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Prevalence, microbiology, and antimicrobial susceptibility profile of bacterial skin and soft tissue infections in pediatric patients with malignancies at a referral teaching hospital in Shiraz, Iran

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Abstract

Background and aims Skin and soft tissue infections (SSTIs) in pediatric oncology patients present significant challenges owing to their immunocompromised condition and susceptibility to severe infections. This study aimed to assess the prevalence, microbiology, and antibiotic resistance patterns of SSTIs in children with malignancies admitted to a referral teaching hospital.

Methods A total of 227 pediatric patients with cancer were included in this descriptive cross-sectional study. The data collected included demographics, malignancy type, neutropenic status, infection sites, microbial culture results, and clinical outcomes. Bacterial cultures were performed on samples from the blood, wounds, and other infection-related sites. Pathogens were identified using standard microbiological methods, and antibiotic susceptibility was determined using the disk diffusion (Kirby-Bauer) method, following the Clinical and Laboratory Standards Institute (CLSI) guidelines.

Results Among the 227 patients, 57.71% were male and 42.29% were female, and the most prevalent age group was 1 to 6 years (39.65%). Hematologic malignancies were observed in 57.33% of the patients, solid tumors in 39.11%, and leukemia was the most common malignancy (40.81%). Bloodstream infections (BSIs) were identified in 7.05% of patients, while a notable proportion of cases (92.95%) were culture-negative, warranting consideration of non-bacterial etiologies or prior antibiotic use. Among the 227 site-specific culture samples, *Escherichia coli* (36.54%) and *Staphylococcus aureus* (23.08%) were the most common pathogens. Other frequently isolated bacteria include

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Pseudomonas aeruginosa, *Klebsiella* spp., and *coagulase-negative Staphylococcus*. Antibiotic sensitivity testing revealed that *E. coli* is sensitive to ampicillin-sulbactam and colistin, whereas *S. aureus* is sensitive to chloramphenicol and cotrimoxazole. In terms of patient outcomes, > 95% of patients achieved complete recovery, whereas 3.96% had fatal outcomes. Multivariate analysis identified age < 5 years (adjusted odds ratio [aOR] = 8.03, $p = 0.004$) and perianal abscesses (aOR = 4.4, $p = 0.038$) as independent risk factors significantly associated with an increased risk of BSI. Male sex was associated with a reduced risk for BSI (aOR = 0.62).

Conclusion Our study highlights the significant burden of SSTIs in pediatric oncology patients, with *E. coli* and *S. aureus* being the predominant pathogens. Younger age and perianal abscesses were identified as independent risk factors of BSI, emphasizing the need for heightened vigilance in these subgroups. These findings underscore the importance of targeted preventive strategies to improve the outcomes in this high-risk population. However, it is important to acknowledge that this study was conducted at a single center and the high rate of culture-negative results suggests that non-bacterial etiologies or prior antibiotic use may play a significant role.

Clinical trial number Not applicable.

Keywords Antibiotic resistance, Clinical outcomes, *Escherichia coli*, Immunocompromised patients, Microbiology, Pediatric oncology, Skin and soft tissue infections, *Staphylococcus aureus*

Introduction

Skin and soft tissue infections (SSTIs) are a heterogeneous group of bacterial infections affecting the skin, subcutaneous tissues, fascia, and muscles. These infections range from mild superficial conditions such as impetigo and folliculitis to severe, life-threatening conditions such as necrotizing fasciitis and gas gangrene [1]. SSTIs often induce local immune responses that are characterized by erythema, edema, pain, and warmth. In severe cases, they may lead to systemic complications such as bacteremia, sepsis, and even death [2–4]. Among these complications, bloodstream infections (BSIs) are of particular concern because of their association with increased morbidity, mortality, and healthcare costs. The development of BSI following SSTI often necessitates prolonged hospitalization and more aggressive antibiotic therapy and can lead to life-threatening sequelae such as septic shock and hematogenous spread of infection (secondary infectious foci). Host-related factors include immunosuppression, chronic diseases, advanced age, and increased vulnerability to SSTIs. Additionally, environmental factors, such as trauma, inadequate hygiene, and skin-to-skin contact contribute to the risk of infection [4, 5]. SSTIs can be categorized into low- and high-inoculum infections based on their inoculum size. Low-inoculum infections typically arise from minor trauma or superficial skin breaches, often involving common pathogens, such as *S. aureus* and *Streptococcus* species. In contrast, high-inoculum infections are associated with more severe conditions, such as necrotizing fasciitis or deep tissue involvement, and may require more aggressive treatment approaches, including surgical intervention [6–8]. Recognizing their impact, the World Health Organization (WHO) has highlighted SSTIs as a significant concern in low- and middle-income countries where they add to the overall burden of infectious diseases and negatively affect patient well-being [9]. In Iran, SSTIs are a significant health concern, particularly in rural areas, owing to limited healthcare access, poor hygiene, overcrowding, traditional treatments, and high rates of chronic diseases such as diabetes, which increase vulnerability to severe and recurrent infections [10, 11]. Compounding this challenge is the increasing prevalence of antibiotic-resistant bacteria, particularly methicillin-resistant *Staphylococcus aureus*, which has emerged as a significant concern in Iran, mirroring global trends [12, 13]. This trend underscores the importance of taking practical steps to control infections and using antibiotics responsibly, ensuring that we can manage resistant pathogens and maintain the effectiveness of current treatments. In pediatric oncology, SSTIs represent a particularly critical concern. Children with malignancies are especially vulnerable due to compromised immune systems caused by cancer, chemotherapy-induced neutropenia, and the use of invasive medical devices [12, 14, 15]. These factors create a favorable environment for a diverse range of opportunistic pathogens, with *S. aureus* and *E. coli* being the most commonly isolated bacteria in pediatric SSTIs [16]. Moreover, the emergence of multidrug-resistant bacteria in pediatric oncology units complicates infection management, leading to increased morbidity and mortality [17, 18]. Despite advancements in SSTI management, regional variations in pathogen profiles and resistance patterns have highlighted the need for localized studies [19]. Data on SSTIs among pediatric oncology patients in Iran remain scarce, particularly given the rising incidence of pediatric cancers and concurrent spread of antibiotic resistance. This study addresses this critical gap by evaluating the prevalence, microbiology, and antimicrobial sensitivity patterns of SSTIs in pediatric oncology patients hospitalized at the Amir Oncology Hospital, Shiraz, Iran, over five years.

