An-Najah National University
Faculty of Graduate Studies

EPIDEMIOLOGY, CHARACTERISTICS, AND RISK FACTORS OF SURGICAL SITE INFECTIONS IN A TERTIARY CARE HOSPITAL IN WEST BANK: A RETROSPECTIVE COHORT STUDY

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This Thesis was Defended Successfully on 26/12/2024 and approved by

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Dedication

This thesis is dedicated to my dearly loved mother, who has meant and still means the world to me. Even though she is no longer among us, her memories continue to influence my life. For my family and valued friends who support and encourage me through this journey.

Acknowledgments

I would like to express my gratitude to my supervisor, Dr. Souad Belkebir, for her invaluable guidance and assistance during this project. who have offered me an enormous amount of guidance and encouragement. I am incredibly appreciative that I had a mentor who were not just kind and understanding but also excellent academic leaders.

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Declaration

I, the undersigned, declare that I submitted the thesis entitled:

EPIDEMIOLOGY, CHARACTERISTICS, AND RISK FACTORS OF SURGICAL SITE INFECTIONS IN A TERTIARY CARE HOSPITAL IN WEST BANK: A RETROSPECTIVE COHORT STUDY

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: Rawan Khalil Jeetaw.

Signature: Rawa

Date: 26/12/2024

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Abstract

Background: Surgical site infections (SSIs) are significant complications following surgery, impacting patient recovery and increasing healthcare costs. SSIs can lead to prolonged hospitalization, excessive medical expenses, and even death. Identifying risk factors and implementing effective prevention strategies is essential to improve patient safety. The incidence of SSIs is notably higher in developing nations, ranging from 2.5% to 41.9%. However, data from Palestine is scarce. This study aims to determine the SSI incidence among patients at An-Najah National University Hospital (NNUH) from 2018 to 2020 and identify associated risk factors.

Methods: This analytical retrospective cohort study included 1,157 patients who underwent surgery between January 2018 and December 2020 at NNUH. Sociodemographic and clinical data were collected and analyzed using descriptive and analytical methods, including binary logistic regression to assess potential risk factors. A significance level of 5% was applied, and IBM SPSS Version 21 was utilized for data analysis.

Results: The study found an overall SSI incidence rate of 7.65% among 1,157 surgical patients. The rate decreased from 18.2% in 2018 to 6.6% in 2019, and further to 0.6% in 2020. Higher SSI rates were observed in patients undergoing prosthesis implantation, longer surgical procedures, and non-laparoscopic surgeries ($p \leq 0.05$). Additionally, patients with an ASA index of IV or higher had a significantly increased risk ($p < 0.001$). Logistic regression indicated that surgeries lasting over two hours were approximately 17 times more likely to result in SSIs ($p < 0.001$), while those with prosthesis implants were nine times more likely ($p = 0.002$). Contaminated wounds increased infection risk by 23 times ($p = 0.005$), and each additional hospital day raised the SSI odds by 4.6% ($p < 0.001$).

Conclusions: The SSI surveillance program at NNUH underscores the importance of minimizing surgery duration, managing blood glucose and temperature post-surgery, and adhering to infection control policies to reduce SSI incidence. Further research is needed to evaluate the effectiveness of these strategies across diverse surgical settings and patient demographics.

Keywords: surgical site infections, risk factors, healthcare associated infections (HAIs), Clean surgery.

Chapter One

Introduction

1.1 Background

Health-care-associated infections (HAIs), nowadays are a serious public health issue. SSIs, which result in a high death rate, major morbidity, a significant prolongation of hospitalization, and higher care costs, are among the most pertinent HAIs (1–3). They are the main reason for readmissions, can result in problems like delayed wound healing and revision surgery, and can increase a patient's susceptibility to hospital-acquired infections by lengthening their hospital stay (2).

SSIs are defined as infections that appear at the site of the incision in surgical patients within 30 days after the procedure if there is no implant, or within a year if there is (4–6).

