Bloodstream Infections and Antibiotic Resistance Patterns in Patients at Major Hospitals in Basra, Iraq (2021–2024)

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ABSTRACT

Background. Bloodstream infections (BSIs) occur when bacteria, fungi, or viruses enter the bloodstream, leading to serious health problems. They are particularly concerning due to the rising threat of multidrug-resistant bacteria. This retrospective study examined culture positivity rates among suspected bloodstream infections (BSIs), bacterial causes, and antibiotic resistance by analyzing blood culture reports from three major hospitals in Basra Province between January 2021 and August 2024.

Methods. The frequency and percentage of confirmed BSIs were calculated. The antibiotic susceptibilities of clinical isolates were determined using the automated Vitek®2 system. Patient's data such as gender and age were recorded.

Results. During the study period, blood cultures were collected from 2,730 patients, with bloodstream infections (BSIs) confirmed in 619 cases (22.7%). Among the isolates, Gram-negative bacteria accounted for 330 (53.3%) and Gram-positive bacteria for 289 (46.6%). The most frequently isolated bacteria were coagulase-negative staphylococci (CoNS) (182; 29.4%), *Staphylococcus aureus* (129; 20.8%), *Escherichia coli* (103; 16.6%), *Klebsiella pneumoniae* (69; 11.1%), *Pseudomonas aeruginosa* (37; 5.9%), *Acinetobacter baumannii* (27; 4.3%), *Salmonella* spp. (20; 3.2%), and *Enterobacter* spp. (14; 2.2%). *S. aureus* and CoNS exhibited high resistance to oxacillin at 73.4% and 63.9%, respectively. The antibiotic resistance profile of Gram-negative bacteria showed high resistance to ampicillin (33.3%–88.8%) and low resistance to amikacin (4%–15.9%), with notable resistance to cephalosporins and carbapenems.

Conclusions. The study revealed that CoNS, *Staphylococcus aureus*, and *Escherichia coli* were the most common causes of bloodstream infections (BSIs). Effective infection control requires attention to both antibiotic prescribing practices and general hygiene measures.

Key word: Blood stream infection, Antibiotics resistance, Blood culture, Basra province.

INTRODUCTION

Bloodstream infections (BSIs) occur when bacteria, fungi, or viruses invade the bloodstream, leading to severe systemic infections that can result in serious health complications or even death. BSIs are associated with significant morbidity, mortality, and healthcare costs, making them a major global concern [1,2]. The incidence of bloodstream infections (BSIs) has risen in recent years due to increased invasive procedures and the misuse of antibiotics. A recent study conducted by the Institute for Health Metrics and Evaluation (IHME) on the global burden of sepsis estimated that, in 2017, there were 48.9 million new cases of sepsis and 11 million deaths associated with the condition worldwide [3]. In developing countries, the proportion of patients with BSIs ranges from 11% to 28%, [4-6]. While studies from the northern hemisphere over the past decade indicates BSI incidence rate of 0.15% to 0.25% annually, with most cases originating in the community [7-10]. European studies show variable trends, with some indicating increases and others decreases [11, 12]. Differences in blood culture methodologies, reporting standards, and definitions of duplicates or contaminants contribute to variations in BSI incidence rates [13]. Other factors influencing BSI epidemiology include demographic characteristics, immunodeficiency, the use of invasive devices, and the prevalence of multidrug-resistant pathogens [14,15].

Bloodstream infections (BSIs) are a major health concern in Iraq, mainly due to the emergence of multidrug-resistant pathogens. A study on battlefield casualties found that 38% of trauma patients developed BSIs, with *Acinetobacter baumannii* being a prominent pathogen [16]. This bacterium, often called "Iraqibacter," has been widely documented in military personnel and is associated with severe infections, including BSIs, posing significant treatment challenges due to its antibiotic resistance [17].

Similarly, research on burn patients in Iraq revealed that BSIs were frequently caused by pathogens resistant to most locally available antibiotics, further complicating treatment [18]. The overall burden of antimicrobial resistance (AMR) in Iraq is substantial, with an estimated 3,400 deaths directly attributable to AMR and 12,400 deaths associated with it in 2019 [19,20]. These findings highlight the urgent need for stronger infection prevention measures, antimicrobial stewardship programs, and continuous surveillance to manage and reduce the impact of BSIs and AMR in Iraq's healthcare system.

