Section: Miscellaneous

Original Research Article

MICROBIOLOGICAL PROFILE IN PEDIATRIC BLOODSTREAM INFECTIONS: A TERTIARY CARE STUDY

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ABSTRACT

Background: Bloodstream infections (BSIs) remain a significant cause of morbidity and mortality in pediatric populations, particularly in hospital settings. The emergence of multidrug-resistant (MDR), extensively drug-resistant (XDR), and fungal pathogens further complicates management. This study aims to analyze the clinical and microbiological profile of pediatric BSI cases and evaluate antimicrobial resistance and sensitivity patterns in a tertiary care hospital.

Materials and Methods: This retrospective observational study included pediatric patients diagnosed with BSI over a defined period. Clinical, hematological, and microbiological data were analyzed, including blood culture results, Gram stain characteristics, organism isolated, resistance profile, and antimicrobial sensitivity. Patients were stratified into Gram-positive, Gram-negative, and fungal groups. Additional cases of candidemia in pediatric oncology patients were included for subgroup analysis. Descriptive statistics and frequency distributions were used to evaluate clinical parameters and resistance patterns.

Results: Of 105 pediatric cases analyzed, 49.5% had culture-positive BSIs. Gram-negative organisms were more prevalent than Gram-positive, with Klebsiella pneumoniae and E. coli being the most common isolates. Staphylococcus aureus was the leading Gram-positive pathogen. XDR isolates were observed predominantly among Gram-negative pathogens, and sensitivity to Ceftazidime-Avibactam was noted. Cefoxitin screening for MRSA was documented for *S. aureus*. Two cases of candidemia were reported in pediatric oncology patients, with a favorable response to Amphotericin B. Elevated CRP, procalcitonin, and lactate levels correlated with poor outcomes, including ICU admission and mortality.

Conclusion: Pediatric BSIs exhibit a diverse microbiological profile, with a rising burden of antimicrobial resistance. Stratifying infections by Gram stain and resistance patterns provides essential guidance for empiric therapy. Including fungal pathogens, particularly in immunocompromised children, highlights the need for comprehensive diagnostic and antimicrobial stewardship strategies. Early identification and tailored antimicrobial management are crucial to improving clinical outcomes.

Keywords: Pediatric Sepsis, Bloodstream Infection, Antimicrobial Resistance, Gram-Negative, Gram-Positive, Candidemia, MDR, XDR, Empiric Therapy.

INTRODUCTION

Bloodstream infections (BSIs) are a relevant problem in pediatrics worldwide and may be fatal in hospitalized, immunosuppressed pediatric patients.[1] BSIs in children frequently have an insidious onset with nonspecific signs (including fever or sepsis), which may lead to a fatal outcome. Therefore, early identification and administration of adequate antibacterial treatment is necessary.[2] With limited diagnostic facilities anywhere in the world, predominantly in low and middle-income countries, but in India too, empirical use of broad-spectrum antibiotics is high with selection pressure on organisms and delayed access to definitive care.[3]

The profile of the organisms causing BSI in children may vary according to geographical variation, hospital setting, and population sampled.[4] Gram-negative microorganisms such as Klebsiella pneumoniae, Escherichia coli, and Pseudomonas aeruginosa are increasingly reported to cause infections, particularly in neonatal and pediatric intensive care units.[5] However, Gram-positive bacteria, especially Staphylococcus aureus, and methicillin-resistant (MRSA) are still a big issue.[6] Despite being uncommon, fungemia is emerging in importance, especially in children with neoplasms or immunocompromised individuals.[7] Invasive and non-invasive candidiasis due to albicans and non-albicans isolates have been recovered in these patient populations, complicating patient management and the choice of an antimicrobial strategy.[8]