While our study provides valuable insights into the local epidemiology of SSTIs in pediatric oncology patients in Iran, studies from other regions have reported varying prevalence rates of specific pathogens and patterns of antimicrobial resistance. For example, a large US study in the Northern California region found a higher prevalence of *Staphylococcus aureus* (80% of positive cultures) than our findings [20], while research in Europe has highlighted the increasing incidence of gram-negative bacteria such as *Escherichia coli* and *Pseudomonas aeruginosa* infections (> 54% of all pathogens) [21]. These differences may reflect variations in healthcare practices, antibiotic use, and regional epidemiology. By comparing our findings with international data, we can better understand the unique challenges and regional importance of our results in the context of global trends in pediatric SSTIs.

This study sought to guide empiric antibiotic therapy, improve clinical outcomes, and contribute to public health strategies to combat antimicrobial resistance by identifying common bacterial pathogens and analyzing their resistance profiles.

Method

Study design and data collection

A descriptive cross-sectional study was conducted on patients admitted to the Amir Oncology Teaching Hospital between 2017 and 2023 who were diagnosed with bacterial SSTIs. Patients were enrolled consecutively, as they met the inclusion criteria during the study period.

Inclusion criteria

Patients were included if they met all of the following criteria: (1) under 18 years of age; (2) diagnosed with bacterial SSTIs by the treating physician with a documented response to antibacterial therapy; (3) had a diagnostic code for bacterial SSTIs at discharge or death with or without microbiological confirmation (e.g., Gram staining and culture); and (4) no evidence of other skin and soft tissue infections, such as fungal, viral, or parasitic infections.

Exclusion criteria

Patients were excluded if they met any of the following criteria: (1) incomplete medical records, (2) initial diagnosis of bacterial SSTIs but did not respond to antibacterial treatment, or (3) alternate diagnoses confirmed through culture, smear, pathology, or molecular methods.

Electronic hospital records were the primary source of information; however, paper charts were examined if electronic records were incomplete. Data were gathered on patient demographics, including sex and age, along with clinical presentations, such as pre-hospitalization and in-hospital fever, erythema, swelling, warmth, tenderness, and local lymph node response. Data on the hospitalization course, including the site of infection, length of hospital stay, duration of fever during hospitalization, and antibiotic use, were also collected. Laboratory evaluations at the time of admission included white blood cell (WBC) count, absolute neutrophil count (ANC), and C-reactive protein (CRP) level. Additionally, microbiological data, including wound cultures, blood cultures, and antimicrobial susceptibility test results, were reviewed to provide insights into pathogens and their resistance profiles. The antimicrobial susceptibility of the bacterial isolates was assessed using the Kirby-Bauer disk diffusion method according to the CLSI guidelines. The susceptibility patterns of isolates, such as *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella* spp., and *coagulase-negative staphylococci*, were analyzed to determine resistance profiles and guide effective therapeutic interventions. Data were extracted using a researcher-designed data collection form and completed based on hospital medical records. For diagnostic confirmation, whenever samples were available, simultaneous bacterial and fungal assessments were conducted, including cultures, Gram staining, KOH testing, wound discharge analysis, pathological examination, or Polymerase Chain Reaction (PCR). The diagnostic and treatment approaches remained consistent throughout the study period, guided by the hospital's infectious disease focal point.

Microbiological procedures

Wound swabs and blood samples were aseptically collected and sent to the microbiology laboratory for processing. The samples were cultured on standard media, including blood agar, MacConkey agar, and chocolate agar. Bacterial identification was performed using standard microbiological techniques, including Gram staining, colony morphology, and biochemical tests, including catalase, coagulase, oxidase, and API 20E/API Staph assays, according to the manufacturer's instructions.

Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method. In brief, bacterial isolates were cultured to achieve a 0.5 McFarland turbidity standard and inoculated onto Mueller-Hinton agar plates (Merck, Germany). Antibiotic-impregnated disks (Mast Diagnostics, UK) were placed on the agar surface and the plates were incubated at 37 °C for 18–24 h. The diameter of the zone of inhibition around each disk was measured, and the results were interpreted as susceptible, intermediate, or resistant according to the CLSI guidelines [22].

Definition of variables

The SSTI CDC/NHSN surveillance definition of healthcare-associated infections and criteria for specific types

of infections in the acute care setting was used for the diagnosis of SSTI in children with cancer [23].

BSI any positive result of bacterial culture with an automated blood culture system (BD BACTEC™) excluding those that considered contamination based on repeated cultures (in asymptomatic patients and those with mixed bacterial culture results). All patients were diagnosed with laboratory-confirmed bloodstream infection (LCBI), mucosal barrier injury laboratory-confirmed bloodstream infection (MBI-LCBI), and central line-associated BSI (CLABSI) criteria from the Centers for Disease Control and Prevention's National Healthcare Safety Network (NHSN) patient safety component manual. Accordingly, MBI-LCBI was diagnosed in patients whose blood cultures tested positive for gram-negative organisms included in the National Healthcare Safety Network NHSN MBI organism list (unrelated to an infection at another site) and who experienced neutropenia within a 7-day window encompassing the date when the positive blood culture was collected [24].

Febrile neutropenia (FN) FN defined as temperature ≥ 38.3 °C or two consecutive temperatures ≥ 38 °C sustained over one hour and an absolute neutrophil count < 0.5 X 10^9 cell/L or expected to fall below $< 0.5 \times 10^9$ cell/L [25].

