

Research Article

Examining the Relationship between Infection Control Practices and ESBL Bacterial Carriage in Healthcare Workers

Hubungan Perilaku PPI dengan Kejadian Karier Bakteri Penghasil ESBL pada Tenaga Kesehatan

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ABSTRACT

The Enterobacteriaceae family widely produces Extended Spectrum Beta-Lactamase (ESBL), and infection by ESBL-producing bacteria can significantly increase morbidity, complicate therapeutic difficulties, escalating healthcare costs, and increase mortality rates. Transmission of these bacteria within the hospital environment may lead to the prevalence of ESBL-producing bacterial carriers among healthcare workers. Health workers' infection prevention and control (IPC) behavior plays a role in transmitting these pathogenic bacteria. This study aimed to determine the relationship between IPC behavior and the incidence of ESBL-producing bacterial carriers in health workers at Banjarnegara Islamic Hospital. This research used an observational analytic approach with a cross-sectional method. The sampling technique involved purposive sampling, resulting in a total sample of 61 people. Data were obtained by completing an IPC behavior questionnaire and collecting rectal swab samples cultured on CHROM ESBL Agar media. Statistical analysis was done using the Mann-Whitney test. The research identified a prevalence of 13.1% (8/61) ESBL-producing bacterial carriers among health workers at Banjarnegara Islamic Hospital. However, based on statistical analysis, the p-value was 0.664, leading to the rejection of the hypothesis (accepted if p-value <0.05). In conclusion, there is no significant relationship between IPC behavior and the incidence of ESBL-producing bacterial carriers in health workers at Banjarnegara Islamic Hospital.

Keywords: Behavior, Enterobacteriaceae, extended-spectrum beta-lactamase, health workers, infection prevention and control

ABSTRAK

Extended Spectrum Beta-Lactamase (ESBL) banyak dihasilkan oleh famili Enterobacteriaceae. Infeksi oleh bakteri penghasil ESBL dapat meningkatkan morbiditas, kesulitan terapi, biaya pelayanan kesehatan, dan meningkatkan mortalitas. Transmisi bakteri tersebut pada lingkungan rumah sakit dapat menyebabkan kejadian karier bakteri penghasil ESBL pada tenaga kesehatan. Perilaku pencegahan dan pengendalian infeksi (PPI) pada tenaga kesehatan berperan dalam transmisi bakteri patogen tersebut. Penelitian ini bertujuan untuk mengetahui hubungan perilaku PPI dengan kejadian karier bakteri penghasil ESBL pada tenaga kesehatan di RSI Banjarnegara. Penelitian ini merupakan penelitian analitik observasional dengan metode *cross sectional*. Pengambilan sampel menggunakan metode *purposive sampling* dengan total sampel sebesar 61 orang. Data diperoleh dengan pengisian kuesioner perilaku PPI dan pengambilan sampel swab rektal yang kemudian dikultur pada media CHROM ESBL Agar. Analisis data menggunakan uji Mann Whitney. Berdasarkan penelitian ditemukan bahwa prevalensi karier bakteri penghasil ESBL pada tenaga kesehatan di RSI Banjarnegara sebesar 13,1% (8/61). Berdasarkan analisis statistik diperoleh nilai *p value* sebesar 0,664 dengan interpretasi hipotesis ditolak (hipotesis diterima apabila *p value* <0,05). Berdasarkan penelitian disimpulkan bahwa tidak terdapat hubungan bermakna antara perilaku PPI dengan kejadian karier bakteri penghasil ESBL pada tenaga kesehatan di RSI Banjarnegara.

Kata Kunci: *Extended spectrum beta-lactamase*, perilaku, pencegahan dan pengendalian infeksi, tenaga kesehatan, Enterobacteriaceae

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INTRODUCTION

Extended Spectrum Beta-Lactamase (ESBL) enzymes are produced by *Enterobacteriaceae*, with a prevalence of infections due to ESBL-producing bacteria in Indonesia reaching as high as 65% (1). Research at Dr. Soeradji Tirtonegoro General Hospital Klaten in 2018 found that ESBL-producing *Enterobacteriaceae* isolates reached 16.9%, with *Klebsiella pneumoniae* (42.1%) and *Escherichia coli* (31.4%) being the most common isolates (1). A study by Decker *et al.*, in 2018 in the United States reported that 3.4% (26/755) of hospital health workers were carriers of ESBL-producing bacteria (2).

