



## Research Article

# The Prevalence and Cost Implications of Bloodstream Infection Producing *Extended-Spectrum Beta-Lactamase (ESBL)* in Adult Patients at Dr. Soetomo General Academic Hospital

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## ABSTRACT

Bloodstream infections (BSIs) caused by extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae represent a growing concern in healthcare settings, particularly in tertiary hospitals. These infections are associated with limited therapeutic options, increased mortality, and rising healthcare costs. This study aimed to describe the clinical, microbiological, and economic characteristics of adult inpatients diagnosed with hospital-acquired (HA) BSIs due to ESBL-producing Enterobacteriaceae at Dr. Soetomo General Academic Hospital from January 1 to December 31, 2024. A cross-sectional study was conducted using retrospective data from adult inpatients ( $\geq 18$  years) with confirmed HA-BSIs caused by ESBL-producing *Escherichia coli*, *Klebsiella pneumoniae*, or *Proteus mirabilis*. Only the first positive blood culture per patient was analyzed. Community-acquired infections and non-Enterobacteriaceae organisms were excluded. The most frequent pathogen was *Escherichia coli* ESBL, especially among patients from medical wards. BSIs occurred predominantly in medical and intensive care units. Notably, microbiological confirmation of ESBL-producing organisms led to higher claim reimbursements through the national health insurance system, yielding a positive cost margin despite longer hospital stays and expensive treatment regimens. In conclusion, ESBL-producing Enterobacteriaceae remain a major challenge in managing HA-BSIs at Dr. Soetomo General Academic Hospital. While clinically burdensome, accurate microbiological diagnosis also supports optimal resource utilization and insurance claim efficiency in the hospital setting.



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### INTRODUCTION

Bloodstream infections (BSIs) remain a significant cause of morbidity and mortality among hospitalized patients worldwide, especially in critical care and immunocompromised populations. The emergence and spread of antimicrobial-resistant organisms, particularly extended-spectrum beta-lactamase (ESBL)-producing *Enterobacteriaceae*, have significantly complicated the clinical management of BSIs. ESBL enzymes confer resistance to a broad range of beta-lactam antibiotics, including penicillins, third-generation cephalosporins, and aztreonam. This limits treatment options and increases dependence on last-line antibiotics such as carbapenems (CDC, 2021).

The global prevalence of ESBL-producing pathogens has been rising, with marked increases reported in both community and healthcare settings, especially in low- and middle-income countries. Hospital-acquired (HA) BSIs caused by ESBL-producing organisms are particularly concerning due to their association with prolonged hospital stays, increased healthcare costs, higher rates of intensive care unit (ICU) admission, and increased mortality (Schwaber & Carmeli, 2007; Jean et al., 2022). Identifying these infections' clinical and epidemiological characteristics is critical for improving infection control, guiding empirical antibiotic therapy, and informing antimicrobial stewardship strategies (NICE, 2016).

Despite the growing clinical importance of ESBL-BSIs, there is limited data specific to Indonesian tertiary care centers, including Dr. Soetomo General Academic Hospital. This study aims to characterize the microbiological features of adult inpatients diagnosed with hospital-acquired bloodstream infections due to ESBL-producing *Enterobacteriaceae*

and the cost implications over one year in Dr. Soetomo General Academic Hospital, Surabaya.

### METHODS

This was a retrospective cohort study conducted at Dr. Soetomo General Academic Hospital, a tertiary care and teaching hospital in Surabaya, Indonesia. The study period covered one full calendar year, from 1st January to 31st December 2024. The study aimed to describe the characteristics of adult inpatients with hospital-acquired (HA) bloodstream infections (BSIs) caused by extended-spectrum beta-lactamase (ESBL)-producing *Enterobacteriaceae*.

Data were obtained from hospitalized adult patients ( $\geq 18$  years old) who developed a laboratory-confirmed BSI due to *Enterobacteriaceae* during their admission. Only HA-BSI cases were included in the analysis. A BSI was classified as hospital-acquired if the first positive blood culture was obtained  $\geq 48$  hours after hospital admission. The date of BSI onset was defined as the date of collection of the first blood sample that yielded an *Enterobacteriaceae* isolate.

Patients were excluded from the study if the BSI was classified as community-acquired, defined as detection of BSI within the first 48 hours of admission. In addition, BSIs caused by non-*Enterobacteriaceae* pathogens were excluded. If the same *Enterobacteriaceae* strain was isolated more than once in the same patient, only the first isolate was included in the analysis to avoid duplication.

