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Association Between Irrational Prophylactic Antibiotic Use and Post-Surgical Infections in Caesarean Section Patients at Indonesian Regional Hospitals

Asociación entre el uso irracional de antibióticos profilácticos y las infecciones posquirúrgicas en pacientes por cesárea en hospitales regionales de Indonesia

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SUMMARY

This study explores the link between irrational prophylactic antibiotic use and post-surgical infections in caesarean sections in Indonesia. A cross-sectional design was used, with medical data collected from patients who underwent caesarean section and received prophylactic antibiotics between 2018 and 2022 in a regional hospital in Indonesia. Antibiotic prescriptions were evaluated for appropriateness according to national guidelines. Medical record data was used to gather information regarding obstetric surgical wound infection (ICD-10 code: O86.1). The adjusted odds ratios (OR) and 95 % confidence intervals (95 % CI) were estimated via multivariate logistic regression. We analyzed data from 274 patients; 31 (11.3 %) were diagnosed with surgical site infection. Our findings show that the risk of surgical site infection significantly increases with inappropriate antibiotic type (aOR: 18.67, 95 % CI: 2.33-149.35) and duration of antibiotic use (aOR: 5.15, 95 % CI: 2.06-12.86). Adhering to national guidelines is crucial to reduce post-caesarean infections.

Keywords: *Caesarean section, antibiotic prophylaxis, postoperative infection, therapeutic guidelines.*

RESUMEN

Este estudio explora el vínculo entre el uso irracional de antibióticos profilácticos y las infecciones posquirúrgicas en cesáreas en Indonesia. Se utilizó un diseño transversal, con datos médicos recopilados de pacientes que se sometieron a cesárea y recibieron antibióticos profilácticos entre 2018 y 2022 en un hospital regional de Indonesia. Se evaluó la idoneidad de las prescripciones de antibióticos de acuerdo con las directrices nacionales. Se utilizaron datos de registros médicos para recopilar información sobre la infección de la herida quirúrgica obstétrica (código CIE-10: O86.1). Los odds ratios (OR) ajustados y los intervalos de confianza del 95 % (IC del 95 %) se estimaron mediante regresión logística multivariada. Se analizaron datos de 274 pacientes, de los cuales 31 (11,3 %) fueron diagnosticados con

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infección del sitio quirúrgico. Nuestros hallazgos muestran que el riesgo de infección del sitio quirúrgico aumenta significativamente con el tipo de antibiótico inadecuado (ORa: 18,46, IC del 95 %: 2,29-148,33) y la duración del uso de antibióticos (ORa: 5,30, IC del 95 %: 2,17-12,96). Cumplir con las directrices nacionales es crucial para reducir las infecciones poscesáreas.

Palabras clave: *Cesárea, profilaxis antibiótica, infección posoperatoria, pautas terapéuticas.*

INTRODUCTION

Caesarean section is a delivery procedure primarily performed to preserve the lives of pregnant women and fetuses when complications related to pregnancy and childbirth are present. The World Health Organization's data suggests that the number of caesarean sections has increased worldwide in recent decades. In 2015, it was recorded that the worldwide prevalence of caesarean sections was between 19 % and 20 % (1). According to the Indonesian Basic Health Survey (Riskesdas) conducted in 2018, the prevalence of caesarean delivery in Indonesia reached 17.6 %. This marks an increase from the 9.8 % reported in the 2013 survey (2).

One of the major complications responsible for 80 % of deaths in childbirth is infection, which usually occurs after delivery (3). Women who undergo a caesarean delivery due to post-operative issues possess a greater risk of infection (4). The most common infectious complications of caesarean delivery include fever, wound infection, endometritis, and urinary tract infections (5).

Surgical site infections (SSIs) are a major post-surgery complication and the most common infection acquired in hospitals, with a notable impact on morbidity, mortality, and healthcare expenses (6,7). The administration of prophylactic antibiotics before surgery is a key strategy to reduce SSI rates, potentially decreasing them by 40 %-60 % (8). For optimal effectiveness, the administration of antibiotics must be accurately timed, dosed, and delivered through the appropriate route so that antibiotic levels in plasma and tissues are achieved immediately before the incision to prevent bacterial colonization (9). Inappropriate surgical antibiotic prophylaxis, including inadequate selection, timing, and duration, increases the prevalence of antibiotic resistance, leading to adverse drug reactions, surgical site infections, and escalating healthcare costs (10). Despite the known benefits of proper antibiotic use, there is still a high rate of misuse in up to 50 % of surgeries (8).

