Simgamsetty et al | Article 10124
J Pure Appl Microbiol. 2025. doi: 10.22207/JPAM.19.3.08
Received: 03 December 2024 | Accepted: 10 June 2025

JPAM JOURNAL OF PURE AND APPLIED MICROBIOLOGY
P-ISSN: 0973-7510; E-ISSN: 2581-690X

RESEARCH ARTICLE OPEN ACCESS

Unveiling the Microbial Landscape and Antimicrobial Drug Susceptibility in Intensive Care Unit Blood Cultures

Susmitha Simgamsetty[1]*, Sai Vineela Pilli[1], Muthusamy Raman[2] and Padmaja Yarlagadda[3]

[1]Saveetha Medical College and Hospital, SIMATS, Thandalam, Chennai, Tamil Nadu, India.
[2]Center for Global Health Research, Saveetha Medical College and Hospital, SIMATS, Chennai, Tamil Nadu, India.
[3]Department of Microbiology, NRI Medical College and General Hospital, Guntur, Andhra Pradesh, India.

Abstract

Bloodstream infections caused by bacteria can cause potentially fatal sepsis, which needs immediate antibiotic therapy to prevent morbidity and death of patient. Blood culture remains the gold standard procedure that provides the vital information for the diagnosis and guiding appropriate antimicrobial treatment. The study sought to assess the antibiotic susceptibility and bacteriological profile of blood culture isolates in intensive care unit (ICU) settings. Understanding the incidence of diverse bacteria in ICU blood cultures, as well as their antibiotic susceptibility, is crucial for developing effective treatment plans that work. During the study period, 3,594 blood cultures underwent analysis, revealing 388 cases positive for growth. To identify isolates, VITEK 2 GN ID cards were utilized, capable of discerning both fermentative and non-fermentative bacteria. Further, VITEK 2 GP ID was employed for selected Gram-positive cocci. Antibiotic susceptibility testing was conducted using VITEK 2 AST 407 Critical Care cards for fermentative and non-fermentative Gram-negative bacilli, with subsequent testing on VITEK 2 AST 628 cards for Gram-positive cocci. Out of which, 230 (59.2%) were *Enterobacteriaceae* isolates, 87 (22.4%) were non-fermenters, and 71 (18.2%) were Gram-positive cocci. The majority of the blood culture isolates were multidrug-resistant (MDR), extended-spectrum beta-lactamase (ESBL) producers, carbapenemase producers, and methicillin-resistant *Staphylococcus aureus* (MRSA). In our study, we observed carbapenem-resistant *Klebsiella* spp., *Escherichia coli* (*E. coli*), *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Burkholderia cepacia*, which is alarming. The results show the diverse range of microorganisms responsible for bloodstream infections in severely ill ICU patients. Understanding the antibiotic susceptibility characteristics of these isolates is crucial for developing effective therapeutic regimens.

Keywords: Bloodstream Infections, Enterobacteriaceae, Intensive Care Unit (ICU), Multidrug-resistant (MDR), Non-fermenters, Methicillin-resistant *Staphylococcus aureus* (MRSA), Extended-spectrum Beta-lactamase(ESBL)

***Correspondence:** singamsettysusmitha25@gmail.com

Citation: Simgamsetty S, Pilli SV, Raman M, Yarlagadda P. Unveiling the Microbial Landscape and Antimicrobial Drug Susceptibility in Intensive Care Unit Blood Cultures. *J Pure Appl Microbiol.* Published online 22 July 2025. doi: 10.22207/JPAM.19.3.08

INTRODUCTION

The term bacteremia is a blood-borne bacterial infection and colonization frequently isn't a serious threat to life. Without any apparent clinical symptoms, there are several physiological causes for the transitory bacteremia.[1] However, bacterial infection of blood results in potentially fatal sepsis. Bloodstream infections (BSIs) are a significant contributor to increased mortality and morbidity on a global level.[2] Chills, fever, tachycardia, malaise, hyperventilation, toxicity, hypertension and prostration, are typical indications in septicemia. Acute renal failure with an adverse outcome and the occurrence of disseminated intravascular coagulation are serious consequences. Blood culture provides crucial information about several diseases, such as endocarditis, pyrexia of unclear origin, and pneumonia, in a patient who is suspected of having sepsis.[3]

The most frequent reasons for hospital admissions are bacterial infections that lead to nosocomial infections, particularly in intensive care unit (ICU) settings.[4] Severity of the patient's condition, the amount of time they spend with invasive devices and procedures, the duration of time they interact with medical staff and other variables are all linked to an increased risk of infection and the duration of the hospital stay.[5] Risk factors for bloodstream infections are complex and varied. Age can be a significant factor, especially for elderly patients and newborns. Premorbid medical disorders such as diabetes mellitus, malignancies, renal failure, burns, and prior hospitalization also play an important role. The use of peripheral and central venous catheters on patients is a critical factor.[6] Bloodstream infections are potentially fatal, so it's important to quickly identify the causing organism and assess its resistance to antibiotics. Bacteremia and septicemia are caused by bacteria, both gram-positive and gram-negative. Endotoxic shock, another name for gram-negative septicemia, is a more serious condition than gram-positive septicemia.[7]