Statistical analysis

Data analysis was performed using STATA version 17. Qualitative variables were described using frequencies and percentages, whereas quantitative variables were summarized using means and standard deviations. Chi-square tests were used to analyze qualitative data, and Student's t-tests were applied for quantitative comparisons.

Given the absence of significant missing data (less than 5% for all variables), we conducted a complete case analysis. Assumptions for statistical tests were verified as follows: normality of continuous variables was assessed using the Shapiro-Wilk test and visual inspection of histograms. For t-tests, the equality of variances was checked using Levene's test. Categorical data were analyzed using chi-square tests, and Fisher's exact test was used when cell counts were < 5.

Multivariate logistic regression analysis was performed to identify independent risk factors for BSI using a purposeful selection strategy. Variables were initially included based on their clinical relevance in the literature. Continuous confounders were retained as linear terms to minimize residual bias, while categorical variables, such as age (< 5 years) and infection type, were dichotomized. Stepwise backward elimination was then performed, sequentially removing the variables with the highest p-values. The final model covariates were age, sex, infection site, malignancy type, and neutropenia status. The Hosmer-Lemeshow test confirmed adequate goodness-of-fit ($p = 0.32$), and variance inflation factors < 2 indicated no multicollinearity.

Ethical considerations

The study was approved by the Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.AH.REC.1401.439), and all ethical principles were strictly adhered to, including maintaining confidentiality and privacy throughout the research process as well as ensuring honest and accurate reporting of all findings, regardless of whether the results were positive or negative.

Result

Among the 227 included patients, 57.71% were male and 42.29% female. The majority (39.65%) of patients were aged 1–6 years. Hematologic malignancies were present in 57.33% of patients, and solid tumors were identified in 39.11%. Leukemia was the most common malignancy (40.81%), followed by lymphoma (12.56%) and sarcoma (19.28%). Bloodstream infections were positive in 7.05% of cases and negative in 92.95% of cases. Febrile neutropenia was observed in 70% of patients, with most infections located in the limbs (71.15%). WBC counts below 500/mm^3 were recorded in 24.55% of the patients (Table 1). Positive wound cultures revealed *the presence of Escherichia coli* (36.54%), CoNS (23.08%), *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Klebsiella* spp. Overall, 96.04% of the patients fully recovered, whereas 3.96% died. Cellulitis accounted for 31.69% of all SSTIs, followed by phlebitis (27.57%), and surgical site or intervention-related infections (16.05%). Perianal abscesses comprised 10.70% of the cases, while the remaining 5.76% were classified as other types of infections (Fig. 1). *E. coli* was the most frequently identified pathogen, with 9 positive wound culture results. This was followed by *S. aureus* and coagulase-negative *staphylococci* (CoNS), each detected in 4 cases. Additionally, *Streptococcus* non-hemolytic group D, *Pseudomonas aeruginosa*, and *Klebsiella* spp. were found in 1 case (Fig. 2). Bacteremia was most frequently attributed to *E. coli*, CoNS, and *P. aeruginosa* based on blood culture results (Fig. 3). The antimicrobial resistance patterns of wound and blood cultures, along with their sensitivity and resistance to the tested antibiotics and different cultured pathogens, are depicted in Figs. 4 and 5, respectively. The characteristics of the patients included in the study were compared based on the occurrence of bloodstream infection (BSI). Age and SSTI type showed statistically significant differences ($P < 0.05$) between the two groups (Table 2). The characteristics and features of patients stratified by hospitalization outcomes are summarized in Table 3. Univariate analysis failed to identify any clinical features or patient characteristics that significantly differed between

Table 1 Baseline characteristics of pediatric Cancer patients with SSTIs ($n = 227$)

Characteristic or Feature	Frequency (%)	Proportion (95% CI)
Gender		
Female	96 (42.29)	0.42 [0.36–0.49]
Male	131 (57.71)	0.58 [0.51–0.64]
Age Group		
<1 year	5 (2.2)	0.02 [0.01–0.05]
1–6 years	90 (39.65)	0.4 [0.33–0.46]
6–12 years	73 (32.16)	0.32 [0.26–0.38]
13–18 years	58 (25.55)	0.26 [0.2–0.32]
>18 years	1 (0.44)	-
Type of Malignancy		
Solid Tumor	88 (39.11)	0.39 [0.33–0.46]
Hematologic	129 (57.33)	0.57 [0.51–0.63]
Non-malignant	8 (3.56)	0.04 [0.02–0.07]
Malignancy Diagnosis		
Leukemia	91 (40.81)	0.41 [0.35–0.47]
Lymphoma	28 (12.56)	0.13 [0.09–0.18]
Sarcoma	43 (19.28)	0.19 [0.15–0.25]
Nervous System Malignancies	27 (12.11)	0.12 [0.08–0.17]
Other Malignancies	26 (11.66)	0.12 [0.08–0.17]
Non-malignant Disorders	8 (3.59)	0.04 [0.02–0.07]
Bloodstream Infection		
Negative	211 (92.95)	0.93 [0.89–0.96]
Positive	16 (7.05)	0.07 [0.04–0.11]
Febrile Neutropenia		
Negative	66 (30)	0.3 [0.24–0.36]
Positive	154 (70)	0.7 [0.64–0.76]
Infection Location		
Limbs	37 (71.15)	0.71 [0.57–0.82]
Port	13 (25)	0.25 [0.15–0.39]
Bone and Bone Marrow	1 (1.92)	0.02 [0–0.13]
Other Sites	1 (1.92)	0.02 [0–0.13]
White Blood Cell Count		
<500	54 (24.55)	0.25 [0.19–0.31]
500–999	25 (11.36)	0.11 [0.08–0.16]
1000–1499	12 (5.45)	0.05 [0.03–0.09]
1500–4999	62 (28.18)	0.28 [0.23–0.35]
5000–15,000	44 (20)	0.2 [0.15–0.26]
>15,000	23 (10.45)	0.1 [0.07–0.15]

SSTI: Skin and Soft Tissue Infections

the non-survivor and survivor groups. Multivariate logistic regression analysis revealed several factors associated with the risk of BSI. Age < 5 years (aOR = 8.03, $p = 0.004$) and the presence of perianal abscesses (aOR = 4.4, $p = 0.038$) were significantly associated with an increased risk of BSI. While solid tumors (aOR = 1.37) and a WBC count less than 500/mm^3 (aOR = 1.58) were also associated with an elevated risk of BSI, these associations did not reach statistical significance. Conversely, the male sex was associated with a significantly reduced risk of BSI (aOR = 0.62). These findings, summarized in Table 4, indicate that the risk of BSI following SSTI is influenced by a combination of demographic and clinical factors.

