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Research Paper

Bacterial pathogens and antibiotic resistance in bloodstream infections: A three-year retrospective analysis from a tertiary hospital in Northern Iran

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ABSTRACT

Bloodstream infections (BSIs) are a major contributor to morbidity and mortality among hospitalized patients, particularly when antimicrobial resistance is rapidly increasing. The increasing prevalence of multidrug-resistant bacteria poses significant challenges to empirical treatment and infection-control efforts. This study aimed to determine the prevalence, bacterial etiology, and antimicrobial susceptibility patterns of BSIs among inpatients at a tertiary hospital in northern Iran over a three-year period. A retrospective observational analysis was conducted at a tertiary university hospital from March 2021 to March 2024. All hospitalized patients with culture-confirmed BSIs and documented antimicrobial susceptibility testing results were included. Bacterial identification followed standard microbiological procedures. A total of 284 cases of BSI were recorded, and based on the number of hospital admissions, the rates of nosocomial infection and BSI were approximately 4% and 1%, respectively. The mean patient age was 59.7 years, and 32.4% were admitted to ICUs. Gram-negative bacteria predominated, with *Klebsiella* spp. (18.3%), *Escherichia coli* (18.0%), and *Acinetobacter* spp. (12.7%) as the most frequent pathogens. High antimicrobial resistance rates were observed among Gram-negative isolates, particularly non-fermenters. Carbapenems and aminoglycosides remained the most active agents against *Enterobacterales*. Among Gram-positive bacteria, approximately half of staphylococcal isolates were methicillin-susceptible, and enterococci showed full susceptibility to vancomycin. BSIs continue to impose a significant clinical burden in northern Iran, dominated by Gram-negative pathogens and marked antimicrobial resistance. The findings highlight the need for ongoing local surveillance, updated empirical treatment guidelines, and reinforced antimicrobial-stewardship and infection-control programs to reduce morbidity, mortality, and the spread of resistant organisms.

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1. Introduction

Bloodstream infection (BSI) remain among the leading causes of morbidity and mortality worldwide, particularly in hospitalized patients and those with comorbidities [1]. BSI impose a considerable burden on healthcare systems and are associated with prolonged hospitalization, increased healthcare costs, and a higher risk of complications [1,2]. The clinical management of BSI is further complicated by the diversity of causative bacterial pathogens and the emergence of antibiotic resistance, which challenges the effectiveness of empirical therapy and threatens patient outcomes [3,4].

Bacterial pathogens play a central role in the etiology of BSIs, especially in hospitalized settings. Despite the geographical differences, studies have demonstrated a predominance of bacteria such as *Escherichia coli*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and staphylococci in blood specimens of inpatients, often exhibiting high rates of multidrug-resistance (MDR) [5-8].

Antimicrobial resistance (AMR) complicates the treatment of bacterial BSIs by limiting the efficacy of standard antibiotics, necessitating the use of broader-spectrum or more toxic agents, which may increase risk of adverse effects, higher costs, and poorer outcomes [6,8]. Globally, AMR has been identified as a major public health threat, especially in inpatient settings where antibiotic use is frequent and pathogen exposure is high [9]. The dynamic interplay between antibiotic prescribing practices, bacterial epidemiology, and resistance evolution underscores the need for continuous surveillance of bacterial etiology and antimicrobial susceptibility in BSIs.

In north of Iran, there remains a lack of comprehensive, long-term data on bacterial pathogens and resistance trends among hospitalized patients with BSIs. Understanding local etiologic patterns and resistance profiles is crucial for guiding empirical antibiotic therapy, informing infection control policies, and optimizing antimicrobial stewardship. Accordingly, the present retrospective study aims to describe the prevalence, bacterial etiology, and antimicrobial resistance patterns of BSI in inpatients over a three-year period.

