blood culture system. Only the first clinically significant isolate per patient was included to avoid duplication.

Identification and Antimicrobial Susceptibility Testing

Identification and antimicrobial susceptibility testing (AST) were performed using the VITEK 2 Compact system in accordance with CLSI 2023 guidelines[11].

Inclusion Criteria:

- Patients with clinical suspicion of bloodstream infection
- All age groups
- First blood culture isolate per patient

Exclusion Criteria:

- Duplicate isolates
- Contaminants without clinical correlation
- Inadequate sample volume

Definitions

- MDR, XDR, and PDR organisms were defined according to Magiorakos et al. (2012) criteria[16].
- Common skin contaminants were excluded unless supported by clinical evidence.

Statistical Analysis

Data were analysed using SPSS software. Chi-square test was applied for categorical variables. Odds ratios (OR) with 95% confidence intervals were calculated. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethics Committee (Registered No.: EC/NEW/INST/2022/3017, NECRBHR, Dept. of Health Research (DHR), No. ECR/2032/Inst/KA/2024, CDSCO/DCGI under New Drugs & Clinical Trials Rules, 2019). Confidentiality of patient data was maintained throughout the study.

RESULTS

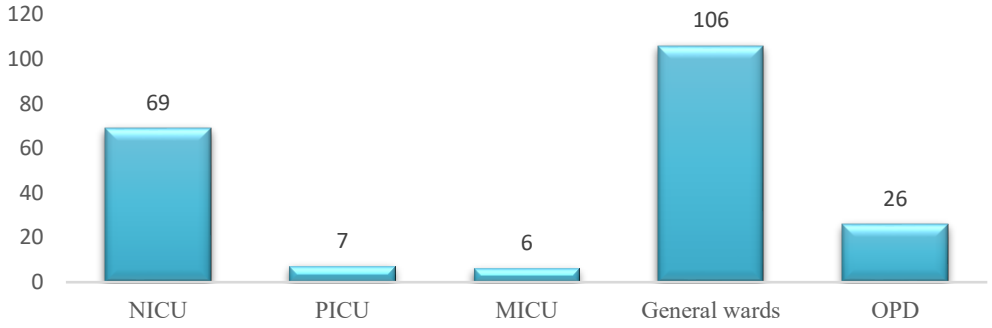
A total of 505 patients with suspected bloodstream infections were included in the study. Among them, 214 cases were culture-positive, yielding an overall positivity rate of 42.4%, while 291 samples showed no growth.

Table 1: Blood culture positivity and Gram-wise distribution of isolates

Parameter	Number	Percentage (%)
Blood Culture Result (n=505)		
Positive	214	42.4
No growth	291	57.6
Gram Distribution (n=214)		
Gram-negative bacilli	182	85.0
Gram-positive cocci	28	13.1
Fungal isolates	4	1.9

Distribution of blood culture results and Gram profile of isolates. Culture positivity was 42.4%. Gram-negative bacilli predominated (85.0%), followed by Gram-positive cocci (13.1%) and fungal isolates (1.9%), showing a significant difference ($p < 0.001$).

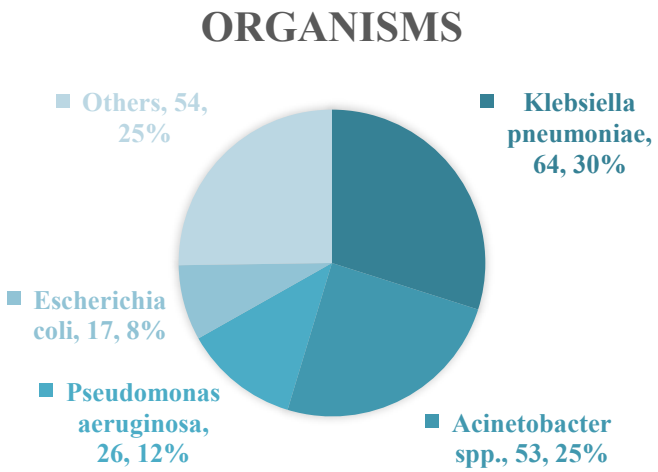
Figure 1: Ward-wise distribution of bloodstream infection cases



Distribution of bloodstream infection cases across hospital wards. Majority of cases were from intensive care units, particularly NICU, indicating higher infection burden in critically ill patients ($p < 0.001$).