This observational study focuses on the critical role of prophylactic antibiotics in surgery, particularly caesarean sections. It aims to explore the relationship between the irrational use of prophylactic antibiotics and the occurrence of postoperative infections. This will promote the rational use of antibiotics, help prevent postoperative infections, and improve surgical outcomes.

METHODS

This cross-sectional retrospective study was conducted to analyze the use of prophylactic antibiotics in caesarean sections and explore the link between inappropriate antibiotic use and postoperative infections. Data were collected from medical records at Andi Makkasau Hospital, Parepare City, a regional hospital in South Sulawesi Province, Indonesia, covering 2018 to 2022.

The study included all patients who underwent caesarean sections at Andi Makkasau Hospital during this period. Medical doctors trained in obstetrics and gynecology (obstetrician-gynecologists) performed all caesarean sections in this hospital. Eligible participants were those who received surgical prophylactic antibiotics and had complete medical record information about their use during caesarean sections. This study obtained ethical approval from the research ethics committee of the Faculty of Public Health, Hasanuddin University (Number: 8076/UN4.14.1/TP.01.02/2022).

Independent and dependent variables

The independent variable encompasses various criteria, such as the antibiotic type, dose, administration route, timing, and duration.

The study assesses the rationality of antibiotic selection and usage by comparing these aspects with the national guideline set by the Indonesian Ministry of Health in Regulation Number 2406/ MENKES/PER/XII/2011.

The primary clinical outcome measured is the occurrence of surgical site infections (SSI), identified by the ICD-10 code O86.1, which refers to infection of the obstetric surgical wound in the superficial incisional site. The study also considers other clinical outcomes, such as patient vital signs (body temperature, pulse, and respiratory rate) and laboratory results (white blood cell counts) measured before and after surgery. This comprehensive analysis aims to determine the effectiveness of antibiotic protocols in preventing post-surgery complications, specifically SSIs, and to ensure the rational use of antibiotics in surgical procedures.

Statistical Analysis

Categorical data variables, including age, gestational age, comorbidities, type of operation, number of caesareans, duration of operation, length of hospitalization before and after maternal delivery, and presence of surgical site infection, were presented as number (n) and percentage (%). Bivariate and multivariate logistic regression analyses were conducted to investigate the correlation between rational prophylactic antibiotic use and surgical site infection. The strength of the association was presented as odds ratios (ORs) along with their corresponding 95 % confidence intervals (CIs). A significance threshold of $p<0.05$ was employed to determine statistical significance. The Statistical Program for Social Sciences (SPSS) version 26.0 software was utilized for all analyses.

RESULTS

This study obtained a total of 274 caesarean-section patients (Table 1). The age group with the highest number of caesarean sections was 26-35 years, representing 142 patients (51.8 %). The study found that 67 patients, accounting for 24.5 % of the total, had at least one comorbidity at admission. In contrast, 207 patients (75.5 %) had no comorbidities.

Table 1. Demographic Data and Operating Characteristics of Patients

Characteristics	Variables	Patients (n= 274, %)
Age	17-25	81 (29.6)
	26-35	142 (51.8)
	>35	51 (18.6)
Gestational Age	Preterm	25 (9.1)
	Aterm	231 (84.3)
	Postterm	18 (6.6)
Comorbidities	Yes	67 (24.5)
	No	207 (75.5)
Type of Surgery	Electives	130 (47.4)
	Emergencies	144 (52.6)
Number of Operations (SC)	1	165 (60.2)
	2	94 (34.3)
	≥ 3	15 (5.5)
Duration of Operation	≤1 Hour	233 (85)
	>1 Hour	1 (15)
Length of Preoperative Hospitalization	≤1 day	256 (93.4)
	>1 day	18 (6.6)
Length of Post-Operative Hospitalization	<3 days	217 (79.2)
	≥3 days	57 (20.8)
Postoperative Infections	Yes	31 (11.3)
	No	243 (88.7)

The study categorized the nature of caesarean section surgeries into elective and emergency. Of the 274 patients, 130 (47.4 %) underwent elective surgery, while 144 (52.6 %) had emergency surgery. Regarding their surgical history, the majority of patients, 165 (60.2 %), had only one caesarean section. Most surgeries, 233 (85 %), lasted ≤1 hour.

