World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Review Article)

Check for updates

Surgical site infection following clear implant surgery in orthopaedic patient: A retrospective review in a tertiary referral hospital from July 2021– July 2022

Moehamad Galang Prasetya [1, *], Dwikora Novembri Utomo [2], Rosy Setiawati [3] and Paulus Rahardjo [3]

[1] *Medical student, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia.*

[2] *Department of Orthopaedic and Traumatology, Faculty of Medicine, Universitas Airlangga – Dr. Soetomo General Academic Hospital, Surabaya, Indonesia.*

[3] *Department of Radiology, Faculty of Medicine, Universitas Airlangga – Dr. Soetomo General Academic Hospital, Surabaya, Indonesia.*

World Journal of Advanced Research and Reviews, 2025, 26(03), 1341-1350

Publication history: Received on 04 May 2025; revised on 11 June 2025; accepted on 13 June 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.26.3.2324

Abstract

Background: Surgical Site Infection (SSI) is among the most common healthcare-associated infections worldwide. Both patient-related and surgical factors contribute to its incidence. Prevention and management of SSI require a multidisciplinary, comprehensive approach, supported by accurate epidemiological data to enhance healthcare quality and patient outcomes.

Methods: This study was retrospective descriptive design. Data were obtained using total sampling from medical records of all patients with SSI post clean surgery with Implant in the Department of Orthopaedic and Traumatology at Dr. Soetomo Hospital from July 2021 to July 2022.

Results: This study showed that SSI occurred in 47 patients. Most patients with SSI were male (61.70%) and elderly (51.06%). Obesity (Obesity I and II) was the most common Body Mass Index (BMI) category (46.81%). Anemia was the most prevalent comorbidity (36.17%). American Society of Anesthesiologists (ASA) score II was most frequently found (65.96%). Most patients had no postoperative complications (93.61%). Prophylactic antibiotics were consistently administered using cefazolin. Elective procedures were the predominant surgery type (85.11%). The duration of surgery exceeding four hours was common (55.32%).

Conclusion: This study concluded that SSI most frequently occurred in elderly male patients. The majority of SSI were associated with elective surgical procedures. These findings highlight the need for targeted preventive strategies.

Keywords: Orthopaedic Surgical Site Infections; Clean implant surgery; Postoperative infection surveillance; Healthcare Associated Infections (HAIs)

1. Introduction

Surgical Site Infection (SSI) is a type of Healthcare-Associated Infection (HAI) that occurs as a consequence of surgical procedures, potentially involving various layers of bodily tissue [1]. In Indonesia, the prevalence of SSI is estimated to range between 2.3% and 18.3%, making it the most common type of nosocomial infection, accounting for approximately 38% of all HAIs [2]. According to the World Health Organization (WHO), the global incidence of SSI ranges from 5% to 15%, indicating that SSI is the third most common hospital-acquired infection, affecting approximately 14–16% of hospitalized patients [3].

* Corresponding author: Moehamad Galang Prasetya

A study by Dani et al. [4] reported that out of 116 patient cases, 9 patients (7.75%) developed SSI, comprising 4 cases of superficial SSI and 5 cases of deep SSI. In the United States, the morbidity associated with SSI in 2018 was reported to be 157,500 cases, with an estimated 8,205 deaths. Notably, 11% of all deaths in intensive care units (ICUs) were related to SSI [5].

The occurrence of SSI can be influe3nced by both surgical factors and patient-related factors. Surgical factors are categorized into preoperative, intraoperative, and postoperative phases. Preoperative factors include: healthcare worker hand hygiene, preoperative diagnosis, trepanation, prophylactic antibiotic administration, skin preparation, aseptic and antiseptic measures, nature of the surgery, and instrument sterilization. Intraoperative factors consist of: hand hygiene, operating room environment, surgical procedures, anesthesia procedures, duration of surgery, presence of implants, type of surgery, surgeon/operator, and microbial resistance and translocation. Postoperative factors include: hand hygiene, ward environment, nutritional status, postoperative care and treatment, and wound management [6].

A study conducted in Brazil reported a significant association between the presence of implants in orthopedic surgeries and an increased risk of SSI ($p = 0.02$) [7]. In addition to surgical factors, patient-related factors also contribute to the risk of SSI. These include: age, BMI, nutritional status, presence of trauma, duration of preoperative hospitalization, therapies or conditions causing immunosuppression, presence of infection at other sites, history of antibiotic use, comorbidities, nutritional status, and ASA physical status classification [6].