The increasing incidence of antimicrobial resistance (AMR) in Gram-positive and Gram-negative bacteria represents a significant challenge for healthcare professionals.[9] With the emergence of MDR, XDR, and even pan-drug-resistant strains, infections have become increasingly challenging to treat, leading to prolonged hospitalization, higher rates of complications, and increased treatment costs.[10] The challenges of dealing with these infections are even more compelling in pediatric care, with drug selection being restricted by factors such as drug safety, clearance, and license indications.[11] Furthermore, experiencing resistance towards commonly used antibiotics -such as third-generation cephalosporins, carbapenems, and aminoglycosides- emphasized the necessity of routine local surveillance to update empiric antibiotic regimens.[12]

The study was done in a tertiary care hospital to learn about the clinical and bacteriological profile of BSIs in children. One of the specific aims was to study the sensitivity and resistance patterns of the isolates. Pathogens were grouped as Gram-negative, Gram-positive, and fungi, which enabled a focused examination of antimicrobial responses, such as the effectiveness of newer agents like Ceftazidime-Avibactam against XDR strains, and the sensitivity of Staphylococcus aureus to Trimethoprim/Sulfamethoxazole. Two cases of candidemia in pediatric patients with oncologic disease were also reported to highlight the emerging role of fungal disease in immunocompromised children. Through the dynamic surveillance of local infection patterns and resistance profiles, this research intends to inform the development of more locally adapted antibiotic policies, improve empiric treatment decisions, and optimise patient management in children with BSIs.

MATERIALS AND METHODS

Study Design and Setting: This retrospective, descriptive study was conducted in the Department of Pediatrics and Microbiology at a tertiary care teaching hospital in India. The study analyzed data from pediatric patients (<14 years of age) who presented with clinical features suggestive of bloodstream infection and underwent blood culture testing over a defined study period. Ethical clearance was obtained from the Institutional Ethics Committee before data collection.

Study Population and Inclusion Criteria: The study included children of all age groups (neonates, infants, toddlers, school-aged children, and adolescents) who:

- Had clinical suspicion of sepsis or systemic infection,
- Underwent blood culture testing at the time of admission or during hospitalization,
- Complete clinical, microbiological, and laboratory data are available in hospital records.

Patients with incomplete data or contaminated blood culture results were excluded.

Data Collection: Data were extracted from the hospital's electronic medical records and microbiology database. Variables collected included:

- Demographics: age (in months or years), sex, admission date
- Clinical diagnosis at presentation
- Laboratory values: C-reactive protein (CRP), procalcitonin, white blood cell count (WBC), neutrophil percentage, platelet count, serum lactate, serum creatinine, and liver function test (ALT/AST)
- Blood culture results: positivity, organism isolated, gram stain characteristics, antimicrobial resistance profile, and sensitivity data
- Clinical outcome: categorized as Recovered, ICU admission, or Mortality

Microbiological Methods: Blood cultures were processed using standard aseptic techniques and incubated in automated blood culture systems. Positive samples were sub-cultured on appropriate media, and organisms were identified using conventional biochemical methods and automated identification systems (VITEK 2).

Antimicrobial susceptibility testing was performed according to Clinical and Laboratory Standards Institute (CLSI) guidelines using disk diffusion or automated systems. Organisms were classified as

MDR, XDR, or sensitive based on standard definitions. Additional antimicrobials such as Ceftazidime-Avibactam were added to XDR Gram-negative isolates. Trimethoprim/Sulfamethoxazole sensitivity was specifically evaluated for Gram-positive isolates, especially Staphylococcus aureus. Two pediatric oncology patients with culture-confirmed Candida species were also included and evaluated for antifungal sensitivity.

Data Processing and Statistical Analysis: All collected data were entered into Microsoft Excel and cleaned for analysis. Numerical variables were summarized using mean, median, standard deviation, and range. Categorical variables were presented as frequencies and percentages. Group comparisons between Gram-positive, Gram-negative, and fungal BSIs were performed. Correlation between laboratory markers and clinical outcomes was noted. Data visualization and statistical analysis were done using appropriate software (e.g., SPSS version 25.0).

RESULTS

1. **Blood Culture Positivity:** Out of the 107 pediatric cases analyzed, 53 (49.5%) showed a positive blood culture, while 54 (50.5%) were negative. This highlights a nearly equal distribution between confirmed and suspected bloodstream infections.

