


Analysis of Bacterial Patterns and Risk Factors Associated with Bacteremia in Adult Intensive Care Unit at Soeradji Tirtonegoro General Hospital Klaten, Indonesia

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ABSTRACT

Introduction: Bloodstream infections (BSI) are life-threatening and pose an increased risk of mortality, particularly in intensive care patients. This study aims to delineate the bacterial patterns and analyze the risk factors associated with bacteremia among patients in the adult intensive care unit at Soeradji Tirtonegoro Hospital. **Methods:** This study used a descriptive-analytical design with a cross-sectional approach. The study population consisted of all adult ICU patients at Soeradji Tirtonegoro Hospital with positive blood cultures during the treatment period from October 1, 2019, to August 31, 2022. Analysis of risk factors associated with bacteremia was performed using Fisher's exact test. **Results:** Analysis shows a significant association between the accumulation of 3 or more risk factors and the bacterial patterns found in patients with bacteremia. Data from 52 patients were selected for analysis, comprising 21 females and 31 males. The risk factors associated with bacteremia included installation of hemodialysis catheters, water-sealed drainage (WSD), ventilator use, a history of diabetes, and previous surgery. Several patients had more than one risk factor associated with bacteremia. Blood culture results revealed that 30 out of 52 cases (57.7%) were caused by Gram-negative bacteria, while 22 out of 52 cases (42.3%) were caused by Gram-positive bacteria. The analysis identified two cases of methicillin-resistant coagulase-negative staphylococci (MR CoNS), but no methicillin-resistant Staphylococcus aureus (MRSA) and extended-spectrum beta-lactamases (ESBLs) or carbapenemase-producing bacteria were found. **Conclusion:** This study identified bacterial patterns and analyzed risk factors associated with bacteremia in adult intensive care units. There was a significant association between the number of accumulated risk factors and specific bacterial pathogens in patients with bacteremia.

Keywords: Bacteremia, bacterial pattern, bloodstream infection, intensive care unit.

ABSTRAK

Pendahuluan: BSI *(bloodstream infection)* merupakan infeksi aliran darah yang sering dialami pasien di unit perawatan intensif dan berisiko mengancam jiwa. Tujuan penelitian ini adalah mengevaluasi pola kuman hasil kultur darah serta menganalisis faktor risiko yang dikaitkan dengan bakteremia pada pasien di unit perawatan intensif dewasa RS Soeradji Tirtonegoro (RSST). **Metode:** Penelitian ini menggunakan desain deskriptif-analitik dengan pendekatan *cross-sectional*. Subjek penelitian adalah seluruh pasien dewasa di ruang perawatan intensif dewasa RSST yang hasil pemeriksaan kultur darahnya positif pada periode 1 Oktober 2019 sampai 31 Agustus 2022. Analisis faktor risiko bakteremia menggunakan uji Fisher *exact*. **Hasil:** Analisis menunjukkan adanya hubungan signifikan antara akumulasi 3 atau lebih faktor risiko dan pola kuman yang ditemukan pada pasien bakteremia. Data dari 52 pasien dipilih untuk analisis, terdiri dari 21 perempuan dan 31 laki-laki. Faktor risiko bakteremia pada studi ini adalah pemasangan *HD-cath*, *water-sealed drainage* (WSD), ventilator, riwayat diabetes, serta tindakan pembedahan sebelumnya. Beberapa sampel didapatkan memiliki lebih dari 1 faktor risiko yang dikaitkan dengan bakteremia. Berdasarkan hasil pemeriksaan kultur darah didapatkan 30 dari 52 kasus disebabkan oleh bakteri Gram negatif dan 22 dari 52 kasus disebabkan oleh bakteri Gram positif. Analisis tersebut mengidentifikasi 2 kasus *Staphylococcus* negatif koagulase yang resisten terhadap *methicillin* (MR CoNS), tetapi tidak ditemukan *Staphylococcus aureus* yang resisten terhadap *methicillin* (*methicillin-resistant Staphylococcus aureus*/MRSA) dan bakteri yang memproduksi beta-laktamase spektrum luas (*extended-spectrum beta-lactamases*/ESBLs) atau *carbapenemase*. **Simpulan:** Studi ini mengidentifikasi pola bakteri dan menganalisis faktor risiko yang terkait pada pasien bakteremia di unit perawatan intensif dewasa. Terdapat hubungan yang signifikan antara jumlah faktor risiko yang terakumulasi dan jenis patogen bakteri spesifik pada pasien dengan bakteremia. **Qonita Imma Irfani. Analisis Pola Bakteri dan Faktor Risiko Bakteremia pada Unit Perawatan Intensif Dewasa di Rumah Sakit Umum Soeradji Tirtonegoro Klaten, Indonesia.**

