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INCIDENCE STUDY OF POST-OPERATIVE SKIN INFECTIONS BY *STAPHYLOCOCCUS AUREUS* AND ANTIBIOTIC REACTIONS AT RSUD Dr PIRNGADI MEDAN

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ABSTRACT

Introduction: Infections acquired through healthcare facilities are a side effect that impacts patient safety globally. Post-operative skin infections defined by the CDC as wound infections that appear within 30 days of surgery. Predominant bacterial isolate that causes surgical wound infections is *Staphylococcus aureus* as well as the MRSA strain. The sensitivity level of *Staphylococcus aureus* to the antibiotic Vancomycin is known 100% followed by Linezolid, while the resistance level to Penicillin reaches 100%. After patient confirmed with post-operative skin infection, antibiotics are adjusted to bacteria causing the infection through examinations. **Objective**: This study is determine the incidence of post-operative skin infections due to *Staphylococcus aureus* at Dr Pirngadi Hospital Medan as an evaluation to control infection di operation room. **Method**: This study is a cross-sectional analytical descriptive study using secondary patient data in medical records. **Results**: The bacteria most commonly causes post-operative skin infections is *Staphylococcus aureus* with 19 samples (33.9%). The gender often experiences post-operative skin infections is men. Comorbidity often found was Diabetes Mellitus (35,7%). Bivariate tests were used to see relationship between *Staphylococcus aureus* with demographics, length of stay, and comorbidities. Results of antibiotic sensitivity test *Staphylococcus aureus* sensitive to Vancomycin, Nitrofurantoin, Tetracycline, Gentamycin, and Ceftriaxone, while 100% resistance to Penicillin. Multivariate tests show gender has significant effect on surgical wound infections by *Staphylococcus aureus*. **Conclusion**: *Staphylococcus aureus* was the dominant cause of surgical wound infections with 100% sensitivity to Vancomycin. Significant relationship was shown by age group with comorbidities and length of stay.

Keywords : ***Postoperative Skin Infection, Staphylococcus aureus, Antibiotic Sensitivity Test***

INTRODUCTION

Hospital-acquired infections (HAIs) are side effects that often impact patient safety globally. Infections classified as HAIs are related to urine, blood, and wounds. The primary cause of HAIs is microorganisms resistant to antibiotic treatment. One of the significant HAIs that contribute to increased morbidity and mortality is postoperative skin infections. These infections are classified as nosocomial infections in areas of surgical incision sites. According to the CDC in 2015, it was estimated that there were 110,800 cases of surgical wound infections in inpatient patients. Data from HAIs in 2021 showed a 3% increase in surgical wound infection cases [1]. According to the World Health Organization (WHO), the global rate of surgical wound infections reached 34%. The estimated incidence of surgical wound infections in Indonesia is 5.3–14% of all surgical procedures. In a 2018 study, male patients dominated abdominal surgeries [2].

Postoperative skin infections are defined by the CDC as wounds that occur within 30 days after surgery. In addition to being detrimental to patients, postoperative skin infections increase the length of care and hospital costs [3]. The types of bacteria that frequently dominate postoperative skin infections include *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, and *Klebsiella pneumoniae*. The occurrence of postoperative skin infections is significantly related to the length of treatment, gender, age, and comorbid diseases. Based on the demographics in a particular study, the common age range of patients undergoing surgery was between ≤20 years and ≥61 years [4].

In a study conducted at RSUP Sanglah Hospital in Denpasar in 2022, a relationship was found between the diagnosis of surgical wound infections and the length of post-operative treatment, with a duration of ≤3 days and >3 days [5]. The predominant gram-positive bacterial isolate causing surgical wound infections was *Staphylococcus* *aureus*, which also appeared in the MRSA (Methicillin-Resistant *Staphylococcus aureus*) strain. The age group most vulnerable to *Staphylococcus aureus* infections was those aged ≥65 years [6].