Escherichia coli is a common causative agent for diarrhea and urinary tract infections (UTIs) (3). Data from the Central Java health profile in 2021 indicates that cases of diarrhea for toddlers and diarrhea for all ages treated at health facilities in Banjarnegara Regency were lower than the average in Central Java (4). However, according to data from Banjarnegara Islamic Hospital in 2021, UTIs ranked among the top 10 diseases that led to hospitalization (5). The high incidence rate and suboptimal handling of infections can potentially lead to pathogen transmission.

ESBL infections are associated with increased morbidity, healthcare costs, therapeutic difficulties, and mortality rates of up to 28%. Preventive measures against transmission, including heightened contact awareness, meticulous attention to the transmission process, robust infection prevention and control measures, and cautious antimicrobial use, are essential to reduce ESBL incidence (6,7).

A lack of discipline in behavior within the hospital environment can escalate the risk of *healthcare-associated Infections* (HAIs) (8). A survey across 10 Indonesian teaching hospitals revealed HAI rates ranging from 6% to 16% (average 9.8%) (9). Personal protective equipment (PPE) use can protect the body and reduce potential hazards (8), while regular handwashing procedures play a crucial role in reducing HAI risk (9). Edimarta *et al.*, highlighted a significant relationship between HAIs and nurses' attitudes, with inappropriate PPE use increasing HAI incidence (10).

Carrying multidrug-resistant organisms (MDROs) like ESBL producers among healthcare workers poses a significant risk of transmitting these pathogens and subsequent MDRO infections in patients. Given the high morbidity and mortality associated with ESBL infections, understanding the epidemiology and determinants of ESBL carriage, including infection control practices, is crucial to prevent transmission. However, research on the relationship between infection prevention and control (IPC) practices and the incidence of ESBL-producing bacterial carriers in health workers, particularly in Indonesia, is limited. This study aimed to examine the relationship between IPC behavior and the incidence of ESBL-producing bacterial carriers in health workers at Banjarnegara Islamic Hospital.

METHODS

This study was conducted in July-August 2023 at Banjarnegara Islamic Hospital and the Faculty of Medicine Microbiology Laboratory, Jenderal Soedirman University. The inclusion criteria for this study are as follows: healthcare workers employed at RSI Banjarnegara for at

least one year, who have direct contact with patients, and who are willing to participate as respondents by agreeing to the informed consent. The exclusion criteria include those working in two or more healthcare facilities and those not completing the questionnaire. The limitations of this study include the absence of analysis of several confounding variables that may influence the study results, such as the duration of employment of healthcare workers, work location, history of antibiotic use, history of contact with patients infected with ESBL, and handwashing habits outside the hospital environment. These variables could affect the incidence of ESBL-producing *Enterobacteriaceae* carriers among healthcare workers but were not controlled for in this study. The research used an observational analytic approach with a cross-sectional study design.

In this study, the following infection prevention and control (IPC) practices were observed among the healthcare workers: hand hygiene compliance with the five moments (before patient contact, before aseptic procedure, after body fluid exposure risk, after patient contact, after contact with patient surroundings); use of personal protective equipment (PPE) such as gloves, surgical masks, eye/face protection when performing procedures/activities with potential exposure to patient's body fluids; contact precautions practices such as using appropriate PPE when handling patients with communicable diseases transmitted by contact/droplet route; decontamination procedures for medical equipment after use; and procedures for handling biological spill (blood, body fluids, secretions).

The structured questionnaire to assess IPC practices consisted of 17 questions with response options ranging from 1 (Never) to 5 (Always). The questionnaire items covered various IPC practices such as hand hygiene, use of PPE, safe handling of patient specimens, and decontamination procedures (see Appendix 1 for the full questionnaire).

