Research Horizon

ISSN: 2808-0696 (p), 2807-9531 (e)

Research Horizon
Volume: 06
Issue: 02
Year: 2026
Page: 873-890

Citation:
Wibowo, R. (2026). The incidence of surgical site infection and the implementation of prophylactic antibiotic use in general surgery patients. *Research Horizon*, *6*(2), 873-890.

Article History:
Received: February 26, 2026
Revised: March 18, 2026
Accepted: April 27, 2026
Online since: April 30, 2026

The Incidence of Surgical Site Infection and the Implementation of Prophylactic Antibiotic Use in General Surgery Patients

Ricky Wibowo[1*]

[1] Universitas Airlangga, Surabaya, Indonesia

[*] *Corresponding author: Ricky Wibowo (ricky.w@fk.unair.ac.id)*

Abstract

Surgical Site Infection (SSI) occurs within 30 days after surgery or 90 days with an implant. Prophylactic antibiotics prevent SSI by reducing bacterial contamination, but misuse can increase infection risk and antibiotic resistance. This study aims to assess the incidence of SSI, types of surgery (clean or clean-contaminated), indications, and appropriateness of prophylactic antibiotics, and adherence to clinical guidelines. A retrospective observational design was used, analyzing secondary data at the General Surgery Clinic from March to June 2025. Adult patients (≥18 years) who received prophylactic antibiotics were included. Findings showed most patients were male, aged 18–25 and 46–55 years. Cefazolin was the most commonly used antibiotic (82.76%), followed by ceftriaxone (17.24%), primarily administered intravenously within 30 minutes before incision. Prophylactic antibiotic use was appropriate in 82.76% of cases, though timing adherence was low (35.63%). SSI incidence was 2.3%, occurring in both clean and clean-contaminated surgeries, with cases linked to ceftriaxone misuse. The study highlights the importance of stricter adherence to prophylactic antibiotic protocols, particularly regarding timing, to further reduce SSI risk.

Keywords

Antibiotic Appropriateness, Clean and Clean-Contaminated Surgery, Prophylactic Antibiotics, Surgical Site Infection.

1. Introduction

Surgical Site Infection (SSI) is a serious postoperative complication occurring within 30 days after surgery, characterized by erythema, swelling, purulent discharge, fever, and *leukocytosis* (Dhole et al., 2023; Lubis et al., 2024). SSI is classified as superficial incisional, deep incisional, or organ/space infection. Globally, SSI occurs in 1.9% of surgeries (16,147 of 849,659 cases), while in Southeast Asia, the incidence reaches 7.8%, affecting 160,000–300,000 individuals annually (WHO, 2016). SSI leads to prolonged hospitalization, loss of productive time, higher healthcare costs, and increased mortality.

In the UK, managing SSI costs approximately £1 million (USD 1.8 million) per year, with hospital stays increasing by 7–10 days and healthcare expenses rising up to 20%. SSI-related mortality can reach 77% (Alsen & Sihombing, 2014). Risk factors are intrinsic, including patient comorbidities, age, sex, ASA score, and nutritional status (WHO, 2016), or extrinsic, such as operating room conditions, surgical type and duration, and microbial contamination (Chairani et al., 2019). The most common pathogens causing SSI are *Staphylococcus aureus* (30.4%), *coagulase-negative staphylococci* (11.7%), *Escherichia coli* (9.4%), and *Enterococcus faecalis* (5.9%).

One preventive strategy for SSI is prophylactic antibiotics, which are given before surgery to prevent postoperative infection. Surgical antibiotic prophylaxis involves administering antibiotics before, during, and up to 24 hours after surgery in patients without infection. Indications depend on patient comorbidities, infection risk, and surgery type. Surgeries are classified as clean, clean-contaminated, contaminated, or dirty, with prophylaxis recommended for clean and clean-contaminated procedures. In clean surgeries, prophylaxis is indicated if prosthetic material is used, the procedure exceeds 3 hours, or massive *hemorrhage* occurs. Prophylactic antibiotics reduce bacterial load and support host defenses, with evidence showing a 2–2.6-fold higher risk of SSI in patients not receiving prophylaxis (Alamrew et al., 2019; Misganaw et al., 2020). Commonly used agents in surgical prophylaxis include first- or second-generation cephalosporins and metronidazole when anaerobic bacteria are suspected. Pratama et al. (2019) reported that cefazolin is the most widely used prophylactic antibiotic in general surgery.

General surgery procedures carry a high risk of SSI and therefore warrant antibiotic prophylaxis. For instance, in hernia repair (herniorrhaphy and hernioplasty), which is classified as clean surgery, prophylactic antibiotics are recommended. SSI incidence in open hernioplasty is reported at 0.91%, ventral hernioplasty 0.90%, and inguinal hernioplasty 0.92% (Muhammad et al., 2023). The predominant pathogen in inguinal hernia repair is *Staphylococcus aureus* (Du et al., 2023). Accordingly, antibiotics with Gram-positive coverage are indicated, with first-generation cephalosporins (cefazolin) being recommended (Bratzler et al., 2013). Similar findings are reported by Boonchan et al. (2017) and Lumbantobing et al. (2022), both highlighting cefazolin as the most frequently used prophylactic agent. Although thyroidectomy is classified as clean surgery, SSI can occur, with an incidence of 0.7% (50 of 7,388 cases), most commonly caused by *Staphylococcus aureus* and *Staphylococcus epidermidis.* While ASHP guidelines recommend no prophylaxis for clean surgeries unless prosthetic material is used, studies have reported cefazolin, cefuroxime, or piperacillin administration in thyroid procedures (Bratzler et al., 2013; Uruno et al., 2015; Iwatani & Saito, 2023).

Mastectomy, though also considered a clean procedure, has been associated with a relatively high SSI rate ranging from 5% to over 10% depending on reconstruction type (Olsen et al., 2015; Palubicka et al., 2019). Gram-positive bacteria, particularly *Staphylococcus spp.*, are the most common pathogens. Although prophylaxis is generally not recommended for clean breast surgery, it may be considered in high-risk patients, with single-dose cefazolin or ampicillin–sulbactam being appropriate choices (Bratzler et al., 2013). Incorrect use of prophylactic antibiotics can contribute to both SSI and antimicrobial resistance. Inappropriate timing, duration, or selection of agents has been documented in multiple studies (Karaali et al., 2019; Hendrawan et al., 2024). For example, prophylactic antibiotic administration beyond 24 hours is unnecessary and offers no reduction in SSI incidence (Amelia & Komar, 2019).

Despite guidelines recommending first- or second-generation cephalosporins, third-generation agents such as ceftriaxone are still frequently prescribed inappropriately. Given these concerns, it is essential to evaluate the incidence of SSI and the appropriateness of antibiotic prophylaxis use in general surgery patients, such as those at Universitas Airlangga Hospital. This study aims to assess the incidence of SSI, types of surgery (clean or clean-contaminated), indications and appropriateness of prophylactic antibiotics, adherence to clinical guidelines, and the timing, route, and dosage of administration to identify areas for improving compliance with recommended protocols.

2. Literature Review

2.1. Introduction and Significance of SSI

Surgical Site Infection (SSI) remains one of the most common complications associated with surgical procedures worldwide and represents a significant burden for health systems, patients, and healthcare providers. According to the Centers for Disease Control and Prevention (CDC), a surgical site infection is defined as an infection that occurs within 30 days after surgery or within one year if an implant is placed and involves the incision, deep tissue, or organ space related to the surgical procedure (Horan et al., 2008). SSIs contribute to increased morbidity, prolonged hospitalization, higher healthcare costs, and increased mortality rates. The prevention of SSI has therefore become a critical focus in surgical care, particularly through the appropriate use of prophylactic antibiotics.