The incidence of SSI has significant impacts on both patients and healthcare facilities. These impacts include: increased morbidity and mortality, prolonged hospital stays, higher healthcare costs, and a decline in hospital service quality [3]. Based on The Indonesian Ministry of Health in Guidelines for Infection Prevention and Control in Healthcare Facilities, SSI must be minimized as much as possible in order to enhance patient safety within healthcare services. Efforts in infection prevention and control, including those targeting SSI, must be an integral part of medical service standards. Risk factors, both patient-related and surgery-related, are important indicators that can be utilized to prevent the occurrence of SSI. By identifying the influential risk factors associated with SSI, this information can serve as a valuable reference for both clinical decision-making and managerial policy development aimed at reducing Healthcare-Associated Infections (HAIs), particularly SSI [8].

Although numerous studies have investigated SSI, there has been no prior research focusing on the risk factor profile for SSI following clean surgeries with implants within the Department of Orthopaedic and Traumatology at Dr. Soetomo Hospital from July 2021 to July 2022. Therefore, this study aims to examine the profile of SSI risk factors in patients undergoing clean surgeries with implants in the Department of Orthopaedic and Traumatology at Dr. Soetomo Hospital, to serve as a reference for the prevention and control of SSI.

2. Material and methods

2.1. Study Design

This study employed a restrospective observational with descriptive design.

2.2. Data Source and Patient Selection

Medical records data from the period of July 2021 to July 2022 were reviewed. The data were collected using a total sampling method and subsequently filtered based on inclusion and exclusion criteria. A total of 47 patients were identified as meeting the study criteria.

2.3. Inclusion and Exclusion Criteria

The following criteria were used to determine the eligibility of patient records for inclusion in this study:

2.3.1. Inclusion Criteria

- Patient diagnosed with SSI post clean surgery with implant at the Orthopaedic and Traumatology Department at the Dr. Soetomo Hospital from July 2021 to July 2022.

2.3.2. Exclusion Criteria

- Incomplete medical records based on the study variables.
- Patients with a postoperative period exceeding 90 days.

2.4. Data Collection

Data were collected retrospectively by reviewing the medical records of patients diagnosed with SSI post clean surgery with implant in the Department of Orthopaedic and Traumatology at Dr. Soetomo Hospital from July 2021 to July 2022. Researchers extracted relevant information based on the study variables: gender, age, BMI, comorbidities, ASA score, prophylactic antibiotics, surgery type (emergency/elective), duration of surgery, and complications.

2.5. Data Analysis and Presentation

The collected data were analysed using Microsoft Excel software. The findings of the analysis were presented in tabular format to illustrate the distribution of the observed variables within the study population

3. Results

Table 1 Distribution of patients based on patient's risk factor

No	Patient's Characteristics	Frequency (n)	Percentage (%)
1	Gender		
	Male	29	61.70
	Female	18	38.30
2	Age		
	Infants and Toddlers (< 5 years)	0	0
	Children (5-9 years)	2	4.26
	Adolescents (10-18 years)	12	25.53
	Adults (19-59 years)	9	19.15
	Elderly (≥ 60 years)	24	51.06
3	BMI		
	Underweight	3	6.38
	Normal	17	36.17
	Overweight	5	10.64
	Obesity I	16	34.04
	Obesity II	6	12.77
4	Comorbidities		
	No comorbidities	15	31.91
	Anemia	17	36.17
	Diabetes Mellitus	6	12.76
	Hypertension	4	8.51
	Ca mammae	1	2.13
	Chronic Hepatitis B	1	2.13
	Bilateral pneumonia	1	2.13
	Pleural effusion	1	2.13

	Pneumonitis	1	2.13
5	ASA score		
	ASA I	7	14.89
	ASA II	31	65.96
	ASA III	8	17.02
	ASA IV	1	2.13
	ASA V	0	0
6	Complication		
	No complications	44	93.61
	Cellulitis	2	4.26
	Osteomyelitis	1	2.13