Tools and Materials

The tools used in the study included analytical scales, Petri dishes, microscopes, autoclaves, object glasses, dropper pipettes, Ose inoculation tools, test tubes, tube racks, 5 ml tubes, incubators, refrigerators, hot plates, and magnetic stirrers. In contrast, the materials used in the study were rectal swab samples, CHROMagar™ ESBL, Triple Sugar Iron Agar (TSIA) media, Amies transport media, MacConkey Agar Media, and oxidase sticks. Mueller-Hinton agar plates were used with clavulanic acid disks and disks containing third-generation cephalosporins, such as cefotaxime and ceftazidime.

Course of Research

The study was initiated by gathering Infection Prevention and Control (IPC) behavior data and obtaining rectal swab samples from health workers at Banjarnegara Islamic Hospital. This study has obtained ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Jenderal Soedirman, with the reference number 079/KEPK/PE/VI/2023, issued on June 12, 2023. Using a validated and reliable IPC behavior questionnaire and providing informed consent sheets, the process commenced with visits to the respective wards where respondents were stationed. During these visits, an explanation of the questionnaire completion process was

provided, and guidance was given for the independent collection of rectal swab samples. Respondents completed the IPC behavior questionnaire and independently collected rectal swab samples using Amies transport media. Subsequently, these collected swab samples were taken to the microbiology laboratory at the Faculty of Medicine of Universitas Jenderal Soedirman for the culture process. The culture process began with the sub-culture of rectal swab samples on MacConkey Agar media to differentiate between lactose fermenter and non-lactose fermenter bacteria. Non-lactose fermenter bacteria underwent an oxidase test. Following this, lactose fermenter and non-lactose fermenter bacteria were cultured on CHROM Agar media and incubated for 24 hours at 37°C. The morphological identification of bacterial colonies on the media was conducted. As a confirmation test for ESBL production, isolates growing on the CHROMagar ESBL media were subjected to the double-disk synergy test according to CLSI guidelines. The test involves placing a disk containing clavulanic acid and third-generation cephalosporins on an inoculated Mueller-Hinton agar plate. After incubation, the zone of inhibition is observed, and any distortion or synergy between the clavulanic acid and cephalosporin disks indicates ESBL production by the isolate.

Data Analysis

Univariate analysis was used to characterize the respondents' descriptive data. Data processing and analysis were performed using IBM SPSS Statistics 22. The analyzed data included demographic information such as age, gender, education level, profession, tenure, access to medical information, main source of medical information, workplace location, total behavior score, prevalence of ESBL-producing bacterial carriers, and isolates found in carriers. Bivariate analysis using the Mann-Whitney test was used to determine the relationship between IPC behavior and the incidence of ESBL-producing bacterial carriers in health workers at Banjarnegara Islamic Hospital.

RESULTS

Based on the demographic data, most respondents were 26-30 years old (52.5%). Regarding gender distribution, 38 respondents (62%) were female, and 23 (37.7%) were male. Based on the education level, most respondents pursued D3 education (73.8%). A predominant number of participants (83.6%) were employed as nurses, with 45.9% stationed in the inpatient ward. Additionally, 90.2% of participants had a working tenure of 1-10 years. The vast majority, at 96.7%, frequently accessed medical information, with 90.2% relying on various mass media sources such as the internet, journals, television, and radio.

The CHROMagarTM ESBL culture results indicated that eight health workers (13.1%) at Banjarnegara Islamic Hospital were carriers of ESBL-producing bacteria, while the remaining 53 individuals (86.9%) were non-carriers. The median total score for career behavior was 83 for carriers and 82 for non-carriers. Among ESBL-producing bacteria carriers, the predominant isolates were *Escherichia coli* (62.5%), followed by *Klebsiella pneumoniae* (25%) and *Acinetobacter baumannii* (12.5%).

Based on the Mann-Whitney test, the significance value is 0.664. Since this value exceeds 0.05, the hypothesis is

rejected. The initial hypothesis suggested a connection between infection prevention and control behavior and Extended Spectrum Beta-Lactamase (ESBL) incidence-producing bacterial carriers among health workers at Banjarnegara Islamic Hospital. Consequently, it can be concluded that there is no significant relationship between IPC behavior and the incidence of ESBL-producing bacterial carriers among health workers at Banjarnegara Islamic Hospital.