A survey conducted in the United States from 1999 to 2005 reported that the number of MRSA cases among inpatient patients reached 278,203 [7]. According to a study conducted in Indonesia in 2020, the prevalence of *Staphylococcus aureus* isolates, including MRSA, ranged from 0.3% to 52%. The sensitivity of MRSA to the antibiotic Vancomycin was reported to be between 87% and 100%, followed by antibiotics Linezolid and Tigecycline [8]. At present, the resistance rate to Penicillin has reached 100% [9]. The prevalence of MRSA in post-surgical patients in the Intensive Care Unit (ICU) of Abdul Moeloek General Hospital, Bandar Lampung, was found in 18 samples, with an overall percentage of 38.24% [10]. In surgical patients at Dr. Sardjito General Hospital, Yogyakarta, the duration of hospitalization for post-operative patients lasting more than 5 days was identified as a risk factor for post-operative skin infections [11].

Antibiotics were a therapy used in patients with post-operative skin infections. The use of antibiotics was needed if there was an inflammatory picture of more than 5 cm and the patient showed systemic symptoms. If a surgical wound infection was suspected due to *Staphylococcus aureus*, Cefazolin, Cefuroxime, and Cloxacillin could be given. In cases of suspected MRSA, vancomycin, linezolid, or glycopeptides could be given. Suspected gram-negative bacterial infections were treated with second or third generation Cephalosporins or Fluoroquinolones. Resistance to antibiotics occurred due to the evolution of pathogenic strains and inappropriate use of antibiotics [12]. In a study at RSU Sylvani Binjai in 2020, effective prophylactic antibiotics for cesarean section patients were Cefotaxime and Ceftriaxone [13]. The administration of prophylactic antibiotics aims to prevent post-operative skin infections. After a post-operative skin infection is confirmed, prophylaxis is given according to the bacteria causing the infection through supporting examinations [14].

Preliminary survey conducted at Dr. Pirngadi Hospital, Medan City, the number of cases with post-operative skin infections for the period 2021-2022 was 62 patients.

Based on the background above, this study interested in conducting research on the study of the incidence of post-operative skin infections caused by *Staphylococcus aureus* with antibiotic reactions with the risk factor on gender, age, also comorbidities.

METHODS

This type of research was descriptive and analytical using a cross-sectional approach retrospectively by examining medical record data of post-operative skin infection patients. The sampling technique for this study was total sampling, meaning all medical records of post-operative skin infection patients, totaling 56 samples, at Dr. Pirngadi Hospital, Medan City, from January 2020 to December 2022, were included according to the inclusion criteria. The sample used in this study was medical records of surgical patients diagnosed with post operative infection. The medical records are collected and checked one bye one. The inclusion criteria for this study were patients with a diagnosis of surgical wound infection, age ≤20 years to ≥61 years, antibiotic sensitivity test results, and hospitalization, while the exclusion criteria were incomplete medical records of post-operative infection patients. This study final objective is to evaluate infection control in the operation room.

The analysis conducted in this study was univariate, bivariate (One-Way ANOVA), and multivariate logistic regression. This study was conducted after obtaining Ethical Clearance from the Faculty of Medicine UMSU and a research permit from Dr. Pirngadi Medan Regional Hospital.

RESULTS

Table 1. Demograhic Characteristics of Subjects

Characteristics	Amount (n)	Percentage (%)
Age Groups		
≤ 20 years old	15	26.8
21-40 years old	14	25
41-60 years old	16	28.6
≥ 61 years old	11	19.6
Gender		
Males	30	53.6
Females	26	46.4
Comorbidities		
Diabetes Melitus	20	35.7
Hypertension	8	14.3
Cancer	2	3.6
Anemia	3	5.4
Heart disease	1	1.8

Kidney disease	2	3.6
Obesity	10	17.9
COPD	1	1.8
Stroke	2	3.6
Lung TB	7	12.5
Length of Stay		
≤ 3 days	21	37.5
>3 days	35	62.5
Total	56	100%

Based on the survey, in the case of post-operative skin infection in the inpatient room, there were 62 patients at Dr. Pirngadi Medan Regional Hospital. The number of samples included in this study was 56 people according to the inclusion criteria.