If the illness is brought on by resistant bacteria morbidity and death will rise, resulting in significant financial loss that includes the use of more costly drugs to treat infections and the potential for antibiotic resistance. MDR organism-caused illnesses have a higher propensity to lengthen hospital stays, raise mortality rates, and require more costly antibiotics for treatment.[8] Numerous bacteria, including gram-negative ones such as *Escherichia coli, Klebsiella* spp., *Serratia* spp., *Pseudomonas* spp., *Salmonella* spp. and *Enterobacter* spp., alongside gram-positive ones like *Staphylococcus* spp., *Streptococcus* spp. and *Enterococcus* spp. have been connect to the development of blood flow contaminations.[9,10] A recent investigation, however, indicates that the number of bloodstream infections (BSIs) caused by multidrug-resistant bacteria has increased. These bacteria include members of the *Enterobacteriaceae* family, as well as some Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant *Enterococci*. Other Gram-negative bacteria include *Klebsiella* spp., *Pseudomonas* spp., *Acinetobacter* spp. and *Citrobacter* spp. The majority of these bacteria produce extended-spectrum beta-lactamases (ESBL).[11,12] Increasing antibiotic resistance in bacteria from hospital infections and community-acquired illnesses has lowered the effectiveness of many antimicrobial drugs.[13,14]

While numerous studies and infection control principles exist, this study also provides a combined organism-wise antibiogram, which includes less commonly described non-fermenters like *Burkholderia cepacia*, *Aeromonas salmonicida*, *Stenotrophomonas maltophilia*, and rare isolates as well, such as *Pandoraea* spp. and *Rhizobacter rhizobium*. The integration of detailed susceptibility patterns rendered the observed patterns more clinically useful and, in addition to guiding local empirical therapy, facilitated ICU-specific antimicrobial stewardship. A relevant bacteriological profile of ICU blood cultures, with a clear distinction between fermentative and non-fermentative Gram-negative bacteria, is presented. Many studies have described the causative agents of bloodstream infections in ICUs, the microbiologic profile and antibiotic resistance patterns tend to considerably differ in different areas and periods of time, given the presence of emerging resistance mechanisms and infection control practices at the local level. This study is unique in presenting a recent and regionally specific profile.

MATERIALS AND METHODS

We conducted a twelve-month prospective exploratory study at Saveetha Medical College in Thandalam, Chennai, from January 2023 to December 2023. A total of 3594 samples were collected from all Intensive Care Unit (ICU) settings like Medical Intensive Care Unit (MICU), Surgical Intensive Care Unit (SICU), Pediatric Intensive Care Unit (PICU), and Neonatal Intensive Care Unit (NICU) following stringent aseptic methods, which included thoroughly disinfecting the venous site utilizing the Triple Swab technique with 70% alcohol, povidone iodine, and alcohol.

Inclusion criteria

Patients brought to the intensive care unit with laboratory evidence of bloodstream infection, as indicated by positive blood cultures, along with clinical signs of infection such as fever and hypotension, are eligible for inclusion. Additionally, patients with risk factors such as recent surgery, use of a central venous catheter, or prolonged stay in the ICU may also be included. Antimicrobial susceptibility testing is a prerequisite for inclusion to ensure that the study evaluates the effectiveness of antibiotics against isolated microorganisms.

Exclusion criteria

Patients with known viral infections, those with compromised immune systems, those on antibiotic medication before enrollment, and patients whose medical records were insufficient are a few examples of these. Patients who are unable to provide informed permission or who have polymicrobial bloodstream infections may also be excluded.

Table 1. Gender-wise distribution of bloodstream infection (BSI) cases in various ICU settings

Type of ICU	Total cases n (%)	Males n (%)	Females n (%)
SICU	183 (47.16%)	128 (46.54%)	55 (48.67%)
MICU	181 (46.64%)	131 (47.63%)	50 (44.24%)
NICU	13 (3.35%)	8 (2.90%)	5 (4.42%)
PICU	11 (2.83%)	8 (2.90%)	3 (2.65%)
Total	388	275 (70.87%)	113 (29.1%)

If it was feasible, the samples were collected from two distinct locations that were twenty minutes apart. There were 2 samples taken in total. Blood was drawn, with an average of 8 to 10 ml per site. Commercial aerobic blood culture vials from BD BACTEC (Becton Dickinson automated blood culture system) were then filled with the obtained blood samples. that contain soybean casein digest broth, yeast, amino acids, sugar, vitamins and sodium polyanethol sulphonate as a blood thinner. In pediatric cases, a blood sample of 1-2 ml was drawn and administered.[15] Upon collection, these bottles were set up promptly in a fully automated blood culture system, the BD Bactec FX-40, to identify growth in the blood culture. Beep alarms with color coding after positive detection. The blood from the vial was subcultured on both MacConkey and blood agar before being incubated at 37 °C overnight in accordance with standard protocols.[16] Following an evaluation of the colony features and the growth's Gram stain, species identification was performed using Biomerieux's Advanced Expert Phenotypic System that is completely automated (VITEK 2) and to detect patterns of antimicrobial susceptibility.[17]