The study population included patients across all age groups, with a predominance of neonates (45.7%), followed by paediatric patients (31.8%). Adults and elderly individuals constituted a comparatively smaller proportion of cases. Males accounted for 56.4% of cases, whereas females comprised 43.6%, with no statistically significant difference observed between genders ($p = 0.143$).

Figure 2: Distribution of bacterial isolates in bloodstream infections



Proportion of organisms isolated from bloodstream infections. *Klebsiella pneumoniae* (30%) and *Acinetobacter* spp. (25%) were the most common isolates, followed by other Gram-negative bacteria.

Gram-negative organisms were the predominant isolates, accounting for 85.0% of culture-positive cases, whereas Gram-positive cocci and fungal isolates constituted 13.1% and 1.9% respectively. This difference was statistically significant ($p < 0.001$). Among the isolates, *Klebsiella pneumoniae* was the most frequently identified organism (29.9%), followed by *Acinetobacter* species (24.8%). Other isolates included *Pseudomonas aeruginosa* and *Escherichia coli*.

A significant association was observed between age group and type of organism isolated ($p = 0.003$), with neonatal cases showing a higher proportion of *Klebsiella* and *Acinetobacter* infections. In addition, the majority of infections were

detected in intensive care settings, particularly the neonatal intensive care unit ($p < 0.001$), indicating a higher burden in critically ill patients.

Most bloodstream infections were monomicrobial (99.1%), with polymicrobial infections being uncommon. The average time to positivity was approximately 28 hours, with Gram-negative organisms showing relatively earlier detection compared to Gram-positive organisms ($p = 0.009$).

Analysis of antimicrobial susceptibility patterns revealed a high level of resistance among Gram-negative isolates. Resistance to third-generation cephalosporins and fluoroquinolones exceeded 70%, limiting their utility in empirical therapy. Carbapenem resistance was observed in 62.1% of Gram-negative isolates, with imipenem demonstrating slightly better activity compared to meropenem ($p = 0.042$). In contrast, colistin and tigecycline showed the highest susceptibility rates, exceeding 90%.

Table 2: Antibiotic susceptibility pattern of bloodstream isolates

Antibiotic	Sensitive (n=214)	Percentage (%)
Colistin	174	95.6
Tigecycline	170	93.4
Amikacin	104	57.1
Imipenem	78	42.9
Meropenem	69	37.9

Antimicrobial susceptibility profile of bloodstream isolates. High resistance was observed to cephalosporins and fluoroquinolones (>70%), with carbapenem resistance of 62.1%. Colistin and tigecycline showed the highest susceptibility (>90%).

Table 3: Association of ICU Stay with Multidrug-Resistant (MDR) Isolates

Variable	MDR (n=121)	Non-MDR (n=93)	Total	Odds Ratio (OR)	95% CI	p-value
ICU Patients	89	41	130	3.53	1.95 – 6.39	0.0004
Non-ICU Patients	32	52	84	1.00	—	—
Total	121	93	214	—	—	—

Relationship between ICU admission and multidrug resistance in bloodstream infection isolates, demonstrating a statistically significant association with higher MDR prevalence among ICU patients.
Overall, 56.5% of isolates were classified as multidrug-resistant, 29.9% as extensively drug-resistant, and 8.4% as pandrug-resistant. The prevalence of multidrug resistance was significantly higher among patients admitted to intensive care units ($p = 0.0004$).