2. Materials and Methods

2.1 Study design and setting

This retrospective observational study was conducted at a tertiary specialist hospital located in northern Iran. The investigation covers a three-year period from March 2021 through March 2024 at Razi University Hospital. The study protocol was reviewed and approved by the institutional ethical board (Approval No. IR.GUMS.REC.1403.130). As this was a retrospective study of anonymized data, the requirement for informed consent was waived by the Ethics Committee. Data were de-identified to protect patient confidentiality and managed in accordance with local data protection regulations and the Declaration of Helsinki.

2.2 Study population

All inpatients who were admitted to the hospital during the study period and had a diagnosis of a BSI with a bacterial culture result from a blood specimens were screened for eligibility.

We included cases fulfilling the following criteria: (1) admission date within the study period; (2) documented bacterial isolation from specimen collected during the period of hospitalization; (3) antimicrobial susceptibility testing (AST) performed and documented. We excluded cases in which the culture was considered to represent colonization rather than true infection based on clinical and microbiological criteria, as well as cases where the patient was discharged, transferred, or died before culture results became available and no additional data could be obtained.

2.3 Data collection

Data were extracted from the hospital's microbiology laboratory database and the patient medical records. Variables collected included: age, gender, date of admission, hospital ward (general ward, ICU), length of hospital stay, underlying comorbidities, type of sample, bacterial species isolated, and results of AST. Bacterial identification was performed using standard microbiological methods.

The antimicrobial susceptibility of isolates was tested in accordance with the guidelines of the Clinical and Laboratory Standards Institute (CLSI) [10]. All data were anonymized prior to analysis.

2.4 Statistical analysis

Data were entered into statistical software SPSS version 22 (IBM Corp., Armonk, NY, USA) for analysis. Descriptive statistics were used to summarize patient demographics, sample types, bacterial species distribution and resistance rates.

Categorical variables are presented as counts and percentages; continuous variables are presented as medians with inter-quartile ranges (IQR) or means ± standard deviation (SD) depending on distribution. The Chi-square (χ^2) test or Fisher's exact test (when appropriate) was used to compare proportions. A p-value < 0.05 was considered statistically significant.

3. Results

A total of 284 cases of BSI were recorded during the three-year period, and based on the number of hospital admissions, the rates of nosocomial infection and BSI were approximately 4% and 1%, respectively. Among these, 25 cases (8.8%) were identified as catheter-related bloodstream infections (CRBSI).

The study population consisted of 143 males (50.4%)

and 141 females (49.6%), with a mean age of 59.7 ± 17.8 years (range: 6–95 years). Overall, 92 patients (32.4%) were admitted to the intensive care units (ICUs), while the remaining cases were from general medical wards. A total of 23 patients (12%) were admitted due to COVID-19 infection. The mean interval between hospital admission and onset of infection was 12.6 ± 14 days, and the average length of hospital stay was 24.4 ± 21.9 days. Out of all infected patients, 187 (65.8%) were discharged, whereas 97 patients (34.2%) died during hospitalization. Gram-negative bacteria predominated among the isolates (Table 1). Enterobacterales were the leading cause of BSIs, with *Klebsiella* spp. (18.3%) being the most frequently isolated pathogens, followed by *E. coli* (18.0%), and *Acinetobacter* spp. (12.7%). Among Gram-positive bacteria, coagulase-negative staphylococci (CoNS) accounted for 10.2%, and *Staphylococcus aureus* for 5.3% of isolates. Detailed antibiotic susceptibility profiles of Gram-negative and Gram-positive isolates are presented in Table 2 and 3. Among Gram-negative bacteria, despite generally low susceptibility rates, relatively higher activity was observed for carbapenems and aminoglycosides. For example, *E. coli* exhibited susceptibility rates of 60.8% to amikacin and 52.9% to gentamicin, while *Klebsiella* spp. showed lower rates (28.8% and 30.8%, respectively). Non-fermenters such as *Acinetobacter* spp. demonstrated marked resistance to most tested agents, with susceptibility below 20% for most antibiotics except doxycycline (36.1%).