Globally, the incidence of surgical site infection varies widely depending on the type of surgery, the healthcare setting, and the quality of infection control practices. Studies in developed countries report SSI rates ranging from 2% to 5% for clean surgical procedures, while rates in developing countries may exceed 10% due to limitations in infection control infrastructure, antibiotic stewardship, and perioperative management (Allegranzi et al., 2016). In Southeast Asia, including Indonesia, several hospital-based studies have reported SSI incidence ranging between 5% and 15%, especially in general surgery procedures involving the gastrointestinal tract or contaminated wounds (Jahangir et al., 2024).

2.2. Classification and Risk Factors

Surgical site infections are generally classified into three categories: superficial incisional SSI, deep incisional SSI, and organ/space SSI. Superficial infections involve the skin and subcutaneous tissue at the incision site, whereas deep incisional infections extend into the fascia and muscle layers. Organ or space infections involve any anatomical structure opened or manipulated during surgery, other than the incision itself (Mangram et al., 1999). Each category has distinct clinical manifestations and varying degrees of severity, which influence treatment strategies and patient outcomes. Multiple risk factors contribute to the development of surgical site infections.

These factors can be categorized into patient-related, procedure-related, and hospital-related factors. Patient-related risk factors include advanced age, diabetes mellitus, obesity, malnutrition, immunosuppression, and smoking status. Procedure-related factors include the duration of surgery, the type of surgical wound classification, surgical technique, and the use of implants. Hospital-related factors include operating room sterility, sterilization protocols, surgical team adherence to infection prevention guidelines, and antimicrobial stewardship practices (Berríos-Torres et al., 2017).

2.3. Prophylactic Antibiotics in SSI Prevention

One of the most effective strategies to prevent Surgical Site Infection (SSI) is the appropriate use of prophylactic antibiotics, which aim to reduce microbial contamination during surgery without sterilizing tissues, thus lowering bacterial load during the critical period of wound vulnerability (Bratzler, 2005; Bratzler & Houck, 2005a; Bratzler & Houck, 2005b; Bratzler & Hunt, 2006). International guidelines recommend administration within 60 minutes before incision, or up to 120 minutes for antibiotics with longer infusion times, such as vancomycin or fluoroquinolones (Berríos-Torres et al., 2017). Timing is a crucial determinant of effectiveness, as early or delayed administration can reduce protection. Selection of antibiotics should target the most common pathogens: *Staphylococcus aureus*, coagulase-negative staphylococci, *Escherichia coli*, and other gram-negative bacteria, especially in gastrointestinal surgeries (Anderson et al., 2014). First-generation cephalosporins, such as cefazolin, are widely recommended due to their effectiveness, safety, and relatively narrow spectrum.

Another important consideration in prophylactic antibiotic use is the duration of administration. Current guidelines recommend that prophylactic antibiotics should not be continued beyond 24 hours after surgery in most cases, as prolonged use does not significantly reduce SSI risk and may contribute to antimicrobial resistance and unnecessary healthcare costs (WHO, 2016). However, several studies in hospital settings have shown that prophylactic antibiotics are often administered for extended periods due to concerns about postoperative infection, physician preference, or lack of adherence to standardized protocols. In Indonesia, the implementation of antibiotic prophylaxis guidelines varies across healthcare institutions. Several studies indicate that inappropriate timing, incorrect antibiotic selection, and prolonged postoperative antibiotic administration remain common challenges in surgical practice (Pradipta et al., 2013). These issues highlight the importance of evaluating current clinical practices in individual hospitals to improve antibiotic stewardship and reduce SSI incidence.

2.4. Rationale for Study at Universitas Airlangga Hospital

A tertiary referral hospital that provides comprehensive surgical services, including general surgery procedures. As a teaching hospital affiliated with Universitas Airlangga, RSUA plays an important role in implementing evidence-based clinical practices and improving patient safety outcomes. Evaluating the incidence of surgical site infections and the implementation of prophylactic antibiotic use among general surgery patients at RSUA is therefore important to assess the effectiveness of current infection prevention strategies and identify potential areas for improvement. Hospital-based surveillance of surgical site infections provides valuable epidemiological data that can guide infection control policies and clinical decision-making. Monitoring SSI rates also enables hospitals to benchmark their performance against national and international standards. Furthermore, evaluating compliance with prophylactic antibiotic guidelines can help ensure that patients receive optimal perioperative care while minimizing the risk of antimicrobial resistance. Previous studies have demonstrated that hospitals implementing strict adherence to prophylactic antibiotic guidelines, combined with comprehensive infection prevention strategies such as proper surgical hand preparation, sterile techniques, and perioperative patient optimization, can significantly reduce SSI rates (Allegranzi et al., 2016).

Therefore, continuous monitoring and evaluation of prophylactic antibiotic practices remain essential components of quality improvement in surgical care. Surgical site infection continues to be a major complication in surgical practice, particularly in general surgery procedures. The appropriate implementation of prophylactic antibiotic therapy, including correct timing, selection, and duration of administration, is a key strategy in preventing SSI (Dhole et al., 2023). Evaluating the incidence of surgical site infections and the implementation of prophylactic antibiotic use in hospitals such as Universitas Airlangga Hospital is essential to improve surgical outcomes, strengthen infection control programs, and promote rational antibiotic use in clinical practice.

3. Methods

This study is observational because the samples were not treated, allowing the assessment of real-world clinical practices without intervention. The study design is retrospective, using secondary data, which enables efficient analysis of existing medical records to evaluate patterns of prophylactic antibiotic use and the incidence of surgical site infections (SSI) over a defined period. This approach is appropriate for studying outcomes that have already occurred and minimizes ethical and logistical constraints associated with prospective designs. This research observed subjects undergoing surgical procedures at the general surgery clinic of Airlangga University Hospital from March to June 2025. The study was conducted in the inpatient wards of IRNA 3–6, the general surgery outpatient clinic, the Operating Room (OR) pharmacy depot, and the inpatient pharmacy depot of Airlangga University Hospital. The population of this study was all inpatients who underwent surgical procedures in the general surgery clinic during this period. The sample consisted of all inpatients at Universitas Airlangga Hospital who underwent surgical procedures in the general surgery clinic between March and June 2025 and met the inclusion criteria of being adult patients aged 18 years or older and receiving prophylactic antibiotics. Patients who did not undergo outpatient follow-up within 30 days of hospital discharge were excluded from the study.

The research sample was selected using a non-probability purposive sampling method, including patients who met the inclusion criteria during the period of March–June 2025. Research instruments consisted of inpatient and outpatient medical records from the general surgery clinic at Universitas Airlangga Hospital and Data Collection Sheets (*Lembar Pendataan*/LPD). The study involved collecting inpatient records of all eligible patients and recording demographic data (name, gender, age, admission and discharge dates, diagnosis, clinical and laboratory results), surgical details (preoperative diagnosis, American Society of Anesthesiologists (ASA) score, surgery type and class, urgency, duration, and blood loss), and prophylactic antibiotic information (type, dose, route, timing, and redosing). Outpatient records were also reviewed to document visitation dates and the presence or absence of surgical site infection indications, with all data entered systematically into the collection sheets.

The collected data were processed and analyzed through a series of steps. First, descriptive analysis was performed to summarize patient demographics, including name, gender, age, and MRS and KRS dates. Second, the pattern of prophylactic antibiotic use was described, covering type, dosage regimen, and duration of administration among general surgery outpatients at Universitas Airlangga Hospital from March to June 2025. Third, the appropriateness of antibiotic use was evaluated based on the Antibiotic Use Guidelines. Statistical analysis using the chi-square test was conducted to examine the relationship between the duration of prophylactic antibiotic administration and the incidence of local infections.