In terms of hospital stay, a significant portion of patients, 256 (93.4 %), had a pre-operative length of stay of ≤1 day. Post-operatively, 217 patients (79.2 %) stayed in the hospital for less than 3 days. Among these patients, 31 (11.3 %) experienced postoperative infections, while a larger group of 243 (88.7 %) had no postoperative infections.

Table 2. Profile of Prophylactic Antibiotic Use in Caesarean Surgery

Variables		Number (%) (n= 274)
Types of Antibiotics	Cefuroxime	90 (32.8)
	Ceftriaxone	121 (44.2)
	Cefotaxime	61 (22.3)
	Ceftazidime	2 (0.7)
Antibiotic Class (Cephalosporins)	Second-generation	90 (32.8)
	Third-generation	184 (67.2)
Administration Dosage	Cefuroxime 1.5 g	90 (32.8)
	Ceftriaxone 1 g	84 (30.7)
	Ceftriaxone 2 g	37 (13.5)
	Cefotaxime 1 g	61 (22.3)
	Ceftazidime 1 g	2 (0.7)
Duration of Administration	≤24 Hours	179 (65.3)
	>24 Hours	95 (34.7)

The profile of prophylactic antibiotic use in caesarean section at Andi Makkasau Parepare Hospital is shown in Table 2. In this study, every patient undergoing a caesarean section received prophylactic antibiotics. The antibiotics used were primarily from the cephalosporin class, with second-generation cephalosporins administered to 90 patients (32.8 %) and third generation cephalosporins to 184 patients (67.2 %). The most commonly used antibiotic was Ceftriaxone, given to 121 patients (44.2 %). Among these, 84 patients (30.7 %) received a 1-gram dose, and 37 (13.5 %) received a 2-gram dose.

Additionally, the study observed the use of other antibiotics: 1.5 grams of Cefuroxime for 90 patients (32.8 %), 1 gram of Cefotaxime for 61 patients (22.3 %), and 1 gram of Ceftazidime for 2 patients (0.7 %). Regarding the duration of antibiotic administration, most patients, 179 (65.3 %), received antibiotics for ≤24 hours, while 95 patients (34.7 %) received them for >24 hours. All antibiotics in this study were administered intravenously and given pre-operatively.

We observed that only 90 (32.8 %) patients received types of antibiotics deemed appropriate for prophylaxis according to national guidelines.

An inappropriate duration of antibiotic prophylaxis was administered to 95 patients (34.7 %). All patients received prophylactic antibiotics with the appropriate dose, route, and administration time per the national therapeutic standard. Due to 100 % adherence in these aspects, their associations with postoperative infections were not analyzed. Clinical outcomes of patients, including vital signs such as body temperature, pulse, and respiratory rate, as well as laboratory values, including white blood cell count before and after surgery, are presented in Table 3.

Table 3. Patient's Clinical Outcome and Laboratory Examination

Parameters	Unit	Reference*	Pre-Op (n = 274)		Post-Op (n = 274)	
			Normal n (%)	Abnormal n (%)	Normal n (%)	Abnormal n (%)
Temperature	ºC	36.5-37.5	144 (52.6)	130 (47.4)	175 (63.9)	99 (36.1)
Pulse Rate	x/Minute	60-100	263 (96)	11 (4)	268 (97.8)	6 (2.2)
Respiratory Rate	x/Minute	16-20	240 (87.6)	34 (12.4)	245 (89.4)	29 (10.6)
White Blood Cell Count	/μL	4 000-10 000	185 (67.5)	89 (32.5)	33 (12)	241 (88)

*Notes: parameter assessment based on referral value from Andi Makkasau Hospital

The percentage of patients exhibiting abnormal body temperature, pulse rate, and respiratory rate before surgery was 47.4 %, 4 %, and 12.4 %, respectively. These percentages were reduced after surgery, with 36.1 %, 2.2 %, and 10.6 % of patients displaying normal levels for each measurement. Conversely, the percentage of patients with abnormal blood cell counts before surgery was 32.5 %, which increased by 88 % post-surgery, suggesting the potential occurrence of postoperative infection.