SSIs affect more than 1 in 10 people who have surgery in low-middle-income countries (LMICS); people in these countries are 3-5 times more likely than people in high-income countries to have SSIs. In the United States, SSIs impact 1% of surgical patients and result in over 400,000 additional hospital days for patients, which costs $10 billion annually (7). In Palestine, a multi-center, prospective cohort study conducted at 11 participating hospitals (4 in Gaza and 7 in the West Bank) showed that, in spite of Palestine's poor economic circumstances, the SSI rate was comparable to those of high-income nations (9.6% vs. 9.4%) (8).

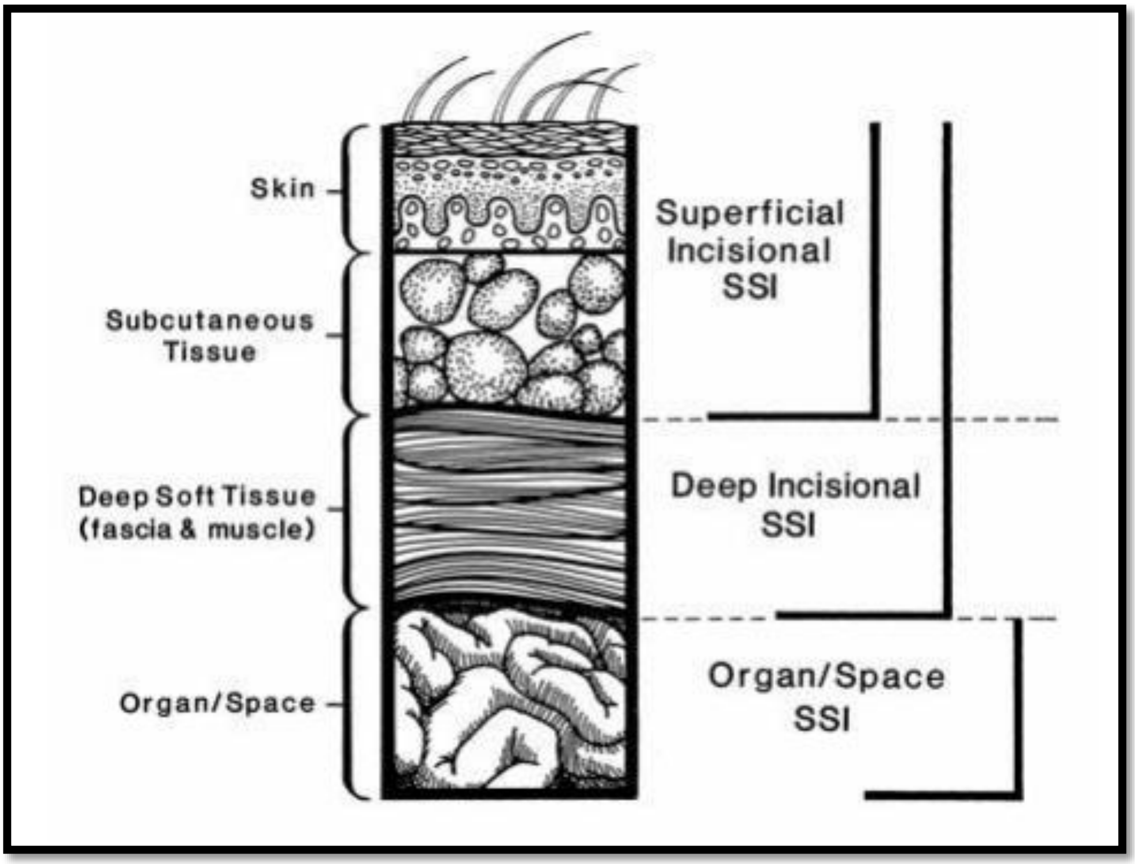
Consequently, surveillance of SSIs with adequate data feedback to surgeons has been found to be an important component of the SSI risk reduction strategy (6,7). Active, patient-based, prospective surveillance is required for SSI monitoring. To detect SSIs after inpatient operating procedures, concurrent and post-discharge surveillance measures should be implemented, as well as post-discharge surveillance for outpatient operative procedures (6, 7).