Table 2. Microorganisms Distribution causing Post Operative Skin Infections

Bacteria	n	%
Staphylococcus aureus	19	33.9
Escherichia coli	12	21.4
Staphylococcus haemolyticus	9	16.1
Pseudomonas aeruginosa	5	8.9
Acinetobacter baumannii	4	7.1
Staphylococcus epidermidis	3	5.4
Klebsiella pneumoniae	4	7.1
Total	56	100%

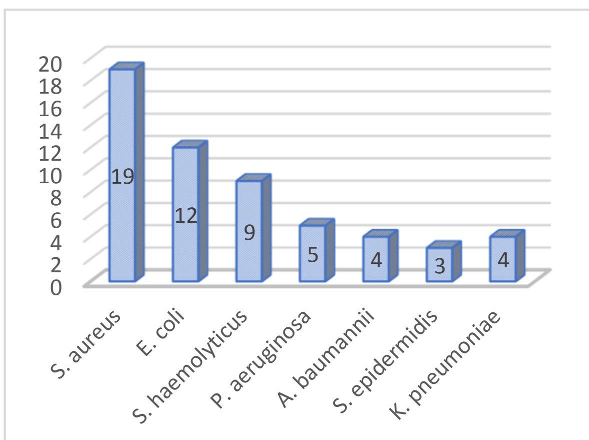

Figure 1. Microorganisms Frequency causing Post Operative Skin Infections

Based on Table 2 and Figure 1, *Staphylococcus aureus* bacteria were found to be the most common cause of post-operative skin infections, with 19 samples (33.9%), followed by *Escherichia coli* with 12 samples (21.4%), *Staphylococcus haemolyticus* with 9 samples (16.1%), *Pseudomonas aeruginosa* with 5 samples (8.9%), *Staphylococcus epidermidis* with 3 samples (5.4%), *Acinetobacter baumannii* with 4 samples (7.1%), and *Klebsiella pneumoniae* with 4 samples (7.1%).

Table 3. Distribution of Antibiotic Sensitivity causing Post-Operative Skin Infections

AB n (%)	***S. aureus***		***S. epi***		***K. pne***		***E. coli***		***S. haemo***		***P. aeru***		***A. baumannii***	
	S	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**
AMP					2 (50)	2 (50)	8 (66.7)	4 (33.3)					4 (100)	0
AMX	5 (26.3)	14 (73.7)					2 (16.7)	10 (83.3)						
CTX							5 (41.7)	7 (58.3)						
FEP			1 (33.3)	2 (66.7)							3 (60)	2 (40)	3 (75)	1 (25)
CRO	15 (78.9)	4 (21.1)			2 (50)	2 (50)							2 (50)	2 (50)
ERY	3 (15.8)	16 (84.2)									2 (40)	3 (60)		
LZD	14 (78.9)	5 (21.1)	3 (100)	0										
NIT	13 (68.4)	6 (31.6)	2 (66.7)	1 (33.3)	4 (100)	0			8 (88.9)	1 (11.1)				
TET	16 (84.2)	3 (15.8)									2 (40)	3 (60)	0	4 (100)
AMK			2 (66.7)	1 (33.3)	3 (75)	1 (25)	10 (83.3)	2 (16.7)						
TOB							8 (75)	4 (25)						
MEM					2 (50)	2 (50)	10 (83.3)	2 (16.7)			3 (60)	2 (40)		
PEN	0	19 (100%)							2 (22.2)	7 (77.8)	1 (20)	4 (80)		
OXA									4 (44.4)	5 (55.6)				
LVX			2 (66.7)	1 (33.3)					2 (22.2)	7 (77.8)				
GEN	16 (84.2)	3 (15.8)			1 (25)	3 (75)			3 (33.3)	6 (66.7)	2 (40)	3 (60)		
CLI									5 (55.6)	4 (44.4)				
RIF									5 (55.6)	4 (44.4)				
TMP					3 (75)	1 (25)					1 (20)	4 (80)	4 (100)	0
VAN	19 (100)	0	3 (100)	0							1 (20)	4 (80)		
CIP			2 (66.7)	1 (33.3)	2 (50)	2 (50)					1 (20)	4 (80)	0	4 (100)
CFZ													3 (75)	1 (25)
Total	19		3		4		12		9		5		4	

S: Sensitive
R: Resistant

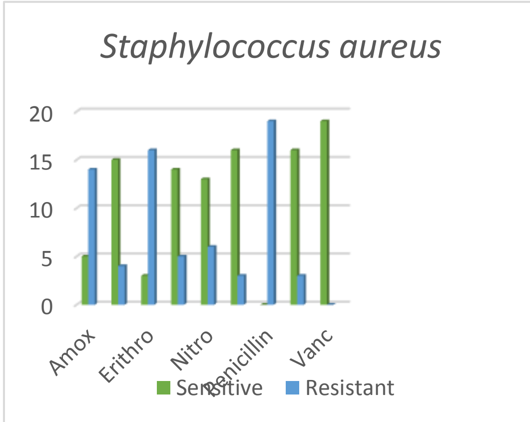

Figure 2. Antibiotics Sensitivity of *Staphylococcus aureus*

Table 3 and Figure 2 showed the prevalence of the most common bacteria causing surgical wound infections found in the samples of this study, namely *Staphylococcus aureus*, with a 100% resistance pattern to Penicillin, 84.2% resistance to Erythromycin, and 100% sensitivity to Vancomycin.