Discussion

In this cross-sectional study, we investigated the burden of SSTIs in pediatric oncology patients, a population that is highly susceptible to infection due to their immunocompromised status. We investigated the prevalence, microbiological profile, and antibiotic resistance patterns of SSTIs in children with malignancies at a referral teaching hospital. Culture analysis revealed that *E. coli* and *S. aureus* were the predominant pathogens isolated from site-specific specimens. A key finding of our study was the identification of age < 5 years and the presence of perianal abscesses as independent risk factors for BSI. Specifically, children under 5 years of age had an eight-fold increased risk of BSI, while the presence of perianal abscesses was associated with a four-fold increased risk. These findings underscore the need for increased vigilance and targeted interventions in high-risk subgroups. The increased risk of BSI in young children may be related to their immature immune systems and higher susceptibility to invasive infections. Similarly, perianal abscesses may serve as a portal of entry for opportunistic pathogens, leading to bloodstream invasions.

A notable finding of our study is the high proportion of culture-negative cases. Several factors may have accounted for this observation. First, a significant proportion of patients may have received antibiotic treatment before sample collection, which could have suppressed bacterial growth and led to false-negative results [26]. Second, the presence of non-bacterial pathogens, such as fungi or viruses, which were not routinely tested, could have contributed to culture-negative results. Third, sampling issues, such as inadequate sample collection or improper handling, could also have affected the sensitivity of the culture.

Although a high proportion of patients (96.04%) achieved complete recovery, our findings underscore the critical need for ongoing surveillance of antibiotic resistance to optimize empirical treatment strategies in this vulnerable patient cohort. SSTIs in pediatric oncology patients, particularly those with neutropenia, represent a critical therapeutic challenge [27]. The sex distribution in our cohort revealed a male predominance compared to females. This observation is consistent with the findings reported by Doern et al., who reported a higher susceptibility to bacterial infections among males [28]. Hormonal and biological differences in males could result in a less robust immune response to bacterial infections [29, 30]. The study population exhibited a high proportion (over one-third) of patients in the 1–6-year age group. This may be attributed to the relative immaturity of the immune system in early childhood, rendering this

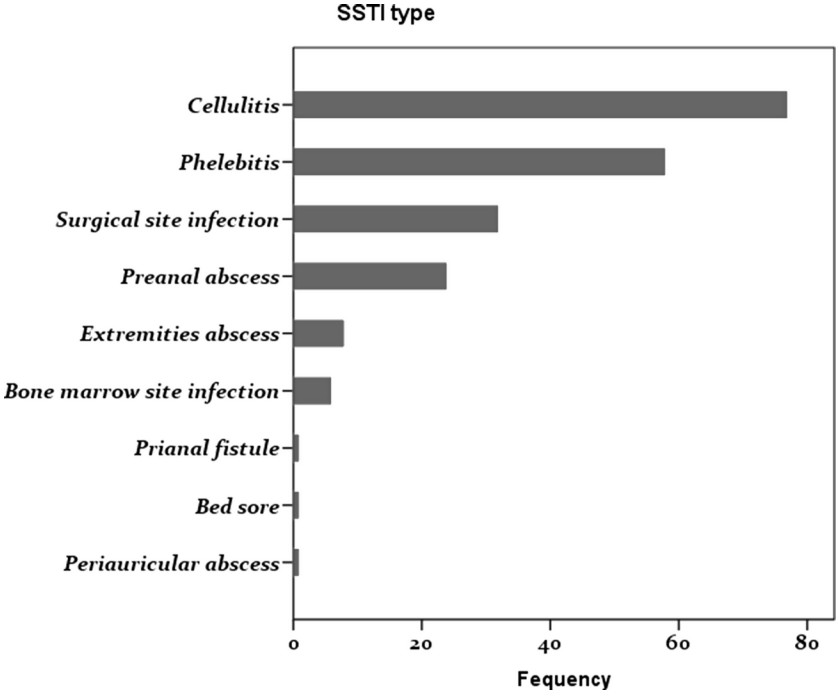

Fig. 1 Distribution of Skin and Soft Tissue Infection Sites Among Pediatric Cancer Patients. Bar chart showing the frequency and percentage of different anatomical sites affected by skin and soft tissue infections (SSTIs) in 227 pediatric oncology patients

