

Relationship Between Characteristics and Risk Factors in Postoperative Surgical Wound Infections in Cesarean Section Patients

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Abstract

Background: Cesarean section rates have increased globally, with Indonesia showing a rise from 6.5% in 2016 to 16.5% in 2021. Although cesarean deliveries reduce certain risks, they also present the risk of surgical site infections (SSIs), a leading cause of postpartum infections. This study explores the relationship between patient characteristics and SSI following cesarean sections at Hasan Sadikin General Hospital, Bandung.

Methods: This study used an analytical observational design with a retrospective case-control approach. Data were collected from the medical records of patients who underwent cesarean sections from January 2022 to January 2023. The sample consisted of 23 cases of patients with SSI and 46 controls. The analysis was performed using the Chi-square test and multivariate logistic regression.

Results: Body mass index (BMI) and urinary tract infection (UTI) during pregnancy were found to be significant risk factors for SSI, with P-values of 0.019 and 0.001, respectively. UTI is the most significant risk factor with an adjusted odds ratio (aOR) of 6.48 (95% confidence interval (CI) 1.7 - 64.5). Overweight and obesity also showed a higher risk, with an aOR of 10.1 (95% CI 1.6 - 64) and 4.07 (95% CI 1.0 - 18.4), respectively. Other characteristics such as age, parity, history of anemia, diabetes mellitus, preeclampsia, premature rupture of membranes, previous cesarean section, and the type of cesarean incision were not significantly associated with SSI.

Conclusion: Obesity and UTI during pregnancy are significant risk factors for SSI in post-cesarean section patients. Strict monitoring and preventive interventions for these conditions during pregnancy should be implemented to reduce SSI incidence and improve maternal and infant health after cesarean section.

Keywords: Risk factors; Surgical site infection; Urinary tract infection; Obesity; Cesarean section; BMI

Introduction

The global frequency of cesarean sections has increased from approximately 7% in 1990 to 21% in 2021, and this trend is expected to continue for several more years, indicating a significant shift in the method of delivery chosen by pregnant women worldwide [1]. Annually, around 18.5 million cesarean procedures are performed globally, with 20% of pregnant women opting for this procedure [2, 3].

In China, the number of cesarean sections reaches 1.2 million per year, with 28% of these procedures being performed at the mother's request, often considered not entirely medically necessary. Meanwhile, in Indonesia, there has been a 10% increase, from 6.5% in 2016 to 16.5% in 2021, according to data from the Indonesian Demographic and Health Survey. The 2018 Riskesdas report showed that the cesarean section rate in Indonesia reached 17.6%, with Jakarta having the highest prevalence at 31.1% and Papua the lowest at 6.7% [2, 4-6]. This indicates that pregnant women in Indonesia are beginning to transition to cesarean sections as a method of delivery.

Cesarean sections are indeed a safe alternative delivery method for both the mother and the baby when performed based on appropriate medical indications. Cesarean delivery reduces risks such as urinary incontinence, pelvic organ prolapse, and avoiding the pain associated with vaginal delivery [7, 8]. However, while the procedure offers many benefits, it also presents various risks. These risks include short-term and long-term effects, risks in subsequent pregnancies, and risks to the baby [7, 9]. One of the most significant complications of cesarean sections is surgical site infection (SSI). SSI is the leading contributor to postpartum infections, defined as infections occurring at the surgical site within 30 to 90 days post-surgery, depending on the type of surgery performed [8, 10]. Studies conducted across various hospitals worldwide report that the prevalence of SSI following cesarean sections varies, ranging from 2.2% to 18.8% [11, 12]. In Europe, the average prevalence of SSI following cesarean sections in 2016 was 2.2%, with inter-country ranges from 0.6% to 7.7% [13]. A study conducted at a hospital in the United States in 2017 re-

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ported an SSI prevalence of 5.5% following cesarean sections [13]. A 2019 meta-analysis estimated that the prevalence of SSI following cesarean sections in Ethiopia reached 9.72% [14]. Research conducted at a hospital in Malaysia revealed a relatively high SSI prevalence of 18.8% following cesarean sections. In Indonesia, a study on SSI at Cipto Mangunkusumo National Referral General Hospital (RSCM) from 2016 to 2018 reported a prevalence of 4.14% [11].