Table 4. Correlation of *Staphylococcus aureus* dan Age Groups

Age Groups	**Yes**	**No**	**Total**	***p-value***
≤20	6	9	15	
21-40	2	12	14	
41-60	5	11	16	0.195
≥61	6	5	11	
Total	19	37	56	

Based on Table 4, the results of the prevalence of *Staphylococcus aureus* against patient age were found to have a p-value of 0.195, which indicated that there was no significant relationship between the prevalence of *Staphylococcus aureus* in SSI patients and the distribution of patient age.

Table 5. Correlation of *Staphylococcus aureus* with Gender

Gender	**Yes**	**No**	**Total**	***p-value***
Males	16	14	30	
Females	3	23	26	0.001
Total	19	37	56	

Table 5 showed the relationship between the prevalence of *Staphylococcus aureus* and patient age, with a p-value of 0.001, which indicated a significant relationship between the prevalence of *Staphylococcus aureus* and the distribution of gender.

Table 6. Correlation of *Staphylococcus aureus* with Post Operative Length of Stay

Length of Stay	**Yes**	**No**	**Total**	***p-value***
≤3 days	2	19	21	
>3 days	17	18	35	0.002
Total	19	37	56	

Based on Table 6, a relationship was found between the prevalence of *Staphylococcus aureus* with post operative care duration, with a p-value of 0.002, indicating a significant relationship between the prevalence of *Staphylococcus aureus* and the length of stay after surgery.

Table 7. Correlation *Staphylococcus aureus* with Comorbidities

Comorbidities	Yes	No	Total	*p-value*
Hypertension	3	5	8	
Diabetes Mellitus	7	13	20	
Cancer	0	2	2	
Anemia	0	3	3	
Heart Disease	1	0	1	
Kidney Disease	1	1	2	0.246
Obesity	2	8	10	
Tuberculosis	2	5	7	
COPD	1	0	1	
Stroke	2	0	2	
Total	19	37	56	

Based on Table 7, the One-Way ANOVA test produced a p-value of 0.246, thus indicating that there was no significant relationship between the prevalence of *Staphylococcus aureus* and the distribution of comorbidities in post-operative patients.

Table 8. Correlation of Post Operative Length Stay with Age Group

Length of Stay	≤20	21-40	41-60	≥61	Total	*p-value*
≤ 3 days	8	6	6	1	21	
≥ 3 days	7	8	10	10	35	0,028
Total	15	14	16	11	56	

Based on Table 8, the results of the relationship between length of stay and age group sshowed a p-value of 0.028,

indicating a significant relationship between length of stay and patient age groups.

Table 9. Correlation Comorbidities with Age Groups

Comorbidities	≤20	21-40	41-60	≥61	Total	*p-value*
Hypertension	0	0	5	3	8	
Diabetes Mellitus	3	5	10	2	20	
Cancer	0	0	1	1	2	
Anemia	2	1	0	0	3	
Heart disease	0	0	0	1	1	
Kidney disease	1	0	0	1	2	0.000
Obesity	5	5	0	0	10	
Lung TB	4	3	0	0	7	
COPD	0	0	0	1	1	
Stroke	0	0	0	2	2	
Total	15	14	16	11	56	

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Based on Table 9, the results of the relationship between the prevalence of comorbidities and the patient's age group showed a p-value of 0.000, indicating a significant relationship between the prevalence of comorbidities and the patient's age groups.