The bivariate logistic regression analysis results in Table 4 show that the variables with a significant correlation ($p<0.05$) were age, the type of surgery, duration of surgery, and length of hospitalization before surgery. These variables were then entered into the multivariate analysis for *adjustments*.

Multivariate analysis showed (Table 5) that inappropriate selection of prophylactic antibiotics (aOR: 18.67, 95 % CI: 2.33-149.35) and inappropriate duration of prophylactic antibiotics (aOR: 5.15, 95 % CI: 2.06-12.86) significantly increased the risk of SSI.

DISCUSSION

The risk of infectious complications is significantly higher in women undergoing caesarean delivery compared to those who have vaginal deliveries (12,13). Common post-caesarean infections include endometritis, wound infection, and urinary tract infections (14). Prophylactic antibiotics in caesarean deliveries have shown considerable benefits in reducing infectious morbidity. Specifically, the rates of endometritis can be lowered by 60 %-70 %, and wound infection rates can be reduced by 30 %-65 % (15).

The WHO defines preoperative prophylactic antibiotic accuracy as timely administration before potential surgical contamination, essential for reducing postoperative infection risks and healthcare costs (16,17). Adhering to clinical guidelines prevents inappropriate use and enhances antibiotic effectiveness, reducing antibiotic resistance. Implementing these clinical guidelines is a strategic step in addressing the

Table 4. Factors Potentially Affecting the Incidence of Postoperative Infection.

Variables	Description	Surgical Infection (n=274)		OR (95%CI)	P-value
		Yes n (%)	No n (%)		
Age (in years)	17-25	8 (25.8)	73 (30)	Reference	
	26-35	10 (32.3)	132 (54.3)	0.69 (0.26 - 1.83)	0.69
	>35	13 (41.9)	38 (15.6)	3.12 (1.19-8.19)	0.02*
Gestational Age	Preterm	3 (9.7)	22 (9.1)	Reference	
	Aterm	27 (87.1)	204 (84)	0.97 (0.27-3.46)	0.96
	Postterm	1 (3.2)	17 (7)	0.43 (0.04-4.52)	0.48
Comorbidities	Yes	10 (32.3)	57 (23.5)	Reference	0.29
	No	21 (67.7)	186 (76.5)	0.64 (0.29-1.45)	
Type of Surgery	Electives	8 (25.8)	122 (50.2)	Reference	0.01*
	Emergencies	23 (74.2)	121 (49.8)	2.89 (1.25-5.73)	
Number of Operations (SC)	1	24 (77.4)	141 (58)	Reference	0.06
	2	6 (19.4)	88 (36.2)	0.40 (0.16-1.02)	0.41
	≥2	1 (3.2)	14 (5.8)	0.42 (0.05-3.34)	
Duration of Operation	≤1 Hour	19 (61.3)	214 (88.1)	Reference	<0.01*
	>1 Hour	12 (38.7)	29 (11.9)	4.66 (2.05-10.58)	
Length of Pre-Op Hospitalization	≤1 day	23 (74.2)	233 (95.9)	Reference	<0.01*
	>1 day	8 (25.8)	10 (4.1)	8.10 (2.91-22.56)	
Length of Post-Op Hospitalization	<3 days	24 (77.4)	193 (79.4)	Reference	0.79
	≥3 days	7 (22.6)	50 (20.6)	1.13 (0.46-2.76)	

Description: CI: Confidence Interval; OR: Odds Ratio; SC: Sectio Cesarea; *statistically significant ($p < 0.05$)

Table 5. Relationship between the Inappropriateness Use of Antibiotic Prophylaxis and Surgical Infection at Andi Makkasau Hospital.

Antibiotic Appropriateness		Surgical Infection (n=274) Yes n (%)	No n (%)	Unadjusted OR (95%CI)	p-value	Adjusted * OR (95%CI)	p-value
Types of Antibiotics	Yes	1 (3.2)	89 (36.6)	Reference	<0.01	Reference	<0.01
	No	30 (96.8)	154 (63.4)	17.65 (2.37-131.61)		18.67 (2.33-149.35)	
Duration of Antibiotics	Yes	10 (32.3)	169 (69.5)	Reference	<0.01	Reference	<0,01
	No	21 (67.7)	74 (30.5)	4.79 (2.15-10.68)		5.15 (2.06-12.86)	

*Adjusted with variables: age, the type of surgery, duration of surgery, and length of hospitalization before surgery.

growing concern of antibiotic resistance (18,19). This underscores the importance of standardized practices in antibiotic administration, particularly in surgical contexts, to ensure optimal patient outcomes and the sustainable use of antibiotic therapies.