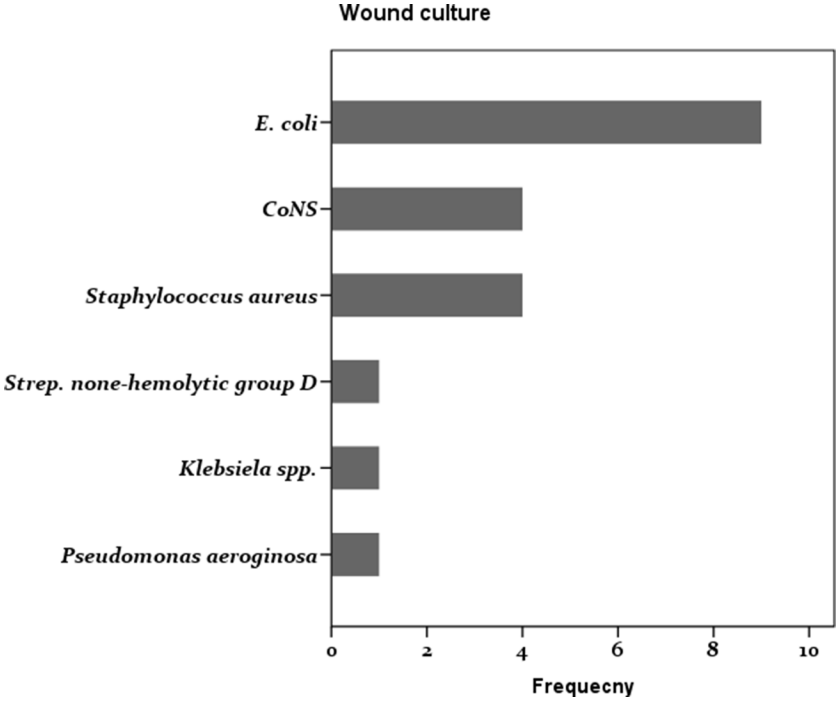

Fig. 2 Bacterial Pathogens Isolated from SSTI Cultures in Pediatric Oncology Patients. Distribution of bacterial species identified from wound- and site-specific cultures in pediatric cancer patients with SSTIs. *Escherichia coli* was the most frequently isolated pathogen, followed by coagulase-negative *staphylococci* (CoNS) and *Staphylococcus aureus*

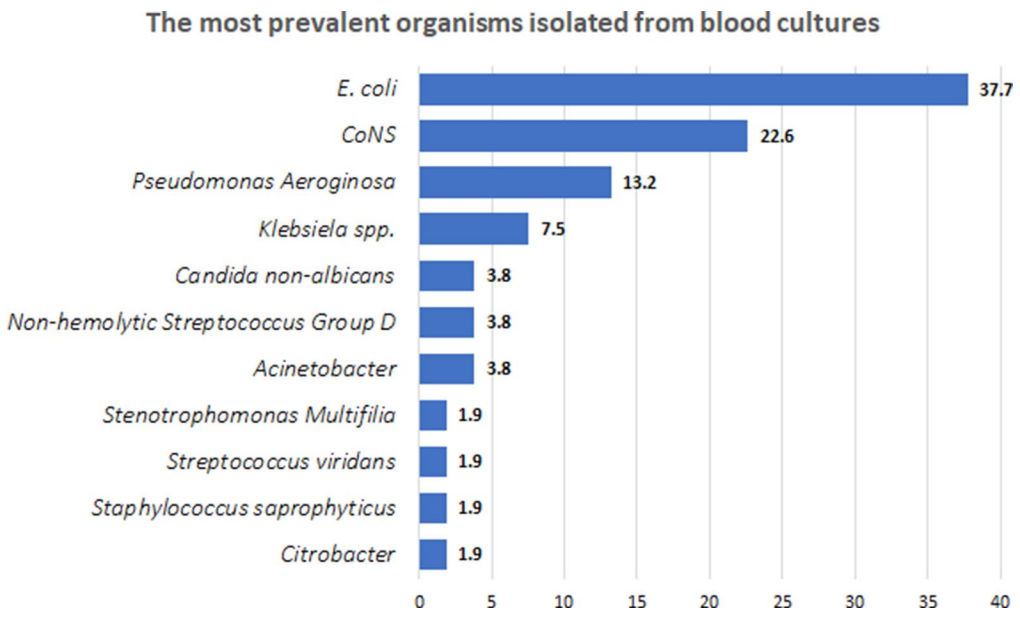

Fig. 3 Etiology of Bloodstream Infections in Pediatric Cancer Patients with SSTIs. The bar chart shows the distribution of bacterial species isolated from positive blood cultures among pediatric oncology patients with SSTIs. The most common etiologies include *Escherichia coli*, coagulase-negative *staphylococci* (CoNS), and *Pseudomonas aeruginosa*