This study aimed to determine the culture positivity rates among suspected bloodstream infections (BSIs), identify the bacterial species responsible for bacteremia, and analyze their antibiotic resistance profiles in regional hospitals in Basra province. By addressing these challenges through enhanced surveillance, innovative treatments, and improved antibiotic stewardship, we can mitigate the growing threat of antibiotic resistance in bloodstream infections and improve patient outcomes.

MATERIALS AND METHODS

Study population and data collected

The study was based on data from suspected BSIs patients collected from three major hospitals in Basra province: Al Sadir Teaching Hospital, Al Basrah General Teaching Hospital, and Al Basrah Maternity & Children's Teaching Hospital, with bed capacities of 591, 747, and 491, respectively. The data covered the period from January 2021 to August 2024.

During the study period, blood cultures were collected from 2730 patients, and BSIs were confirmed in 619 including 296 females and 323 males, with ages ranging from less than 1 month to 100 years. The collecting data included patient's characteristics, bacterial culture, bacterial pathogen identified, and antibiotic susceptibility test results. The study was approved by the Research and Development and Ethic Committee/Health Authority in Basra province. Due to the retrospective nature of this study, which began several years ago, obtaining informed consent was challenging. As a result, informed consent was not obtained; however, all patient records were deidentified prior to analysis to ensure confidentiality.

Blood sample collection and blood culture:

Blood samples were collected from two separate venipuncture sites to improve diagnostic accuracy and distinguish contamination from true infection. A total volume of 20–30 mL was obtained, with 6 mL from adult patients and 4 mL from pediatric patients transferred into 30 mL BacT/ALERT FA Plus culture bottles (bioMérieux, Durham, NC). The samples were incubated for five days using the BACT/ALERT® 3D automated microbial detection system (bioMérieux, France).

Both aerobic and anaerobic culture bottles were used unless clinically contraindicated. Positive BacT/ALERT blood samples were processed for Gram staining and subcultured on solid media, including MacConkey agar, blood agar, and chocolate agar plates (Oxoid Limited, Hampshire, England). Bacterial colonies were identified using the VITEK® 2 system (bioMérieux, France).

Blood cultures were typically ordered for patients with suspected BSIs based on clinical suspicion and symptoms indicating a systemic infection. Common indications include: fever of unknown origin (FUO), sepsis or septic shock, endocarditis, local infection with systemic signs, post-surgical or nosocomial infections.

The diagnosis of bloodstream infections (BSIs) was confirmed based on two consecutive positive blood cultures and the patient's clinical symptoms.

Antibiotic susceptibility testing

All isolated bacteria were tested for antibiotic susceptibility using the automated VITEK® 2 system (bioMérieux, France), with results interpreted according to the recommendations of the Clinical and Laboratory Standards Institute (CLSI) [21]. The tested antibiotics were categorized into Access, Watch, and Reserve groups [22].

Statistical analysis

A package for Social Sciences (SPSS) Version 22 software was used for statistical analysis. Results are presented as numbers and percentages and a P-value < 0.05 was considered statistically significant.

RESULTS

Study population and data collection.

During the study period, a total of 2,730 blood samples were cultured, with 619 (22.7%) testing positive for bloodstream infections (BSIs). Among these 619 patients, 323 (52.2%) were male, and 296 (47.8%) were female ($P > 0.05$). The highest number of positive BSIs was reported in patients younger than one year of age (246, 39.7%). Table 1 provides a detailed summary of the characteristics of the enrolled patients.

Culture Yield and Common Pathogenic Bacteria Isolated.

The blood culture positivity rate was varied over the years of the study period with average of 22.7%. The lowest blood culture positivity rate was 16.1% in 2024 and highest rate in 2022 (42%) (Table 2).

Among the isolated bacteria, 330 (53.3%) were identified as gram-negative bacteria, while 289 (46.6%) were gram-positive organisms. These included *Staphylococcus aureus* (129; 20.8%), *Streptococcus pneumoniae* (6; 0.9%), *Escherichia coli* (103; 16.6%), *Klebsiella pneumoniae* (69; 11.1%), *Pseudomonas aeruginosa* (37; 5.9%), *Salmonella spp*. (20; 3.2%), and *Acinetobacter* *baumannii* (27; 4.3%). Additionally, coagulase-negative staphylococci (182; 29.4%) and a few other pathogens were isolated from patients suspected of having bloodstream infections (BSIs). Detailed information is provided in Table 2.