Table 1 shows the majority of patients were male, accounting for 29 patients (61.70%). Most patients were elderly with 24 patients (51.06%). Adolescents represented the second largest age group, with 12 patients (25.53%). The most common BMI category was normal weight, observed in 17 patients (36.17%), but overall, the highest number of IDO patients had an obese BMI (combined obesity class I and II), totaling 22 patients (46.81%). In this study, anemia was observed in 17 patients (36.17%). Diabetes mellitus was present in 6 (12.76%) patients, while hypertension was found in 4 patients (8.51%). The most frequent ASA score was ASA II, identified in 31 patients (65.96%), followed by ASA III in 8 patients (17.07%) and ASA I in 7 patients (14.89%). The least common ASA score was ASA IV, found in 1 patient (2.13%). The majority of patients experienced no complications, accounting for 44 patients (93.61%), while complications included cellulitis in 2 patients (4.27%) and osteomyelitis in 1 patient (2.12%).

Table 2 Distribution of patients based on risk factor of surgery

No	Characteristics of surgery	Frequency (n)	Percentage (%)
1	Prophylactic antibiotics		
	Cefazolin	47	100
	Other	0	0
2	Surgery type		
	Emergency	7	14.89
	Elective	40	85.11
3	Duration of surgery		
	< 2 hours	2	4.26
	2 – 4 hours	19	40.43
	> 4 hours	26	55.32

Table 2 presents that all patients received the same prophylactic antibiotic, cefazolin. The most common type of surgery was elective, performed in 40 patients (85.11%), followed by emergency surgeries in 7 patients (14.89%). In this study, the most frequently observed surgical duration was more than 4 hours, recorded in 26 patients (55.32%), followed by durations of 2–4 hours in 19 patients (40.43%). The least common surgical duration was less than 2 hours, found in 2 patients (4.26%).

4. Discussion

4.1. Gender

This study shows that among patients with Surgical Site Infections (SSI) following clean surgeries with implants in the Department of Orthopaedic and Traumatology at Dr. Soetomo General Hospital from July 2021 to July 2022, the majority were male, accounting for 29 patients (61.70%). A similar finding was reported by Omer et al. [9] who noted that male sex is a significant risk factor for SSI. Their study identified male gender as a major demographic factor associated with a higher incidence of SSI compared to females. According to Aghdassi et al. among 1,266,782 patients, 18,824 developed SSI, with a higher proportion of male patients affected in orthopedic and trauma procedures. However, some studies have reported differing results; for example, research by Langelot et al. [10] found no significant difference in SSI incidence between male and female patients undergoing orthopedic surgery.

Estrogen has a significant healing effect in the wound healing process, including the prevention of SSI. This hormone plays a role in enhancing the immune response, accelerating angiogenesis (the formation of new blood vessels), and reducing inflammation at the wound site [11]. Estrogen also promotes collagen production, which is essential for tissue regeneration. Females, who generally have higher levels of estrogen compared to males, tend to experience faster wound healing and a lower risk of infection [11].

The difference in chromosomes between males and females can influence individual susceptibility to disease. In the mechanism of X-chromosome inactivation (XCI), certain genes on the X chromosome can escape inactivation and remain active, contributing to gene expression. This can result in higher levels of gene expression in females compared to males. The differential expression of genes that escape XCI may contribute to sex-based differences in disease susceptibility and severity. A stronger immune response observed in females also provides an advantage in combating infections [12].

4.2. Age

The results of this study concluded that the most common patient group was the elderly. This finding is consistent with the study by Bischoff P. et al. [13] which reported that the highest incidence of SSI occurred in elderly patients aged 76–80 years. In that study, surgical data from 2009 to 2018 documented in Germany's national surveillance system showed that out of 418,312 Total Hip Replacement (THR) procedures, 3,231 patients developed SSI, and out of 286,074 Total Knee Replacement (TKR) procedures, 1,288 patients developed SSI. Dangsri et al. [14] found that the highest incidence of SSI occurred in the 70–79 age group, followed by the 60–69 age group.

The decline in immune function due to aging, known as immunosenescence, affects both the innate and adaptive immune systems, leading to a reduced ability to respond to and fight infections. This process also contributes to the development of a chronic, low-grade inflammatory state known as inflammaging, which impairs the body's ability to cope with various stressors. Inflammaging is characterized by increased levels of pro-inflammatory cytokines such as interleukin (IL)-1, IL-6, and tumor necrosis factor (TNF)-α, and decreased levels of anti-inflammatory cytokines such as IL-10 and transforming growth factor-β (TGF-β) [15]. Elevated levels of inflammaging-associated biomarkers (IFA) detected in the cerebrospinal fluid (CSF) of patients with Multiple Sclerosis (MS) indicate suboptimal inflammation, with these increases associated with advancing disease stages and older age [16]. Additionally, postmenopausal women are more susceptible to infections due to decreased estrogen levels, as estrogen plays a role in tissue regeneration [11].