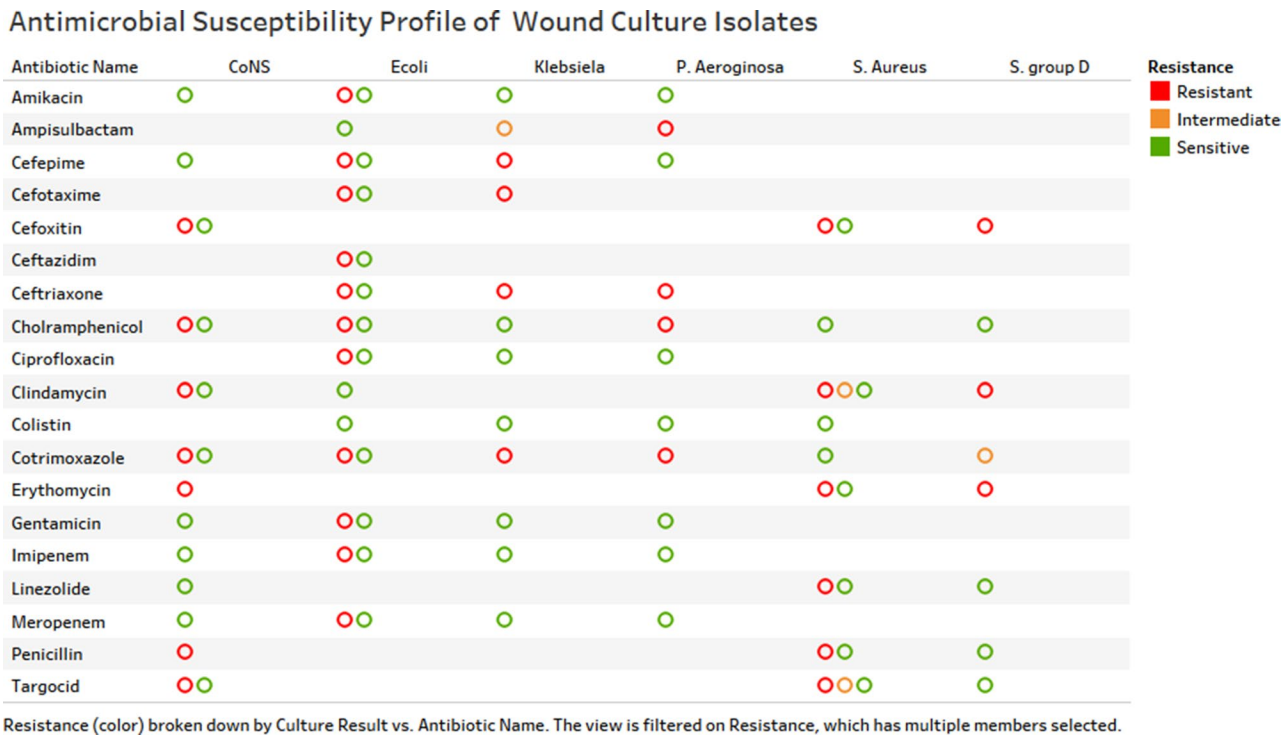

Fig. 4 Antimicrobial Susceptibility Profiles of Bacterial Isolates from SSTI Cultures. The graph illustrates the antibiotic resistance and sensitivity patterns of bacterial pathogens isolated from SSTI site cultures. The results were based on disk diffusion testing according to CLSI guidelines

age group more vulnerable to SSTIs. Furthermore, the immunocompromised status of these pediatric oncology patients, often exacerbated by chemotherapy and other immunosuppressive regimens, further compromises their natural defenses against pathogens [31, 32].

In our study cohort, leukemia was identified in 40% of cases, a finding consistent with previous reports that established leukemia as a common malignancy associated with SSTIs [33]. Patients with leukemia are more vulnerable to bacterial infections due to immunosuppression

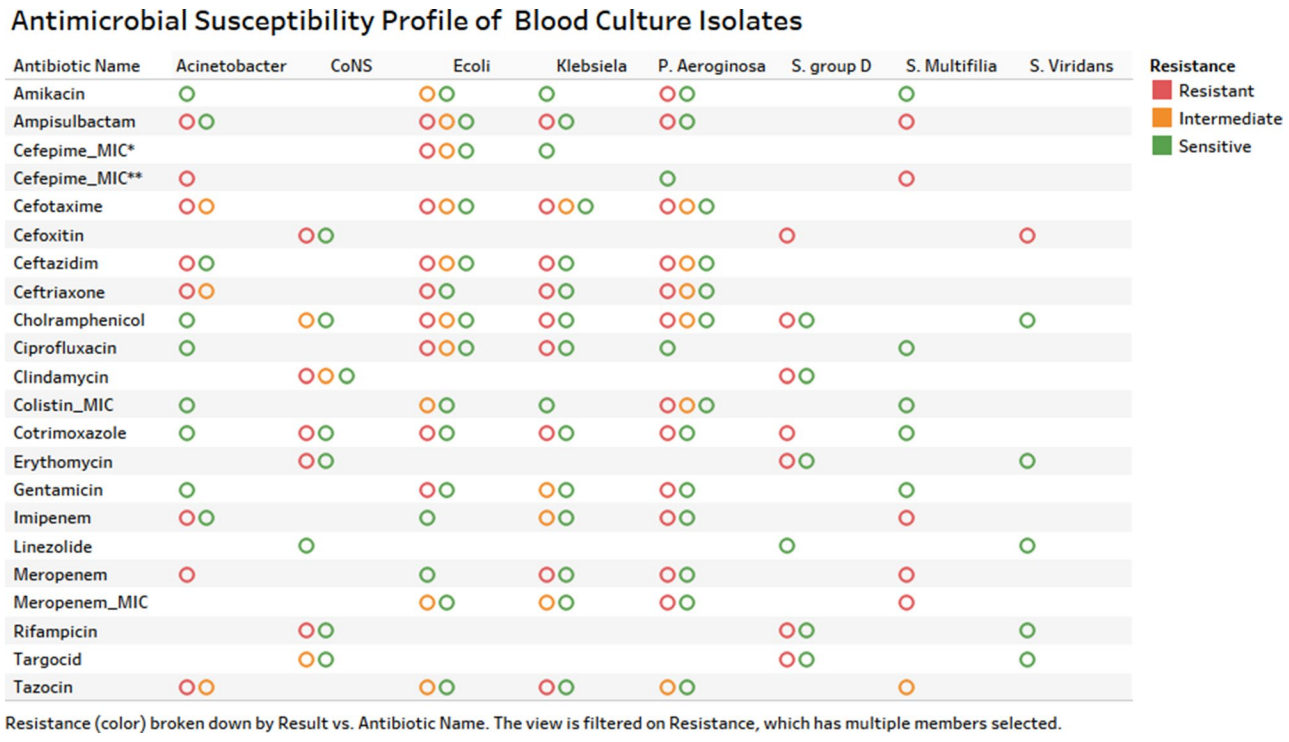

Fig. 5 Antimicrobial Susceptibility Profiles of Bacterial Isolates from Blood Cultures. Graph summarizing the resistance and sensitivity patterns of bacterial pathogens isolated from blood cultures of pediatric oncology patients with SSTIs. Antibiotic susceptibility was determined using the disk diffusion method

caused by the disease itself and immunosuppressive treatments. Neutropenia, commonly associated with chemotherapy and more prevalent in these patients, further increases their risk of systemic infections such as BSI [34, 35].