Microbiological data were collected from the hospital's clinical microbiology laboratory records. Blood cultures were processed according to standard procedures, and identification of *Enterobacteriaceae* and ESBL production was performed using the BD Phoenix automated system and confirmed by



phenotypic confirmatory tests according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

The information, including ward of hospitalization and medical cost, was extracted from electronic medical records. Data were analyzed using descriptive statistics to determine the frequency and distribution of ESBL-producing *Enterobacteriaceae* BSI characteristics during the study period. This study has been ethically approved by the Ethics Committee of Dr. Soetomo General Academic Hospital with reference number 1294/KEPK/IV/2025.

## RESULTS

Table 1 shows the extended-spectrum beta-lactamase (ESBL)-producing *Enterobacteriaceae* that caused hospital-acquired (HA) bloodstream infections (BSIs) in Dr. Soetomo General Academic Hospital in 2024 were *Escherichia coli* ESBL, *Klebsiella pneumoniae* ESBL, and *Proteus mirabilis* ESBL. The total of these isolates was 170.

**Table 1.** Total ESBL bacteria

PATHOGENS	ESBL (%)	Number of isolates
<i>Escherichia coli</i> ESBL	61.53 %	105
<i>Klebsiella pneumoniae</i> ESBL	33.13 %	57
<i>Proteus mirabilis</i> ESBL	4.75 %	8
Total	100	170

**Table 2.** Distribution of ESBL Bacteria

ROOMS	AMOUNTS	%
<b>Emergency Department</b>	<b>12</b>	<b>8.29</b>
<i>Klebsiella pneumoniae</i> ESBL	4	2.37
<i>Escherichia coli</i> ESBL	8	5.92
<b>Surgery Wards</b>	<b>11</b>	<b>6.51</b>
<i>Klebsiella pneumoniae</i> ESBL	3	1.78
<i>Escherichia coli</i> ESBL	7	4.14
<i>Proteus mirabilis</i> ESBL	1	0.59
<b>Medical Wards</b>	<b>72</b>	<b>42.60</b>
<i>Klebsiella pneumoniae</i> ESBL	24	13.60
<i>Escherichia coli</i> ESBL	45	26.63
<i>Proteus mirabilis</i> ESBL	3	1.78
<b>Intensive Care Unit</b>	<b>72</b>	<b>42.60</b>
<i>Klebsiella pneumoniae</i> ESBL	26	15.38
<i>Escherichia coli</i> ESBL	42	24.85
<i>Proteus mirabilis</i> ESBL	4	2.37
<b>Total</b>	<b>170</b>	<b>100</b>



Table 3. Distribution of Loss and Profit by ESBL Bacteria Type

ROOMS	LOSS (Patients)	PROFIT (Patients)
Emergency Department	5	7
<i>Escherichia coli</i> ESBL	5	3
<i>Klebsiella pneumoniae</i> ESBL	0	4
EMERGENCY DEPARTMENT INTENSIVE ROOM	16	27
<i>Escherichia coli</i> ESBL	12	22
<i>Klebsiella pneumoniae</i> ESBL	3	3
<i>Proteus mirabilis</i> ESBL	1	2
SURGERY WARDS	1	10
<i>Escherichia coli</i> ESBL	0	7
<i>Klebsiella pneumoniae</i> ESBL	0	3
<i>Proteus mirabilis</i> ESBL	1	
MEDICAL WARDS	20	52
<i>Escherichia coli</i> ESBL	12	33
<i>Klebsiella pneumoniae</i> ESBL	7	17
<i>Proteus mirabilis</i> ESBL	1	2
INTENSIVE CARE UNIT	2	30
<i>Escherichia coli</i> ESBL	2	9
<i>Klebsiella pneumoniae</i> ESBL	0	20
<i>Proteus mirabilis</i> ESBL	0	1
Total Patients	44	126

Table 2 shows the most common distribution of ESBL-producing *Enterobacteriaceae* that caused HA-BSIs from medical wards and intensive care units. The most common ESBL-producing *Enterobacteriaceae* that caused HA-BSIs were *Escherichia coli* ESBL in medical wards.

Table 3 shows the distribution of medical costs' loss and profit by ESBL-producing *Enterobacteriaceae* that caused HA-BSIs in Dr. Soetomo General Academic Hospital in 2024. It shows that the microbiological culture that resulted in ESBL-producing *Enterobacteriaceae* from HA-BSIs gave more profit in the claim of medical insurance.