This study evaluated the appropriateness of prophylactic antibiotic usage among patients who underwent caesarean sections regarding the selection of antibiotic types, dosages, routes of administration, timing, and duration of use compared to the therapeutic guideline set by the Ministry of Health of the Republic of Indonesia. All 274 patients included in this study were administered prophylactic antibiotics for surgical purposes. This complies with therapeutic guidelines that strongly suggest administering prophylactic antibiotics to all caesarean section patients, except those with other infectious diseases who are already undergoing antibiotic therapy (20,21). Prophylactic antibiotics have been demonstrated to reduce postoperative infectious disease morbidity in high-risk and low-risk women (22,23).

Beta-lactam antibiotics, particularly cephalosporins, are popular for prophylaxis due to their broad spectrum of activity and minimal side effects (11). In this study, Cefuroxime, a second-generation cephalosporin, was the only antibiotic aligned with the national therapeutic guideline, accounting for 32.8 % of all antibiotic use. This finding is comparable to a study by Astuti et al. (2022) in a private hospital in Lempuyangwangi, Yogyakarta, Indonesia. That study reported that only 35.8 % of prophylactic antibiotics used for caesarean sections were the appropriate choice (24).

Other types of antibiotics observed in this study, including Ceftriaxone, Cefotaxime, and Ceftazidime, did not align with the national guideline, with Ceftriaxone being the most commonly used. This finding is consistent with previous research. For example, Maakh et al. (2019) reported that 84 % of patients in a regional hospital in Atambua (East Nusa Tenggara, Indonesia) received Ceftriaxone for caesarean section prophylaxis in 2018 (25). Similar results were found by Muthoharoh et al. (2018), in which Ceftriaxone became the drug of choice for prophylactic antibiotics in the caesarian section in a regional hospital in Pekalongan (Central Java, Indonesia) (26). Another study conducted in a public hospital in Riau (Riau, Indonesia) also found that Ceftriaxone was the dominant antibiotic used (55.7 %) as a prophylactic measure before the caesarian section (27). Romero Viamonte et al. (2021) noted that variations in prophylactic antibiotic choice could result from local microbial patterns, prescribing habits, lack of proper prescribing protocols, or non-adherence to therapeutic guidelines (28).

All prophylactic antibiotics were administered at doses aligned with therapeutic recommendations. The national guideline suggests that antibiotics can be administered up to 24 hours after surgery. In this study, 65.3 % of antibiotic courses adhered to this recommended duration. The remaining 34.7 % of antibiotics were administered for a duration exceeding 24 hours. Our findings are comparable to a study by Latief et al. (2024), which reported that approximately 68 % of prophylactic antibiotics for caesarean section in a private hospital in Jakarta (Indonesia) were administered for a prolonged duration (>24 hours) (29).

There is no significant difference in postoperative infection rates between single and repeated antibiotic doses (14,30). However, inappropriate or excessive use can lead to microbial resistance and increase the risk of adverse patient reactions, such as allergies or side effects, consequently raising treatment costs (28).

The timing and route of antibiotic administration are critical for effective prophylaxis. Achieving adequate drug levels in blood and tissues is essential to prevent postoperative infections. The national guideline recommends administering surgical prophylactic antibiotics intravenously before surgery (preoperatively). This study found that the timing and route of administration were consistent with the guidelines. Intravenous or intramuscular injection of antibiotics ensures 100 % bioavailability. Some antibiotics are administered parenterally due to poor oral absorption or ineffectiveness (31). A randomized controlled trial (RCT) by Dlamini et al. (2015) found that giving prophylactic antibiotics before skin incision significantly reduces postoperative infections, particularly endometritis. This underscores the importance

of correct antibiotic administration in surgical settings (32).