The most frequently identified microbial agents in this study were *Escherichia coli* and CoNS. This observation aligns with prior research indicating *that E. coli* is a prominent etiological agent of SSTIs that affects patients with malignancies [36, 37]. *E. coli*, commonly residing in the gut, can easily invade the bloodstream and cause systemic infections in immunocompromised patients, particularly through open wounds or treatment-related injuries like catheter placements [38, 39]. CoNS was identified as the second most common cause of bacterial SSTIs in this study, consistent with the findings of Ashour and El-Sharif [40]. CoNS, which naturally inhabits the skin surface, can easily cause infections in immunocompromised patients, especially those with medical devices such as catheters. In vulnerable individuals, CoNS can penetrate deeper into tissues, leading to severe infections [41]. *E. coli* exhibited good sensitivity to antibiotics such as amikacin, meropenem, and imipenem, indicating the strong efficacy of these drugs against resistant bacteria. Another notable finding of this study was the relatively low prevalence of BSI observed in our cohort, with only 7% of the patients affected. This incidence is lower than that reported in several prior studies [42]. This discrepancy may be attributed to the implementation of rigorous infection prevention protocols at our institution. Enhanced adherence to hygiene standards (including hand hygiene), improved surveillance and management of medical devices, and enforcement of stringent hospital-acquired infection (HAI) prevention practices likely contribute to this lower observed incidence [33, 43]. A notable observation in this study was the significant association between perianal abscesses and increased risk of BSI. This finding aligns with Szvalb and Rolston (2020), who demonstrated that perianal abscesses, owing to their proximity to the lymphatic and vascular systems, can readily disseminate infections throughout the body [34]. Therefore, patients with such infections require closer monitoring to prevent seeding of the infection. The low mortality rate observed in our study cohort (less than 4%) was noteworthy. This finding aligns with previous reports demonstrating that judicious antibiotic utilization and comprehensive infection management strategies are associated with a significant reduction in mortality among patients with malignancies [27, 35].

Although a WBC count less than 500/mm^3 did not reach statistical significance in our multivariate analysis, the trend towards an increased risk of BSI (aOR = 1.69) warrants further consideration. Clinically, neutropenia is a well-established risk factor for infection in

Table 2 Characteristics of pediatric Cancer patients with SSTIs, stratified by bloodstream infection (BSI) status: results of univariate analysis

Characteristics	Negative Blood Culture (*n*, %)	Positive Blood Culture (*n*, %)	Chi^2	*P*
Gender				
Male	88 (91.67)	8 (8.33)	0.42	0.517
Female	123 (93.89)	8 (6.11)		
Age Group				
<1 year	3 (60)	2 (40)	16.78	**0.002***
1–6 years	79 (87.78)	11 (12.22)		
6–12 years	72 (98.63)	1 (1.37)		
13–18 years	56 (96.55)	2 (3.45)		
>18 years	1 (100)	0 (0)		
Type of Malignancy				
Solid Tumor	80 (90.91)	8 (9.09)	1.43	0.49
Hematologic malignancy	122 (94.57)	7 (5.43)		
Specific Diagnosis				
Leukemia	85 (93.41)	6 (6.59)	3.59	0.61
Lymphoma	28 (100)	0 (0)		
Sarcoma	39 (90.7)	4 (9.3)		
CNS tumor	25 (92.59)	2 (7.41)		
Other Tumors	23 (88.46)	3 (11.54)		
Non-malignant dis.	7 (87.5)	1 (12.5)		
Febrile Neutropenia				
Negative	64 (96.97)	2 (3.03)	2.52	0.113
Positive	140 (90.91)	14 (9.09)		
Infection Site				
Limbs	32 (86.49)	5 (13.51)	0.35	0.95
Port	11 (84.62)	2 (15.38)		
Bone and bone marrow	1 (100)	0 (0)		
Others	1 (100)	0 (0)		
White Blood Cell Count*				
<500	48 (88.89)	6 (11.11)	10.93	0.053
500–999	20 (80)	5 (20)		
1000–1499	11 (91.67)	1 (8.33)		
1500–4999	61 (98.39)	1 (1.61)		
5000–15,000	42 (95.45)	2 (4.55)		
>15,000	22 (95.65)	1 (4.35)		
Type of SSTI				
Phlebitis	66 (98.51)	1 (1.49)	22.92	**0.006***
Perianal Abscess	22 (84.62)	4 (15.38)		
Bone and Bone Marrow	6 (100)	0 (0)		
Surgical Site Infection	30 (90.91)	3 (9.09)		
Cellulitis	72 (93.51)	5 (6.49)		
Limb abscess	9 (100)	0 (0)		

SSTI: Skin and Soft Tissue Infections

A p-value less than 0.05 was considered statistically significant

*Unit: cell/mm^3

immunocompromised patients, and even a modest reduction in WBC count can impair the ability to mount an effective immune response [44]. Therefore, although not statistically significant in our study, close monitoring and aggressive management of infections in pediatric oncology patients with low WBC counts remains crucial to prevent progression to BSI.

A key limitation of our study is its single-center retrospective design, which may restrict the generalizability of our findings to broader pediatric oncology populations. Patient demographics, clinical practices, and microbial epidemiology can vary significantly across different institutions and geographic regions, potentially influencing the prevalence and resistance patterns of the SSTIs observed in this study. Additionally, retrospective data collection is subject to inherent biases such as incomplete records and selection bias, which may affect the accuracy and completeness of the data. Therefore, our results should be interpreted with caution, and we recommend that future research employ multicenter, prospective designs to validate and expand our findings in diverse settings. Finally, data regarding prior antibiotic exposure were not available, precluding a more nuanced analysis of potential associations. Future research should include multicenter studies with larger sample sizes to enhance the generalizability of the results. Furthermore, emphasis should be placed on bolstering infection prevention protocols specifically tailored for neutropenic and oncology patients to mitigate the burden of hospital-acquired infections in this vulnerable population.

Conclusion

This study highlights the significant prevalence of SSTIs in pediatric oncology patients, identifying *E. coli* and *S. aureus* as predominant pathogens. Although a high recovery rate was observed, continuous monitoring of antibiotic resistance is crucial for optimizing treatment in this vulnerable population. It is important to acknowledge that this study was conducted at a single center and the high rate of culture-negative results suggests that non-bacterial etiologies or prior antibiotic use may play a significant role. Therefore, our results should be interpreted with caution, and we recommend that future research employ multicenter, prospective designs to validate and expand our findings in diverse settings.