Table 10. Multivariate Test

							95% C l for EXP(B)	
	B	S.E	Wald	df	Sig.	Exp(B)	Lower	Upper
Lenth of Stay	-2.184	.888	6.044	1	.014	.113	.020	.642
Age Groups	-.266	.351	.574	1	.449	.766	.385	1.526
Comorbidities	-.123	.127	.935	1	.334	.884	.690	1.134
Gender	2.341	.814	8.276	1	.004	10.391	2.109	51.199
Constant	2.415	1.970	1.503	1	.220	11.194		

Table 10 above showed the effect of independent variables on the prevalence of surgical wound infections due to *Staphylococcus aureus* with logistic regression analysis. The gender variable showed a significant value of 0.004 with an Odds ratio value of 10.391, indicating that this variable had a significant relationship to surgical wound infections due to *Staphylococcus aureus*.

DISCUSSIONS

Staphylococcus aureus was the most common etiology of surgical wound infections because this bacteria also acted as normal flora in the skin area. Other types of bacteria that often caused post-operative skin infections included *Escherichia coli* and *Staphylococcus haemolyticus*. This was in line with research conducted by Ali A, Gebretsadik D, and Desta K in 2023, which stated that the major bacterial isolates of surgical wound infections were *Staphylococcus aureus*, followed *by E. coli*, *Klebsiella sp*., and *Streptococcus sp.*[4] Another study conducted by Shakir A, et al. in 2021 found that the prevalence of post-operative skin infections was due to *Staphylococcus aureus* as the most common isolate. [15]

Diabetes Mellitus was associated with the risk of post-operative skin infections because it acted as chronic inflammation that could reduce the body's immune system response to surgical stress. In a study conducted by Sanglah Hospital from 2017 to 2018, patients with diabetic wounds were found to have bacterial isolates, including *Staphylococcus aureus*, with sensitivity test results to the antibiotics Vancomycin and Linezolid. DM conditions reduced the immune system by inhibiting leukocyte activity in phagocytosis, thereby prolonging the recovery of surgical wounds.[16]

The results of the age frequency distribution showed that 15 people were aged ≤20 years, 14 people were aged 21-40 years, 16 people were aged 41-60 years, and 11 others were aged ≥61 years. In a study conducted in 2023 in Iran, the prevalence of age at risk for post-operative skin infections was found to be in the range of 18-65 years. In the results of this study, it was found that men were more at risk of post-operative infections, in line with the survey conducted in 2018.[2] However, it was stated in a study by Dias Aghdassi, S.J.S., Schröder, C., and Gastmeier, P. that gender did not significantly affect the occurrence of surgical wound infections. This could be further reviewed by examining bacteria and comorbidities from both sexes.[17]

The relationship between Staphylococcus aureus prevalence and gender was shown to have significant results. Male surgical wound infection samples were found to be more infected with Staphylococcus aureus than female samples. It was suggested that female hormones affected the immune response, leading to a faster neutrophil response. Generally, it was observed that a stronger immune response to foreign antigens was exhibited by women compared to men.[18] Men's and women's skin were found to have different collagen compositions, especially in scars. Women's skin was characterized by the accumulation of collagen III, which was not found in men, making surgical wound healing tend to be faster in women. The thickness of women's skin was affected by estrogen levels. Scarred skin in women was also found to have high levels of the FOXN1 protein. It was suggested that this protein content contributed to wound healing through the epithelialization of mesenchymal tissue.[19]

In the One-Way ANOVA bivariate test, the results of the prevalence of *Staphylococcus aureus* were found to be related to the length of treatment for surgical wound infection cases. It was determined that a hospitalization length of more than 3 days allowed for an increased risk of infection. Patients who were hospitalized longer tended to have a higher risk of exposure to bacterial contamination of the scar. This was in line with research on factors that influenced the length of hospitalization for appendectomy patients at Sanglah General Hospital, Denpasar, in 2022.[5] One study conducted by Mujagic E, Marti WR, Coslovsky

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M, et al. also stated that the length of post-surgery care had a greater influence on surgical wound infections than pre-operative factors. The process of wound infection was found to involve several factors, such as the patient's immune condition and foreign objects.[20]

The antibiotic sensitivity test carried out on *Staphylococcus aureus* yielded results for several antibiotics, namely Amoxicillin, Ceftriaxone, Erythromycin, Linezolid, Nitrofurantoin, Tetracycline, Penicillin, Gentamycin, and Vancomycin. In previous studies, Vancomycin was used as the first-line therapy for suspected MRSA. This was also supported by reports in several studies that Vancomycin, Linezolid, and Nitrofurantoin were still found to be sensitive for use against *Staphylococcus aureus* infections.[8]