Muzayyanah et al. (2018) highlighted that the effectiveness of prophylactic antibiotics can be gauged through patient clinical conditions, such as temperature, pulse, and respiration, as well as laboratory tests like white blood cell (WBC) counts and C-reactive protein (CRP) levels (33). According to the study's findings, as shown in Table 3, most patients had normal vital signs both before and after surgery. Before surgery, 144 patients (52.6 %) had normal body temperature, which increased to 175 patients (63.9 %) post-surgery. For pulse rate, 263 patients (96 %) were within the normal range before surgery, and 268 (97.8 %) maintained this post-surgery. Regarding the respiratory rate, 240 patients (87.6 %) were normal before surgery, and 245 patients (89.4 %) were normal afterward. These results indicate that patients' vital signs generally remained within the normal range before and after surgery, suggesting effective management and control of potential complications.

The study's results on white blood cell (WBC) counts showed a significant shift from pre-surgery to post-surgery. Before surgery, 185 patients (67.5 %) had WBC counts in the normal range, but 241 patients (88 %) exhibited abnormal WBC counts post-surgery. This increase in WBCs post-caesarean section is consistent with findings by Lebdowicz et al. (2018), who observed a rise in neutrophils after caesarean deliveries (34). The sudden increase in white blood cell count occurs within minutes to hours following surgery, a typical physiological response essential for wound healing. This alteration in white blood cell count is associated with the physical strain of surgery, stimulating a surge in stress hormones, such as cortisol and catecholamines, in the blood. These hormones trigger mature granulocytes in the bone marrow and tissues, resulting in the swift release of white blood cells that, in turn, elevate the WBC count in circulation (35-37). This response is a natural component of the body's recuperative process following surgery and signifies the body's recovery and efforts to fight potential infections.

The study found a notable difference in infection rates based on the nature of the caesarean section surgery. Patients undergoing emergency surgery had a higher risk of infection rate than those who had elective surgery (OR: 2.89; 95 % CI: 1.25-5.73; p: 0.01). This aligns with findings from Misha et al. (2021), who also reported a higher risk of postoperative infection in emergency surgeries. One key reason for this increased risk in emergency surgeries is the lack of optimal preoperative preparation. There is often insufficient time to thoroughly assess the patient's comorbidities or adequately prepare for the surgery in emergencies. This leads to a higher likelihood of contamination than elective surgeries, where there is more time for comprehensive preparation and assessment (38).

The study highlighted that the duration of surgery is a significant factor in the risk of postoperative infection. Specifically, patients who underwent surgeries lasting more than 1 hour had a higher infection rate than those with surgeries under 1 hour (OR: 4.66; 95 % CI: 2.05-10.58; $p<0.01$). This finding aligns with research by Misganaw et al. (2020), who also reported an increased risk of postoperative infection in surgeries exceeding 1 hour (39). Several factors may contribute to this increased risk of longer surgeries. These include prolonged exposure of body tissues to the external environment, extended periods of hypothermia, decreased antibiotic levels in the blood over time, or potential errors in maintaining aseptic techniques during the surgery (38).

The study also examined the relationship between the length of preoperative hospital stay and the incidence of infection. Patients with a preoperative hospital stay of more than 1 day had a significantly higher rate of infection with an OR value of 8.10, 95 % CI: 2.91-22.56, $p<0.01$, suggesting a strong association between longer preoperative hospitalization and increased infection risk. One possible explanation for this pattern is that the longer patients stay in the hospital before surgery, the greater their risk of exposure to nosocomial (hospital-acquired) infections. This is supported by research from Syafitri et al. (2020), who also highlighted the correlation between extended hospital stays and higher infection risks (40).

Surgical site infections (SSIs) are a common and severe postoperative complication, leading to increased morbidity and mortality. They