SSI surveillance is defined by the Centers for Disease Control and Prevention (CDC)and National Healthcare Safety Network (NHSN) as three types of wound infections: superficial, deep incisional, and organ/space SSIs (6).

The phases of SSI are described in the diagram below Figure 1.

Figure 1

Abdominal wall cross-section showing the CDC/NHSN surgery site infection categories



"Adapted from: NHSN categorization of SSIs. (From Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. Infect Control Hosp Epidemiol. 1992;13 (10): 606-608; with permission)" (9).

For an infection to be classified as a superficial incisional surgical site infection (SIP), it must have commenced within 30 days post-operative and be limited to the skin and subcutaneous tissue. Deep incisional surgical site infection (DIP) is an infection associated with surgical procedures, affecting the deep soft tissues. It manifests after 30 days post-operation in the absence of an implant, or after one year if an implant is present, involving fascia and muscle layers (6, 10).

An organ or space SSI is defined as an infection in any region of the body other than the incision that was opened or modified during the procedure, that appears to be connected to the surgical procedure, and that occurs within 30 days if no implant was used or within a year if one was. (10) The criteria of SSI according to each classification are as the following (6).

Superficial incisional: The event occurs within 30 days of the NHSN surgical procedure (day 1 reflects the procedure date), includes just the incision's skin and subcutaneous tissue, and the patient possesses at least one of the following:

a. Purulent discharge.
b. Organism (s) detected by a culture-based or nonculture-based microbiologic testing method from an aseptically obtained specimen from the superficial incision or subcutaneous tissue used for clinical diagnosis or treatment.
c. When a surgeon or physician purposefully opens a superficial incision, no culture-based or non-culture-based examination of the shallow incision or subcutaneous tissue is carried out.
d. At least one of the following symptoms or signs is present in the patient: localized erythema, heat, swelling, or discomfort or tenderness.

Deep incisional: The event date occurs within 30 or 90 days after the NHSN operational procedure (day 1 reflects the procedure date), and includes the deep soft tissues of the incision (such as the layers of muscle and fascia), and the patient possesses at least one of the following:

a. Purulent discharge from the deep wound
b. A deep incision that a physician or surgeon purposefully opens or aspirates.
c. Organism(s) detected by a culture-based or nonculture-based microbiologic testing method from an aseptically obtained specimen from the superficial incision or subcutaneous tissue used for clinical diagnosis or treatment.

The patient develops at least one of the symptoms or indicators listed below: fever (above 38°C); localized soreness or pain c. an abscess or other infection-related sign involving the deep incision found by imaging, histopathologic, or gross anatomical examination.

Organ/Space: The event date occurs within 30 or 90 days after the NHSN operational procedure (day 1 reflects the procedure date), includes any part of the body that is opened or modified during the surgical operation that is deeper than the layers of muscles or fascial, and the patient possesses at least one of the following:

a. Purulent drainage from a drain that is inserted into the organ or space (such as an open drain, T-tube drain, closed suction drainage system, or CT-guided drainage).
b. Organism(s) detected from tissue or fluid within the organ or space using a microbiologic testing technique based on culture or non-culture that is carried out for clinical diagnosis or therapy.
c. an abscess or other infection-related evidence involving the organ or space that is discovered by:

- A gross anatomical examination.
- A histopathologic examination.
- Imaging test evidence that is conclusive or inconclusive for infection and satisfies at least one requirement for a particular organ or space infection site specified in the Surveillance Definitions for Specific Types of Infections.

There are a variety of reasons why a patient may develop SSI, which can be classified as patient specific or procedure-specific, with both factors being controllable or non-modifiable (11, 12).

Obesity, current smoking status, high serum glucose preoperatively or postoperatively above 180 mg/dL, poor nutrition status of the patient, and nasal carriage of *Staphylococcus aureus* are all modifiable patient-specific variables (5–7).