Table 1. Distribution of blood culture positivity rates by age and sex.

Characteristic	Number (%)				
Age/ years	2021	2022	2023	2024	Total
≤ 1 (infant)	79 (62.2)	73 (36.7)	70 (31.8)	24 (32.9)	246 (39.7)
1 – 9	17(13.3)	15(7.5)	12(5.4)	2(2.7)	46(7.4)
10 – 19	9(7.0)	16(8.0)	13(5.9)		48(7.7)
20 – 29	3(2.3)	13(6.5)	12(5.4)	2(2.7)	30(4.8)
30 – 39	5(3.9)	7(3.5)	8(3.6)	3(4.1)	23(3.7)
40 – 49	6(4.7)	14(7.0)	13(5.9)	5(6.8)	28(4.5)
50 – 59	4(3.1)	18(9.0)	27(12.2)	7(9.5)	56(9.0)
60 – 69	3(2.3)	16(8.0)	26(11.8)	11(15.0)	56(9.0)
70 – 79	1(0.7)	19(9.5)	21(9.5)	13(17.8)	54(8.7)
80 – 89		8(4.0)	13(5.9)	5(6.8)	26(4.2)
90 – 100			5(2.2)	1(1.3)	6(0.9)
Total	127	199	220	73	P value <0.00001
Sex					
Male	68(53.5)	100(50.2)	121(55)	34(46.5)	323(52.2)
Female	59(46.4)	99(49.7)	99(45)	39(53.4)	296(47.8)
					P-value >0.05

Table 2. Blood culture positivity rates over the study period (2021–2024) and bacterial isolates from positive blood cultures.

All Hospital	2021 N	2022 N (%)	2023 N (%)	2024 N (%)	Total
Total number of blood samples processed for culture	332	472	1475	451	**2730**
Number of positive blood culture	N (%)	N (%)	N (%)	N (%)	Total N (%)
	127 (38.2)	199 (42.1)	220 (14.9)	73 (16.1)	**619 (22.67)**
Gram-positive	**63 (49.6)**	**109 (54.7)**	**115 (52.2)**	**43 (58.9)**	**330 (53.3)**

staphylococcus aureus	47(37.0)	37(18.5)	29(13.1)	16(21.9)	129(20.8)
coagulase-negative staphylococci	16(12.5)	68(34.1)	75(34.0)	23(31.5)	182(29.4)
Streptococcus spp		1(0.5)	4(1.8)	1(1.3)	6(0.9)
Enterococcus spp		1(0.5)	2(0.9)	1(1.3)	4(0.6)
Aerococcus viridans			2(0.9)		2(0.3)
Kocuria spp		2(1.0)		1(1.3)	3(0.4)
Leuconostoc spp			3(1.3)	1(1.3)	4(0.6)
					P-value <0.00001
Gram – negative	**64 (50.3)**	**90 (45.2)**	**105 (47.7)**	**30 (41.0)**	**289 (46.6)**
E.coli	30(23.6)	37(18.5)	24(10.9)	12(16.4)	103(16.6)
Proteus spp	1(0.7)	2(1.0)	5(2.2)		8(1.2)
Pantoea spp		1(0.5)	1(0.4)		2(0.3)
Pseudomonas spp	5(3.9)	15(7.5)	15(6.8)	2(2.7)	37(5.9)
Enterobacter spp	2(1.5)	4(2.0)	4(1.8)	4(5.4)	14(2.2)
salmonella spp	10(7.8)	4(2.0)	5(2.2)	1(1.3)	20(3.2)
Klebsiella spp	14(11.0)	19(9.5)	34(15.4)	2(2.7)	69(11.1)
Acinetobacter spp	2(1.5)	5(2.5)	14(6.3)	6(8.2)	27(4.3)
Achromobacter xylosoxidans		1(0.5)			1(0.1)
Serratia marcescens			2(0.9)	1(1.3)	3(0.4)
Stenotrophomonas maltophide			1(0.4)		1(0.1)
Morganella morganii				2(2.7)	2(0.3)
Citrobacter youngae		1(0.5)			1(0.1)
Burkholderia cepacian		1(0.5)			1(0.1)
					P-value <0.0004

Antibiotic resistance patterns of the most common isolated pathogens.