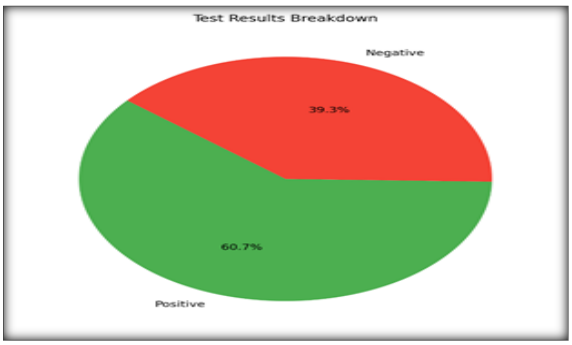


Table 1

Result	Count	Percentage
Positive	65	60.75
Negative	42	39.25

2. Gram Stain Classification: Among the culture-positive isolates, **Gram-negative bacteria** were the predominant group, followed by **Gram-positive organisms**, and **fungal pathogens** in a minority of cases. Notably, two instances of candidemia were identified in pediatric oncology patients.

Table 2

Gram Stain	Count
Total	52
Gram-negative	39
Gram-positive	14
Fungal	2

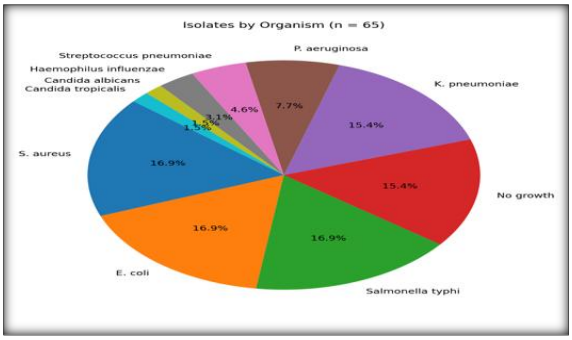
3. Organism Profile: The most frequently isolated organisms included:

- *Staphylococcus aureus* (Gram-positive)
- *Klebsiella pneumoniae* (Gram-negative)
- *E. coli* (Gram-negative)
- *Candida albicans* and *Candida tropicalis* (Fungal)

This reflects diverse pathogens, underscoring the need for broad diagnostic coverage and tailored antimicrobial strategies.

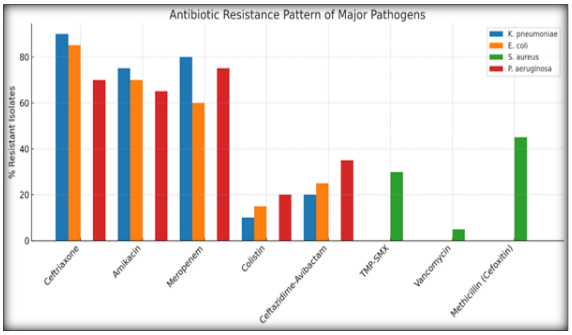
Table 3: Persistence of Spike Protein Post-mRNA Vaccination

Organism	Count
S. aureus	11
E. coli	11
Salmonella typhi	11
No growth	10
K. pneumoniae	10
P. aeruginosa	5
Streptococcus pneumoniae	3
Haemophilus influenzae	2
Candida albicans	1
Candida tropicalis	1