To identify isolates, VITEK 2 GN ID cards were utilized, capable of discerning both fermentative and non-fermentative bacteria. Further, VITEK 2 GP ID was employed for selected Gram-positive cocci. Antibiotic susceptibility testing was conducted using VITEK 2 AST 407 critical care cards for fermentative and non-fermentative

Table 2. Prevalence of Enterobacteriaceae isolates in BSI among ICU patients

Enterobacteriaceae isolates	ICU-n (%)
Klebsiella spp.	101 (43.91%)
Escherichia coli	92 (40%)
Salmonella typhi	11 (4.78%)
Enterobacter aerogens	9 (3.91%)
Serratia marcescens	7 (3.04%)
Citrobacter freundii	4 (1.73%)
Pantoea dispersia	3 (1.30%)
Salmonella parathphi A	2 (0.86%)
Proteus mirabilis	1 (0.43%)
Total	230 (100%)

Gram-negative bacilli, with subsequent testing on VITEK 2 AST 628 cards for Gram-positive cocci. Isolates were identified as extended-spectrum beta-lactamases (ESBL) with CRE, MRSA, and AmpC-producing organisms.

Antibiotic susceptibility was assessed in accordance with Clinical and Laboratory Standards Institute (CLSI) recommendations. For analysis and presentation, intermediate results were grouped with resistant isolates (CLSI M100, 2024 edition).

Table 3. Prevalence of non fermenters in BSI among ICU patients

Non Fermentative Gram-negative bacteria	ICU-n (%)
Acinetobacter baumanii	32 (36.78%)
Pseudomonas aeroginosa	17 (19.54%)
Burkholderia cepacia	16 (18.39%)
Aeromonas salmonicida	14 (16.09%)
Stenotrophomonas maltophilia	4 (4.59%)
Sphingomonas paucimobilis	1 (1.14%)
Elizabethkingia meningoseptica	1 (1.14%)
Rhizobacter rhizobium	1 (1.14%)
Pandoraea spp.	1 (1.14%)
Total	87 (100%)

Table 4. Prevalence of Gram-positive cocci in BSI among ICU patients

Gram-positive cocci	ICU-n (%)
Coagulase negative *Staphylococci*	36 (50.70%)
Staphylococcus aureus	25 (35.21%)
Enterococcus faecalis	9 (12.67%)
Streptococcus agalactiae	1 (1.40%)
Total	71 (100%)

Table 5. Antibiotic susceptibility Patterns of Enterobacterial Isolates in BSI

Antibiotic	*K. pneumoniae* 101 (25.96%)	*E. coli* 92 (23.65%)	*Citrobacter* spp. 4 (1.02%)	*Pantoea dispersia* 3 (0.77%)	*Enterobacter* spp. 9 (2.31%)
Amikacin	5 (4.95%)	0	0	0	3 (33.33%)
Cefepime	23 (22.77%)	40 (43.47%)	3 (75%)	1 (33.33%)	2 (22.22%)
Cefoperazone/ Sulbactum	1 (0.99%)	4 (4.34%)	1 (25%)	0	0
Ceftazidime	22 (21.78%)	0	0	0	1 (11.11%)
Ciprofloxacin	0	20 (21.73%)	2 (50%)	0	3 (33.33%)
Colistin	65 (64.35%)	70 (76.08%)	0	1 (33.33%)	5 (55.55%)
Gentamicin	0	0	0	0	1 (11.11%)
Imipenem	4 (3.96%)	18 (19.56%)	0	0	0
Meropenem	31 (30.69%)	52 (56.52%)	3 (75%)	0	4 (44.44%)
Piperacillin/ Tazobactum	0	0	0	0	1 (11.11%)
Tetracycline	28 (27.72%)	43 (46.73%)	2 (50%)	2 (66.67%)	6 (66.66%)
Tigecycline	0	0	3 (75%)	0	0
Ceftrixone	0	35 (38.04%)	0	0	0
Amox/clav	12 (11.88%)	1 (1.08%)	0	0	1 (11.11%)
Cotrimoxazole	0	23 (25%)	2 (50%)	1 (33.33%)	4 (44.44%)
ceftizoxime	22 (21.78%)	35 (38.04%)	1 (25%)	0	2 (22.22%)
Tobramycin	26 (25.74%)	51 (55.43%)	3 (75%)	1 (33.33%)	5 (55.55%)
Minocycline	0	0	0	1 (33.33%)	0
Ceftazidime/ Avibactum	37 (36.63%)	47 (51.09%)	3 (75%)	0	4 (44.44%)
Chloramphenicol	30 (29.70%)	59 (64.13%)	0	0	2 (22.22%)
Polymyxin B	65 (64.35%)	66 (71.74%)	0	0	1 (11.11%)
Ceftazidime+ Tazobactum	33 (32.67%)	44 (47.83%)	0	0	1 (11.11%)

Note. Susceptibility testing followed CLSI guidelines, with isolates showing intermediate susceptibility considered resistant in this analysis.