Male gender, advanced age (over 50 years), diabetes mellitus, and other characteristics are non-modifiable risk factors for SSIs. (12,13) is employed for evaluating the level of a patient's "physical state" or "illness" before choosing an anesthetic or conducting surgery. An ASA score of I–IV indicates that the patient has significant systemic disease; a score of III or higher indicates this (14).

By the end of the 1960s, the field of hospital infection prevention had gotten a lot more attention. (15) The study's primary focus was on the nature and quantities of bacteria that contaminate wounds, as well as the characteristics of human microbial flora in disease states. Consequently, there has been a major advancement in the use of antibiotics, both preventive and therapeutic, in surgical patients (16).

Antibiotic prophylaxis can lower the incidence of postoperative wound infections, but it also raises the selective pressure favoring the emergence of antimicrobial resistance, as well as exposing patients to reactions and Clostridium difficile infections (12, 16).

First-generation cephalosporin, such as cefazolin, is still the prophylactic, broad-spectrum antibiotic of choice for the majority of surgeries. Preoperative intravenous antibiotics should be given within 60 minutes of the incision, according to the latest standards, including therapeutic antibiotic guidelines. For the majority of surgeries, a single preoperative dose is sufficient. Intravenous antibiotics (up to 24 hours after surgery) are only required in specific instances, such as some cardiac and vascular procedures and lower limb amputations (16, 17).

Most diseases are caused by endogenous causes, such as bacteria on the patient's skin. Staphylococcus aureus is the most frequently found isolate linked to the development of SSIs and the most frequently found microorganism found on the skin. Exogenous sources of bacteria that contribute to SSIs include transient flora from surgical team members' hands, fingernails, forearms, and jewelry that are transported to patients. Instruments, tools, and other materials used in the operating room may also become contaminated with bacteria if they are not properly sterilized (18).

Most studies have found that *Staphylococcus aureus, Staphylococcus epidermis, Pseudomonas, Klebsiella spp., and Escherichia coli* are the most common causal pathogens. (19–22)Despite the latest innovations, wound infections remain the most common nosocomial infection in surgical and wound treatment systems, particularly in surgical patients. An estimated 31% of all HAIs and 20% of readmissions following surgery were attributed to SSIs (23).