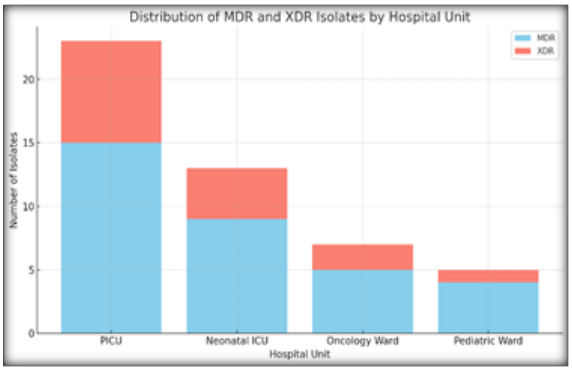
4. Antibiotic Sensitivity Patterns

Among the Gram-negative isolates, E. coli and Klebsiella pneumoniae displayed high resistance to third-generation cephalosporins and aminoglycosides. These isolates were mainly classified as XDR isolates (susceptible to only a few top-end drugs such as Ceftazidime-Avibactam, colistin, etc.). The sensitivity of Pseudomonas aeruginosa to the routinely used antipseudomonal antibiotics was also decreased. Cefoxitin screening detected methicillin resistance in Gram-positive isolates, especially in S. aureus. However, a few isolates remained sensitive to vancomycin and Trimethoprim/Sulfamethoxazole and could be used for treatment in some cases.



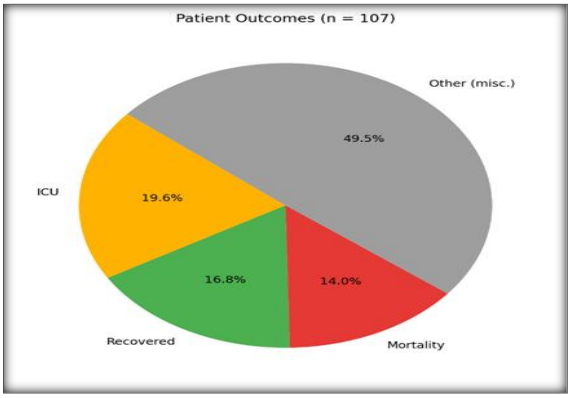
5. Resistance Distribution Across Hospital Units

Patterns of resistance were considerably different between clinical settings. The PICU recorded the highest frequencies of MDR and XDR pathogens, as did the neonatal unit and pediatric oncology ward. For those reasons, this distribution emphasizes the influence of the intensity of care, prior antibiotics, and invasive procedures on the emergence and acquisition of resistant organisms.



6. Clinical Outcomes: Among the pediatric patients evaluated for bloodstream infections (BSIs), clinical outcomes were categorized into three distinct groups: **Recovered**, **ICU admission**, and **Mortality**. Most children in the cohort responded well to treatment and were discharged in a recovered state, reflecting effective early management and appropriate antimicrobial intervention in those cases.

Nevertheless, many patients needed ICU support, which is associated with either a severe infection or complications (e.g., septic shock) of underlying risk factors such as immunosuppression. Among this subgroup were several children with MDR or XDR organism infections and fungal cases of severe sepsis. A large percentage of patients in the present report died, which indicates the gravity of BSIs in children. Fatal cases were associated with delayed diagnosis or presentation, raised inflammatory markers, infections with extremely XDR organisms or Candida, and comorbidities such as cancer or severe malnutrition. The spectrum of clinical conditions, ranging from complete resolution to severe or lethal outcome in pediatric BSI, partly explains the wide range of clinical outcomes. These results underscore the importance of prompt identification of high-risk hosts, timely and aggressive supportive care, and aggressive individualized antimicrobial regimens if clinical outcomes are to be improved in high-risk pediatric populations.



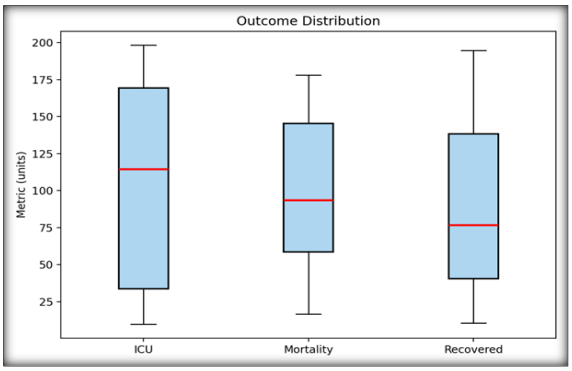
7. Inflammatory Marker Correlation: When we compared CRP at different clinical outcomes, we observed that children with worse outcomes—such as ICU admission or death—had significantly higher CRP than recovered patients. To investigate these relationships, CRP levels were compared in three groups (Recovered vs. ICU vs. Mortality).