Kata Kunci: Bakteremia, pola kuman, infeksi aliran darah, unit perawatan intensif.

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INTRODUCTION

Bloodstream infection (BSI), also commonly referred to as a circulatory system infection, can be a life-threatening condition for patients treated in hospitals and frequently occurs in intensive care patients. Around 7% of intensive care patients are at risk of encountering BSI. The incidence of BSI is frequently associated with a higher mortality rate specifically, 40%–60%, with patients in intensive care units having a 3-times higher risk of death.[1]

Bloodstream infections are caused by the presence of pathogenic microorganisms within the circulatory system, as demonstrated by positive results on microbiological blood cultures. This circumstance contributes to an inflammatory response, which causes changes in clinical, laboratory, and hemodynamic parameters.[2] The types of microorganisms that are regularly found to cause bloodstream infections in intensive care units are dominated by Gram-negative bacteria (44%), such as *Klebsiella pneumoniae* and *Escherichia coli*, followed by Gram-positive bacteria (41%), which are dominated by CoNS, and the last is caused by fungi (14.6%).[3]

Currently, there is increased surveillance of BSI cases that happen due to treatment in hospitals. This surveillance provides valuable data within the microbiological process of identifying patients who have infections. Additionally, it facilitates the process of identifying risk factors that contribute to BSI during hospital care. Through these efforts, it will be easier for clinicians to conduct appropriate intervention measures related to the patient's condition.[4]

Research on bacterial patterns from blood cultures of patients in adult intensive care units, High Care Unit (HCU), Intensive Care Unit (ICU), and Intensive Cardiology Care Unit (ICCU) at the RSUP dr. Soeradji Tirtonegoro has never been done previously. Accordingly, this study aimed to describe and analyze bacterial profiles, risk factors, and evidence of bacteremia from blood cultures of patients in adult intensive care units (HCU, ICU, and ICCU) at RSUP dr. Soeradji Tirtonegoro.

METHODS

This research follows a descriptive-analytical design with a cross-sectional approach. Data collection was carried out retrospectively at Soeradji Tirtonegoro Hospital (RSST) by evaluating secondary records of patients hospitalized from October 1, 2019, to August 31, 2022. All laboratory analyses were conducted at the RSST Clinical Microbiology Laboratory.

This study included patients treated in adult intensive care units (HCU, ICU, and ICCU) at the Soeradji Tirtonegoro General Hospital in Klaten, during the period from October 1, 2019, to August 31, 2022, with positive blood culture results at the Clinical Microbiology Laboratory of Soeradji Tirtonegoro General Hospital. The exclusion criteria included situations where blood culture and antibiotic sensitivity data cannot be traced, either due to lost samples or other administrative issues. Additionally, patients with incomplete medical records or missing medical data will be excluded from this study, as incomplete information may affect the validity and accuracy of the research results.

All samples were selected by total sampling. This study was conducted at RSST using secondary data obtained from the treatment period between October 1, 2019, and August 31, 2022. The data collection process began by gathering positive blood culture results recorded in the microbiology laboratory's summary report. The identified information was then forwarded to the medical records department to obtain the medical records of patients with positive blood culture results. Data in the medical records were reviewed to ensure the completeness of the required information. During this period, the microbiology laboratory examined 329 blood cultures from patients in the adult intensive care unit; only 58 cultures yielded positive results; 58 isolates were identified; six did not meet the inclusion criteria and were excluded from the study: 2 records could not be found in the medical records, while the other four had incomplete medical records. Only 52 data entries were processed and analyzed as research samples.