Table 3 outlines the antibiotic resistance patterns of the gram-positive bacteria. Among the *Staphylococcus aureus* isolates tested, the highest resistance was observed against oxacillin (73.4%) and penicillin (79.3%), both are classified as Access group antibiotics [22]. Resistance against Watch group antibiotics ranged from 8.8 to 39%, with the highest resistance observed for vancomycin (39%), followed by erythromycin (37.3%). Low resistance was observed for linezolid (4%), Reserve group antibiotics [22].

Coagulase-negative staphylococci (CoNS) exhibited the highest resistance to Oxacillin (63.9%) as Access group antibiotic followed by erythromycin (63.7%), both classified as Watch group antibiotics.[22] Additionally, noticeable resistance to vancomycin (25%) was observed among the tested coagulase-negative staphylococci. Similar to *S. aureus*, CoNS exhibited low resistance to chloramphenicol (1.2%) and linezolid (2.3%).

For *Streptococcus pneumoniae*, the highest resistance was observed against tetracycline (66.6%, an Access group antibiotic) and levofloxacin (66.6%, a Watch group antibiotic). Notably, no resistance to vancomycin (Watch group antibiotics) was detected among the *Streptococcus pneumoniae* isolates tested.

Table 4 summarizes the antibiotic resistance patterns of gram-negative (*Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Salmonella* spp., and *Acinetobacter baumannii*). Resistance levels against Access group antibiotics ranged from 4% to 88.8%, with the highest resistance observed for ampicillin (33.3%–88.8%) and the lowest for amikacin (4%–15.9%).

For Watch group antibiotics, resistance ranged from 0% to 100%. The highest resistance was observed against ticarcillin/clavulanic acid (33%–100%), while the lowest resistance was noted for piperacillin/tazobactam (0%–32.2%). Resistance to cephalosporins ranged from 25.6% to 47.9%, while resistance to carbapenems ranged from 20.4% to 22.1%.

For Reserve group antibiotics, resistance to aztreonam ranged from 16.7% to 100%, while resistance to colistin ranged from 0% to 50%. %. Among the tested bacteria, *Proteus* spp. exhibited the highest sensitivity to most of the tested antibiotics.

Table 3 Antibiotic resistance patterns for Gram-positive bacteria isolated from blood cultures.

Antibiotics	**Gram positive***		***S. aureus***		**Coagulase-negative *Staphylococci***		***Streptococcus* spp**	
Access group	Tested	Resistant	Tested	Resistant	Tested	Resistant	Tested	Resistant

Chloramphenicol	163	7(4.2)	81	5(6.1)	77	1(1.2)	5	1(20)
Clindamycin	313	114(36.4)	128	35(27.3)	179	76(42.4)	6	3(50)
Doxycycline	231	36(15.5)	117	14(11.9)	109	20(18.3)	5	2(40)
Gentamycin	301	75(24.9)	118	13(11)	179	61(34)	4	1(25)
Oxacillin	324	202 (62.3)	128	94 (73.4)	169	108 (63.9)	NT	NT
Penicillin	292	184(63)	121	96(79.3)	167	97(58)	4	1(25)
Tetracycline	307	99(32.2)	129	29(22.4)	172	66(38.3)	6	4(66.6)
Trimethoprim\sulfamethoxazole	297	53(17.8)	129	14(10.8)	162	39(24)	6	0(0)
Watch group								
Azithromycin	180	75(41.6)	50	10(20)	125	63(50.4)	5	2(40)
Cefotaxime	80	15(18.75)	42	6(14.2)	32	7(21.8)	6	2(33.3)
Ciprofloxacin	229	52 (22.7)	84	11(13)	145	41(28.7)	NT	NT
Clarithromycin	168	35(20.8)	58	7(12)	105	27(25.7)	5	1(20)
Erythromycin	302	158(52.3)	123	46(37.3)	174	111(63.7)	5	1(20)
Fusidic acid	175	55 (31.4)	63	6 (9.5)	112	49 (43.8)	NT	NT
Levofloxacin	292	76(26)	123	13(10.5)	163	59(36.1)	6	4(66.6)
Meropenem	51	4(7.8)	34	3(8.8)	12	0(0)	5	1(20)
Moxifloxacin	263	52(19.7)	103	18(17.4)	155	33(21.2)	5	1(20)
Vancomycin	254	80(31.4)	128	50(39)	120	30(25)	6	0(0)
Reserve group								
Linezolid	254	8(3.1)	123	5(4)	126	3(2.3)	5	0(0)

*Note: Not all samples were tested for all antibiotics because of technical issues with the VITEK® cards.