necessitate additional antibiotic use, prolong hospital stays, inflate healthcare costs, and diminish patient quality of life (11). These infections can originate from the patient's normal flora (endogenous) or contamination during surgical procedures (exogenous). Data from the National Nosocomial Infections Surveillance System (NNISS) indicate that the most common pathogens isolated from SSIs include *Staphylococcus aureus*, *Coagulase-negative staphylococci*, *Enterococci*, *Escherichia coli*, and *Pseudomonas aeruginosa* (41). A study from a regional hospital in Pasuruan (East Java, Indonesia) found *Hafnia alvei* (a gram-negative bacterium) as a pathogen isolated at the injection site after the caesarian section (42). Other findings from Dirgagita et al. (2020) reported that *Staphylococcus aureus* (59.4 %), *Staphylococcus epidermidis* (25 %), and *Escherichia coli* (15.6 %) were the pathogens isolated from the wound of patients with SSI in a regional hospital in Banjarmasin (South Kalimantan, Indonesia) (43). Additionally, Irawan et al. (2022) reported various types of pathogenic bacteria found in SSIs after caesarian section in a regional hospital in Bandung (west Java, Indonesia) during 2020-2021, including *Acinetobacter baumannii* (20 %), *Escherichia coli* (20 %), *Staphylococcus aureus* (10 %), *Staphylococcus epidermidis* (10 %), *Staphylococcus haemolyticus* (5 %), *Enterobacter cloacae* (10 %), *Pseudomonas aeruginosa* (5 %), *Enterococcus faecalis* (5 %), *Klebsiella pneumoniae* (5 %), *Morganella morganii ss. Morganii* (5 %) (44).

The risk of SSI is influenced by several factors, including the number and virulence of the organisms involved and the patient's immune system condition. Organisms from the patient's normal flora can become pathogenic when they migrate to normally sterile areas, such as *S. aureus* or *S. epidermidis* migrating from the skin surface to deeper tissues or *E. coli* traveling from the colon to the peritoneal cavity, bloodstream, or urinary tract. The patient's immune system significantly influences this risk. Impairment of specific immune factors, including the activation of complement proteins, tissue innate inhibitors such as proinflammatory cytokines, and cell-mediated responses like T cell function, can significantly elevate the risk of SSIs. The effectiveness of granulocytic or phagocytic cells, like neutrophils and macrophages, is also vital in preventing infection. When these immune mechanisms are compromised, either due to the patient's existing conditions or the stress of surgery, the risk of developing an SSI increases substantially (41).

This retrospective study investigated how the imprecision of antibiotic use affects the occurrence of postoperative infections. The statistical analysis revealed inaccuracies in choosing the type of antibiotic (aOR: 18,67 95 % Confidence Interval, CI: 2.33-149.35) and in determining the duration of prophylactic antibiotic administration (aOR: 5.15, 95 % CI: 2.06-12.86) significantly increased the risk of postoperative infections.

It is crucial to regularly update and implement national treatment guidelines among healthcare professionals to improve the accuracy of antibiotic administration and promote rational prescribing (45). Moreover, implementing an Antimicrobial Stewardship program can significantly enhance the use of surgical prophylactic antibiotics. Such programs focus on optimizing antibiotic prescribing to improve patient outcomes, ensure cost-effective therapy, and reduce adverse side effects, including antibiotic resistance (46).

Some limitations in our study are worth mentioning, particularly regarding the comprehensive clinical information related to caesarean procedures and post-operative wound management. We lacked specific details such as the duration of labor preceding the caesarean section, occurrences of premature rupture of membranes, presence of associated pathologies such as toxemia, and a detailed technical description of the surgical incision approach—whether longitudinal or transverse, the specific surgical instruments and materials utilized, assessment of the thickness of the abdominal wall layers, method of skin closure (e.g., sutures, staples), and observations regarding the presence or absence of clinical signs like erythema, edema, wound secretions, and wound dehiscence. Given the retrospective nature of our study design, we heavily relied on the data extracted from the medical records of the patients who underwent caesarean deliveries.

Future studies may benefit from incorporating more comprehensive data collection methods, including real-time documentation of surgical procedures and post-operative assessments, to enhance the depth and accuracy of our findings related to caesarean outcomes.

CONCLUSIONS

The research concluded that the use of inappropriate types of antibiotics and the incorrect duration of prophylactic antibiotic administration significantly increased the risk of postoperative infections. These findings highlight the importance of adhering to established guidelines for antibiotic use in surgical settings to minimize the risk of infections and improve patient outcomes.

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Conflict of interest

All authors declare no conflict of interest.

Authors' contributions

Conceptualization: RJ, MAM, MAB; Methodology: RJ, MAM, MAB; formal analysis and investigation: RJ, MAB; writing-original draft: RJ; writing—review, editing, and provided final draft: MAM, MAB; supervision: MAM, MAB.

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