4. Results

This study aimed to evaluate the incidence and characteristics of SSI among patients undergoing general surgery. A retrospective observational design was used to analyze patient demographics, types of surgical procedures, and infection outcomes. Understanding these patterns is essential for identifying potential risk factors, improving perioperative management, and guiding effective infection prevention strategies. The following section presents the study results.

Table 1. Characteristics of General Surgery Patients (Continued)

Characteristic	Category / Value	Number of Patients	Percent (%)
Gender	Female	36	41.38
	Male	51	58.62
Age	18 – 25	18	20.69
	26 – 35	16	18.39
	36 – 45	11	12.64
	46 – 55	18	20.69
	56 – 65	15	17.24
	> 65	9	10.34
Temperature	Normal	78	89.66
	Hypothermia (<36°C)	9	10.34
	Hyperthermia (>36°C)	0	0.00
Pulse	Normal	83	95.40
	Tachypnea (>20x/min)	4	4.60
Leukocytes	Normal	20	66.67
	Leukocytosis (>12000/mL)	10	33.33
	Leukopenia (<4000/mL)	0	0.00
Comorbidities	Diabetes	14	16.09
	Other Comorbidities	25	28.74
	No Comorbidities	48	55.17
ASA Score	ASA 1	22	26.51
	ASA 2	49	59.04
	ASA 3	12	14.46
Surgery Class	Clean	50	63.22
	Clean Contamination	35	17.24
	Contamination	2	13.79
Surgery Urgency	Elective	83	95.40
	Emergency	4	4.60
Bleeding	<1500 mL	87	100.00
	>1500 mL	0	0.00
Surgery Duration	<3 hours	87	100.00
	>3 hours	0	0.00
Surgery Procedure	Herniotomy-Hernioplasty	22	25.29
	Tumor Excision (STT, FAM)	36	41.38
	Appendectomy	10	11.49
	Hemorrhoidectomy	7	8.05
	Extirpation	1	1.15
	Debridement	9	10.34
	Amputation	1	1.15
	Fistulectomy	1	1.15
Diagnosis	Soft Tissue Tumor	24	27.59
	Appendicitis	10	11.49
	Hernia	22	25.93
	Hemorrhoid	7	7.41
	Abscess (Mammae, Thorax, Abdomen, Regio Colli)	7	6.17
	Gangrene	1	1.23
	Ganglion Cyst	1	1.23
	Malignant Melanoma	1	1.23
	Mammae Aberans	1	1.23

Characteristic	Category / Value	Number of Patients	Percent (%)
	Lymphadenopathy	1	1.23
	Ulcer (Pedis, Sacrum)	5	6.17
	Condyloma	3	3.70
	Acuminata	3	3.70
	FAM	0	0.00
	Perianal Fistula	1	1.23
LOS	3 days	59	67.82
	>3 days	28	32.18
Total	—	87	100.00

Based on Table 1, the majority of general surgery patients at Universitas Airlangga Hospital from March to June 2025 were male (58.62%), with the highest age groups being 18–25 and 46–55 years (20.69%). Most patients showed no signs of infection, and 55.17% had no comorbidities, while 16.09% had diabetes and 28.74% had other comorbidities. Diabetes was identified as a significant risk factor for SSI due to impaired immune function (Xu et al., 2021; Amirah et al., 2024). ASA scores indicated that most patients were ASA 2 (59.04%), reflecting moderate preoperative health risks (Bhat et al., 2024). Clean surgeries were most common (57.57%), followed by clean-contaminated (40.23%) and contaminated (2.30%). The most frequent indications were soft tissue tumors (27.59%), hernias (25.29%), and appendicitis (11.00%) (Murdiana, 2022). Elective surgeries accounted for 95.40%, with lengths of stay mostly three days, although some patients stayed longer due to clinical conditions. All surgeries lasted less than three hours with blood loss under 1500 mL, so no repeat doses of prophylactic antibiotics were indicated, in accordance with Ministry of Health guidelines (Cheng et al., 2017).

Table 2. Patterns of Prophylactic Antibiotic Use in General Surgery Patients

Characteristic	Category	Total	Percent (%)
Types of Prophylactic Antibiotics	Cefazolin	7	82.76
	Ceftriaxone	7	82.76
	Prophylactic Antibiotic Dosage	15	17.24
	2 gram	87	100.00
Route of Administration of Prophylactic Antibiotics	Intravenous (i.v)	87	100.00
Time of Administration (before incision)	< 30 mins	51	58.62
	30 – 60 mins	31	35.63
	> 60 mins	0	0.00
	After incision	5	5.75
Redosing	Exist	0	0.00
	Not exist	87	100.00
Duration of Administration	< 24 hours	87	100.00
	> 24 hours	0	0.00

Based on Table 2, prophylactic antibiotics were administered for 50 clean surgeries, 35 clean-contaminated surgeries, and 2 contaminated surgeries. According to the Ministry of Health Regulation and UNAIR Hospital guidelines, prophylactic antibiotics are recommended for clean and clean-contaminated procedures, while empirical antibiotics are indicated for contaminated and dirty surgeries. In this study, prophylactic antibiotics were appropriately used in hernia repair (due to mesh placement) and clean-contaminated procedures such as appendectomy, hemorrhoidectomy, and tumor excision with abscess. However, prophylactic antibiotics were administered in some clean surgeries, such as tumor excision and FAM, because of potential long surgery duration or high patient infection risk. In contaminated surgeries, prophylactic antibiotics were sometimes used where empirical therapy would be more appropriate, often due to intraoperative findings differing from preoperative diagnoses, with ceftriaxone continued postoperatively as empirical therapy (Bratzler et al., 2013).

The selection of prophylactic antibiotics considers bacterial sensitivity, narrow spectrum, low toxicity, bactericidal effect, and affordability. Cefazolin, a first-generation cephalosporin, was the most commonly used (82.76%), followed by ceftriaxone (17.24%). Cefazolin is preferred for its effective anti-staphylococcal activity, safety profile, compatibility with anesthetics, moderate half-life (~2 hours), and lower cost compared to ceftriaxone, making it the drug of choice for surgical prophylaxis (Bratzler et al., 2013; Marni et al., 2020). Cephalosporins act as time-dependent antibiotics, inhibiting bacterial cell wall synthesis and preventing infection at the surgical site.

Table 3. Appropriateness of Prophylactic Antibiotic Use in General Surgery Patients

Category	**Conformity Based on Guidelines**			**According to the Guidelines**		**Not According to the Guidelines**	
	PPAB RS	**ASHP**	**Ministry of Health Regulation**				
Types of Prophylactic Antibiotics					(%)		(%)
Cefazolin	✓	✓	✓	72		0	
Ceftriaxone	✗	✗	✗	0		15	
Total				72	82.76	15	17.26
Dose							
2 gram	✓	✓	✓	87		0	
Total				87	100.00		0.00
Route of Administration							
Intravenous (i.v)	✓	✓	✓	87		0	
Total				87	10.00		0.00
Time of Administration							
< 30 mins	✗	✗	✗	0	0.00	51	
30 – 60 mins	✓	✗	✓	31		0	
> 60 mins	✗	✗	✗	0		0	
After incision	✗	✗	✗	-		5	
Total				31	35.63	54	64.37
Duration of Administration							
< 24 hours	✓	✓	✓	87		0	
> 24 hours	✗	✗	✗	0			
Total				87	100.00		0.00

Table 3 shows the use of prophylactic antibiotics in 87 general surgery patients. The most commonly used drug was cefazolin (82.76%), followed by ceftriaxone (17.24%). Cefazolin is preferred due to its higher anti-staphylococcal activity, safety, moderate half-life, and cost-effectiveness, while ceftriaxone has lower activity against staphylococci (Gallagher & MacDougall, 2023). The decision to use ceftriaxone was based on individual clinician preference. Both antibiotics were administered at a 2 g intravenous dose, ensuring adequate tissue levels to reach the Minimum Inhibitory Concentration (MIC), and dose compliance reached 100%

according to the Regulation of the Minister of Health, ASHP, and PPAB UNAIR guidelines.