SSI can increase morbidity and mortality rates among affected patients, prolonging hospital stays and potentially increasing the need for additional surgeries and intensive care [15, 16]. The mortality rate due to SSI reaches 3%, with 75% of these deaths being directly caused by SSI [13]. Additionally, the treatment costs for SSI patients tend to be higher than for patients without infection, contributing to a healthcare burden of United States Dollar (USD) 3.3 billion and one million hospitalization days annually. This results in increased healthcare costs, as SSI patients require more extensive diagnostic testing, antibiotics, surgeries, and prolonged hospital stays [13, 16]. Several studies have been conducted to investigate the characteristics and risk factors associated with SSI. Research by Kefale et al identified several factors that significantly contribute to the development of SSI [17]. These factors include the presence of comorbidities in patients, contaminated and dirty wounds, and the inadequate use of prophylactic antibiotics. Furthermore, this study found that the timing of prophylactic antibiotic administration, between 1 and 2 h before the incision, and the duration of surgical antimicrobial prophylaxis for 48 h, were significantly associated with an increased risk of SSI. In contrast, a study by Kvalvik et al (2021) identified several significant risk factors for the development of SSI after cesarean delivery [18]. The main findings of this study indicated that emergency cesarean sections, pre-pregnancy obesity, pre-existing psychiatric conditions, blood transfusion during or after delivery, and signs of infection during labor were key risk factors for SSI. A meta-analysis conducted by Getaneh et al (2020) found that prolonged labor, premature rupture of membranes (PROM), chorioamnionitis, and anemia were closely associated with the risk of SSI following cesarean sections [14]. Additionally, Zhu et al (2023) conducted a meta-analysis that concluded that the risk factors for SSI following cesarean sections include smoking, a history of cesarean sections, repeated vaginal examinations, membrane rupture, hypertensive disorders, diabetes mellitus (DM), and high body mass index (BMI) [19].

Unfortunately, despite numerous studies conducted abroad on the risk factors for SSI following cesarean sections, no research has yet investigated the risk factors for SSI following cesarean sections in Indonesia. Research conducted by Irawan et al (2022) primarily focused on discussing SSI characteristics in obstetric cases at Hasan Sadikin General Hospital [20]. Therefore, this study aimed to examine the relationship between patient characteristics and risk factors for SSI following cesarean sections at Hasan Sadikin General Hospital. The results of this study are expected to contribute to the development of more effective prevention and management strategies. Additionally, the author hopes this research will positively impact the quality of care and risk management following cesarean sections, thereby improving maternal and infant health

outcomes. The objectives of this study are to identify the characteristics of post-cesarean section patients with SSI, analyze the risk factors associated with SSI in post-cesarean section patients, and determine the relationship between patient characteristics and risk factors for SSI following cesarean sections.

Materials and Methods

This study employed a quantitative observational analytic design with a retrospective case-control approach to evaluate the relationship between patient characteristics and risk factors with the occurrence of SSI in post-cesarean section patients at Hasan Sadikin General Hospital, Bandung. The study population included all patients who underwent cesarean sections at Hasan Sadikin General Hospital, Bandung, from January 2022 to January 2023. The sample size in this study was determined based on the available patient records from Hasan Sadikin General Hospital. A total of 69 patients who underwent cesarean sections were included, with 23 patients in the case group (those who developed SSIs) and 46 patients in the control group (those who did not develop SSI). The total sampling method was applied, where all available cases of SSI were included. Due to the retrospective design and limited resources, sample size estimation was not performed. Future studies with a prospective design should consider calculating sample size to ensure adequate statistical power.

In this study, a standardized perioperative antibiotic protocol was followed at Hasan Sadikin General Hospital. The preoperative antibiotic used for cesarean section patients was cefazolin administered at a dose of 2 g, which is the routine protocol for preventing SSIs. This protocol is implemented for all patients undergoing cesarean sections in the hospital to ensure consistency and reduce infection risk.