N: number; T: tested; R: resistant; NT: not tested

Table 4 Antibiotic resistance patterns for Gram-negative bacteria isolated from blood cultures.

Antibiotics	**Gram negative** N (%)		*Klebsiella spp* N (%)		*Pseudomonas spp* N (%)		*E.coli* N (%)		*Salmonella spp* N(%)		*Proteus spp* N (%)		*Acinetobacter spp* N (%)		*Enterobacter spp* N (%)	
Access group	**T**	**R**	**T**	**R**	**T**	**R**	**T**	**R**	**T**	**R**	**T**	**R**	**T**	**R**	**T**	**R**
Amikacin	242	25(10.3)	69	11(15.9)	32	3(9.3)	100	4(4)	13	3(23)	8	2(25)	7	1(14.2)	13	1(7.6)
amoxicillin-clavulanate	186	73(39.2)	48	16(33.33)	19	10(52.6)	85	26(30.5)	8	7(87.5)	3	1(33.33)	15	7(46.66)	8	6(75)
Ampicillin	210	115(54.7)	57	31(54.3)	26	12(46.1)	95	52(54.7)	10	5(50)	3	1(33.3)	10	6(60)	9	8(88.8)
Doxycycline	187	46(24.5)	48	8(16.66)	20	5(25)	98	26(26.5)	7	1(14.2)	5	3(60)	6	1(16.66)	3	2(66.66)
Gentamycin	267	78(29.2)	68	25(36.7)	36	8(22.22)	103	27(26.2)	13	3(23)	8	3(37.5)	26	10(38.4)	13	2(15.3)
Tetracycline	195	47(24.1)	47	11(23.4)	6	2(33.33)	95	20(21)	16	3(18.75)	2	1(50)	20	7(35)	9	3(33.33)
trimethoprim\sulfamethoxazole	214	76(35.5)	49	19(38.7)	18	6(33.33)	92	37(40.2)	16	1(6.25)	6	4(66.66)	23	8(34.7)	10	1(10)
Watch group																
Azithromycin	127	22(17.3)	42	5(11.9)	12	3(25)	59	10(16.9)	4	1(25)	1	0(0)	3	1(33.33)	6	2(33.33)
Cefepime	252	93(36.9)	61	21(34.4)	35	12(34.2)	98	32(32.6)	17	8(47)	6	2(33.33)	21	12(57.1)	14	6(42.8)
Cefotaxime	214	63(29.4)	62	19(30.6)	16	4(25)	98	24(24.4)	10	4(40)	7	4(57.1)	17	8(47)	4	0(0)
Cefoxitin	183	47(25.6)	56	11(19.6)	26	10(38.4)	69	12(17.3)	7	1(14.2)	5	0(0)	9	4(44.44)	11	9(81.8)
Ceftazidime	265	127(47.9)	69	29(42.02)	33	11(33.33)	102	55(53.9)	16	12(75)	6	0(0)	25	10(40)	14	10(71.4)
Ceftriaxone	167	48(28.7)	38	11(28.9)	24	8(33.33)	69	10(14.4)	5	3(60)	5	1(20)	21	13(61.9)	5	2(40)
Cefuroxime	89	36(40.4)	31	11(35.4)	8	1(12.5)	38	17(44.7)	2	1(50)	4	1(25)	1	1(100)	5	4(80)
Ciprofloxacin	259	73(28.1)	68	17(25)	33	6(18.1)	103	29(28.1)	13	5(38.4)	8	5(62.5)	24	10(41.66)	10	1(10)
Imipenem	259	64(24.7)	69	16(23.1)	33	12(36.3)	103	18(17.4)	11	1(9)	7	3(42.8)	25	12(48)	11	2(18.1)
Levofloxacin	166	34(20.4)	47	8(17.02)	18	0(0)	63	15(23.8)	6	3(50)	5	1(20)	21	6(28.5)	6	1(16.66)