The recommended timing for prophylactic antibiotics is 30–60 minutes before incision (Bratzler et al., 2013). In this study, only 31 patients (35.63%) received antibiotics within this window, 51 patients received them <30 minutes before incision, and 5 patients received antibiotics after incision, which was common in tumor excision and hernia repair procedures. Mistimed administration can increase the risk of SSI and often results from operating room dynamics, such as delayed support staff, prolonged prior surgeries, or slow patient turnover.

To address timing challenges, control measures like pre-incision sign-in checklists or alarms are recommended. While administration within 30 minutes before incision can reduce infection risk, giving antibiotics too close to or after incision may increase SSI risk (Bratzler et al., 2013; De Jonge et al., 2017; Odah et al., 2023). Drug selection and dose compliance were high, but timing compliance was moderate, highlighting the need for improved perioperative antibiotic stewardship to minimize SSI.

According to the Centers for Disease Control and Prevention in 2025, an SSI is an infection associated with a surgical procedure that occurs near the surgical site within 30 days of surgery or within 90 days if an implant is present. Of the 87 patients, two were suspected of having an SSI. Patients are considered suspected of having an SSI if they meet the following criteria: the presence of pus or pus from the surgical wound, at least one symptom of infection (such as fever, swelling, and redness of the wound), and confirmation of a suspected surgical site infection by the attending physician. In this study, direct observation was conducted by examining the patient's wound during a follow-up visit and then followed up to 30 days postoperatively.

Table 4. Frequency of SSI Occurrence

SSI Occurrence	Total Patients	Percent (%)
SSI*	2	2.30
No SSI	85	97.70

Based on Table 4, the incidence of surgical site infection was 2.30%, indicating that preoperative monitoring and adherence to surgical procedures were generally effective. Common postoperative findings, such as pain and redness around the surgical wound, were noted but did not meet the criteria for suspected SSI. Two patients were identified as having suspected SSI. The first patient was a 51-year-old male with a soft tissue tumor, ASA score 3, grade 2 hypertension, history of CVA, active smoking, and elevated renal function. Surgery was classified as clean, lasted two hours, and involved no massive bleeding. Prophylactic ceftriaxone 2 grams was administered 30–60 minutes before incision, which was considered inappropriate given the typical microbial flora for back tumors. Postoperatively, wound oozing, pus, odor, and fever were observed, requiring wound care, drain removal, and suture closure.

The second patient was a 30-year-old female undergoing appendectomy for acute appendicitis, with an ASA score of 3, with obesity, hyponatremia, and anemia. Surgery was classified as clean-contaminated, lasted 2 hours and 35 minutes, and had no massive hemorrhage. Prophylactic ceftriaxone 2 grams was administered less than 30 minutes before incision. Postoperative complications included redness, pus discharge, and fever (39°C), requiring antibiotic therapy, incision and drainage, debridement, and empiric antibiotics (ceftriaxone and metronidazole). Gradual wound improvement was observed over multiple follow-up visits.

SSI occurs due to an imbalance between the agent, host, and environmental factors (Masriadi & Km, 2017). Host factors contributing to infection included an ASA score of 3, comorbidities such as hypertension and anemia, obesity, and active smoking. High ASA scores indicate severe systemic disorders with limited functional capacity, which can compromise immune response and delay wound healing (Bhat et al., 2024). Smoking negatively affects wound healing through toxic compounds such as nicotine and carbon monoxide, which reduce tissue oxygenation and induce oxidative damage, increasing the risk of SSI. Environmental factors, including surgical duration, type, prophylactic antibiotic use, operating room cleanliness, aseptic technique, and wound care, also contributed to the development of SSI in these cases.

Table 5. Empirical Antibiotic Prescription During Outpatient Care

Antibiotic Prescription During Outpatient Care	Total Patient	Percentage (%)
Yes	11	12.64
No	76	87.36
Total	87	100.00

Table 5 shows that 11 patients received empiric antibiotics in the form of cefixime 200 mg during outpatient checkups, while 76 patients did not receive empiric antibiotics. Of these 11 patients, 1 patient received cefixime 200 mg as prescribed due to signs of infection, such as fever and pus discharge from the surgical wound. The other 10 patients showed no signs of infection but received cefixime 200 mg. The rationale for prescribing cefixime 200 mg to patients without any indication of infection is that the surgical wound has not healed, and the sutures are open. In some patients, the incision site, located in the crease, has a high moisture level, which is a potential risk of infection.

Therefore, empiric antibiotics are administered as a preventative measure to prevent infection in patients. Using empiric antibiotics inappropriately can increase the risk of antibiotic resistance. Patients who do not show signs of infection should not require empiric antibiotics. Patients should receive education on proper wound care and proper nutritional intake (balanced nutrition). One way that patients can prevent infection is by not touching the incision area with their hands, washing their hands before and after treating the wound, using sterile/germ-free wound care tools, cleaning the wound using septic and antiseptic techniques, and after cleaning the incision, covering the wound with a bandage (Alexandra, 2015). Meanwhile, regarding nutritional fulfillment, when the required nutritional status is insufficient, it will affect the wound healing process, increase susceptibility to infection, contribute to an increased incidence of complications, and result in longer/prolonged treatment. Protein is one of the things needed for wound healing and rebuilding various body tissues that experience changes after surgery (Siswandi et al., 2020).

Table 6. Surgical Site Infection by Timing and Regimen of Prophylactic Antibiotics

Time / Regimen of Prophylactic Antibiotics	SSI Yes	SSI Yes (%)	SSI No	SSI No (%)	Total Patients	p-value	R^2
30–60 mins before incision	1	3.23	30	96.77	31	1.000	0.046
Other than 30–60 mins before incision	1	1.79	55	98.21	56	—	—
Total	2	2.30	85	97.70	87	—	—
Single regimen	2	2.50	78	97.50	80	1.000	0.045
Continued >24 hours	0	0.00	7	100.00	7	—	—
Total	2	2.30	85	97.70	87	—	—

Based on the results presented in Table 6, the most common time for prophylactic antibiotic administration was 30–60 minutes before incision, with an SSI incidence of 1.79%. Meanwhile, administration within the guideline timeframe of 30–60 minutes before incision resulted in a slightly higher SSI incidence of 3.23%. Statistical analysis using the Fisher exact test showed no significant association between the timing of prophylactic antibiotic administration and SSI incidence (p = 1.000), and the R value of 0.046 indicates a very low strength of relationship. These findings align with Adzillina et al. (2024), who also found no significant association, but differ from Amelia and Komar (2019), who reported a significant relationship between timing and SSI incidence. Despite the lack of a significant association in this study, PPAB RSUA guidelines and the Indonesian Ministry of Health recommend administering prophylactic antibiotics 30–60 minutes before incision to ensure effective tissue concentrations at the time of incision, inhibiting bacterial growth. Pharmacokinetically, cefazolin reaches peak plasma levels within 5–15 minutes but requires 30–40 minutes to reach optimal concentrations in interstitial, subcutaneous, and muscle tissue. Although administration within 30 minutes is tolerable, it may result in suboptimal tissue levels, supporting the recommendation for 30–60 minutes pre-incision administration.

Regarding the duration of prophylactic antibiotic administration, Table 6 shows that a single regimen was most commonly used, with an SSI incidence of 2.50%, while continued administration for more than 24 hours resulted in no SSI cases. Statistical analysis indicated no significant relationship between the duration of prophylactic antibiotic use and SSI incidence (p = 1.000; R = 0.045), consistent with findings from Adzillina et al. (2024). Prolonged postoperative administration, however, may increase the risk of side effects and contribute to antimicrobial resistance (Akresh et al., 2025). Therefore, administration of prophylactic antibiotics as a single regimen remains the recommended practice.