4.3. Body Mass Index

Based on the results of this study, patients with an obese BMI (obesity class I and II) accounted for the highest number of SSI, totaling 22 patients (46.81%). A similar finding was reported by Dangsri et al. [14], who found that the majority of SSI cases occurred in the obese BMI category, with 21 patients affected (13 classified as obesity class I and 8 as obesity class II). Patients with obesity class II (BMI ≥ 30.0 kg/m^2) were found to have a 5.72 times higher risk of developing SSI. Research by Meijs et al. [17] showed among 387,919 patients analyzed by BMI, 154,339 (40%) were overweight, 104,288 (27%) had obesity class I, and 8,838 (2%) had obesity class II. The study demonstrated a clear trend of increasing SSI risk as BMI increased from normal to obesity class II, with the highest risk observed in surgeries involving clean wounds.

Obesity is considered a risk factor that can increase the likelihood of SSI both directly and indirectly by affecting the immune system and the body's inflammatory response [18]. Obesity also contributes to immune dysfunction. Adipose tissue produces cytokines, leptin, and adiponectin, which are essential for immune regulation. In individuals with obesity, both innate and adaptive immune responses are impaired [14]. Excessive expansion of adipose tissue in obese individuals leads to metabolic stress and local hypoxia, triggering the infiltration of immune cells—primarily macrophages—into the adipose tissue. This process results in the secretion of pro-inflammatory cytokines such as TNF-α, IL-6, and MCP-1. These cytokines create a chronically inflamed environment known as low-grade chronic inflammation or metaflammation. This state of inflammation not only contributes to metabolic dysfunction but also weakens the immune response against external pathogens, thereby increasing susceptibility to infections [19].

4.4. Comorbidities

This study data showed that anemia was the most common comorbidity among patients. Findings from Amirah et al. [20] reported a significant association between the occurrence of SSI and several factors, including blood transfusion, anemia, history of previous surgeries, and operative duration longer than 14 days.

Immune dysfunction is a significant consequence of anemia, particularly iron deficiency anemia, which can increase susceptibility to infections. Iron deficiency can impair the proliferation and activity of immune cells, including T cells and phagocytes, which are essential in combating infections [21]. Anemia also affects cytokine production; lower levels of interleukin-6 (IL-6) have been observed in patients with iron deficiency anemia. Such alterations in cytokine levels may disrupt immune signaling pathways critical for mounting an effective immune response [22]. Furthermore, anemia can lead to chronic inflammation, known as Anemia of Chronic Disease (ACD). Inflammation associated with anemia may elevate hepcidin levels—a hormone that regulates iron homeostasis—thereby inhibiting iron absorption and release from storage. This creates a vicious cycle that exacerbates inflammation and further weakens the body's immune response [23].

The results of this study also revealed the presence of diabetes mellitus and hypertension as comorbidities among patients. This is consistent with findings from Gundel et al. [24] who reported that among 335 patients with SSI, the most common comorbidities were smoking (36.1%), hypertension (30.8%), cardiovascular disease (17.4%), diabetes mellitus (9.3%), and pulmonary disease (8.1%). Comorbidities were found to significantly increase the risk of SSI. The study also indicated that diabetes mellitus, obesity, and liver disease are associated with a higher risk of developing SSI [20].

Diabetes mellitus significantly impairs the immune system, leading to increased susceptibility to infections. This impairment is largely due to hyperglycemia, which negatively affects the function of neutrophils and macrophages. In diabetic patients, there is a reduction in chemotaxis, phagocytosis, and bacterial killing capacity [25]. Furthermore, CD4+ and CD8+ T cells in individuals with diabetes mellitus exhibit reduced cytokine production (IFN-γ, IL-2) and diminished cytotoxic activity against pathogens, indicating that the adaptive immune response is also compromised [26]. Chronic inflammation is another characteristic feature in diabetic patients. Excess visceral fat contributes to the production of pro-inflammatory cytokines such as TNF-α and IL-6. These cytokines promote a state of chronic inflammation that disrupts insulin signaling pathways, leading to insulin resistance. Additionally, this inflammatory process contributes to endothelial dysfunction, increasing the risk of atherosclerosis and cardiovascular disease [27].