Meropenem	248	55(22.1)	69	19(27.5)	28	6(21.4)	103	16(15.5)	6	2(33.33)	8	0(0)	24	11(45.8)	10	1(10)
Minocycline	215	53(24.6)	63	22(34.9)	15	4(26.66)	90	22(24.44)	13	0(0)	4	3(75)	20	1(5)	10	1(10)
piperacillin\tazobactam	224	170(75.8)	62	20(32.2)	16	4(25)	98	27(27.5)	5	1(20)	7	0(0)	24	9(37.5)	12	3(25)
Ticarcillin	198	85(42.9)	57	22(38.5)	20	6(30)	88	40(45.4)	5	3(60)	5	4(80)	16	5(31.25)	7	5(71.4)
ticarcillin\clavulanic acid	182	68(37.3)	49	18(36.7)	28	9(32.1)	69	26(37.6)	2	2(100)	4	2(50)	19	7(36.8)	11	4(36.3)
Tobramycin	253	80(31.6)	63	22(34.9)	36	7(19.44)	97	35(36)	13	5(38.4)	5	2(40)	26	7(26.9)	13	2(15.3)
Reserve group																
Aztreonam	191	94(49.2)	51	24(47)	9	5(55.6)	103	53(51.4)	9	2(22.2)	6	1(16.7)	2	2(100)	11	7(63.6)
Colistin	81	7(8.6)	14	0(0)	22	4(18.1)	29	1(3.4)	2	1(50)	NT	NT	14	1(7.1)	NT	NT

*Note: Not all samples were tested for all antibiotics because of technical issues with the VITEK® cards.

N: number; T: tested R: resistant NT: not tested

DISCUSSION

Bloodstream infections (BSIs) occur globally, affecting both developed and developing countries. Many cases involve antibiotic-resistant microorganisms that can spread through hospital personnel. Proper antibiotic guidelines help clinicians choose effective treatments and prevent resistance. The present study examined BSI rates and antibiotic resistance patterns in bacterial isolates from patients in major hospitals in Basra, Iraq.

This study found that 619 (22.7%) of 2,730 bloodstream samples collected from patients suspected of having BSI tested positive. Among these 619 patients, 323 (52.2%) were male and 296 (47.8%) were female ($P > 0.05$). The highest BSI positivity rate was observed in patients younger than one year of age (246, 39.7%).

The prevalence rate of BSIs in the current four-year study (22.7%) exceeds the rates reported in India (9%), Europe (14%), southern Sweden (13.7%), Iran (16.3%), and Italy (17.2%) [23-27]. However, it is lower than the rates documented in southern Poland (47.4%) and Cameroon (28%) [28]. Variations in BSI incidence rates and blood culture yields are influenced by multiple factors. Differences in blood culture methodologies, reporting standards, and definitions of duplicates or contaminants play a significant role [13]. Key factors include adherence to diagnostic criteria for bloodstream infections before initiating antibiotics, the volume and source of blood samples, and the timing and frequency of collection [29]. Laboratory efficiency, the type of blood culture systems, and logistical challenges, such as sample transportation and storage conditions, also significantly influence results [29,30].

The notably high frequency of BSI observed during 2021 and 2022 in our study could be attributed to inadequate infection prevention and control (IPC) measures in hospital settings. Additionally, the reorganization of hospital wards during the COVID-19 pandemic likely contributed to this issue, as severely ill non-COVID-19 patients were placed in general wards due to ICU overcrowding. Unlike specialized ICUs, general wards often lack the stringent IPC protocols necessary to prevent the acquisition and transmission of pathogens. Other factors such as antibiotic usage patterns in the community could have had implications on this.

Among the positive blood cultures, this study found a high occurrence of neonatal bacteremia, which may be attributed to factors such as a low immune response, poor hygiene, socioeconomic conditions, and bottle feeding.