Table 7. Relationship of Risk Factors to the Incidence of SSI in General Surgery Patients

Variable	Category	SSI Yes	%	SSI No	%	Total	p-value*	R**
Gender	Female	1	2.78	35	97.22	36	1.000	-0.027
	Male	2	1.96	50	98.04	51		
Age (years)	18–25	0	0.00	18	100.00	18	0.573	0.192
	26–35	1	6.25	15	93.75	16		
	36–45	0	0.00	11	100.00	11		
	46–55	1	5.56	17	94.44	18		
	56–65	0	0.00	15	100.00	15		
	>65	0	0.00	9	100.00	9		
Comorbidities	Exist	2	5.13	37	94.87	39	0.198	0.170
	Not Exist	0	0.00	48	100.00	48		
Comorbidities (Type)	Diabetes	0	0.00	14	100.00	14	0.528	-0.174
	Other than Diabetes	2	8.00	23	92.00	25		
ASA Score	ASA 1	0	0.00	22	100.00	22	0.018	0.382
	ASA 2	0	0.00	49	100.00	49		
	ASA 3	2	16.67	10	83.33	12		
Type of Surgery	Clean	1	2.00	49	98.00	50	0.924	0.036
	Clean Contaminated	1	2.86	34	97.14	35		
	Contaminated	0	0.00	2	100.00	2		
Surgery Properties	Elective	2	2.41	81	97.59	83	1.000	0.034
	Emergency	0	0.00	4	100.00	4		
Total		2	2.30	85	97.70	87		

*Note: *Fisher's exact test performed; **Phi and Cramer's V tests performed*

Based on the results presented in Table 7, the study found that the predominant gender was male, with SSI incidence observed in both males (2.78%) and females (1.96%). Statistical analysis using the Fisher exact test showed no significant association between gender and SSI incidence (p=1.000, p>0.05), supported by a very low R value of 0.027, indicating minimal strength of the relationship. This suggests that gender is not a primary factor influencing SSI. Similar findings were reported by Aghdassi et al. (2019) and Caesarridha et al. (2024), who also noted no clear gender-related pattern in SSI incidence.

Age distribution showed that general surgery patients were predominantly aged 18–25 and 46–55, with SSI cases found in patients aged 26–35 (6.25%) and 46–55 (5.56%). No significant relationship was identified between age and SSI incidence (likelihood ratio p=0.573, p>0.05), with a very low R value of 0.192. The small and uneven sample distribution may have contributed to the weak association. Although Awoke et al. (2019) reported that patients over 40 have a 6.45 times higher likelihood of SSI due to comorbidities and declining immunity, this study aligns with Rohana et al. (2024), showing no significant age-related association.

Regarding comorbidities, 48 patients had none, while SSI was observed in 5.13% of patients with comorbidities. No significant association was found (Fisher's exact p=0.198, R=0.170), suggesting that well-managed comorbid conditions may mitigate SSI risk (Haryanto, 2024). In particular, 14 patients had diabetes, yet no SSI cases were observed in this group. SSI occurred in patients with other comorbidities such as obesity, anemia, and hypertension, with no significant association (Fisher's exact p=0.528, R=0.174). Although diabetes can impair immune function and wound healing by Amirah et al. (2024), preoperative management likely controlled the risk, consistent with Rusli et al. (2025).

A significant association was found between ASA score and SSI incidence (p=0.018, R=0.382), with SSI most common in patients with an ASA score of 3 (16.67%). Higher ASA scores indicate compromised preoperative health and immunity, which may hinder infection control, aligning with Bhat et al. (2024). Conversely, surgery type and the nature of operation showed no significant relationships with SSI (likelihood ratio p=0.924, R=0.036; Fisher exact p=1.000, R=0.034). SSI occurred in clean and clean-contaminated surgeries, mainly elective procedures, supporting findings by Nirbita et al. (2017) and Huda et al. (2022), where patient risk factors rather than procedural classification primarily influenced SSI incidence.

5. Discussion

The present study provides insight into patient characteristics, surgical procedures, and SSI incidence among general surgery patients at Airlangga University Hospital between March and June 2025. The majority of patients were male (58.62%), consistent with prior studies indicating male predominance in general surgical cases such as hernia, appendicitis, and soft tissue tumors (Dalbøge et al., 2017; Dianat et al., 2018). Lifestyle factors, occupational exposure, and higher physical activity levels among men may contribute to this pattern. Age distribution showed peaks in the 18–25 and 46–55 years groups, each representing 20.69% of the sample. Younger patients often underwent procedures for appendicitis, trauma, or soft tissue tumors, whereas middle-aged individuals were more frequently treated for hernia or hemorrhoids. The relatively smaller proportion of elderly patients (>65 years) may reflect referral patterns, surgical eligibility, or higher comorbidity prevalence, limiting operative intervention.

Clinical parameters prior to surgery were predominantly within normal limits, with most patients showing normal body temperature (89.66%) and pulse rate (95.40%), while leukocyte counts were normal in 66.67% of cases. These findings indicate limited active infection at the time of surgery and support the appropriate use of prophylactic antibiotics rather than empirical therapy. Prophylactic antibiotics are intended for infection prevention in otherwise stable patients, aligning with standard surgical guidelines (Dhole et al., 2023).

Comorbidities were present in a notable portion of patients, with diabetes mellitus observed in 16.09% and other conditions such as hypertension, tuberculosis, HIV, and asymptomatic bradycardia in 28.74%. While the majority of patients (55.17%) had no comorbidities, those with underlying conditions are at increased risk of postoperative complications, including SSI. Diabetes, in particular, is recognized as a key risk factor due to impaired neutrophil and macrophage function, microvascular compromise, and delayed wound healing (Witsø, 2012; Tjitrawati et al., 2023; Lee et al., 2024). Despite this, no SSI cases were observed among diabetic patients, likely reflecting effective preoperative glycemic control, a finding consistent with Rusli et al. (2025).

ASA classification showed that most patients were ASA 2 (59.04%), followed by ASA 1 (26.51%) and ASA 3 (14.46%). Higher ASA scores indicate more severe systemic disease and reduced physiological reserve, predisposing patients to postoperative complications, including SSI (Horasan et al., 2013; Russ & Kennedy, 2016; Mayhew et al., 2019; Meyer et al., 2021). The presence of ASA 3 patients emphasizes the need for careful perioperative management.

Surgical classification revealed that most procedures were clean (63.22%), followed by clean-contaminated (17.24%) and contaminated (13.79%), reflecting the predominance of hernia repair and tumor excision. Clean-contaminated surgeries, such as appendectomy or hemorrhoidectomy, carried a higher inherent infection risk (Tjandra et al., 2008; Kamel et al., 2013; Sartelli et al., 2018; Soper & Chelmow, 2018; Stefanou et al., 2020; Tjitrawati & Romadhona, 2024; Vierra et al., 2024; Tigora et al., 2025). The predominance of clean surgeries and elective procedures (95.40%) likely contributed to the low SSI incidence observed, as elective operations allow optimal preoperative preparation and prophylactic antibiotic administration (Wilson et al., 1999; Gustafsson et al., 2019; Menz et al., 2021; Wahyudi et al., 2024).