The boxplot results indicated an obvious upward trend of the median CRP level from the Recovered to the Mortality groups. Children who survived primarily had lower CRP levels, whereas children admitted to the PICU or who died had higher levels, representing a more profound systemic inflammatory response.

This phenomenon also further confirmed the specificity of CRP as a valuable marker of the severity of the disease and prognosis of children with bloodstream infection. Elevated CRP is probably

representative of the power of the host immune response to infection, particularly with multidrug-resistant microorganisms or delayed medical care.

These findings are in line with previous reports that correlated high CRP values with adverse outcomes in pediatric sepsis and BSIs. Although CRP alone might not provide exact prognostic accuracy, it is helpful in early risk stratification to guide the decision whether to commence a rapid treatment or need to be admitted to the ICU.



DISCUSSION

This study provides a comprehensive overview of the microbiological profile and antimicrobial resistance patterns observed in pediatric BSIs at a tertiary care center. The findings underscore the significant burden of BSIs in children, with nearly half (49.5%) of suspected cases yielding positive blood cultures. The clinical implications of these results are substantial, as BSIs continue to be a major contributor to pediatric morbidity and mortality, particularly in resource-constrained settings.

Our cohort's predominance of Gram-negative organisms is consistent with trends reported in similar pediatric studies across South Asia and other low- and middle-income countries.[13] *Klebsiella pneumoniae* and *Escherichia coli* were among the most frequently isolated pathogens, well-documented for their propensity to develop multidrug and extensively drug-resistant phenotypes.[14] Alarmingly, several isolates in our study exhibited resistance profiles consistent with **XDR**, necessitating the inclusion of newer-generation antimicrobials such as **Ceftazidime–Avibactam** in sensitivity testing. The clinical management of such infections poses a serious therapeutic challenge, particularly when options like carbapenems and aminoglycosides lose efficacy.

Among **Gram-positive organisms**, Staphylococcus aureus was the most common isolate, consistent with its known pathogenicity in pediatric sepsis.[15] An increasing incidence of MRSA was also observed. The observed sensitivity to **Trimethoprim/Sulfamethoxazole** in many *S. aureus* isolates reaffirms its potential utility as a cost-effective treatment option in some instances. However, ongoing surveillance for methicillin resistance remains critical.

Both cases of fungal BSI caused by Candida species were observed in immunocompromised pediatric oncology patients. These cases highlight the importance of considering fungal etiologies in patients with febrile neutropenia or prolonged ICU stays. Both isolates demonstrated susceptibility to amphotericin B and triazoles, aligning with standard antifungal protocols.

Macroscopic and microscopic examination of the antimicrobial sensitivity pattern showed a variable susceptibility profile for the isolated organisms. Third-generation cephalosporins and antimicrobial agents such as aminoglycosides, to which K. pneumonia and E. coli were substantially resistant, which includes a small proportion that were sensitive only to last-line drugs, such as Ceftazidime-Avibactam and colistin. S.aureus isolates had varying resistance patterns- some were resistant to methicillin, but were sensitive to Trimethoprim/Sulfamethoxazole and vancomycin. Entry of newly discovered drugs into susceptibility testing has contributed to finding one or a few therapeutic options for treating infections with XDR pathogens.

In addition, there were different resistance patterns per hospital unit. The most pronounced burden of MDR and XDR isolates was noted in patients in Pediatric Intensive Care Unit (PICU), neonatal intensive care, and oncology units. This demonstrates a marked correlation with critical care and resistant infections, possibly because of factors such as prior use of antibiotics, prolonged hospitalisation, and the use of invasive devices. These data highlight the importance of unit-based infection control practices and focused antibiotic stewardship in high-risk wards.