Table 1. Descriptive data of respondents

Characteristics	Total	Percentage (%)
Age		
21-25 years old	5	8.2
26-30 years old	32	52.5
31-35 years old	18	29.5
36-40 years old	6	9.8
Gender		
Female	38	62.3
Male	23	37.7
Education Level		
D3	45	73.8
D4	2	3.3
Nurse Profession	5	8.2
S1	8	13.1
S2	1	1.6
Profession		
Specialist doctors	0	0
General practitioners	1	1.6
Nurse	51	83.6
Midwife	9	14.8
Work Location		
Emergency room	18	29.5
VK	9	14.8
Perinatology	6	9.8
Ward	28	45.9
Length of Service		
1-10 years	55	90.2
10-20 years	5	8.2
>20 years	1	1.6
Access to Medical Information		
Often	59	96.7
Rare	2	3.3
Primary Source of Medical Information		
Mass media (internet, journals, television, and radio)	55	90.2
Training	6	9.8

DISCUSSION

The CHROMagarTM ESBL culture results indicated that eight health workers (13.1%) at Banjarnegara Islamic Hospital were carriers of ESBL-producing bacteria, while the remaining 53 individuals (86.9%) were non-carriers. Among ESBL-producing bacteria carriers, the predominant isolates were *Escherichia coli* (62.5%), followed by *Klebsiella pneumoniae* (25%) and *Acinetobacter baumannii* (12.5%). These results are in line with Konoralma in 2019, which identified the most bacteria causing HAIs as *Escherichia coli* (33.3%), *Vibrio cholerae* (33.3%), *Klebsiella sp.* (17%), and gram-positive coccus (17%) (11). Adler et al. in 2014 reported that ESBL-producing *Enterobacteriaceae* found in health workers were *Escherichia coli* (76%) followed by *Klebsiella pneumoniae* (19%) (12).

The total score of IPC behavior was obtained by summing

the scores from the 17-question questionnaire with a score range of 1 to 5, which resulted in a total score interval of 17 to 85. The highest score obtained by respondents was 85, while the lowest was 68. The median total behavior score for ESBL carriers was 83, while for non-carriers, 82, which suggests good behavior in both groups.

Based on the Mann-Whitney test, the significance value is 0.664. Since this value exceeds 0.05, the hypothesis is rejected. The initial hypothesis suggested a connection between infection prevention and control behavior and Extended Spectrum Beta-Lactamase (ESBL) incidence-producing bacterial carriers among health workers at Banjarnegara Islamic Hospital. Consequently, it can be concluded that there is no significant relationship between IPC behavior and the incidence of ESBL-producing bacterial carriers among health workers at Banjarnegara Islamic Hospital.

The finding of no significant relationship between IPC behavior and the incidence of ESBL-producing bacterial carriers among health workers at Banjarnegara Islamic Hospital contrasts with research by Diantoro and Rizal in 2019, which indicated a significant relationship between nurse compliance in handwashing and HAIs incidence (13) Proper use of personal protective equipment, sterile patient equipment, and environmental control can reduce the risk of occupational accidents and reduce infection spread in hospitals. Failure to close syringes after use, however, increases the risk of occupational accidents, particularly needlestick incidents, which have the potential to transmit pathogenic infections, especially blood-borne infections (14).

Meanwhile, Decker et al. 2018 found a low spread of MDRO (*Multi-Drug Resistant Organisms*) in health workers despite frequent contact with MDRO patients (2). The risk of ESBL bacteria transmission is higher among family members of patients than among health workers. This high risk is associated with factors such as the patient's older age, high and intense contact time, familial relationship (daughter or female partner), and the presence of chronic lung disease (12).

Most respondents, totaling 32 individuals (52.5%), were 26-30. Age, recognized as a factor influencing performance, highlights the productivity of the 20-40 age group (15). Regarding gender distribution, 38 respondents (62.3%) were female. Research by Manuaba et al. in 2021 on pneumonia patients indicated a higher prevalence of infections caused by ESBL-producing *Escherichia coli* and *Klebsiella pneumoniae* in men than women. However, statistical tests revealed no significant difference (16).