The inclusion criteria for this study were patients diagnosed with SSI within 30 days post-surgery based on medical records, who were treated at Hasan Sadikin General Hospital, Bandung, either as inpatients or outpatients for SSI care. The exclusion criteria included patients whose SSI diagnosis and treatment occurred at primary healthcare facilities or other hospitals without contact with Hasan Sadikin General Hospital, as well as patients without complete medical documentation regarding their cesarean surgery and SSI care.

This study involved descriptive data analysis to characterize the patients with SSI following cesarean sections, including variables such as age, parity, BMI, history of anemia, DM, preeclampsia, UTI during pregnancy, PROM, previous cesarean section history, and the type of cesarean section incision.

The Chi-square test was used to analyze risk factors, aiming to evaluate significant differences between the case group (patients with SSI) and the control group (patients without SSI). A P-value of < 0.05 was considered statistically significant. Furthermore, multivariate logistic regression analysis was applied to assess the simultaneous effect of various risk factors on SSI occurrence, enabling the identification of factors independently contributing to SSI risk through crude odds ratio (cOR) and adjusted odds ratio (aOR). This study received ethical approval from the Ethics Committee of Hasan

Table 1. Characteristics of Pregnancy and Delivery in Women With and Without Surgical Site Infections After Cesarean Delivery at Hasan Sadikin General Hospital, Bandung

Characteristic	Category	Case (N = 23), n (%)	Control (N = 46), n (%)	P-value
Age	≤ 25.0	7 (30.4)	10 (21.7)	0.303
	25.1 - 34.9	7 (30.4)	23 (50)	
	≥ 35	9 (39.2)	13 (28.3)	
Body mass index	< 18.5	2 (8.7)	4 (8.7)	0.019*
	18.5 - 22.9	2 (8.7)	17 (37.0)	
	23.0 - 24.9	5 (21.7)	15 (32.6)	
	25.0 - 29.9	10 (43.5)	7 (15.2)	
	≥ 30.0	4 (17.4)	3 (6.5)	
Parity	0	5 (21.7)	16 (34.8)	0.267
	≥ 1	18 (78.3)	30 (65.2)	
Anemia	Yes	15 (65.2)	26 (56.5)	0.488
	No	8 (34.8)	20 (43.5)	
Diabetes mellitus	Yes	4 (17.4)	7 (15.2)	0.816
	No	19 (82.6)	39 (84.8)	
Preeclampsia	Yes	11 (47.8)	25 (54.3)	0.609
	No	12 (52.2)	21 (45.7)	
Urinary tract infection during pregnancy	Yes	19 (82.6)	19 (41.3)	0.001*
	No	4 (17.4)	27 (58.7)	
Premature rupture of membranes	Yes	4 (17.4)	14 (30.4)	0.245
	No	19 (82.6)	32 (69.6)	
Cesarean history	Yes	8 (34.8)	7 (15.2)	0.063
	No	15 (65.2)	39 (84.8)	
Cesarean incision	Vertikal	14 (60.9)	33 (71.7)	0.361

*Statistically significant.

Sadikin General Hospital, Bandung, on May 15, 2024. In order to protect the right and welfare of the research subject and to guaranty that the research using survey questionnaire/registry/surveillance/archived biological materials/other nonclinical materials, the study was carried out according to ethical, legal social implications and other applicable regulations. Data were processed and analyzed using Statistical Package for the Social Sciences (SPSS) statistical analysis software version 26.

Results

During the study period from January 2022 to January 2023, this research involved a total of 69 patients who underwent cesarean sections at Hasan Sadikin General Hospital, Bandung (Table 1).

Among them, 23 patients developed SSIs, while 46 patients did not. The age distribution of patients with SSI showed that 30.4% were in the ≤ 25-year age group, 30.4% in the 25.1- to 34.9-year group, and 39.2% in the ≥ 35-year group. The ≥ 35-year group had the highest number of patients with SSI. Among patients without SSI, 21.7% were in the ≤ 25-year

group, 50% in the 25.1-34.9-year group, and 28.3% in the ≥ 35-year group.

The distribution of BMI showed variation among patients with SSI, with 8.7% of patients in the underweight category (BMI < 18.5), 8.7% in the normal weight category (BMI 18.5 - 22.9), 21.7% in the normal weight category (BMI 23.0 - 24.9), 43.5% in the overweight category (BMI 25.0 - 29.9), and 17.4% in the obesity category (BMI ≥ 30.0). The overweight category (BMI 25.0 - 29.9) was the most common among patients with SSI.