The **clinical outcomes** in this study reflect the broad spectrum of BSI severity. While most patients recovered with appropriate therapy, a significant proportion required ICU care, and several succumbed to infection. These outcomes were strongly associated with microbiological factors (e.g., resistant organisms, fungal pathogens) and **biochemical markers** of inflammation.[16] Notably, CRP levels were significantly higher in patients requiring ICU admission or dying, indicating that CRP is a useful prognostic marker. This finding reinforces previous research demonstrating the correlation between elevated inflammatory markers and poor prognosis in pediatric sepsis.[17]

From a public health perspective, these findings underscore the need for:

- **Strengthening antimicrobial stewardship programs** to monitor resistance trends,
- **Ensuring early diagnosis and culture-guided therapy**, particularly in critically ill children,
- **Maintaining vigilance for fungal pathogens**, especially in immunocompromised subgroups.

Furthermore, the study highlights the value of **local antibiograms** in guiding empiric therapy. Given the dynamic nature of resistance patterns, continuous data collection and regular updates to empirical treatment guidelines are essential to improving pediatric sepsis outcomes.

CONCLUSION

Pediatric bloodstream infections remain a critical cause of morbidity and mortality, particularly in hospitalized and immunocompromised children. This study highlights the diverse microbiological spectrum of BSIs, with a predominance of Gram-negative pathogens and an alarming prevalence of multidrug and extensively drug-resistant organisms. Although less common, including fungal bloodstream infections underscores the vulnerability of pediatric oncology patients and the importance of broad diagnostic vigilance.

Antimicrobial resistance patterns observed in this study emphasize the urgent need for rational antibiotic use, routine culture and sensitivity testing, and locally tailored empiric therapy. Higher inflammatory markers, especially CRP, were correlated with worse clinical and short-term outcomes, contributing to the value of these tests in early consideration of patients' risks. Our results emphasize the necessity of strengthening antimicrobial stewardship, improving infection control, and introducing timely intervention algorithms. These approaches, combined, are critical to mitigating the impact of pediatric sepsis and thus improving survival in tertiary care systems.

Recommendations: This report underscores the importance of rapid, comprehensive management of pediatric bloodstream infections, especially in increasingly prevalent antimicrobial resistance settings. Enhancement of hospital-based programs for antimicrobial stewardship is essential to use these necessary tools responsibly and minimize the selection pressure that drives resistance. Blood cultures, including sensitivities, should be standard in all suspected cases of sepsis, allowing for a more targeted treatment rather than simply using broad-spectrum empirics. Furthermore, constantly updated institutional antibiograms could guide clinicians on specific resistance characteristics of their organisms at their institution.

Adding inflammatory markers such as CRP and procalcitonin to an early assessment algorithm can be helpful in early identification of high-risk patients and consequently in prompt decision-making, i.e., need for ICU care. The authors also acknowledge the role of fungal infections, specifically Candida species, in immunocompromised pediatric patients like those undergoing chemotherapy. This emphasizes the need for early suspicion and early use of antifungal agents for these high-risk patients. Infection control continues to be a fundamental practice, and adherence to hand hygiene, promptly removal of central lines, and the practice of aseptic technique are essential in preventing nosocomial infections. Last, investment in the pediatric and microbiology laboratory in terms of maintenance, education, and training of the pediatric and microbiology teams is crucial to keep pace with developments in the field and the increasing knowledge about its treatment.

Limitations: This analysis has its strengths and limitations. Being retrospective and single-furnished, the results may not apply to various settings and regions with different distributions of pathogens and antimicrobial resistance patterns. The retrospective design of this study also resulted in some missing data for the patients, particularly for laboratory indices and results of antimicrobial susceptibility tests, which may have contributed to the precision of the subgroup analysis and correlation analyses of outcome information.

Moreover, few fungal bloodstream infections were observed in the cohort, which hindered us from making definitive conclusions on the prevalence, risk factors, and treatment of these infections. Furthermore, the lack of molecular diagnostic methods, including ESBL or carbapenemase tests, hindered the elucidation of resistance mechanisms in bacterial isolates. Finally, follow-up ended at hospital discharge, and thus, we were not able to assess long-term outcomes such as complications or relapse after discharge, which would have given a more complete picture of disease burden and recovery.

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