The most frequently isolated microorganisms were CoNS (29.4%), *S. aureus* (20.8%), and *E. coli* (16.6%). Several studies have identified CoNS and *S. aureus* as the most prevalent bacteria isolated from BSIs [31-34]. *S. aureus* consistently emerges as a prominent pathogen in various studies. For example, a Norwegian study spanning 2013–2017 identified *S. aureus* as the most common Gram-positive bacterium across all age groups [35]. Similarly, a cross-sectional study conducted in Nepal (2017–2018) found *S. aureus* to be the predominant Gram-positive organism, accounting for 63% of the isolates [36]. Similar results were reported by Sajedi et al. in Iran [37]. Research across different regions highlights the consistent prevalence of *S. aureus* and CoNS as the dominant Gram-positive organisms in pediatric blood cultures [38,39]. This widespread consistency underscores the global significance of these pathogens and their critical clinical relevance in diverse healthcare settings. Our findings revealed that *S. aureus* and CoNS exhibited significant resistance to oxacillin (63.9%–73.4%), indicating the presence of methicillin-resistant *Staphylococcus aureus* (MRSA). Consistent with recent reports from other countries, our study also observed notable resistance to vancomycin and linezolid [40]. This resistance may be linked to the unrestricted use of these antibiotics within the community. In Iraq, there is limited data on the prevalence and antimicrobial resistance profiles of MRSA and vancomycin-resistant

Staphylococcus aureus (VRSA), particularly strains associated with community-acquired infections. Consequently, generating localized data on antimicrobial resistance in *S. aureus* is crucial for informing strategies to control and manage MRSA infections effectively.

In our study, the most frequently isolated Gram-negative bacteria were *E. coli*, *Klebsiella pneumoniae*, *Pseudomonas spp*., *Acinetobacter spp*., and *Salmonella spp*., all of which are classified as WHO priority pathogens. These findings align with those reported in other studies [41].

E. coli demonstrated high resistance to piperacillin (55.4%), third- and second-generation cephalosporins (ceftazidime, 53.9%; cefuroxime, 44.7%), and monobactams (aztreonam, 51.4%). These resistance rates are lower than those reported in a local study by Thari et al. (2024) and in studies conducted across the Middle, including Ghotaslou et al. (2023) in Iran, Aabed et al. (2021) in Saudi Arabia, and Helmy et al. (2023) in Egypt [42-45].

In the present study, amikacin was the most effective antibiotic against *E. coli*, with 96% susceptibility. This finding aligns with results from another local study by Thari et al. (2024) and a study conducted in Colombia by Saavedra et al [41,42].

In the current study, *Klebsiella pneumoniae* exhibited lower resistance to cephalosporins and ciprofloxacin compared to findings reported in a local study by Thari et al [42].

In our study, Acinetobacter spp. accounted for 4.3% of the microorganisms isolated from patients with bloodstream infections (BSIs), highlighting its clinical significance. These isolates exhibited high resistance rates to ampicillin (60%) and amoxicillin-clavulanate (46.66%) and showed significant resistance to all generations of cephalosporins and carbapenems. This aligns with the growing prevalence of Acinetobacter spp. bacteremia reported in Asian countries and neighboring regions, including Iraq, Kuwait, Turkey, and Afghanistan [46-48]. Supporting this trend, a recent surveillance study from Iran identified Acinetobacter spp. as the most frequently isolated bacteria in both hospital- and community-acquired BSIs [26]. However, while our study observed carbapenem resistance among Acinetobacter spp., the rates were relatively lower compared to those reported in other studies, which ranged from 72% to 87% [49-51].

Furthermore, resistance to colistin among gram-negative bacteria was also detected in our findings, underscoring a significant healthcare concern due to its potential to restrict therapeutic options. Despite this, colistin susceptibility remains exceptionally high, approaching 100% in most countries across the Middle East and North Africa, offering some reassurance in treatment strategies [52].

It is concluded that, in our hospitals, Gram-positive bacteria were more commonly associated with bloodstream infections (BSIs) than Gram-negative bacteria. CoNS, *S aureus*, and *E. coli* were the most frequently isolated organisms from blood cultures, accounting for 66.88% of the total isolates. Notably, the majority of the isolated bacteria are classified as WHO priority pathogens, highlighting the urgent need for robust infection prevention and control measures, as well as ongoing surveillance of antibiotic resistance. Among the tested antibiotics, amikacin was found to be the most effective against Gram-negative bacteria.

CONCLUSIONS

The study revealed that CoNS, *Staphylococcus aureus*, and *Escherichia coli* were the most common causes of bloodstream infections (BSIs). Effective infection control requires attention to both antibiotic prescribing practices and general hygiene measures.

Declarations

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Author contributions

N T: Conceptualization, Methodology, Formal Analysis.

K M: Writing – Original Draft Preparation, Writing – Review & Editing.

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Data availability: Data supporting this study are available upon request from the corresponding author.

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