Table 1. The distribution of bacterial etiology of bloodstream infections

Bacteria	Frequency	Percent
Klebsiella spp.	52	18.3
E. coli	51	18.0
Acinetobacter spp.	36	12.7
Citrobacter spp.	33	11.6
Enterobacter spp.	33	11.6
CoNS	29	10.2
Pseudomonas spp.	21	7.4
S. aureus	15	5.3
Micrococcus spp.	8	2.8
Proteus spp.	2	0.7
Burkholderia spp.	2	0.7
Enterococcus spp.	1	0.4
Other	1	0.4
Total	284	100.0

CoNS: Coagulase-negative staphylococci.

Table 2. Antibiotic susceptibility pattern of Gram-negative bacteria [a].

Antibiotic	*Klebsiella*	*E. coli*	*Enterobacter*	*Citrobacter*	*Proteus*	*Acinetobacter*	*Pseudomonas*	*Burkholderia*
AMK	28.8	60.8	21.2	45.4	100.0	11.1	33.3	-
GEN	30.8	52.9	45.4	39.4	100.0	16.7	38.1	-
IMP	19.2	41.2	21.2	21.2	50.0	13.9	33.3	100 [b]
TZP	0	37.2	18.2	21.2	50.0	5.6	47.6	-
TET	-	-	-	-	-	16.7	-	-
DOX	-	-	-	-	-	36.1	-	-
CFZ	15.4	29.4	3.0	6.1	-	-	-	-
CFP	15.4	15.7	21.2	6.1	50.0	5.6	14.3	-
CAZ	13.5	35.3	18.2	12.1	100.0	11.1	28.6	0
CIP	21.1	35.3	36.4	30.3	50.0	25.0	33.3	50 [c]
SXT	25.0	29.4	42.4	27.3	-	22.2	-	50

a: The percentage values were calculated according to the number of tested isolates. b: Meropenem. C: Levofloxacin. Abbreviations: AMK: Amikacin; GEN: Gentamicin: IMP: Imipenem; TZP: Piperacillin-Tazobactam; TET: Tetracycline; DOX: Doxycycline; CFZ: Cefazolin; CFP: Cefepime; CAZ: Ceftazidim; CIP: Ciprofloxacin; SXT: Trimethoprim/sulfamethoxazole.

Table 3. Antibiotic susceptibility pattern of Gram-positive bacteria [a].

Antibiotic	CoNS	*S. aureus*	*Enterococcus*	*Micrococcus*
ERY	6.9	20.0	0	0
TET	34.5	33.3	0	25.0
GEN	44.8	53.3	0	25.0
DOX	41.4	46.7	0	37.5
FOX	37.9	46.7	-	12.5
CIP	37.9	20.0	100	25.0
CLI	20.7	33.3	0	0
SXT	41.4	33.3	100	12.5
VAN	-	-	100	-

a: The percentage values were calculated according to the number of tested isolates. Abbreviations: ERY: Erythromycin; TET: Tetracycline: GEN: Gentamicin: DOX: Doxycycline; FOX: Cefoxitin; CIP: Ciprofloxacin; CLI: Clindamycin; SXT: Trimethoprim/sulfamethoxazole; VAN: Vancomycin. CoNS: Coagulase-negative staphylococci.

Among Gram-positive isolates, approximately half of the staphylococcal isolates were methicillin-susceptible based on cefoxitin testing. Both *S. aureus* and CoNS displayed moderate susceptibility to gentamicin, doxycycline, and trimethoprim-sulfamethoxazole, while *Enterococcus* spp. isolates remained fully susceptible to vancomycin