The research applied ethical principles during the course of the research. Only patient medical record data is taken for research purposes. Patient identity data, such as the patient's name and address, were not taken and will not be included in this research, but will be replaced using the research serial number used for identification purposes. The identities of patients from medical records involved in this research are confidential; only researchers have access. The published data have been processed and presented in the form of research results. Raw data will be destroyed.

This research was cleared (ethical clearance, or EC) by the Medical and Health Research Ethics Committee (MHREC), Faculty of Medicine, Nursing, and Public Health, Gadjah Mada University - General Hospital, Sardjito, no KE/FK/1459/EC/2022. This research received permission from the Soeradji Tirtonegoro Hospital based on the Research Publication Permission Letter No. DP.04.03/D. XXVI/1380/2025 by the Soeradji Tirtonegoro Hospital authority. Basic data is presented in the form of tables, diagrams, presentations, and narratives. Analysis was performed using *IBM SPSS Statistics for Windows, Version 25.0*.[5] Fisher's exact test was used to analyze risk factors.

RESULTS

Demographic Characteristics

This research was conducted at the Soeradji Tirtonegoro Klaten Central General Hospital. Secondary data were obtained from patient medical records between October 1, 2019, and August 31, 2022. The age distribution of the study population was based on the WHO age classifications, namely: youth (18–65 years), middle-aged (66–79 years), and elderly (80–99 years). During this period, 58 positive culture data isolates were obtained; six were excluded due to incomplete data, so only 52 data of positive cultures will be analyzed. The subjects consisted of 21 females (40.4%) and 31 males (59.6%) **(Table 1).**

Risk Factors

Several risk factors associated with bacteremia were identified. Several patients have more than 1 risk factor.

Analysis of risk factors associated with bacteremia revealed varying distributions of Gram-positive and Gram-negative bacteria (**Table 2**). Among patients with hemodialysis (HD) catheters (n = 14), 10 cases were associated with Gram-positive bacteria and


Table 1. Demographic characteristics.

Age (Years)	Gender		Care Unit			Death	
	Male	Female	ICU	ICCU	HCU	Male	Female
18–65	23	16	23	16	-	10	5
66–79	4	5	2	7	-	2	1
80–99	4	-	2	2	-	3	-

Abbreviations: ICU: Intensive care unit; ICCU: Intensive cardiology care unit; HCU: High care unit.

4 with Gram-negative bacteria, accounting for 26.9% of all bacteremia cases. In patients using wound surgical drainage (WSD) devices (n = 7), all cases were caused by Gram-positive bacteria, representing 13.5% of total bacteremia cases. Ventilator use (n = 21) was associated with 14 cases of Gram-positive and 7 cases of Gram-negative infections, comprising 40.4% of the total bacteremia cases. In the subgroup of diabetes mellitus patients (n = 10), infections were equally distributed between Gram-positive and Gram-negative bacteria, with 5 cases each, contributing 19.2% to the total. The highest proportion of bacteremia cases (48.1%) was observed in patients who had undergone surgical procedures (n = 25), with 16 cases due to Gram-positive and 9 cases due to Gram-negative bacteria.

Causative Bacteria

Several species of pathogens were identified, with the majority being Gram-negative bacteria. We did not find multiple pathogens in any blood culture and did not report the finding of any anaerobic bacteria. The identified isolates consisted entirely of Gram-negative aerobic/facultative bacilli (such as *E. coli* and *K. pneumoniae*) and Gram-positive cocci (such as *E. faecalis* and *Staphylococcus* species). The bacterial isolates and the percentage of samples are listed in **Table 3.** The rate of positive blood cultures for pathogens was very low compared to cultures from specimens other than blood (such as urine, sputum, wound swabs, etc.). Previous antibiotic use also affected the likelihood of pathogen growth during the culture process.[6]

Table 2. Suspected risk factors associated with bacteremia.