Table 3 . Characteristics of pediatric Cancer patients with SSTIs, stratified by In-Hospital mortality: results of univariate analysis

Characteristics	Death *n* (%)	Recovery *n* (%)	Chi^2	*P*
Gender				
Male	4 (4.17)	92 (95.83)	0.02	0.849
Female	5 (3.82)	126 (96.18)		
Age Group				
<1 year	0 (0)	5 (100)	2.9	0.574
1–6 years	4 (4.44)	86 (95.56)		
6–12 years	1 (1.37)	72 (98.63)		
13–18 years	4 (6.9)	54 (93.1)		
>18 years	0 (0)	1 (100)		
Type of Malignancy				
Solid Tumor	1 (1.14)	87 (98.86)	3.84	0.147
Hematologic Malignancy	8 (6.2)	121 (93.8)		
Non-malignant	0 (0)	8 (100)		
Specific Diagnosis				
Leukemia	8 (8.79)	83 (91.21)	9.38	0.095
Lymphoma	0 (0)	28 (100)		
Sarcoma	1 (2.33)	42 (97.67)		
Nervous System Tumor	0 (0)	27 (100)		
Other Tumors	0 (0)	26 (100)		
Non-malignant disorders	0 (0)	8 (100)		
Febrile Neutropenia				
Negative	3 (4.55)	63 (95.45)	2.52	0.824
Positive	6 (3.9)	148 (96.1)		
Infection Site				
Limbs	4 (10.81)	33 (89.19)	1.76	0.624
Port	0 (0)	13 (100)		
Others	0 (0)	1 (100)		
Bone and bone marrow	0 (0)	1 (100)		
White Blood Cell Count*				
<500	3 (5.56)	51 (94.44)	2.78	0.734
500–999	2 (8)	23 (92)		
1000–1499	0 (0)	12 (100)		
1500–4999	1 (1.61)	61 (98.39)		
5000–15,000	2 (4.55)	42 (95.45)		
>15,000	1 (4.35)	22 (95.65)		
Culture of Infection Site				
Coagulase-negative Staphylococcus	0 (0)	12 (100)	12.71	0.24
Acinetobacter	1 (50)	1 (50)		
Pseudomonas aeruginosa	0 (0)	7 (100)		
Klebsiella	0 (0)	4 (100)		
Citrobacter	0 (0)	1 (100)		
Staphylococcus saprophyticus	0 (0)	1 (100)		
Streptococcus viridians	0 (0)	1 (100)		
E. coli	2 (10.53)	17 (89.47)		
Non-hemolytic Streptococcus Group D	0 (0)	2 (100)		
Stenotrophomonas maltophilia	0 (0)	1 (100)		
Non-albicans Candida	1 (50)	1 (50)		
Type of skin and soft tissue Infection				

Table 3 (continued)

Characteristics	Death *n* (%)	Recovery *n* (%)	Chi^2	*P*
Phlebitis	1 (1.49)	66 (98.51)	3.03	0.553
Perianal Abscess	1 (3.85)	25 (96.15)		
Surgical Site Infection	2 (5.13)	37 (94.87)		
Cellulitis	5 (6.49)	72 (93.51)		
Others	0 (0)	14 (100)		

SSTI: Skin and Soft Tissue Infections

A p-value less than 0.05 was considered statistically significant

*Unit: cell/mm^3

Table 4 Independent risk factors for bloodstream infection (BSI) in pediatric Cancer patients with SSTIs: results of multivariate logistic regression analysis

Characteristic or Feature	aOR	SE	z	95% CI	*P*
Gender					
Male	0.62	0.37	-0.8	[0.19–2.02]	0.424
Age Group					
0–5 years	8.03	5.78	2.9	[1.96–32.9]	0.004
Type of Malignancy					
Solid Tumor	1.37	0.84	0.51	[0.41–4.53]	0.61
Type of SSTI					
Perianal Abscess	4.4	3.14	2.08	[1.09–17.78]	0.038
White Blood Cell Count					
<500	1.69	1.09	0.81	[0.48–5.96]	0.416

SSTI: skin and soft tissue Infection

aOR: adjusted Odds Ratio, SE: Standard Error, CI: Confidence Interval, P: P-value

Abbreviations

SSTI	Skin and soft tissue infection
CLSI	Clinical and Laboratory Standards Institute
BSI	Bloodstream infection
WHO	World Health Organization
WBC	White blood cell
ANC	Absolute neutrophil count
CRP	C-reactive protein
PCR	Polymerase Chain Reaction
LCBI	Laboratory-confirmed bloodstream infection
MBI-LCBI	Mucosal barrier injury laboratory-confirmed bloodstream infection
CLABSI	Central line-associated BSI
FN	Febrile neutropenia
CoNS	Coagulase-negative staphylococci
HAI	Hospital-acquired infection

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Author contributions

Study concept and design: AA; data acquisition: AA, FN, and YP; Statistical Analysis: AA, SRAM, and EM. Data analysis and interpretation: AA, SRAM, and EM; manuscript drafting: AA, SRAM, FN, YP, AF, and FH; manuscript critical revision for important intellectual content: AA, SRAM, and EM; Study supervision: AA and SRAM. The final manuscript has been revised and approved by all authors.

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Data availability

The dataset used and analyzed during the current study will be available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted following the Helsinki guidelines, national norms, and regulations for conducting medical research. This study was approved by the Research Ethics Committee of the School of Medicine at Shiraz University of Medical Sciences (approval ID: IR. SUMS. MED. REC.1401.536) [45]. All of the precipitants or their parents were informed about this study, and next-of-kin of all the patients gave written informed consent for their child's participation and anonymized use of their clinical data in the study.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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