Table 6. Antibiotic susceptibility Patterns of Enterobacterial Isolates in BSI

Antibiotic	*P. mirabilis* 1 (0.25%)	*S. marcesence* 7 (1.79%)	*S. typhi* 11 (2.82%)	*S. paratyphi* A 2 (0.51%)
Amikacin	0	0		
Ceftazidime	0	0	6 (54.54%)	2 (100%)
Cefoperazone/ Sulbactum	0	0	NT	NT
Netilmicin	1 (100%)	6 (85.71%)	NT	NT
Ciprofloxacin	0	0	5 (45.45%)	1 (50%)
Tobramycin	0	4 (57.14%)	4 (36.36%)	0
Gentamicin	0	3 (42.85%)	2 (18.18%)	2 (100%)
Imipenem	0	0	9 (81.81%)	1 (50%)
Meropenem	0	6 (85.71%)	7 (63.63%)	1 (50%)
Piperacillin/ Tazobactum	0	0	4 (36.36%)	1 (50%)
Tigecycline	0	4 (57.14%)	NT	NT
colistin	0	0	NT	NT
Azithromycin	NT	NT	NT	0
Ceftrixone	NT	NT	4 (36.36%)	1 (50%)
Cotrimoxazole	NT	NT	5 (45.45%)	2 (100%)
Minocycline	NT	NT	4 (36.36%)	1 (50%)
Chloramphenicol	NT	NT	8 (72.72%)	1 (50%)

Note. Susceptibility testing followed CLSI guidelines, with isolates showing intermediate susceptibility considered resistant in this analysis.

Statistical analysis and data management

SPSS version 20.0 and Microsoft Excel 2007 were used for data entry, results interpretation and analysis. Descriptive statistics were used for analyzing the patient demographic profile, the pattern of prescribing antibiotics and the isolation of different organisms and their antibiograms. Results were expressed as frequencies and percentages. No inferential statistical tests were used.

RESULTS

Of the 3594 blood cultures examined during the research period, 388 (10.7%) were positive for growth. In the ICU settings, SICU had the highest number of cases at 183 (47.1%), while PICU had 11 cases (2.8%). In terms of gender distribution, males comprised the majority (70.8%) across all the units compared to females as shown in Table 1.

Table 1 shows the number and percentage of BSI cases among male and female patients in the Surgical Intensive Care Unit (SICU), Medical Intensive Care Unit (MICU), Neonatal Intensive Care Unit (NICU), and Pediatric Intensive Care Unit (PICU).

Out of 388 positive cultures, 230 (59.2%) were Enterobacteriaceae isolates, 87 (22.4%) were non-fermenters and 71 (18.2%) were Gram-positive cocci.

Among 230 Enterobacteriaceae isolates, the predominant isolate was *Klebsiella* spp. accounting for 101 (43.9%) cases, while the lowest case was one instance of *Proteus mirabilis* (0.4%), as highlighted in Table 2.

Among the 87 (22.4%) non-fermenter isolates, the predominant isolate was *A. baumannii* with 32 cases (36.7%), while the lowest were one (1.1%) each *of Elizabethkingia meningoseptica, Rhizobacter rhizobium,* and *Pandoraea* spp. respectively, as highlighted in Table 3.

Among the 71 (18.2%) Gram-positive isolates, the most common type was coagulase-negative *staphylococci* (CoNS), accounting for 36 (50.7%) cases, while the least common was *Streptococcus agalactiae* with one case (1.4%), as shown in Table 4.

Table 7. Exploring Antibiotic susceptibility Patterns: non-fermenter Isolates in BSI