In individuals with hypertension, the body experiences a state of low-grade chronic inflammation. This condition can lead to the activation of immune cells such as macrophages and T cells. The activation of these cells results in the release of pro-inflammatory cytokines, including IL-6 and TNF-α, which can impair the body's immune response [28].

4.5. ASA Score

Based on the results of this study, the most common ASA score among patients was ASA II. This finding is consistent with the study by Bhat et al. [29] which showed that patients with ASA II and ASA III scores had similar percentages of SSI. This may be due to other contributing factors to SSI that are not fully captured by the ASA classification system. However, other studies have reported that patients with ASA IV scores had a higher percentage of SSI, followed by ASA I, ASA III, and ASA II [14]. Other result, a study by Legesse et al. [30] found that ASA score did not have a statistically significant association with the incidence of SSI.

The ASA classification system categorizes patients based on the severity of their systemic disease. Higher ASA scores (e.g., ASA III or IV) indicate more severe systemic illness or comorbidities, such as poorly controlled diabetes, chronic kidney disease, or cardiovascular conditions. Patients with higher ASA score often exhibit impaired immune function and reduced tissue regeneration due to their underlying conditions, making them more vulnerable to infections, including SSI [31].

4.6. Complication

Surgical site infections (SSI) following implant placement can progress to osteomyelitis due to the ability of bacteria to form biofilms on implant surfaces, rendering them more resistant to systemic antibiotics. This adhesion facilitates bacterial attachment to bone and abscess formation, which may hinder healing and exacerbate the infection [34]. Bacteria such as Staphylococcus aureus can adhere to bone by expressing adhesin receptors that bind to collagen, allowing attachment to cartilage, while fibronectin-binding adhesins enable attachment to both bone and implant materials [35]. Preventive measures include aseptic surgical techniques, proper sterilization of instruments, prophylactic antibiotic administration, and managing patient risk factors such as blood glucose control. By reducing the incidence of SSI, the risk of complications such as osteomyelitis can be minimized [34].

Cellulitis occurs when bacteria penetrate the skin and trigger an immune response. The immune system responds by releasing cytokines and neutrophils, leading to redness, swelling, warmth, and tenderness in the affected area. The released cytokines and neutrophils induce an epidermal response, which includes the production of antimicrobial peptides and keratinocyte proliferation. Cellulitis can lead to several complications; if the bacterial infection reaches the bloodstream, it may result in bacteremia [36].

4.7. Prophylactic Antibiotics

Based on results of this study, it was found that all patients received the same prophylactic antibiotic, cefazolin, at a dose of 2 grams administered intravenously via drip 30–60 minutes before incision over a period of 15 minutes. This approach aligns with current guidelines and represents the first-line recommendation for prophylactic antibiotic administration to prevent SSI [37]. The use of cefazolin as prophylactic antibiotic prior to surgery was associated with a lower incidence of SSI compared to clindamycin and/or vancomycin [38]. However, a study by Marni et al. [39] involving 30 surgical procedures found no significant difference in the incidence of SSI between patients receiving cefazolin and those receiving ceftriaxone. Both groups did not develop SSI. The administration of prophylactic antibiotics is one of the preventive measures against SSI. However, it does not entirely eliminate the possibility of patients developing SSI despite receiving prophylactic antibiotics [37].

4.8. Surgery Type

The results of this study indicate that SSI occurred more frequently in patients undergoing elective surgeries compared to emergency surgeries. This finding is consistent with the study by Dangsri et al. [14] which reported a higher incidence of SSI in elective procedures. In a study involving 300 patients, 36 developed SSI, with 20 cases following elective surgeries and 16 following emergency procedures. Similarly, the study by Duran et al. [40] found that SSI were more prevalent among patients undergoing elective operations (41 cases) than emergency operations (23 cases). Study by Legesse et al. [30] involving 105 patients reported 20 SSI cases, with 14 following elective surgeries and 6 following emergency surgeries. These findings collectively suggest that SSI are more commonly associated with elective surgical procedures.