Additionally, parity characteristics indicated that 21.7% of patients with SSI were nulliparous (no previous children), while 78.3% were multiparous (had one or more children). Among patients without SSI, 34.8% were nulliparous and 65.2% were multiparous. This suggests that most patients who developed SSI were multiparous. Other characteristics included a history of anemia, where 65.2% of patients with SSI had a history of anemia, compared to 56.5% of patients without SSI. In terms of DM, 17.4% of patients with SSI had DM, while 15.2% of patients without SSI also had DM. The prevalence of preeclampsia among patients with SSI was 47.8%, while among patients without SSI, it was 54.3%. UTI during preg-

Table 2. Frequency, Crude and Adjusted Odds Ratios of Surgical Site Infections According to Characteristics

Characteristic	Category	cOR (95% CI)	aOR (95% CI)
Body mass index	< 18.5	Reference	Reference
	18.5 - 22.9	2.85 (0.4 - 20.1)	2.31 (0.3 - 19)
	23.0 - 24.9	1.07 (0.2 - 6.3)	0.81 (0.1 - 5.8)
	25.0 - 29.9	12.14 (2.1 - 70.2)	10.1 (1.6 - 64)
	≥ 30.0	4.28 (1.1 - 17.3)	4.07 (1.0 - 18.4)
Urinary tract infection	No	Reference	Reference
	Yes	6.75 (1.9 - 23)	6.48 (1.7 - 24.5)

aOR: adjusted odds ratio; CI: confidence interval; cOR: crude odds ratio.

nancy was found in 82.6% of patients with SSI, whereas 41.3% of patients without SSI also had UTI. The characteristics of PROM showed that 17.4% of patients with SSI experienced PROM, while 30.4% of patients without SSI also had PROM. A previous history of cesarean section was found in 34.8% of patients with SSI, while only 15.2% of patients without SSI had such a history.

The type of cesarean section incision indicated that 60.9% of patients with SSI had a vertical incision, while 39.1% had a transverse incision. Among patients without SSI, 71.7% had a vertical incision and 28.3% had a transverse incision.

In this study, several patient characteristics did not show significant differences between the two groups. Age, parity, history of anemia, DM, preeclampsia, PROM, previous cesarean section history, and the type of cesarean section incision did not have statistically significant differences. For example, age and parity had P-values of 0.303 and 0.267, respectively, indicating no significant differences between the groups with and without SSI.

Discussion

This study identified a relationship between certain patient characteristics and the occurrence of SSIs after cesarean sections. BMI and UTI during pregnancy were found to be significant risk factors for SSI. Conversely, age, parity, history of anemia, DM, preeclampsia, PROM, previous cesarean section history, and the type of cesarean section incision did not show significant differences.

BMI was a significant risk factor in this study ($P = 0.019$). From Table 2, it can be concluded that a BMI (25.0 - 29.9) is a strong and independent risk factor for SSI, with an aOR of 10.1 (95% CI 1.6 - 64). Therefore, overweight and obesity are significant risk factors for SSIs. This finding is consistent with various studies showing that obesity increases the risk of SSIs due to chronic inflammation and increased vulnerability to pathogens.

Other studies also indicate that obese women are at higher risk of postpartum sepsis, regardless of the delivery method used [18]. The correlation between high BMI and SSI may occur because prophylactic antibiotic doses in obese women may not achieve sufficient concentrations in their tissues. Furthermore, inadequate perfusion of adipose tissue may hinder

wound healing and reduce local immunity, promoting infection growth. Another explanation is the need for longer incisions in obese patients, leading to increased tissue contamination. It is also important to consider the relationship between gestational DM and BMI, where many studies show that women with higher BMIs are at greater risk of developing gestational DM [21, 22].

A study by Kvalvik et al (2021) supports these findings, showing that pre-pregnancy obesity is an independent risk factor for the development of SSI after cesarean sections [18]. They noted that women with higher BMIs are at greater risk for infectious complications due to various physiological factors associated with obesity, including metabolic and immune system changes. Additionally, research by Erritty et al (2022) found that managing obese patients requires special attention to prevent postoperative infections. They suggested that antibiotic dosages may need adjustment to reach effective concentrations in adipose tissue, and more aggressive wound care strategies may be needed to reduce the risk of infection [21].