Antibiotic	*A. baumanii* 32 (8.22%)	*P. aeruginosa* 17 (4.37%)	*B. cepacia* 16 (4.11%)	*S. maltophilia* 4 (1.02%)	*S. paucimobilis* 1 (0.25%)
Amikacin	0	2 (11.76%)	0	0	0
Cefepime	5 (15.62%)	4 (23.53%)	3 (18.75%)	0	1 (100%)
Cefoperazone/ Sulbactum	0	3 (17.65%)	1 (6.25%)	0	0
Levofloxacin	8 (25%)	9 (52.94%)	7 (43.75%)	4 (100%)	1 (100%)
Ceftazidime	0	5 (29.41%)	2 (12.5%)	0	0
Ciprofloxacin	4 (12.5%)	2 (11.76%)	0	0	1 (100%)
Colistin	12 (37.5%)	0	0	0	1 (100%)
Imipenem	0	0	0	0	0
Meropenem	9 (28.12%)	10 (58.82%)	10 (62.5%)	0	1 (100%)
Netilmicin	12 (37.5%)	7 (41.18%)	5 (31.25%)	0	0
Piperacillin/ Tazobactum	0	0	0	0	0
Tetracycline	12 (37.5%)	4 (23.53%)	5 (31.25%)	0	0
Tigecycline	0	0	0	0	0
Ceftrixone	12 (37.5%)	1 (5.88%)	8 (50%)	0	1 (100%)
Azetreonam	0	0	0	0	0
Tobramycin	11 (34.37%)	11 (64.71%)	3 (18.75%)	0	1 (100%)
Minocycline	5 (15.62%)	0	8 (50%)	1 (25%)	0
Ceftazidime/ Avibactum	0	5 (29.41%)	4 (25%)	0	0
Polymyxin B	13 (40.62%)	3 (17.65%)	0	0	0
Ceftazidime + Tazobactum	0	4 (23.53%)	1 (6.25%)	0	NT

Note. Susceptibility testing followed CLSI guidelines, with isolates showing intermediate susceptibility considered resistant in this analysis.

Investigation evaluated the susceptibility of Enterobacterial isolates' to antibiotics as highlighted in Table 5 and 6.

Among Enterobacteriaceae *E. coli* and *Klebsiella* spp. showed highest susceptibility rates Colistin, Polymyxin B, Ceftazidime/Avibactam, Meropenem as shown in Table 5. The susceptibility rates to other antibiotics varied. These results highlight the importance of individualized antibiotic treatment for the management of bloodstream infections, especially in critical care units. A number of antibiotics, including Amikacin, Cefepime, Cefoperazone/Sulbactam, Ceftazidime, Imipenem, Piperacillin/Tazobactam, Ceftazidime/Avibactam, Polymyxin B, and Ceftazidime/Tazobactam, did not show susceptibility against these non-fermenter isolates in the study.

Table 7 shows the antibiotic susceptibility patterns of non-fermentative Gram-negative bacteria that were found in the blood of ICU patients with bloodstream infections (BSIs). The information shows how many and what proportion of isolates of *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Burkholderia cepacia*, *Stenotrophomonas maltophilia*, and *Sphingomonas paucimobilis* are responsive to different antibiotics. NT: Not Tested.

Table 8 shows the antibiotic susceptibility profiles of *Aeromonas salmonicida*, *Elizabethkingia meningoseptica*, *Rhizobium radiobacter*, and *Pandoraea* spp. isolated from ICU patients with BSIs. The data show the number and percentage of isolates sensitive to various antibiotics. NT: Not Tested.

Table 9 shows sensitivity gram-positive organism patterns. *Staphylococcus aureus* showed highest sensitive to teicoplanin followed by followed by vancomycin, linezolid, daptomycin, rifampicin, clindamycin, and tetracycline (76%). Resistance was higher against erythromycin,

Table 8. Exploring Antibiotic susceptibility Patterns of non-fermentative Gram-negative isolates in BSI

Antibiotic	*A. salmonicida* 14 (3.59%)	*E. meningoseptica* 1 (0.25%)	*R. rhizobium* 1 (0.25%)	*Pandorea* spp. 1 (0.25%)
Amikacin	0	0	0	1 (100%)
Cefepime	0	0	0	0
Cefoperazone/ Sulbactum	1 (7.14%)	0	0	0
Levofloxacin	2 (14.28%)	0	1 (100%)	1 (100%)
Ceftazidime	1 (7.14%)	0	0	0
Ciprofloxacin	1 (7.14%)	0	1 (100%)	1 (100%)
Colistin	1 (7.14%)	0	0	0
Imipenem	0	0	0	0
Meropenem	2 (14.28%)	0	0	0
Netilmicin	1 (7.14%)	0	0	0
Piperacillin/ Tazobactum	0	0	0	0
Tetracycline	1 (7.14%)	1 (100%)	0	0
Tigecycline	1 (7.14%)	0	0	0
Ceftrixone	0	0	0	0
Azetronam	1 (7.14%)	NT	NT	NT
Tobramycin	0	0	0	1 (100%)
Minocycline	1 (7.14%)	0	0	0
Ceftazidime/ Avibactum	0	0	0	0
Polymyxin B	0	0	0	0
Ceftazidime + Tazobactum	0	0	0	0

Note. Susceptibility testing followed CLSI guidelines, with isolates showing intermediate susceptibility considered resistant in this analysis.

benzylpenicillin, co-trimoxazole, and ciprofloxacin. *Enterococcus faecalis* shows 100% sensitivity to linezolid with least sensitivity to erythromycin, ciprofloxacin and tetracycline *Streptococcus agalactiae* demonstrated 100% sensitivity to tetracycline, vancomycin, and linezolid.