Different results were found in a study which out of 42 patients who developed SSI, 24 cases occurred in emergency surgeries, while 18 were associated with elective procedures [29]. Furthermore, Aghdassi et al. [10] reported that emergency surgical procedures significantly increased the risk of SSI. Study by Farid et al. [41] demonstrated a significant association between emergency surgeries and the occurrence of SSI.

Elective surgeries often require longer operative durations, which has been shown to significantly impact patient outcomes. A comprehensive meta-analysis published in the Journal of Surgical Research demonstrated that prolonged operative time during elective procedures is robustly associated with an increased risk of postoperative complications, including infections. These findings were consistent across various surgical specialties and were statistically significant in both retrospective and prospective cohort studies. Therefore, managing and minimizing the duration of elective surgeries, when feasible, is crucial for reducing postoperative morbidity and improving overall surgical outcomes [42].

4.9. Duration of Surgery

The study results indicated that the longest surgery duration (> 4 hours) was associated with the highest number of patients experiencing SSI. This finding aligns with Cheng et al. [43] who analyzed 12 observational studies in orthopedic surgeries and reported an average surgery duration of 2.5 hours. An increase in surgery duration beyond the average significantly raises the risk of SSI ($p = 0.0003$). Similarly, Papadopoulos et al. [44] found that surgery lasting more than 90 minutes significantly increased the incidence of SSI ($p < 0.0001$). Additionally, Bhat et al. [29] reported a significant association between surgery duration and SSI risk, averaging 206.33 minutes ($p = 0.001$).

Prolonged surgery duration exposes the patient's surgical incision to the environment for an extended period, thereby increasing the risk of bacterial contamination. Additionally, prolonged exposure causes tissue desiccation at the incision site, further raising the likelihood of contamination [43]. Surgery duration serves as an independent risk factor for SSI and is potentially modifiable. Factors such as preoperative planning, surgical expertise, operating room staff experience, and equipment availability can influence the length of surgery [29].

5. Conclusion

Based on this study that has been carried out, regarding the description of the characteristics of SSI post clean surgery with implant patients at the orthopaedic and traumatology outpatient clinic at Dr. Soetomo Hospital from July 2021 to July 2022, several conclusions were obtained from this study. The majority of patients were male. The most common age group was the elderly. Most patients had a BMI in the obese category. The most frequent comorbidity was anemia. The most common ASA score was ASA II. Most patients did not experience any complications. All patients received the same prophylactic antibiotic, cefazolin. Most surgeries were elective, and the majority had a duration of more than 4 hours. Given that the risk factors for SSI originate from both patient-related conditions and surgical procedures, the findings of this study may serve as a valuable reference for the development and implementation of effective SSI prevention measures.

Compliance with ethical standards

Acknowledgments

The authors would like to thank Dr. Soetomo Hospital for allowing us to conduct this study.

Disclosure of conflict of interest

The authors declare no conflicts of interest.

Statement of ethical approval

Ethical approval was received from Ethics Committee of Dr. Soetomo Hospital (Approval No. 1994/123/4/II/2023).

References

[1] Centers for Disease Control and Prevention. 9 Surgical Site Infection (SSI) Event [Internet]. Atlanta, GA: Centers for Disease Control and Prevention; 2023 [cited 2025 Jan 11]. Available from: https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf.

[2] Retnawati Y, Sukesi N, Hadi C. Nurse compliance in implementing SSI bundles and surgical site infection incidence. Nursing Journal. 2024;16(3):1145-56.

[3] Setianingsih S, Zukhri S, Indriani N. Factors influencing the incidence of surgical site infection in post-cesarean section patients. In: University Research Colloquium; 2020. p. 419–30.

[4] Dani MA, Yusuf M, Pranadyan R, Prasetyo B. Causes of post-cesarean surgical site infection at South Konawe Hospital, Southeast Sulawesi, Indonesia, February–July 2017. Indonesian Journal of Obstetrics and Gynecology. 2018;26(3):118–22.

[5] Zabaglo M, Sharman T. Postoperative wound infection. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan– [updated 2022 Sep 19; cited 2022 Dec 27]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK560533/.

[6] Nirbita A, Rosa EM, Listiowati E. Risk factors for surgical site infection in digestive surgery at a private hospital. Journal of the Faculty of Public Health. 2017;11(2):93–8.