4. Discussion

This retrospective three-year investigation provides actionable data for clinicians and public health specialists in northern Iran and contribute to the global evidence base on BSIs in hospitalized populations. In our study, 284 BSI cases were recorded during the three-year period, yielding estimated rates of approximately 4% for nosocomial infections and 1% for BSI relative to total hospital admissions. These findings align with prior reports from Iran and other regions, where hospital-acquired BSI rates typically range from 1% to nearly 10% of admissions depending on setting and surveillance definitions [11-15]. The relatively stable incidence over the three-year interval suggests a persistent clinical burden and underscores the need for ongoing infection-control vigilance. It also reflects that despite advances in care, BSIs remain a non-negligible contributor to patient morbidity and cost. Given the known association between BSIs and increased length of stay, mortality, and healthcare expenditures [16,17], our findings reinforce the importance of continued monitoring and prevention efforts in similar tertiary care centers.

Our analysis demonstrates a predominance of Gram-negative organisms among BSI isolates, with *Klebsiella* spp., *E. coli*, and *Acinetobacter* spp. emerging as leading pathogens. This pattern is consistent with studies in Iran and across Middle-East, where Gram-negatives constitute the majority of BSI pathogens, often outnumbering Gram-positive agents [11,12,18]. For example, a four-year retrospective study from Isfahan reported that Gram-negative organisms, including notably *Klebsiella* spp. (27.1%), and *Acinetobacter* spp. (25.3%), were among the most frequently isolated pathogens in BSIs [11]. In a five-year pediatric study in Tehran, Gram-negatives comprised 54% of isolates, with *Pseudomonas* spp. (17.6%), *K. pneumoniae* (16%), *Stenotrophomonas maltophilia* (13.5%), and *Enterobacter* spp. (10.8%) accounting for large shares of the Gram-negative burden [5].

The resistance profiles observed in our study are concerning. High rates of drug-resistance among Gram-negatives, especially for non-fermenters such as *Acinetobacter*, indicate limited therapeutic options. Prior Iranian studies documented methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and extended-spectrum beta-lactamase (ESBL)-producing *Enterobacterales* at significant levels [19-21]. In our setting, the persistence of carbapenem and aminoglycoside susceptibility among certain isolates provides a valuable empirical therapeutic window; nevertheless, the escalating resistance trends highlight the urgent need for antimicrobial-stewardship programs and strengthened infection-control interventions. Similar resistance patterns have been reported in other countries, including Nepal and Tunisia [7,8]. Such programs should emphasize prudent use of broad-spectrum antibiotics, rapid diagnostic implementation, and targeted de-escalation strategies [3]. Moreover, the interplay between device utilization (e.g., central lines), prolonged ICU stay, and multidrug-resistant bloodstream infections warrants further prospective investigation.

Our study has several limitations. First, the retrospective design and single-center setting may limit generalizability to other hospitals or regions in Iran. Second, clinical outcome data were not systematically taken, restricting our ability to correlate microbiological findings with patient prognosis. Lastly, although we attempted to exclude probable contaminants, the precise differentiation between infection and contamination (especially for CoNS) may not be flawless.

In summary, this three-year retrospective review illustrates that BSIs remain a meaningful burden in a northern Iranian tertiary hospital, with Gram-negative bacteria constituting the main pathogens and significant antimicrobial resistance marked. The findings advocate for sustained surveillance, refinement of empirical antibiotic regimens based on local susceptibility patterns, and strengthening of infection-control and antimicrobial-stewardship frameworks to reduce the impact of drug-resistant BSIs.

Authors' contributions

TY, MH: designed the study and supervised data acquisition. SJ: data acquisition and results analysis. NB, SJ: performed the statistical analysis and drafted the initial manuscript. TY, MH: critically revised the manuscript for important intellectual content. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest

No potential conflict of interest was reported by the authors.

Ethical declarations

The study protocol was reviewed and approved by the institutional ethical board (Approval No. IR.GUMS.REC.1403.130). As this was a retrospective study of anonymized data, the requirement for informed consent was waived by the Ethics Committee. Data were de-identified to protect patient confidentiality and managed in accordance with local data protection regulations and the Declaration of Helsinki.

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