All surgeries were relatively short (<3 hours) with minimal blood loss (<1500 mL), reducing the risk of contamination, tissue trauma, and impaired wound healing. The most common procedures were tumor excision (41.38%), herniotomy/hernioplasty (25.29%), appendectomy (11.49%), and hemorrhoidectomy (8.05%), consistent with leading diagnoses of soft tissue tumors (27.59%), hernia (25.93%), and appendicitis (11%). Most patients had hospital stays of ≤3 days (67.82%), limiting exposure to hospital-acquired infections, although longer stays in some cases may indicate higher comorbidity or recovery complexity. Patient characteristics suggest stable preoperative conditions and low intraoperative risk, contributing to the low SSI incidence. However, the presence of comorbidities and higher ASA scores in some patients highlights the need for careful preoperative assessment and perioperative management to reduce postoperative complications.

6. Conclusion

Based on the analysis of 87 general surgery patients, the incidence of surgical site infections was 2.30%, with one case occurring in clean surgery and one in clean-contaminated surgery. One SSI was superficial, while the other was deep and required re-surgical intervention. Both cases involved prophylactic antibiotics (ceftriaxone, 2 grams) that were not in accordance with standard guidelines. Cefazolin was the most commonly used prophylactic antibiotic (82.76%), and antibiotics were generally administered within 30 minutes before incision (58.62%). While the selection, dose, and route of prophylactic antibiotics largely complied with established guidelines, the timing of administration showed lower adherence, with only 35.63% of patients receiving antibiotics at the recommended time. Duration of administration was fully compliant, as antibiotics were not continued beyond 24 hours after surgery.

These results indicate that although prophylactic antibiotic use is generally appropriate in terms of selection and dosage, improving the timing of administration is crucial to further reduce SSI risk. Adherence to standardized protocols can enhance patient safety and surgical outcomes. Limitations of this study include a relatively small sample size, a single-center design, and a lack of detailed information on patient comorbidities, surgical complexity, or intraoperative factors that may affect SSI risk. Future research is recommended to include larger, multi-center studies to validate these findings, assess interventions to improve guideline adherence, and examine patient- and procedure-specific factors that influence SSI occurrence. Such studies could provide more comprehensive strategies for optimizing prophylactic antibiotic use in surgical practice.

References

Adzillina, E., Sundari, S., & Ijabah, S. M. (2024). Evaluation of Administration Prophylactic Antibiotic against Incidence of Surgical Site Infection in Post Appendectomy at Panembahan Senopati Hospital, Indonesia. *JMMR (Jurnal Medicoeticolegal dan Manajemen Rumah Sakit)*, *13*(1), 1-15.

Aghdassi, S. J. S., Schröder, C., & Gastmeier, P. (2019). Gender-related risk factors for surgical site infections. Results from 10 years of surveillance in Germany. *Antimicrobial Resistance & Infection Control*, *8*(1), 95-106.

Akresh, A. B., Alzeet, D. S., Alshalan, N. Z., Alhawsawi, M. M., Alsaleh, N. A., Binsuwaidan, R. A., ... & Alnajjar, L. I. (2025). The impact of antibiotic prophylaxis appropriateness, duration and associated cost on the rate of surgical site infection at a tertiary hospital in Riyadh, Saudi Arabia: A retrospective study. *Saudi Medical Journal*, *46*(6), 65-76.

Alamrew, K., Tadesse, T. A., Abiye, A. A., & Shibeshi, W. (2019). Surgical antimicrobial prophylaxis and incidence of surgical site infections at Ethiopian tertiary-care teaching hospital. *Infectious Diseases: Research and Treatment*, *12*(1), 117-129.

Alexandra, O. (2015). *Pencegahan infeksi dalam pelayanan keluarga berencana (Manual rujukan berdasarkan pemecahan masalah)*. Jakarta: PKMI.

Allegranzi, B., Bischoff, P., De Jonge, S., Kubilay, N. Z., Zayed, B., Gomes, S. M., ... & Solomkin, J. S. (2016). New WHO recommendations on preoperative measures for surgical site infection prevention: an evidence-based global perspective. The Lancet Infectious Diseases, 16(12), 276-287.

Alsen, M., & Sihombing, R. (2014). Infeksi luka operasi. *Majalah Kedokteran Sriwijaya*, *46*(3), 229-235.

Amelia, K., & Komar, H. (2019). Kajian pola penggunaan antibiotik profilaksis hubunganya dengan angka kejadian infeksi daerah operasi (IDO) pada pasien bedah digestif. *Jurnal Sains Farmasi & Klinis*, *6*(3), 186-190.

Amirah, A., Harahap, J., Willim, H. A., Suroyo, R. B., & Henderson, A. H. (2024). Effect of comorbidities on the incidence of surgical site infection in patients undergoing emergency surgery: a systematic review and meta-analysis. *Journal of Clinical Medicine Research*, *16*(7-8), 345-355.

Anderson, D. J., Podgorny, K., Berríos-Torres, S. I., Bratzler, D. W., Dellinger, E. P., Greene, L., Nyquist, A.-C., Saiman, L., Yokoe, D. S., Maragakis, L. L., & Kaye, K. S. (2014). Strategies to prevent surgical site infections in acute care hospitals: 2014 update. *Infection Control & Hospital Epidemiology*, *35*(2), S66–S88.

Awoke, N., Arba, A., & Girma, A. (2019). Magnitude of surgical site infection and its associated factors among patients who underwent a surgical procedure at Wolaita Sodo University Teaching and Referral Hospital, South Ethiopia. *Plos One*, *14*(12), 226-240.

Berríos-Torres, S. I., Umscheid, C. A., Bratzler, D. W., Leas, B., Stone, E. C., Kelz, R. R., Reinke, C. E., Morgan, S., Solomkin, J. S., Mazuski, J. E., Dellinger, E. P., Itani, K. M. F., Berbari, E. F., Segreti, J., Parvizi, J., Blanchard, J., Allen, G., Kluytmans, J. A. J. W., Donlan, R., & for the Healthcare Infection Control Practices Advisory Committee. (2017). Centers for disease control and prevention guideline for the prevention of surgical site infection, 2017. *JAMA Surgery*, *152*(8), 784–799.

Bhat, R. A., Isaac, N. V., Joy, J., Chandran, D., Jacob, K. J., & Lobo, S. (2024). The effect of American Society of Anesthesiologists score and operative time on surgical site infection rates in major abdominal surgeries. *Cureus*, *16*(2), *9*(5), 76-88.

Boonchan, T., Wilasrusmee, C., McEvoy, M., Attia, J., & Thakkinstian, A. (2017). Network meta-analysis of antibiotic prophylaxis for prevention of surgical-site infection after groin hernia surgery. *British Journal of Surgery*, *104*(2), 106–117.

Bratzler, D. W. (2005). Use of antimicrobial prophylaxis for major surgery: Baseline results from the National Surgical Infection Prevention Project. *Archives of Surgery*, *140*(2), 174-186.

Bratzler, D. W., & Houck, P. M. (2005a). Antimicrobial prophylaxis for surgery: An advisory statement from the National Surgical Infection Prevention Project. *The American Journal of Surgery*, *189*(4), 395–404.

Bratzler, D. W., & Houck, P. M. (2005b). Reply to Chenoweth et al. *Clinical Infectious Diseases*, *41*(1), 123–124.

Bratzler, D. W., & Hunt, D. R. (2006). Healthcare epidemiology: The surgical infection prevention and surgical care improvement projects: National initiatives to improve outcomes for patients having surgery. *Clinical Infectious Diseases*, *43*(3), 322–330.

Bratzler, D. W., Dellinger, E. P., Olsen, K. M., Perl, T. M., Auwaerter, P. G., Bolon, M. K., Fish, D. N., Napolitano, L. M., Sawyer, R. G., Slain, D., Steinberg, J. P., & Weinstein, R. A. (2013). Clinical practice guidelines for antimicrobial prophylaxis in surgery. *American Journal of Health-System Pharmacy*, *70*(3), 195–283.