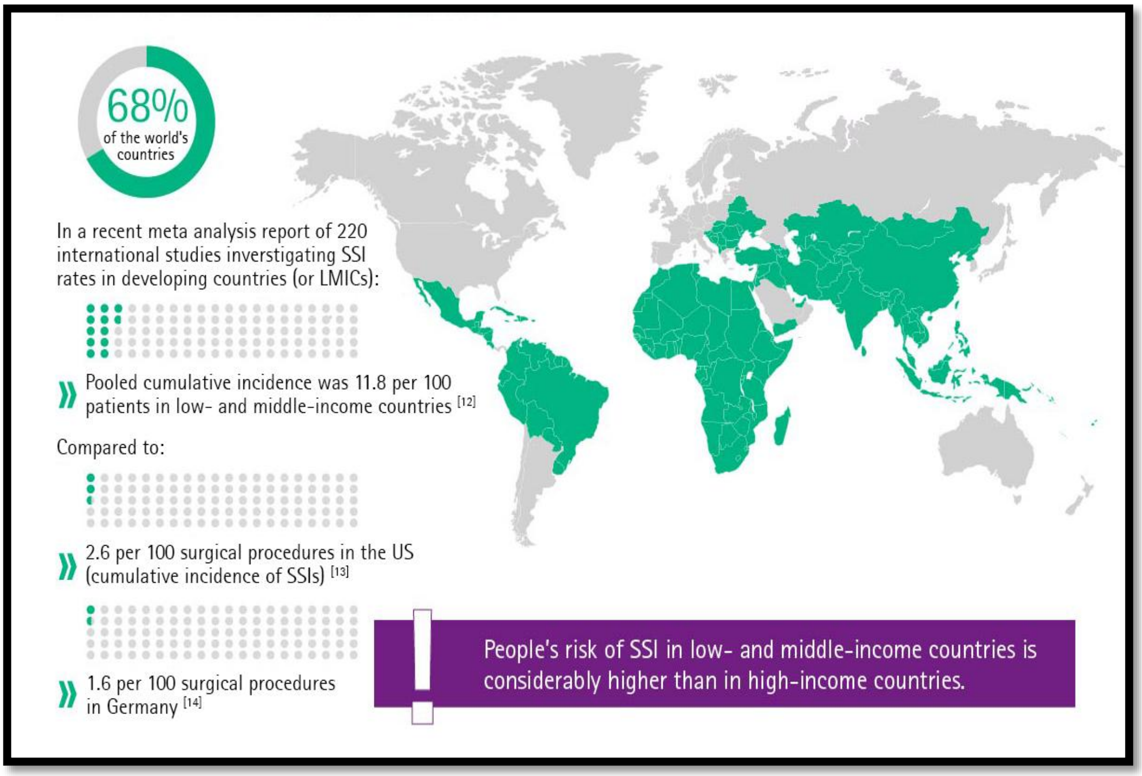
1.2 Epidemiology of SSIs

Globally, SSI rates have been estimated to range from 2.5 to 41.9%. In addition, surgical mortality is 10 times higher in developing nations than in wealthy ones (23,24).

However, the incidence differs between developed and developing countries; patients in the former group are more likely to be impacted than those in the developing countries, SSI was found to be 2.6 %, 1.6 % in Germany, and 2.9 % in different countries (25, 26). With a pooled incidence of 11.8 per 100 surgical patients, it is most common in low-and middle-income countries (23). Patients with SSIs are 2–11 times more likely to die than those without SSIs (11). Figure 2 shows the incidence of Low- and middle-income countries.

Figure 2

The incidence of SSI at Low- and middle-income countries



Adapted from:" The global problem of post-operative infections. https://www.bbraun.co.za/en/products-and-therapies/degenerative-spinal-disorders/sterile-supply/tray-organizing-manager/infection-prevention-cssd.html (27).

According to a recent research investigation that followed the PRISMA procedures for the systematic review and meta-analysis of 43 publications from 39 different countries, the global pooled incidence of SSI was 2.5% (95% CI: 1.6, 3.7), with Africa having the greatest incidence. (28) Also, a systematic review and meta-analysis in 2019 was conducted in developing countries in Africa/Middle East, Latin America, Asia, and China found that the overall prevalence of SSIs was 10% (29).

The International Nosocomial Infection Control Consortium (INICC) report, covering data from 30 countries between 2005 and 2010, reveals significant insights into the epidemiology and impact of SSIs globally. It's been found that SSIs in low-income countries (LICs) can be notably higher compared to high-income countries. INICC research has reported incidence rates of SSIs ranging from approximately 10% to 20% or higher in certain LIC settings. (30) SSI is the leading cause of healthcare-associated infections (HAI) in LMICs and the most frequent surgical complication (31).

These discrepancies can be explained in a number of ways. Aside from the quality of infection prevention measures and patient demographic disparities, it may reflect poor quality of care (32).

SSI becomes obvious only after discharge, between 10 and 82 % of SSI cases are discovered after patients have been discharged. In countries with limited resources, the postoperative stay is frequently longer (33–36).

1.3 Methodology differences in SSI surveillance

Many SSI surveillance strategies have been proposed in the literature, each with its own set of benefits and drawbacks. The approaches for detecting SSI can be classified as active or passive. Infection control personnel identify SSI by checking patient records and laboratory findings, discussing patients with the ward staff, and calling patients after discharge using an active strategy. SSIs are recognized passively by infection control professionals or a surgeon inspecting the surgical site. It's feasible to mix and match elements in both ways (6).

A surveillance-based strategy for preventing SSIs that focuses on five key areas determined by global experts.