[7] Ercole FF, Franco LM, Macieira TG, Wenceslau LC, Resende HI, Chianca TC. Risk of surgical site infection in patients undergoing orthopedic surgery. Latin American Journal of Nursing. 2011;19(6):1362–8.

[8] Indonesian Ministry of Health. Regulation of the Minister of Health Number 27 of 2017 concerning Guidelines for the Prevention and Control of Infections in Health Care Facilities [Internet]. Jakarta: Ministry of Health, Republic of Indonesia; 2017 [cited 2022 Dec 27]. Available from: https://peraturan.bpk.go.id/Details/112075/permenkes-no-27-tahun-2017.

[9] Omer AM, Anees A, Malik EM. Assessment of risk factors associated with surgical site infection following abdominal surgery: a systematic review. BMJ Surgery, Interventions, and Health Technologies. 2023;5(1):e000182.

[10] Aghdassi SJS, Schröder C, Gastmeier P. Gender-related risk factors for surgical site infections. Results from 10 years of surveillance in Germany. Antimicrobial Resistance and Infection Control. 2019;8:95.

[11] Horng HC, Chang WH, Yeh CC, Huang BS, Chang CP, Chen YJ, Tsui KH, Wang PH. Estrogen effects on wound healing. International Journal of Molecular Sciences. 2017;18(11):2325.

[12] Youness A, Miquel CH, Guéry JC. Escape from X chromosome inactivation and the female predominance in autoimmune diseases. International Journal of Molecular Sciences. 2021;22(3):1114.

[13] Bischoff P, Kramer TS, Schröder C, Behnke M, Schwab F, Geffers C, Gastmeier P, Aghdassi SJS. Age as a risk factor for surgical site infections: German surveillance data on total hip replacement and total knee replacement procedures 2009 to 2018. Euro Surveillance. 2023;28(9):2200535.

[14] Dangsri P, Monkong S, Roopsawang I. Factors predicting surgical site infection in older adults undergoing abdominal surgery: a retrospective cohort study. Pacific Rim International Journal of Nursing Research. 2024;28(3):537-51.

[15] Quiros-Roldan E, Sottini A, Natali PG, Imberti L. The impact of immune system aging on infectious diseases. Microorganisms 2024;12(4):775.

[16] Bolton C. An evaluation of the recognised systemic inflammatory biomarkers of chronic sub-optimal inflammation provides evidence for inflammageing (IFA) during multiple sclerosis (MS). Immunity and Ageing. 2021;18(1):18.

[17] Meijs AP, Koek MBG, Vos MC, Geerlings SE, Vogely HC, Greeff SC. The effect of body mass index on the risk of surgical site infection. Infection Control and Hospital Epidemiology. 2019;40(9):991-6.

[18] Shimi G, Sohouli MH, Ghorbani A, Shakery A, Zand H. The interplay between obesity, immunosenescence, and insulin resistance. Immunity and Ageing. 2024;21(1):13.

[19] Savulescu-Fiedler I, Mihalcea R, Dragosloveanu S, Scheau C, Baz RO, Caruntu A, Scheau AE, Caruntu C, Benea SN. The interplay between obesity and inflammation. Life. 2024;14(7):856.

[20] Amirah A, Harahap J, Willim HA, Suroyo RB, Henderson AH. 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. 2024;16(7-8):345-54.

[21] Abuga KM, Rockett KA, Muriuki JM, Koch O, Nairz M, Sirugo G, Bejon P, Kwiatkowski DP, Prentice AM, Atkinson SH. Interferon-gamma polymorphisms and risk of iron deficiency and anaemia in Gambian children. Wellcome Open Research. 2020;5:40.

[22] Hassan TH, Badr MA, Karam NA, Zkaria M, El Saadany HF, Abdel Rahman DM, Shahbah DA, Al Morshedy SM, Fathy M, Esh AMH, Selim AM. Impact of iron deficiency anemia on the function of the immune system in children. Medicine. 2016;95(47):e5395.

[23] Weiss G, Ganz T, Goodnough LT. Anemia of inflammation. Blood. 2019;133(1):40-50.

[24] Gundel O, Gundersen SK, Dahl RM, Jørgensen LN, Rasmussen LS, Wetterslev J, Meyhoff CS. Timing of surgical site infection and pulmonary complications after laparotomy. International Journal of Surgery. 2018;52:56-60.

[25] Berbudi A, Rahmadika N, Tjahjadi AI, Ruslami R. Type 2 diabetes and its impact on the immune system. Current Diabetes Reviews. 2020;16(5):442-9.