Risk Factor	Quantity (n)	Gram-Positive Bacteria	Gram-Negative Bacteria	Percentage (%)
Use of HD catheter	14	10	4	26.9
Use of WSD	7	7	0	13.5
Use of ventilator	21	14	7	40.4
Diabetes mellitus	10	5	5	19.2
Surgical procedure	25	16	9	48.1

Abbreviations: HD: Hemodialysis; WSD: Water-sealed drainage.

Table 3. Causative bacteria.

Bacterial Isolates	Quantity (n)	Percentage (%)
Gram-Negative bacteria	**30**	**57.6**
Klebsiella pneumoniae	7	13.4
Serratia marcescens	1	1.9
Escherichia coli	13	25
Citrobacter freundii	2	3.8
Moraxella	1	1.92
Enterobacter cloacae	1	1.92
Pseudomonas fluorescens	1	1.92
Acinetobacter baumannii	3	5.76
Enterobacter aerogenes	1	1.92
Gram-Positive bacteria	**22**	**42.4**
Streptococcus viridans	3	5.76
Staphylococcus aureus	5	9.61
Staphylococcus hominis	1	1.92
Enterococcus faecalis	7	13.5
Staphylococcus haemoliticus	2	3.8
Staphylococcus epidermidis	2	3.8
Methicillin-Resistant *S. epidermidis*	**2**	3.8

In this study, patients with bacteremia were categorized into 3 groups: patients with 1 risk factor (13 patients), patients with 2 risk factors (13 patients), and patients with 3 or more bacteremia risk factors (12 patients). A more detailed breakdown can be seen in **Table 4**. The significance of the association between the number of risk factors and the type of bacteria was analyzed using *p*-values.

The p-values were included in **Table 4** to evaluate the statistical significance of the association between the accumulation of risk factors and the resulting bacterial patterns, while **Tables 1, 2,** and **3** were primarily intended for descriptive statistics to illustrate the distribution of demographics, individual risk factor frequencies, and bacterial species. The analysis revealed that for patients with a single risk factor, the p-value was 0.126 ($p > 0.05$), indicating no statistically significant association between a single risk factor and the type of bacteria identified. Similarly, for 2 risk factors, the *p*-value was 0.431, suggesting that the distribution of Gram-positive and Gram-negative bacteria did not differ significantly in this group. However, a highly significant association was observed in patients possessing 3 or more risk factors ($p < 0.001$), suggesting that the association between risk factors and specific bacterial


Table 4. Analysis on risk factors.

Number of Risk Factors	Gram-Positive Bacteria	Gram-Negative Bacteria	Quantity (n)	*P* value
No risk factors	1	13	14	0.001
Single risk factor	4	9	13	0.126
Two risk factors	6	7	13	0.431
Three or more risk factors	11	1	12	< 0.001

patterns in bloodstream infections became significant only when at least 3 distinct risk factors were present.

The analysis for each risk factor used samples with only a single risk factor, totaling 13 samples. This study focused only on a single risk factor to ensure identification of the risk factor most associated with bacteremia **(Table 5)**. This approach was taken to avoid confusion when multiple risk factors are interrelated. In cases with 2 or more risk factors, the most significant risk factor in the occurrence of bacteremia could not be determined, because multiple risk factors were identified simultaneously at one point in time, which could lead to bias in determining the most influential risk factor.

Table 5 shows the distribution of Gram-positive and Gram-negative bloodstream infections (BSI) based on individual risk factors. Each risk factor is analyzed to determine whether it is significantly associated with the type of bacterial pathogen. No statistically significant association for any single risk factor.

For illustration, correlation of multiple bacteremia risk factors with Gram-positive and Gram-negative bacteria patterns in ICU settings is visible on **Figure**.

DISCUSSION

In a study in Norway (2022), BSI patients were 51.3% male and 48.7% female, influenced by several risk factors such as lifestyle, smoking habits or alcohol consumption, educational background, risk factors related to cardiovascular organ function (systolic blood pressure, non-HDL cholesterol, and excess body mass index), and other comorbid factors.[7] BSI in adult intensive care unit patients was more common in males (59.6%).[7,8]

Installation of an HD-cath or double-lumen venous catheter in the neck (jugular), chest (subclavian), or groin (femoral) for the hemodialysis process may also act as a potential risk factor for BSI. In a study in a tertiary hospital *in Uganda*, the incidence of bloodstream infections (BSI) in patients using an HD cath for hemodialysis was more commonly caused by Gram-negative bacteria.[9] However, another study in India reported that BSI in hemodialysis patients using HD cath was commonly caused by Gram-positive bacteria.[10] In this study, HD-cath was installed in 26.9% sample with various underlying causes, and BSI in HD-cath users were also dominated by Gram-positive bacteria.