These five areas are as follows: 1. gathering reliable, high-quality data; 2. connecting HAIs to financial constraints, emphasizing the necessity of giving infection prevention initiatives top priority; 3. integrating SSI surveillance into infection prevention and control (IPC) programs to implement structural changes, improve procedural skills, and change the behaviors of healthcare workers; 4. giving IPC training for healthcare workers in LMICs top priority in order to conduct broad-based surveillance and to create and implement locally applicable IPC programs; and 5. creating an extremely precise and impartial international system for defining SSIs that can be easily translated globally (37).

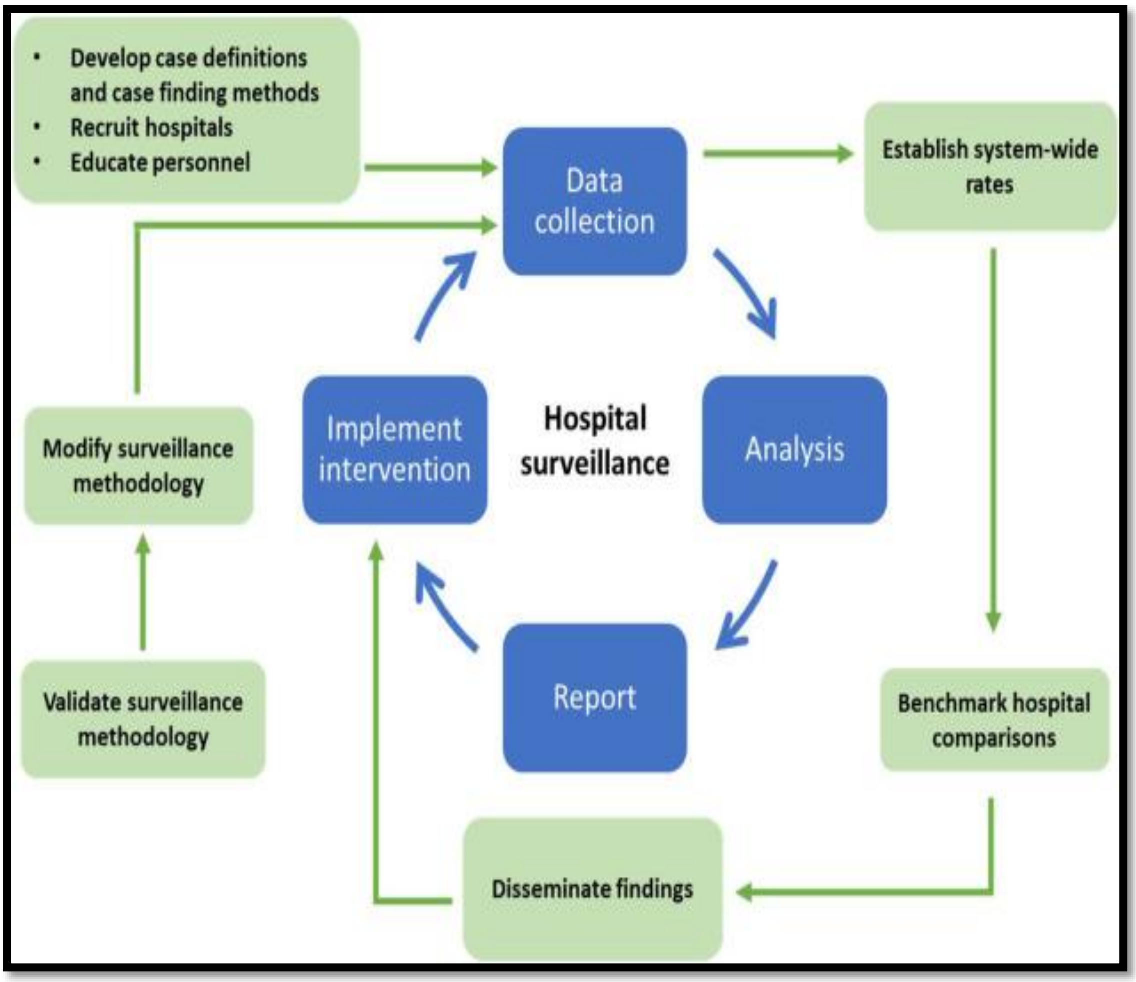
The most accurate technique of surveillance is the active method, which involves daily inspection of the surgical site beginning 24–48 hours after surgery. While the direct technique is the gold standard for research, it is rarely employed in practice due to its resource needs and impracticality. The passive method of SSI surveillance, on the other hand, is less time-consuming and can be easily implemented by infection preventionist specialists during surveillance rounds (12).