Caesarridha, D. K., Wintoko, R., Mustofa, S., & Soleha, T. U. (2024). Hubungan usia, jenis kelamin, dan jarak jahitan luka dengan kejadian infeksi luka operasi pada pasien apendisitis perforasi di RSUD Dr. H. Abdul Moeloek Provinsi Lampung tahun 2020-2021. *Medical Profession Journal of Lampung*, *14*(5), 971–978.

Chairani, F., Puspitasari, I., & Asdie, R. H. (2019). Insidensi dan faktor risiko infeksi luka operasi pada bedah obstetri dan ginekologi di rumah sakit. *Jurnal Manajemen Dan Pelayanan Farmasi (Journal of Management and Pharmacy Practice)*, *9*(4), 274–283.

Cheng, H., Chen, B. P.-H., Soleas, I. M., Ferko, N. C., Cameron, C. G., & Hinoul, P. (2017). Prolonged operative duration increases risk of surgical site infections: A systematic review. *Surgical Infections*, *18*(6), 722–735.

Dalbøge, A., Frost, P., Andersen, J. H., & Svendsen, S. W. (2017). Surgery for subacromial impingement syndrome in relation to occupational exposures, lifestyle factors and diabetes mellitus: A nationwide nested case–control study. *Occupational and Environmental Medicine*, *74*(10), 728–736.

De Jonge, S. W., Gans, S. L., Atema, J. J., Solomkin, J. S., Dellinger, P. E., & Boermeester, M. A. (2017). Timing of preoperative antibiotic prophylaxis in 54,552 patients and the risk of surgical site infection: A systematic review and meta-analysis. *Medicine*, *96*(29), 69-83.

Dhole, S., Mahakalkar, C., Kshirsagar, S., & Bhargava, A. (2023). Antibiotic prophylaxis in surgery: Current insights and future directions for surgical site infection prevention. *Cureus*, *15*(10), 931-945.

Dianat, I., Bazazan, A., Souraki Azad, M. A., & Salimi, S. S. (2018). Work-related physical, psychosocial and individual factors associated with musculoskeletal symptoms among surgeons: Implications for ergonomic interventions. *Applied Ergonomics*, *67*(10), 115–124.

Du, Y., Han, S., Zhou, Y., Chen, H. F., Lu, Y. L., Kong, Z. Y., & Li, W. P. (2023). Severe wound infection by MRCNS following bilateral inguinal herniorrhaphy. *BMC Infectious Diseases*, *23*(1), 85-99.

Gallagher, J. C., & MacDougall, C. (2023). *Antibiotics simplified* (5th ed.). London: Jones & Bartlett Learning.

Gustafsson, U. O., Scott, M. J., Hubner, M., Nygren, J., Demartines, N., Francis, N., ... & Ljungqvist, O. (2019). Guidelines for perioperative care in elective colorectal surgery: enhanced recovery after surgery (ERAS®) society recommendations: 2018. *World Journal of Surgery*, *43*(3), 659-695.

Haryanto, E. (2024). Hubungan penyakit penyerta dengan terjadinya infeksi luka operasi pada pasien di ruang bedah dan syaraf RSD Kalisat. Jember: Universitas dr. Soebandi (Doctoral dissertation)

Hendrawan, F., Nugrahningsih, D. A. A., Purnomo, E., & Azdy, N. A. (2024). Risk factor for inappropriate use of prophylactic antibiotics in inguinal hernia repair surgery. *The Medical Journal of Malaysia*, *79*(4), 58-62.

Horan, T. C., Andrus, M., & Dudeck, M. A. (2008). CDC/NHSN surveillance definition of health care–associated infection and criteria for specific types of infections in the acute care setting. *American Journal of Infection Control*, *36*(5), 309–332.

Horasan, E. S., Dağ, A., Ersoz, G., & Kaya, A. (2013). Surgical site infections and mortality in elderly patients. *Médecine et Maladies Infectieuses*, *43*(10), 417–422.

Huda, F., Shasheendran, S., Basu, S., Kumar, N., Rajput, D., Singh, S. K., David, L. E., & Subramanian, C. (2022). Risk factors of surgical site infection in elective laparotomy in a tertiary care center: An observational study. *International Journal of Burns and Trauma*, *12*(3), 106–113.

Iwatani, T., & Saito, S. (2023). Surgical site infections in thyroid and parathyroid surgery in Japan: An analysis of the Japan Nosocomial Infections Surveillance database from 2013 to 2020. *International Wound Journal*, *20*(6), 1874–1881.

Jahangir, F., Haghdoost, A., Moameri, H., & Okhovati, M. (2024). Incidence and risk factors of surgical site infection in abdominal surgeries: A scoping review of cohort and case-control studies. *Iranian Journal of Medical Sciences*, *49*(7), 402-412.

Kamel, C., McGahan, L., Mierzwinski-Urban, M., & Embil, J. (2013). *Preoperative skin antiseptic preparations and application techniques for preventing surgical site infections: A systematic review of the clinical evidence and guidelines*. Canada: Canadian Agency for Drugs and Technologies in Health.

Karaali, C., Emiroğlu, M., Çalık, B., Kebapci, E., Kaya, T., Budak, G. G., ... & Sert, I. (2019). Evaluation of antibiotic prophylaxis and discharge prescriptions in the general surgery department. *Cureus*, *11*(6), 33-43.

Lee, H., Kim, M.-J., Lee, I.-K., Hong, C.-W., & Jeon, J.-H. (2024). Impact of hyperglycemia on immune cell function: A comprehensive review. *Diabetology International*, *15*(4), 745–760.

Lubis, A., Wintoko, R., Ismunandar, H., & Windarti, I. (2024). Surgical site infection. *Medical Profession Journal of Lampung*, *14*(2), 213–217.

Lumbantobing, R., Maulia, S. H., & Novelyn, S. (2022). Overview of evaluation of prophylactic antibiotics in patients with hernia cases at a private hospital in South Tangerang, Indonesia, during the period January 2019–December 2020. *Journal of Complementary and Alternative Medical Research*, *19*(4), 31-42.

Mangram, A. J., Horan, T. C., Pearson, M. L., Silver, L. C., Jarvis, W. R., & The Hospital Infection Control Practices Advisory Committee. (1999). Guideline for prevention of surgical site infection, 1999. *Infection Control & Hospital Epidemiology*, *20*(4), 247–280.

Marni, H., Djanas, D., & Bachtiar, H. (2020). Pengaruh pemberian antibiotik profilaksis sefazolin, seftriakson dan antibiotik seftriakson sebelum dan sesudah operasi terhadap infeksi luka pasca operasi. *Andalas Obstetrics and Gynecology Journal*, *7*(4), 77–86.

Masriadi, H., & Km, S. (2017). *Epidemiologi penyakit menular*. Surabaya: PT. RajaGrafindo Persada-Rajawali Pers.

Mayhew, D., Mendonca, V., & Murthy, B. V. S. (2019). A review of ASA physical status – historical perspectives and modern developments. *Anaesthesia*, *74*(3), 373–379.

Menz, B. D., Charani, E., Gordon, D. L., Leather, A. J., Moonesinghe, S. R., & Phillips, C. J. (2021). Surgical antibiotic prophylaxis in an era of antibiotic resistance: Common resistant bacteria and wider considerations for practice. *Infection and Drug Resistance*, *14*(7), 235–5252.

Meyer, A. C., Eklund, H., Hedström, M., & Modig, K. (2021). The ASA score predicts infections, cardiovascular complications, and hospital readmissions after hip fracture—A nationwide cohort study. *Osteoporosis International*, *32*(11), 2185–2192.