In this study, 40.4% samples used ventilators with various diagnoses and isolates of microorganisms. Ko, *et al*. found 8.6% BSI cases used mechanical ventilators, and this was closely related to the increased length of stay (LOS).[11] This study is comparable with a similar study from India, where 40.4% of BSI cases had a history of ventilator use, while in the Indian study, 8.6% of BSI cases also had a history of ventilator use. This significant difference confirms that the population in this study has a heavier risk profile, so the analysis focused on groups with risk factors.

The incidence of bloodstream infection (BSI) among adult patients in the intensive care unit who underwent surgical procedures during their treatment was found to be 48.1%. This rate is considerably higher compared to a study conducted in the United States, which reported that only 13% of 77 patients with a history of previous surgery developed bacteremia.[12]

The history of diabetes mellitus plays an important role as a risk factor for BSI. Diabetes mellitus patients have a greater risk of infections, such as respiratory tract, digestive tract, urinary tract, and bloodstream

Table 5. Analysis on bacteria distribution in single risk factors associated with bacteremia.

Single Risk Factor (n)	Gram-Positive Bacteria	Gram-Negative Bacteria	*P* value
Mechanical ventilator usage (4)	3	1	0.341
Diabetes mellitus (2)	0	2	0.656
Surgical history (5)	1	4	0.463
HD-cath usage (2)	2	0	0.348

Abbreviations: HD: Hemodialysis; statistical analysis using Fisher's exact tests; *$p < 0.05$ considered significant.

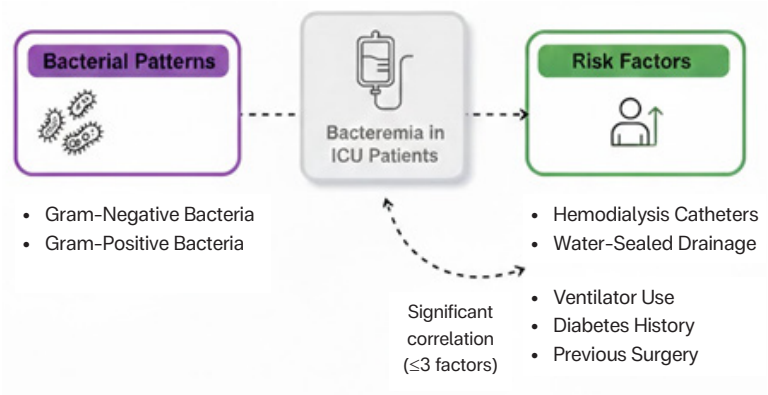

Figure. Correlation of multiple bacteremia risk factors with Gram-positive and Gram-negative bacteria patterns in ICU settings.

infections.[13] In this study, 19.2% patients had diabetes mellitus. Bryce (2020) found that BSI patients with a history of diabetes mellitus had a higher risk of death,[14] similar to a study in Israel, which found the incidence of BSI was 6% among patients with high blood sugar, but only 2% in patients with normal blood sugar.[15]

The blood culture results found 57.6% Gram-negative bacteria dominated by *E. coli* (25%), 42.4% isolates were positive for Gram-positive bacteria, dominated by *E. faecalis* (13.5%). In a study by Bassetti, most Gram-negative bacteria isolated in BSI cases include *E. coli, K. pneumoniae, A. baumanii,* and *Pseudomonas sp*., but in a study in a hospital in Ethiopia, BSI is more often caused by Gram-positive bacteria such as *S.aureus, E. faecallis* and CoNS.[16,17]