DISCUSSION

The study set out to identify the bacterial profile and susceptibility pattern of the organisms that cause bloodstream infections (BSIs). The prevalence of blood culture positivity was observed in 10.7% of samples in our study. The low culture positivity rate of 10.7% seen in this investigation is comparable to results from a few other studies carried out by Khanal *et al*. and Gohel *et al*., which showed culture positivity rates from BSI patients in India of 10.3% and 9.2%, respectively.[12,18] Culshaw *et al*. reported 12.2%, which is slightly higher than our study findings.[19] Similar to studies by Kalpesh *et al*. and Oluwalana *et al*., CoNS (50.7%) and *S. aureus* (35.2%) were the most common isolates among Gram-positive isolates in our study.[12,20] Among isolates, *E. coli, Klebsiella* spp. and *A. baumannii* complex were the common Gram-negative isolates in this study. This is comparable to the studies conducted by Gohel, Bhatia *et al*., ASM Areef *et al*., and Fatima *et al*.[12,21-23] Gram-negative isolates caused more septicemia in this study than Gram-positive isolates, as has been shown in other studies as well.[24-26]

Enterobacteriaceae group was responsible for the majority of sepsis cases (59.2%). Among all Enterobacteriaceae isolates, *Klebsiella* spp., *E. coli*, followed by *Salmonella typhi* and *Enterobacter* spp. were predominant. This study has similarities to those carried out by Palewar *et al*., Gupta *et al*., Vanitha *et al.* and Banik et al.[24-27]

Table 9. Exploring Antibiotic susceptibility Patterns: gram-positive Isolates in BSI

Antibiotic	*S. aureus* 25 (6.42%)	CoNS 36 (9.25%)	*E. faecalis* 9 (2.31%)	*S. agalactiae* 1 (0.25%)
Benzylpenicilin	9 (36%)	2 (5.55%)	5 (56%)	0
cefoxitin	8 (32%)	11 (30.55%)	NT	0
Erythromycin	10 (40%)	8 (22.22%)	2 (22%)	0
Clindamycin	20 (80%)	8 (22.22%)	0	0
Cotrimoxazole	7 (28%)	19 (52.77%)	0	0
Gentamicin	17 (68%)	13 (36.11%)	0	0
Ciprofloxacin	6 (24%)	9 (25%)	2 (22%)	0
Vancomycin	23 (92%)	18 (50%)	0	1 (100%)
Teicoplanin	24 (96%)	17 (47.22%)	8 (89%)	0
Linezolid	23 (92%)	20 (55.55%)	9 (100%)	1 (100%)
Rifampicin	21 (84%)	18 (50%)	0	0
High level Gentamicin	NT	NT	6 (67%)	0
Amoxicilin/ clavulinic acid	0	3 (8.33%)	0	0
Tetracycline	19 (76%)	16 (44.44%)	1 (11%)	1 (100%)
Ampicilin	NT	NT	0	NT
Daptomycin	23 (92%)	16 (44.44%)	8 (89%)	0
Amikacin	0	5 (13.88%)	0	0
Cefoperazone/ Sulbactum	0	0	0	0

Note. Susceptibility testing followed CLSI guidelines, with isolates showing intermediate susceptibility considered resistant in this analysis.

Among non-fermenter isolates, *A. baumannii* (36.78%) predominated, followed by *P. aeruginosa* (19.5%) and *B. cepacia* (18.3%). This is comparable to the studies conducted by ASM Ahsan *et al*., Fasih *et al*., and Baral *et al*.[22,23,28]

Among 71 (18.2%) isolates of Gram-positive cocci, *S. aureus* and *Enterococcus* spp. showed >80% sensitivity to Teicoplanin, Vancomycin, Linezolid, Daptomycin, and Clindamycin. A total of 42 methicillin-resistant strains including CoNS and *S. aureus* were not 100% sensitive to Vancomycin. This is in contrast to the study conducted by Oluwalana *et al*.[2] but consistent with studies conducted by Garg *et al*., Gupta *et al*., and Kavitha *et al*.[7,25,29] Teicoplanin should be considered as a treatment option for MRSA strains before Vancomycin, as most of the MRSA and VRSA strains were sensitive to Teicoplanin in this study. Therefore, Teicoplanin should be taken into consideration to treat Vancomycin-resistant *Staphylococcus* strains (VRSA). This is consistent with studies conducted by Garg *et al*. and Kalowsky *et al*.[7,30]

Among Enterobacteriaceae isolates, there was poor sensitivity to quinolones, penicillins, cephalosporins, carbapenems, aminoglycosides, and colistin. This is similar to the studies conducted by Kalpesh *et al*., Ahsan *et al*., and Prakash *et al*.[12,22,31] The susceptibility and resistance patterns found are consistent with CLSI-defined breakpoints (CLSI M100, 2024), as described in the Methods.[32]