When one study compared the sensitivity and specificity of several passive approaches to the gold standard of direct surveillance, they discovered that the sensitivity was 70% and the specificity was 100%. Review of nursing notes, International Classification of Diseases, ninth revision codes, and antimicrobials administered were all components of the indirect approaches that were linked to the highest sensitivities (38).

The national and international surveillance systems for nosocomial infections acknowledge the different obstacles to SSI surveillance in LMICs and offer a set of basic elements of a surveillance program that can be first put into place at the departmental and institutional level. This is essential to guarantee prompt action for anomalous findings and to modify surgical ward practices. After the program has gained experience and confidence, it can then be expanded to a national level.

Figure 3

Components of the ideal SSI surveillance cycle



Adapted from: "Edmond MB. National and international surveillance systems for nosocomial infections. In: Wenzel RP, editor. Prevention and control of nosocomial infections. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2003. pp. 109e19.47" (39).

1.4 Risk indexes

Multiple techniques for SSI prediction and stratification have been developed. Classification of surgical wounds was the only variable used to predict SSI. Two CDC efforts: The National Nosocomial Infections Surveillance (NNIS) system and the Research on the Efficacy of Nosocomial Infection Control Study (SENIC) added additional predictor elements to the SSI risk scores. The observed misclassifications of incisions and the fact that the SSI risk varied by several percentages even within the group with clean wounds served as the justification for this (40, 41).

Every operation has its own unique NNIS risk index. The index values, which range from 0 to 3, are determined by three independent and equally weighted variables: contaminated or dirty wounds, ASA score III or higher, and operation over T hours (where T varies depending on the operative procedure being performed; surgeries beyond the 75th percentile of surgery duration score one point) (40,42).

The use of the risk index was not utilized in this particular study due to the characteristics of the population being studied; the focus was on identifying specific risk factors for SSIs rather than using a generalized risk index.

1.5 SSI risk factors

Different risk variables related to patients and operations have been investigated to see how much they influence the likelihood of SSI. Information about the surgical procedure and patient characteristics that may influence the development of SSI is useful in two ways: (1) it allows for better stratification of procedures, resulting in more comprehensive surveillance data, and (2) knowing risk factors before surgery may allow for targeted prevention measures. Risk stratification also allows for the identification of changes in SSI rates that are not related to differences in unchangeable factors, such as the patient's vulnerability (40, 43).

Patient variables

1.5.1 Age

Most of the studies reported that age above 50 has been associated with an increased risk of SSI. According to Kaye's research, which was a cohort study conducted at Duke University Medical Center in Durham, North Carolina, included patients who underwent surgery between February 1991 and July 2002, the chance of infection climbed by 1.1% between the ages of 17 and 65, then declined by 1.2% per year after that.

These results indicate that SSI risk is significantly influenced by age, with older patients being at higher risk. The immune system of older persons frequently deteriorates, making the body less effective at fighting illnesses. Additionally, wound healing is hampered by age-related changes in the flexibility of the skin and tissue, and wound recovery and infection resistance are further compromised by prevalent comorbidities in older patients, such as diabetes, vascular disease, and malnutrition. When combined, these physiological variables make older individuals more vulnerable to SSIs (44).

1.5.2 Gender

SSIs can affect both men and women, although the causes of these infections can differ. The risk of SSIs varies by gender and is influenced by a variety of factors, including biological differences; gender differences in skin flora can affect the risk of SSI.