[26] Daryabor G, Atashzar MR, Kabelitz D, Meri S, Kalantar K. The effects of type 2 diabetes mellitus on organ metabolism and the immune system. Frontiers in Immunology. 2020;11:1582.

[27] Tsalamandris S, Antonopoulos AS, Oikonomou E, Papamikroulis GA, Vogiatzi G, Papaioannou S, Deftereos S, Tousoulis D. The role of inflammation in diabetes: current concepts and future perspectives. European Cardiology. 2019;14(1):50-9.

[28] Harrison DG, Patrick DM. Immune mechanisms in hypertension. Hypertension. 2024;81(8):1659-74.

[29] Bhat RA, Isaac NV, Joy J, Chandran D, Jacob KJ, Lobo S. The effect of American Society of Anesthesiologists score and operative time on surgical site infection rates in major abdominal surgeries. Cureus. 2024;16(2):e55138.

[30] Legesse Laloto T, Hiko Gemeda D, Abdella SH. Incidence and predictors of surgical site infection in Ethiopia: prospective cohort. BMC Infectious Diseases. 2017;17(1):119.

[31] American Society of Anesthesiologists (ASA). Statement on ASA Physical Status Classification System [Internet]. Schaumburg, IL: American Society of Anesthesiologists; 2020 [cited 2025 Jan 11]. Available from: https://www.asahq.org/standards-and-practice-parameters/statement-on-asa-physical-status-classification-system.

[32] Frank FA, Pomeroy E, Hotchen AJ, Stubbs D, Ferguson JY, McNally M. Clinical outcome following management of severe osteomyelitis due to pin site infection. Strategies Trauma Limb Reconstr. 2024;19(1):21-25. https://doi.org/10.5005/jp-journals-10080-1607.

[33] Cousin AS, Bouletreau P, Giai J, et al. Severity and long-term complications of surgical site infections after orthognathic surgery: a retrospective study. Scientific Reports. 2020;10(1):12015.

[34] Urish KL, Cassat JE. Staphylococcus aureus osteomyelitis: Bone, bugs, and surgery. Infection and Immunity. 2020;88(3):e00932-19.

[35] Momodu II, Savaliya V. Osteomyelitis [Internet]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; [updated 2023 May 31; cited 2025 Jan 11]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK532250/.

[36] Brown BD, Hood Watson KL. Cellulitis [Internet]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; [updated 2022 Aug 8; cited 2025 Jan 11]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK549770/.

[37] Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, et al. Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017. JAMA Surg 2017;152(8):784-91.

[38] Norvell MR, Porter M, Ricco MH, Koonce RC, Hogan CA, Basler E, et al. Cefazolin vs second-line antibiotics for surgical site infection prevention after total joint arthroplasty among patients with a beta-lactam allergy. Open Forum Infect Dis. 2023;10(6):ofad224.

[39] Marni H, Djanas D, Bachtiar H. The effect of prophylactic antibiotic administration of cefazolin, ceftriaxone, and pre- and post-operative ceftriaxone on post-operative wound infection. Andalas Obstetrics and Gynecology Journal. 2020;:77–86.

[40] Duran A, Gülay H, Terzi M. Risk factors in surgical site infections. Surg Sci 2024;15:64-80.

[41] Farid A, Iqbal M, Irfan T, Shafqatullah S, Ali R, Mehboob A. Surgical site infection following elective and emergency surgical procedures. J Surg Pak. 2023;28(2):33-7.

[42] Cheng H, Clymer JW, Chen BPH, Sadeghirad B, Ferko NC, Cameron CG, Hinoul P. Prolonged operative duration is associated with complications: a systematic review and meta-analysis. J Surg Res. 2018;229:134-44.

[43] Cheng H, Chen BPH, Soleas IM, Ferko NC, Cameron CG, Hinoul P. Prolonged operative duration increases risk of surgical site infections: a systematic review. Surg Infect. 2017;18(6):722-35.

[44] Papadopoulos A, Machairas N, Tsourouflis G, Chouliaras C, Manioti E, Broutas D, Kykalos S, Daikos GL, Samarkos M, Vagianos C. Risk factors for surgical site infections in patients undergoing emergency surgery: a single-centre experience. In Vivo. 2021;35(6):3569-74.