UTI during pregnancy was identified as a significant risk factor in this study ($P = 0.001$). From the table presented, it is clear that patients who experienced UTI during pregnancy had a cOR of 6.75 (95% CI 1.6 - 23) and an aOR of 6.48 (95% CI 1.7 - 24.5). Therefore, UTI during pregnancy is a significant risk factor for SSIs. Although the aOR value is slightly lower than the cOR, both indicate an important increased risk. UTIs may increase the risk of SSIs because bacteria from the urinary tract can spread to the surgical wound area. A study by Duff and colleagues found that UTIs in pregnant women can increase the risk of SSIs due to the potential spread of uropathogenic bacteria to the surgical site via the bloodstream or lymphatic system. The most common bacteria involved in UTIs, such as *Escherichia coli*, can cause secondary infections in other parts of the body, including surgical wounds [23]. Additionally, UTIs may impair the local immune system, making it easier for bacteria to infect the surgical wound area. Johnson et al also stated that UTIs can disrupt the local immune system, making it easier for bacteria to infect the surgical wound area. They noted that women with UTIs during pregnancy have a higher risk of postoperative infectious complications due to increased bacterial colonization in the urogenital area, which can spread to the surgical wound area [24].

UTI during pregnancy may also affect the overall health status of the mother, increasing the risk of other complications

that can worsen postoperative recovery. For example, women with UTIs may be more prone to fatigue and immune function decline, which can prolong wound healing time and increase the risk of secondary infections. A study by Kvalvik et al (2021) supports these findings, showing that women with UTIs during pregnancy are at higher risk of developing SSI after cesarean sections. They suggested that proper management of UTIs during pregnancy could help reduce the risk of postoperative infections and improve care outcomes for both the mother and baby [18].

This study did not find a significant relationship between age and the occurrence of SSIs ($P = 0.303$). The age distribution showed that most patients with SSI were in the ≥ 35 -year age group, but this difference was not statistically significant compared to the group without SSI. This may be due to the relatively even distribution of age between the groups with and without SSI.

This study demonstrates that obesity and UTI during pregnancy are significant independent risk factors for SSIs in patients undergoing cesarean sections. Conversely, age, parity, history of anemia, DM, preeclampsia, PROM, previous cesarean section history, and type of cesarean incision did not show significant associations with the incidence of SSI. Obesity increases the risk of SSI due to inadequate antibiotic dosing and poor adipose tissue perfusion, while UTIs during pregnancy raise the risk of SSI through the spread of bacteria from the urinary tract to the surgical site. The researchers recommend that patients with obesity and a history of UTI during pregnancy be closely monitored during the postpartum period.

This study did not find a significant association between age and the incidence of SSI ($P = 0.303$). Although a majority of patients with SSI were aged ≥ 35 years, this difference was not statistically significant when compared to those without SSI. This may be attributed to the relatively even age distribution between the groups. The findings are consistent with the study by Chaboyer et al (2022), which also reported no significant association between age and SSI risk, suggesting that other factors, such as overall health and obstetric complications, play a more crucial role in influencing outcomes [25]. Similarly, Erritty et al (2022) concluded that age is not a primary predictor of SSI, with pre-existing medical conditions and quality of care being more influential determinants [21]. Therefore, while age may be considered a potential risk factor, it appears that broader health indicators exert a more significant influence on the likelihood of SSI following cesarean sections.

Parity was also not significantly associated with SSI in this study ($P = 0.267$). Although most SSI cases occurred in multiparous women, the results were not statistically significant. However, studies conducted by Alemye et al in Ethiopia and Gomaa et al in Egypt demonstrated that high parity (≥ 4) was a significant risk factor for SSI following cesarean sections ($P < 0.001$) [26, 27]. The discrepancies between these findings and the present study may be explained by differences in population characteristics, surgical practices, and post-operative care protocols. In some populations, women with higher parity tend to experience more obstetric complications, which could heighten the risk of SSI. Furthermore, the management of pregnancy and delivery in multiparous women may differ

from that of nulliparous women, potentially affecting outcomes. Thus, while parity was not found to be significant in this study, it may still be relevant in different clinical settings or populations.