Regarding educational levels, 45 individuals (73.8%) pursued D3 education. Sari et al. 2020 asserted that formal education significantly influences an individual's health behavior (17). A significant proportion of respondents, 51 individuals (83.6%), worked as nurses, a profession associated with high exposure and prolonged contact with patients, leading to an increased risk of Healthcare-Associated Infections (HAIs) (18). The majority, 28 individuals (45.9%), worked in inpatient wards, where the potential for HAIs is elevated, particularly in Class III inpatient wards, which carry a threefold higher risk than Class I due to larger patient and visitor numbers and insufficient septic and antiseptic procedures (19). The data shows that 55 respondents

(90.2%) have worked for 1-10 years. However, research by Astuti and Yanza in 2019 found no significant relationship between nurses with a long working period (≥ 3 years) and new nurses in HAIs prevention behavior in postoperative wound care (20).

The vast majority of respondents, 59 (96.7%), frequently accessed medical information, with 55 respondents (90.2%) relying on mass media sources such as the internet, journals, television, and radio. Well-informed individuals will likely possess good knowledge and exhibit proper behavior (21).

In addition to IPC practices, the incidence of ESBL-producing *Enterobacteriaceae* carriers in hospitals can also be caused by irrational antibiotic use, bacterial colonization during treatment, duration of hospitalization, use of medical equipment, and immunocompromised conditions (22). Community-acquired infections due to ESBL-producing *Enterobacteriaceae* are quite high, with a 66.7% prevalence of ESBL-producing *Enterobacteriaceae* carriers in the Purwokerto community. The irrational use of antibiotics can increase the incidence of ESBL carriers in the community (23).

Furthermore, the unwise use of antibiotics in animal farms has led to the emergence of multiresistant bacteria that can infect humans through food or foodborne diseases. Contamination of ESBL-producing *Escherichia coli* in milk can cause public health problems (24). *Escherichia coli* can be found in soil and water due to fecal contamination. Antibiotic resistance in farm animals can result in resistant bacteria being carried through feces and can infect humans through drinking water sources, food hygiene, and cleanliness of drinking places (25,26). By horizontal transfer, *E. coli*, multiresistant to antibiotics, can contaminate food and transmit their resistance genes and toxin genes to other bacteria. The use of antibiotics in inappropriate doses or for inappropriate durations can lead to the development of antibiotic resistance, resulting in other bacteria becoming multiresistant to antibiotics (27).

The prevalence of ESBL-producing bacterial carriers among health workers at Banjarnegara Islamic Hospital is 13.1%, and all health worker respondents demonstrated good behavior. Based on the conducted research, it is concluded that there is no significant relationship between infection prevention and control behavior and the incidence of ESBL-producing bacterial carriers among health workers at Banjarnegara Islamic Hospital.

CONFLICTS OF INTEREST

There is no conflict of interest.

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APPENDIX

Behavioral Questionnaire for Infection Prevention and Control

1: Never

2: Rarely

Instructions: Read the following statements carefully and check () the column that matches your condition.

3: Sometimes

Description:

4: Often

5: Always

No.	Statement	1	2	3	4	5
1	Washing hands after contact with different patients					
2	Washing hands after removing gloves					
3	Immediately washing hands after contact with blood, body fluids, secretions, excretions, and dirty substances					
4	Wearing gloves when taking blood samples					
5	Wearing gloves when disposing of feces and urine					
6	Wearing gloves when handling skin abnormalities in patients					
7	Wearing gloves when handling patient mucosa					
8	Wearing gloves when handling saliva or sputum cultures					
9	Wearing gloves when performing parenteral injections for treatment					
10	Wearing gloves when treating wounds					
11	Wearing gloves when cleaning blood residues					
12	Wearing gloves when in contact with blood					
13	Wearing a mask when performing surgery or procedures that may cause exposure to blood, body fluids, secretions, and excretions					
14	Wearing eye protection when performing surgery or procedures that may cause exposure to blood, body fluids, secretions, and excretions					
15	Wearing a gown when performing surgery or procedures that may cause exposure to blood, body fluids, secretions, and excretions					
16	Recapping needles after use					
17	Disposing needles and blades in a special disposal container after use					