DISCUSSION

This study highlights the epidemiological and clinical characteristics of adult inpatients diagnosed with bloodstream infections (BSIs) caused by extended-spectrum beta-lactamase (ESBL)-producing organisms at Dr. Soetomo General Academic Hospital. The high incidence of ESBL-producing pathogens, particularly *Escherichia coli*, *Klebsiella pneumoniae*, and *Proteus mirabilis*, reflects an ongoing challenge in managing hospital-acquired (HA) infections in tertiary care settings (Lee et al., 2019; Rodríguez-Baño et al., 2018). These infections predominantly originated from medical wards and intensive care units (ICUs), where patients often present with complex comorbidities and are exposed to broad-spectrum antibiotics and



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invasive procedures (Yap et al., 2021). Notably, the most frequent isolate was *Escherichia coli* ESBL, especially in patients from medical wards, indicating a possible link to urinary tract-related bloodstream infections or post-abdominal surgery complications (Russo & Johnson, 2003).

The presence of ESBL-producing bacteria significantly complicates BSI management due to resistance to third-generation cephalosporins and monobactams, necessitating the use of last-resort antibiotics such as carbapenems (Paterson & Bonomo, 2005; Bush & Bradford, 2016). Although most isolates in this study remained carbapenem-susceptible, reliance on these agents raises concerns about the rise of carbapenem-resistant *Enterobacteriaceae* (CRE) (Meletis, 2016; Tamma et al., 2021).

Compared with regional data, the prevalence of ESBL-BSIs in this study is consistent with findings from other tertiary hospitals in Southeast Asia (Jean et al., 2022). However, antimicrobial resistance patterns may vary due to differences in antimicrobial use, diagnostic resources, and infection control policies (World Health Organization, 2017). Continuous local surveillance and antimicrobial stewardship are essential to ensure empirical treatment remains effective and to reduce selective pressure for resistance (Tamma et al., 2021; Indonesian Ministry of Health, 2023).

Economically, ESBL-related infections are known to increase healthcare resource use, including longer hospital stays and higher drug costs (Russo & Johnson, 2003). Interestingly, analysis of national health insurance claims at Dr. Soetomo General Academic Hospital in 2024 revealed that HA-BSI cases caused by ESBL-producing *Enterobacteriaceae* yielded higher reimbursement due to classification as high-severity cases (Direktorat Jenderal Pelayanan Kesehatan, 2022). This allowed

hospitals to claim for comprehensive diagnostics and advanced antimicrobial treatments. Consequently, although ESBL infections impose a greater clinical burden, they also result in a net positive hospital margin due to successful claim approvals, demonstrating the dual value of microbiological confirmation (Ritchie & Roser, 2019). These findings reinforce the importance of infection control bundles, including hand hygiene, antimicrobial de-escalation, catheter care, and early removal of invasive devices (Kaye et al., 2021; Indonesian Ministry of Health, 2023). Special attention should be paid to high-risk units like medical wards and ICUs, where ESBL-producing *Enterobacteriaceae* are most frequently isolated.

This study has several limitations, including its retrospective design and single-center scope, which limit generalizability. Additionally, molecular analysis of ESBL genes was not performed, which could have offered further insights into resistance mechanisms and transmission (Rodríguez-Baño et al., 2018). Nonetheless, this study contributes meaningful data on the clinical, microbiological, and economic aspects of ESBL-BSI in a high-volume Indonesian tertiary hospital. Future prospective multicenter studies are needed to assess molecular resistance patterns and evaluate cost-effective prevention strategies in similar healthcare settings.

## CONCLUSION

Hospital-acquired bloodstream infections caused by ESBL-producing *Enterobacteriaceae* remain a significant clinical and economic concern at Dr. Soetomo General Academic Hospital. In 2024, the predominant pathogens were *Escherichia coli*, *Klebsiella pneumoniae*, and *Proteus mirabilis*, with *E. coli* ESBL being most commonly isolated from medical ward



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patients. These infections were associated with prolonged hospitalization and complex clinical management, yet they also generated higher insurance claim reimbursements due to their classification as severe cases requiring intensive diagnostics and high-cost treatments. Strengthening infection control measures, antimicrobial stewardship, and early microbiological diagnostics is essential to mitigate the burden of ESBL-related BSIs while optimizing both clinical outcomes and hospital resource utilization.

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