Types of antibiotics that were found to have high resistance to *Staphylococcus aureus* included Erythromycin, Penicillin, and Amoxicillin. *Staphylococcus aureus* resistant to Penicillin was classified as part of the MRSA group. These results were in line with those of A. Shakir, D. Abate, F. Tebeje, et al., where *Staphylococcus aureus* resistance to Penicillin reached 100%.[15] MRSA strains were first discovered in 1940 and had continued to develop until this decade. *Staphylococcus aureus* became resistant to antibiotics through various mechanisms, including acquiring the mecA gene, which was responsible for providing resistance to several antibiotics. Additionally, *Staphylococcus aureus* could acquire resistance genes from other bacteria through horizontal gene transfer, allowing resistance to spread. In this study, no significant relationship was found between *Staphylococcus aureus* infection and the age of surgical wound infection patients. In a study conducted by McClelland et al. in 2019, it was found that the risk of *Staphylococcus aureus* infection was higher in patients aged 65 years or more. Patient care in hospital areas with a high prevalence of HA-MRSA was considered a risk factor for *Staphylococcus aureus* infection. The presence of surgical wound infection was visible through the appearance of erythema, pus, and pain in the surgical scar.[12]

In this study, no significant relationship was found between *Staphylococcus aureus* infection and the age of surgical wound infection patients. In a study conducted by McClelland et al. in 2019, the risk of *Staphylococcus aureus* infection was found to be in patients aged 65 years or more.[6] Patient care in hospital areas with a high prevalence of HA-MRSA was considered a risk factor for *Staphylococcus aureus* infection. The presence of surgical wound infection was visible from the appearance of erythema, pus, and pain in the surgical scar.[15]

In this study, post-operative care for the prevalence of *Staphylococcus aureus* was found to have a significant relationship, with a p-value of 0.003. Nineteen samples with a treatment length of less than 3 days were not infected with *Staphylococcus aureus*, while 2 samples with a treatment length of ≤ 3 days and 17 samples with a treatment length of > 3 days were confirmed to be infected with *Staphylococcus aureus*. This was in line with the research of Edin M, et al., which found a significant relationship between post-operative length of stay and surgical wound infection.[20] Based on the One-Way ANOVA test, many patients aged 41-60 years and ≥ 61 years were found to have a length of stay > 3 days with a diagnosis of post-operative skin infection. The p-value of 0.028 indicated a significant relationship between the two variables. This was in line with a study by Rahmayati E, et al. in 2017, which showed that patients over 40 years of age were more susceptible to infection, thus prolonging the length of stay. However, in this study, no significant relationship was found between the diagnosis of surgical wound infection and the length of stay of post-operative patients.[21]

Before a multivariate test was conducted, variables were selected through the results of the One-Way ANOVA test with a p-value < 0.25. Furthermore, a multivariate test was performed with *Staphylococcus aureus* infection as the dependent variable, and age, gender, length of postoperative care, and comorbid diseases as covariates. The results of the logistic regression showed a significance value of 0.004 for the gender variable, with the largest odds ratio (OR) of 10.391. It was concluded that gender had a significant effect on surgical wound infections due to *Staphylococcus aureus*.

CONCLUSIONS

Based on the results of the study conducted to determine postoperative skin infection cases caused by *Staphylococcus aureus* and the description of antibiotic reactions, the following conclusions were obtained: the sample population of postoperative skin infections was dominated by men, with a total of 30 samples, or 53.6%. The age group that experienced the most postoperative skin infections was in the range of 41-60 years, with the most common comorbid disease being diabetes mellitus (DM). *Staphylococcus aureus* prevalence was found in 19 samples. Antibiotic sensitivity tests on *Staphylococcus aureus* revealed 100% resistance to Penicillin and 100% sensitivity to Vancomycin. A significant relationship was found between age group and comorbidities, as well as between age group and length of postoperative care. In the multivariate test results, gender was identified as the most influential variable on the prevalence of *Staphylococcus aureus* in postoperative skin infection cases.

CONFLICT OF INTEREST STATEMENT

There are no conflicts of interest have an effect of writing this article. This study were conducted objectively with scientific principles.

ETHICAL STATEMENT

Ethical clearance was granted by the Faculty of Medicine, UMSU, and permission to conduct the study was obtained from RSUD Dr. Pirngadi Medan.

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