This study did not find MRSA and ESBL or carbapenemase-producing bacteria, only two cases of methicillin resistance were caused by negative Staphylococcus coagulase bacteria. Methicillin-resistant Coagulase-Negative Staphylococci (MR CoNS) are a type of opportunistic pathogen, which is currently increasing in the incidence of bacteremia. Coagulase-Negative Staphylococci (CoNS) are often contaminants in blood cultures, therefore to ensure that CoNS are real pathogens, they must be isolated from 2 different culture sites.[6] Study in China (2019) found that 8.8% bacteremia caused by CoNS were false positives, so it is important that positive cultures were from 2 different sites.[18] Bacteremia caused by CoNS is closely related to the use of invasive medical devices as a *port de entree* into the bloodstream. Methicillin-resistant CoNS can be considered a potential cause of bacteremia; MRCoNS bacteremia presents significant therapeutic challenges due to multiple factors. These organisms exhibit resistance to methicillin and are often multidrug-resistant, thereby limiting effective antibiotic options. Additionally, MRCoNS are capable of forming biofilms in indwelling medical devices, such as central venous catheters and prosthetic implants, protecting the bacteria from both antimicrobial agents and host immune defenses. Although considered less virulent than other pathogens, MRCoNS can cause persistent infections, particularly in immunocompromised patients or those with foreign bodies, leading to prolonged and difficult-to-treat bacteremia. Furthermore, as MRCoNS are part of the normal skin flora, distinguishing true bacteremia from contamination in blood cultures remains a diagnostic challenge, potentially delaying appropriate treatment and complicating clinical management.[18,19] Overview of bacteremia in the adult Intensive Care Unit is visible on **Table 6**.

The main limitations of this study were the relatively small sample size and the single-center study setting. The limited number of patients with positive blood cultures (n = 52) may have reduced the statistical power and limited the ability to detect associations between specific risk factors and bacterial pathogens, as well as the detection of multidrug-resistant organisms. In addition, this study was conducted in a single tertiary care hospital, which may limit the generalizability of the findings to other institutions with different patient characteristics, microbiological profiles, and infection control practices.

CONCLUSION

This study delineated the bacterial patterns and analyzed the associated risk factors among bacteremia patients in the adult intensive care unit at Soeradji Tirtonegoro Hospital. The microbiological analysis revealed that 57.6% of bloodstream infections (BSI) were caused by Gram-negative bacteria, predominantly *Escherichia coli*, while 42.4% were attributed to Gram-positive bacteria, led by *Enterococcus faecalis*. Notably, while no MRSA and ESBL or carbapenemase-producing bacteria were detected, the study identified 2 specific cases of BSI caused by methicillin-resistant Coagulase-Negative Staphylococci (MRCoNS).

A critical finding of this research is the significant association observed between patient complexity and microbial outcomes. A statistically significant association between the number of accumulated risk factors and the specific type of bacterial pathogen was only evident in patients possessing 3 or more risk factors. This demonstrates that as risk factors accumulate, the predictability and patterns of bloodstream infections shift significantly.

In conclusion, these findings highlight the profound impact of cumulative clinical risk factors associated with infection patterns in the Adult Intensive Care Unit. The results emphasize the necessity for heightened clinical vigilance and the implementation

Table 6. Overview of bacteremia in the adult Intensive Care Unit.

Category	Component	Key Data/Findings
1. Demographics	Gender prevalence	Primarily males (59.6%)
2. Clinical Risk Factors	Invasive procedures	Surgical history (48.1%), ventilator usage (40.4%), water-sealed drainage (13.5%)
	Comorbidities	Diabetes mellitus (19.2%)
3. Microbial Isolates	Gram-negative (57.6%)	Dominant: *Escherichia coli* (25%)
	Gram-positive (42.4%)	Dominant: *Enterococcus faecalis* (13.5%)
4. Critical Challenge	MRCoNS	Identification: 2 cases found
		Diagnosis: Requires 2 different culture sites
		Impact: Biofilm formation & multidrug resistance
5. Statistical Finding	Significant association	3+ Risk factors lead to specific bacterial patterns ($p < 0.001$)

of targeted infection control strategies, particularly for high-complexity patients. By identifying these specific risk thresholds, clinicians can better anticipate pathogen types and improve management strategies for those at the highest risk of infection.

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