Misganaw, D., Linger, B., & Abesha, A. (2020). Surgical antibiotic prophylaxis use and surgical site infection pattern in Dessie Referral Hospital, Dessie, Northeast of Ethiopia. *BioMed Research International*, *2020*(1), 169-183.

Muhammad, S. D., Faisal, M. S., Shafiq, M. A., & Saeed, M. R. (2023). Incidence of surgical site infection following open hernioplasty and comparison of infection rate among ventral and groin hernia repairs at a THQ hospital Lahore: A single surgeon experience. *JPMA: The Journal of the Pakistan Medical Association*, *73*(6), 1241–1244.

Murdiana, H. E. (2022). Evaluasi penggunaan profilaksis antibiotik bedah umum di rumah sakit pemerintah di Yogyakarta. *Health Sciences and Pharmacy Journal*, *6*(1), 1–9.

Nirbita, A., Rosa, E. M., & Listiowati, E. (2017). Faktor risiko kejadian infeksi daerah operasi pada bedah digestif di rumah sakit swasta. *Jurnal Fakultas Kesehatan Masyarakat*, *11*(2), 93–98.

Odah, A., Alhusban, H., Kaff, A. A., Alkhawaldeh, F., Alwraikat, S., & Alshoufeen, S. (2023). Proper timing for administration of prophylactic intravenous antibiotics for elective surgical procedures. *SAS Journal of Surgery, 9*(4), 309–314.

Olsen, M. A., Nickel, K. B., Fox, I. K., Margenthaler, J. A., Ball, K. E., Mines, D., Wallace, A. E., & Fraser, V. J. (2015). Incidence of surgical site infection following mastectomy with and without immediate reconstruction using private insurer claims data. *Infection Control & Hospital Epidemiology, 36*(8), 907–914.

Palubicka, A., Jaworski, R., Wekwejt, M., Swieczko-Zurek, B., Pikula, M., Jaskiewicz, J., & Zielinski, J. (2019). Surgical site infection after breast surgery: A retrospective analysis of 5-year postoperative data from a single center in Poland. *Medicina, 55*(9), 512-524.

Pradipta, I., Sodik, D., Parwati, I., Lestari, K., Halimah, E., Diantini, A., & Abdulah, R. (2013). Antibiotic resistance in sepsis patients: Evaluation and recommendation of antibiotic use. *North American Journal of Medical Sciences, 5*(6), 344-357.

Pratama, N. Y., Suprapti, B., Ardhiansyah, A. O., & Shinta, D. W. (2019). Analisis penggunaan antibiotik pada pasien rawat inap bedah dengan menggunakan defined daily dose dan drug utilization 90% di Rumah Sakit Universitas Airlangga. *Indonesian Journal of Clinical Pharmacy, 8*(4), 256-278.

Rohana, Q., Amrullah, A. W., Rahardjoputro, R., & Widyastuti, E. Z. (2024). Analisis rasionalitas penggunaan antibiotik profilaksis pada pasien bedah di Rumah Sakit X Surakarta. *JIKES: Jurnal Ilmu Kesehatan, 3*(1), 81–89.

Rusli, S. R., Juhamran, R. P., Jafar, M. A., Gani, A. B., & Hasbi, B. E. (2025). Hubungan antara infeksi daerah operasi (IDO) dan faktor risiko pada pasien pasca operasi di rumah sakit pancaitana kabupaten bone tahun 2023. *Jurnal Ilmiah Manusia dan Kesehatan, 8*(1), 227-240.

Russ, A., & Kennedy, G. D. (2016). Postoperative complications. In *The ASCRS Textbook of Colon and Rectal Surgery* (pp. 121-140). Cham: Springer International Publishing.

Sartelli, M., Guirao, X., Hardcastle, T. C., Kluger, Y., Boermeester, M. A., Raşa, K., ... & Catena, F. (2018). 2018 WSES/SIS-E consensus conference: recommendations for the management of skin and soft-tissue infections. *World Journal of Emergency Surgery, 13*(1), 58-68.

Siswandi, A., Wulandari, M., Erianto, M., & Mawaddah Noviska, A. (2020). Hubungan status gizi dengan proses penyembuhan luka pada pasien post apendektomi. *ARTERI: Jurnal Ilmu Kesehatan, 1*(3), 226–232.

Soper, D. E., & Chelmow, D. (2018). Prevention of infection after gynecologic procedures. *Obstetrics and Gynecology, 131*(6), E172-E189.

Stefanou, A., Worden, A., Kandagatla, P., Reickert, C., & Rubinfeld, I. (2020). Surgical wound misclassification to clean from clean-contaminated in common abdominal operations. *Journal of Surgical Research, 246*(6), 131–138.

Tigora, A., Radu, P. A., Garofil, D. N., Bratucu, M. N., Zurzu, M., Paic, V., ... & Ramboiu, S. (2025). Modern perspectives on inguinal hernia repair: a narrative review on surgical techniques, mesh selection and fixation strategies. *Journal of Clinical Medicine, 14*(14), 48-65.

Tjandra, J., Clunie, G. J., Kaye, A. H., & Smith, J. A. (Eds.). (2008). *Textbook of surgery.* London: John Wiley & Sons.

Tjitrawati, A. T., & Romadhona, M. K. (2024). Living beyond borders: The international legal framework to protecting rights to health of Indonesian illegal migrant workers in Malaysia. *International Journal of Migration, Health and Social Care, 20*(2), 227-45.

Tjitrawati, A. T., Tavip, M., & Romadhona, M. K. (2023). Integrative social-health security for Indonesian migrant workers: Does fully covered and protected? *Malaysian Journal of Medicine and Health Sciences, 19*(12), 67–78.

Uruno, T., Masaki, C., Suzuki, A., Ohkuwa, K., Shibuya, H., Kitagawa, W., Nagahama, M., Sugino, K., & Ito, K. (2015). Antimicrobial prophylaxis for the prevention of surgical site infection after thyroid and parathyroid surgery: A prospective randomized trial. *World Journal of Surgery, 39*(5), 1282–1287.

Vierra, M., Rouhani Ravari, M., Soleymani Sardoo, F., & Shogan, B. D. (2024). Tailored pre-operative antibiotic prophylaxis to prevent post-operative surgical site infections in general surgery. *Antibiotics, 13*(1), 99-110.

Wahyudi, I., Kinasih, S. E., Ida, R., Koesbardiati, T., Romadhona, M. K., & Kim, S. (2024). Biosecurity infectious diseases of the returning Indonesian migrant workers. *Global Security: Health, Science and Policy, 9*(1), 238-247.

WHO. (2016). *Global guidelines for the prevention of surgical site infection.* Retrieved on August, 20, 2025 from https://iris.who.int/bitstream/handle/10665/250680/9789241549882-eng.pdf?sequence=1.

Wilson, J., Woods, I., Fawcett, J., Whall, R., Dibb, W., Morris, C., & McManus, E. (1999). Reducing the risk of major elective surgery: Randomised controlled trial of preoperative optimisation of oxygen delivery. *BMJ, 318*(71), 1099–1103.

Witsø, E. (2012). The role of infection-associated risk factors in prosthetic surgery. *HIP International, 22*(8), 5–8.

Xu, Z., Qu, H., Gong, Z., Kanani, G., Zhang, F., Ren, Y., Shao, S., Chen, X., & Chen, X. (2021). Risk factors for surgical site infection in patients undergoing colorectal surgery: A meta-analysis of observational studies. *Plos One, 16*(10), 259-274.

Acknowledgment

We gratefully acknowledge the contributions of individuals who supported the completion of this article.

Funding Information

This research did not receive any funding.

Conflict of Interest Statement

The authors declare that there is no conflict of interest.

Ethical Approval and Originality Statement

Ethical approval was obtained for this study. The manuscript represents original work and has not been previously published, nor is it under consideration by another journal.

Data Disclosure Statement

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