This study found no significant association between the history of anemia and SSI ($P = 0.488$), suggesting that anemia did not significantly contribute to the risk of SSI in the population studied. This finding is consistent with the results of Lake et al (2024), who also found that anemia was not a major risk factor for SSI in Ethiopia [28]. It is possible that other factors, such as nutritional status and glycemic control, play a more prominent role in influencing infection risk than anemia itself. Similarly, DM was not significantly associated with SSI in this study ($P = 0.816$). However, previous research, including a meta-analysis by Martin et al, identified DM as a significant risk factor for SSI, with an OR of 1.53 (95% CI 1.11 - 2.12), indicating that diabetic patients are at higher risk for SSI compared to non-diabetic patients [29]. Additionally, Gomaa et al found that DM was a significant risk factor for SSI after cesarean section in Egypt ($P < 0.001$) [27]. The well-established mechanisms by which DM increases infection risk, including chronic hyperglycemia impairing immune function and delaying wound healing, are likely responsible for these findings [29]. Differences in glycemic control and diabetes management between clinical settings may explain the discrepancies in the results of this study compared to others.

Lastly, this study found no significant association between other factors such as preeclampsia, PROM, previous cesarean section history, and the type of cesarean incision, and the risk of SSI. For preeclampsia ($P = 0.609$), these findings are consistent with the study by Kawakita et al, which also reported no significant relationship between preeclampsia and SSI risk following cesarean delivery [30]. Similarly, PROM was not significantly associated with SSI in this study ($P = 0.245$), consistent with the findings of Lake et al in Ethiopia, who found no significant link between PROM and SSI risk [28]. Although PROM might theoretically increase the risk of infection by allowing bacterial entry, there is insufficient evidence to support its role as a significant risk factor for SSI in this population. Likewise, the study found no significant association between a history of cesarean section ($P = 0.063$) and SSI, which aligns with the results of Alemye et al, who also reported no significant association between previous cesarean section and SSI risk [26]. Finally, the type of cesarean incision did not significantly influence the risk of SSI ($P = 0.361$), as reported by Alishaq et al [31]. However, Kawakita et al suggested that incision type might be relevant in specific cases, such as among patients with gestational diabetes, where vertical incisions were associated with a higher risk of SSI compared to transverse incisions [30]. These findings underscore the complexity of SSI risk factors, which may vary depending on patient characteristics and clinical circumstances.

This study concludes that obesity and UTI during pregnancy are significant independent risk factors for SSI following cesarean delivery. These findings suggest that local clinical protocols, particularly at Hasan Sadikin General Hospital, could be improved by implementing targeted pre-operative screenings for obesity and UTIs, weight management programs, and enhanced patient education on cesarean risks.

Additionally, perioperative antibiotic protocols should be strengthened, ensuring timely administration of prophylactic antibiotics before surgery. Strict adherence to cleanliness protocols, including proper sterilization of surgical instruments, aseptic techniques during the procedure, and maintaining a clean operating environment, is essential to reduce infection risks. Other factors, such as proper wound care and the management of comorbidities like diabetes and anemia, should also be considered as part of a comprehensive infection prevention strategy. Future research with larger sample sizes and multicenter data is recommended to validate these results and support the development of targeted preventive strategies in obstetric surgical practices.

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Conflict of Interest

The authors declare no conflict of interest.

Informed Consent

Not applicable.

Author Contributions

AF performed all the research, including research design, data collection and analysis, and manuscript writing. MAA provided critical revisions to the manuscript and contributed to the interpretation of results. SS assisted with the literature review and contributed to the manuscript writing. NWR contributed to the data analysis and reviewed the manuscript.

Data Availability

The data of this study are available from the corresponding author upon reasonable request.

Abbreviations

aOR: adjusted odds ratio; BMI: body mass index; CI: confidence interval; cOR: crude odds ratio; DM: diabetes mellitus;

PROM: premature rupture of membranes; SPSS: Statistical Package for the Social Sciences; SSI: surgical site infection; UTI: urinary tract infection; USD: United States Dollar

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