Among non-fermenter isolates, *A. baumannii* was predominantly 100% resistant to carbapenems, aminoglycosides, cephalosporins, and monobactam drugs, followed by *P. aeruginosa*, *B. cepacia*, *S. maltophilia*, and *S. paucimobilis*. This is consistent with the studies conducted by Ahsan *et al*. and Baral *et al*.[22,28]

CONCLUSION

In conclusion, implementation of hospital-wide program like bloodstream infection (BSI) surveillance in ICU settings improves patient outcomes and lowers the burden of infections. Essentially, using antibiograms in conjunction with BSI surveillance accounts to a multimodal strategy for antibiotic administration and infection control in critical care units. Hospitals may upgrade patient safety, mitigate the risk of bloodstream infections, along with support the overall goals of antimicrobial stewardship and healthcare quality improvement by effectively using these innovations.

ACKNOWLEDGMENTS

The authors express their gratitude to all healthcare workers and laboratory personnel who assisted in the collection and analysis of blood culture samples in the ICU. Their effort and skills were critical to the success of our investigation. The authors would also like to thank the Institutional Ethics Committee for their assistance and permission to conduct this study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

FUNDING

None

DATA AVAILABILITY

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

ETHICS STATEMENT

The study protocol was reviewed and approved by the Institutional Ethics Committee, Saveetha Medical College, with approval no.: SMC/IEC/2024/078

INFORMED CONSENT

Written informed consent was obtained from the participants before enrolling in the study.

REFERENCES

1. Qureshi M, Aziz F. Prevalence of microbial isolates in blood cultures and their antimicrobial susceptibility profiles. *Biomedica.* 2011;27(6):136-139.
2. Reinhart K, Bauer M, Riedemann NC, Hartog CS. New approaches to sepsis: molecular diagnostics and biomarkers. *Clin Microbiol Rev.* 2012;25(4):609-634. doi: 10.1128/CMR.00016-12
3. Kingsley OC, Ifeanyi AO, Edet AE, Smart OC. Bacteriologic profile and antibiotic susceptibility pattern of suspected septicaemic patients in Uyo, Nigeria. *Res J Med Sci.* 2013;7(2):35-39. doi: 10.3923/rjmsci.2013.35.39
4. Magill SS, Edwards JR, Bamberg W, et al. Multistate point-prevalence survey of health care-associated infections. *N Engl J Med.* 2014;370(13):1198-1208. doi: 10.1056/NEJMoa1306801
5. Savanur SS, Gururaj H. Study of antibiotic sensitivity and resistance pattern of bacterial isolates in intensive care unit setup of a tertiary care hospital. *Indian J Crit Care Med.* 2019;23(12):547-555. doi: 10.5005/jp-journals-10071-23295
6. Sainfer A, Bevin C, Jianfang L, Elaine L. Prevalence and risk factors for bloodstream infections present on hospital admission. *J Infect Prev.* 2017;19(1):37-42. doi: 10.1177/1757177417720998
7. Garg A, Anupurba S, Garg J, Goyal RK, Sen MR. Bacteriological profile and antimicrobial resistance of blood culture isolates from a university hospital. *J Indian Acad Clin Med.* 2007;8(2):139-143.
8. Subedi S, Chaudhary M, Shrestha B. High MDR and ESBL producing *Escherichia coli* and *Klebsiella pneumoniae* from urine, pus, and sputum samples. *J Adv Med Med Res.* 2016;13(10):1-10. doi: 10.9734/BJMMR/2016/23350
9. Ahmed D, Nahid MA, Sami AB, et al. Bacterial etiology of bloodstream infections and antimicrobial resistance in Dhaka, Bangladesh, 2005-2014. *Antimicrob Resist Infect Control.* 2017;6:2. doi: 10.1186/s13756-016-0162-z
10. Rolston KV, Yadegarynia D, Kontoyiannis DP, Raad II, Ho DH. The spectrum of Gram-positive bloodstream infections in patients with hematologic malignancies, and the *in vitro* activity of various quinolones against Gram-positive bacteria isolated from cancer patients. *Int J Infect Dis.* 2006;10(3):223-230. doi: 10.1016/j.ijid.2005.05.007
11. Collee JG, Duguid JP, Fraser AG, Marmion BP, Simmons A, editors. Laboratory strategies in the diagnosis of infective syndromes. In: Collee JG, Duguid JP, Fraser AG, Marmion BP, Simmons A, editors. Mackie and McCartney Practical Medical Microbiology. 14th ed. New Delhi, India: Elsevier. 2006:55-57.
12. Gohel K, Jojera A, Soni S, Gang S, Sabnis R, Desai M. Bacteriological profile and drug resistance patterns of blood culture isolates in a tertiary care nephrourology teaching institute. *Biomed Res Int.* 2014;2014(1):1-5. doi: 10.1155/2014/153747
13. Karki S, Rai GK, Manandhar R. Bacteriological analysis and antibiotic sensitivity pattern of blood cultures isolated in Kanti Children hospital. *J Nepal Paediatr Soc.* 2010;30(2):94-97. doi: 10.3126/jnps.v30i2.2482
14. Magiorakos AP, Srinivasan A, Carey RB, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert

proposal for interim standard definitions for acquired resistance. *Clin Microbiol Infect.* 2012;18(3):268-281. doi: 10.1111/j.1469-0691.2011.03570.x
15. Padmaja K, Sudhaharan S, Vemu L, Teja VD. Early identification and antimicrobial susceptibility testing of short versus standard incubated blood cultures from a tertiary care centre in southern India. *J Clin Diagn Res.* 2022;16(2):DC20-DC24. doi: 10.7860/JCDR/2022/52679.16004
16. Bergey DH, Buchanan RE, Gibbons NE. Bergey's Manual of Determinative Bacteriology. Baltimore: Williams & Wilkins Co.. 1975:71-348.
17. BioMerieux. VITEK 2 User Manual. Durham, NC: BioMerieux Clinical Diagnostics. 2015.
18. Khanal LK. Bacteriological profile of blood culture and antibiogram of the bacterial isolates in a tertiary care hospital. *Int J Health Sci Res.* 2020;10(8):10-14.
19. Culshaw N, Glover G, Whiteley C, et al. Healthcare-associated bloodstream infections in critically ill patients: descriptive cross-sectional database study concordance with clinical sites isolates. *Ann Intensive Care.* 2014;4:34. doi: 10.1186/s13613-014-0034-8
20. Oyekale TO, Ojo BO, Olajide AT, Oyekale OI. Bacteriological profile and antibiogram of blood culture isolates from bloodstream infections in a rural tertiary hospital in Nigeria. *Afr J Lab Med*. 2023;11(1):1-10. doi: 10.4102/ajlm.v11i1.1807
21. Bhatia A, Kalra J, Kohli S, Kakati B, Kaushik R. Antibiotic resistance pattern in intensive care unit of a tertiary care teaching hospital. *Int J Basic Clin Pharmacol.* 2018;7:906-911. doi: 10.18203/2319-2003.ijbcp20181633
22. Ahsan A, Fatema K, Barai L, et al. Prevalence and antimicrobial resistance pattern of blood isolates in patients of septicemia in ICU: single centre observation Bangladesh. *Crit Care J.* 2016;4(2):100-104. doi: 10.3329/bccj.v4i2.30025
23. Fasih F, Baig S, Zameer S, Naseem S, Sharafat S. Bacteriological profile and drug resistance patterns of blood culture isolates: a five year audit from tertiary care hospital. *Isra Med J.* 2019;11(6):449-453.
24. Palewar M, Mudshingkar S, Dohe V, Kagal A, Karyakarte R. Bacteriological profile and antibiogram of blood culture isolates from a tertiary care hospital of Western India. *J Datta Meghe Inst Med Sci Univ.* 2020;15(2):261-265. doi: 10.4103/jdmimsu.jdmimsu_10_20
25. Gupta S, Kashyap B. Bacteriological profile and antibiogram of blood culture isolates from a tertiary care hospital of North India. *Trop J Med Res.* 2016;19:94-99. doi: 10.4103/1119-0388.185426
26. Vanitha RN, Kannan G, Venkata NM, et al. A retrospective study on bloodstream infections and antibiotic susceptibility patterns in a tertiary care teaching hospital. *Int J Pharm Sci.* 2012;4:543-548.
27. Banik A, Bhat SH, Kumar A, Palit A, Snehaa K. Bloodstream infections and trend of antimicrobial sensitivity patterns at Port Blair. *J Lab Physicians.* 2018;10(3):332-337. doi: 10.4103/JLP.JLP_50_18
28. Barai L, Fatema K, Haq JA, et al. Bacterial profile and their antimicrobial resistance pattern in an intensive care unit of a tertiary care hospital in Dhaka. *Ibrahim Med Coll J.* 2010;4(2):66-69. doi: 10.3329/imcj.v4i2.6499
29. Kavitha P, Sevitha B, Sunil R. Bacteriological profile and antibiogram of blood culture isolates in a pediatric care unit. *J Lab Physicians.* 2010;2(2):85-88. doi: 10.4103/0974-2727.72156
30. Karlowsky JA, Jones ME, Draghi DC, et al. Prevalence and antimicrobial susceptibilities of bacteria isolated from blood cultures of hospitalized patients in the United States in 2002. *Ann Clin Microbiol Antimicrob.* 2004;3:7. doi: 10.1186/1476-0711-3-7
31. Simkhada P, KC SR, Lamichhane S, Subedi S, Thapa Shrestha U. Bacteriological profile and antimicrobial susceptibility patterns of clinical isolates in a tertiary care hospital. *Glob J Med Res C Microbiol Pathol.* 2016;16(1):1-10
32. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing. 34th ed. CLSI supplement M100. Wayne, PA: Clinical and Laboratory Standards Institute; February 28, 2024.