Table 4: Association of Comorbid Conditions with MDR Isolates

Variable	MDR (n=121)	Non-MDR (n=93)	Total	Odds Ratio (OR)	95% CI	p-value
With Comorbidities	57	14	71	5.03	2.54 – 9.98	0.001
Without Comorbidities	64	79	143	1.00	—	—
Total	121	93	214	—	—	—

Relationship between comorbid conditions and multidrug resistance, showing a statistically significant increase in MDR isolates among patients with underlying comorbidities.

Among adult patients, a substantial proportion had underlying comorbid conditions. A statistically significant association was found between the presence of comorbidities and multidrug resistance ($p = 0.001$), indicating a higher likelihood of resistant infections in this group.
In terms of clinical outcomes, 78.0% of patients with bloodstream infections recovered, while 11.7% succumbed to the illness. Mortality was higher among patients with infections caused by multidrug-resistant organisms and those admitted to intensive care units.

DISCUSSION

The present study demonstrated a clear predominance of Gram-negative organisms in bloodstream infections, which is consistent with previously published Indian data (Vasudeva et al., 2016; Indian Council of Medical Research [ICMR], 2022; Sharma et al., 2018; Rajni et al., 2014). The high isolation rates of *Klebsiella pneumoniae* and *Acinetobacter* spp. reinforce their established role as major nosocomial pathogens in tertiary care settings (Gandra et al., 2017; Veeraraghavan et al., 2017).

The observed carbapenem resistance rate of 62.1% is comparable to findings reported in Indian surveillance studies, including those from the ICMR antimicrobial resistance network (Indian Council of Medical Research [ICMR], 2022;

Gandra et al., 2017). This high level of resistance is concerning, as carbapenems are often considered last-resort agents for severe Gram-negative infections. The resistance is likely mediated by carbapenemase enzymes such as NDM and OXA-type β-lactamases, along with additional mechanisms like efflux pumps and porin loss.

The predominance of *Klebsiella pneumoniae* and *Acinetobacter* spp. in neonatal and ICU settings in the present study may reflect local antimicrobial pressure, frequent use of invasive devices, and prolonged hospital stay. Similar patterns have been observed in Indian tertiary care centres, highlighting the need for unit-specific antibiotic policies (Wattal et al., 2010; Veeraraghavan et al., 2017).

The high prevalence of multidrug resistance observed in this study is comparable to findings from Indian tertiary care hospitals (Wattal et al., 2010; Veeraraghavan et al., 2017).

The predominance of infections in neonatal and intensive care units highlights the vulnerability of these patient populations. Factors such as invasive procedures, prolonged hospital stay, and immature immunity contribute significantly to infection risk.

A statistically significant association between comorbidities and multidrug resistance was observed, which aligns with previous reports suggesting that repeated healthcare exposure and prior antibiotic use increase the likelihood of resistant infections (Indian Council of Medical Research [ICMR], 2022).

Although colistin and tigecycline retained good activity against most isolates, their use must be judicious due to potential toxicity and the emerging risk of resistance. The findings emphasize the urgent need for strengthening antimicrobial stewardship programs and periodic antibiogram-based empirical therapy protocols.

Conflict of Interest
The authors declare no conflict of interest.
Funding
No external funding was received.

LIMITATIONS

- Single-centre study limiting generalizability
- Short duration of study
- Lack of molecular characterization of resistance mechanisms
- ESBL and carbapenemase production not confirmed phenotypically
- Limited follow-up for long-term outcomes
- Single blood culture per patient in some cases may have affected sensitivity

CONCLUSION

This study highlights a high burden of Gram-negative bloodstream infections with significant antimicrobial resistance, particularly in intensive care settings. The strong association of multidrug resistance with ICU stay and comorbid conditions underscores the need for targeted interventions.

Continuous microbiological surveillance, strict infection control practices, and rational antimicrobial stewardship are essential to optimize empirical therapy and improve patient outcomes.

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