Males have thicker skin and produce more sebum, which may impact bacterial colonization and raise the risk of infection. (45) Hormonal impacts; while testosterone in men may cause a greater inflammatory response after surgery, estrogen in women has anti-inflammatory qualities that might speed up the healing of wounds (45).

Surgical procedures; when it comes to procedures involving the pelvic or reproductive regions, women are more at risk, while it was noticed that males were more prone to get infections following cardiac surgery. (46) In addition, different health-seeking behaviors among both genders may also have an impact as women are typically more proactive in seeking medical attention and following postoperative instructions than men.

Men prefer to delay seeking medical assistance until after surgery, according to research by Olsen et al. This may lead to an earlier diagnosis and treatment of SSIs in women (47).

1.5.3 Obesity

One established risk factor for SSIs is obesity, which is defined as a body mass index (BMI) greater than 30 kg/m2. (48) A prospective cohort study of 206 National Health Service (NHS) hospitals in England found that depending on the kind of surgery, obesity was linked to an increase in the adjusted risks of developing SSI of 1.1– 4.4 times higher than that of normal weight (49).

Because obesity reduced wound healing, changed immunological responses, and caused difficulties with wound management after surgery, because adipose tissue is less vascularized, obesity can delay wound healing by lowering blood flow and oxygen supply to tissues. Adipose tissue also raises inflammatory reactions, which can weaken immunity and increase the risk of infection.

Obese individuals also have a harder difficulty undergoing surgery, which frequently leads to longer operating periods and wider incisions, which increases the risk of SSIs. (50) In order to lower the incidence of SSIs in obese patients, these concerns highlight the significance of focused preventative measures, including preoperative weight management, improved surgical methods, and careful postoperative care.

1.5.4 Diabetes

Diabetes can cause immunological compromise, delayed wound healing, microvascular problems, hyperglycemia, and related comorbidities; it is therefore a significant risk factor for SSIs (48, 51).

Patients with diabetes have a markedly increased risk of SSIs after a variety of surgeries, including orthopedic, cardiac, and gastrointestinal procedures, because blood vessels can be damaged by high blood glucose, which lowers blood flow to the surgical site and limits the delivery of nutrients and oxygen that are necessary for healing.

Additionally, diabetes weakens the immune system, which makes it more difficult for the body to fend off infections. Furthermore, high blood sugar encourages the growth of bacteria, raising the risk of infection at the wound site. When combined, these variables increase the risk of SSIs following surgery for diabetics.

Keeping blood glucose levels 180 mg/dL or below, prior to and after surgery has been demonstrated to effectively lower the risk of SSIs. (51, 52) This risk is especially high in patients with poor glycemic control. Preventing SSIs in people with diabetes mellitus requires careful blood sugar control prior to, during, and following surgery.

1.5.5 Smoking

Smoking impairs tissue oxygenation, immune system performance, and wound healing; it is a major risk factor for surgery site infections. Smokers compromised immune systems, the vasoconstrictive effects of nicotine, and the loss in oxygen delivery caused by carbon monoxide all raise the risk of SSI. Smokers are more vulnerable to having wound dehiscence, delayed healing, and bacterial colonization at surgical sites, all of which increase the risk of SSIs. Cessation of tobacco use before surgery can reduce these risks and enhance the results of the procedure as a whole (53).

1.5.6 Nutritional status

Severe calorie-protein deficit characterized by more than two of the following traits: 1. noticeable, substantial muscular atrophy and loss of subcutaneous fat; 2. dietary intake that is less than 50% of the required amount for at least two weeks (as determined by the dietitian); 3. bedridden or with a markedly diminished ability to function; 4. Patients who lost more than 2% of their body weight in a week, 5% in a month, or 7.5% in three months had a considerably higher risk of SSI (54).

Malnourished patients are more susceptible to infections due to impaired immune function, delayed wound healing, and compromised tissue integrity (55). Particularly insufficient protein intake can delay the process of wound healing by affecting collagen synthesis, angiogenesis, and fibroblast function (56). This highlights the importance of identifying and addressing severe protein-calorie deficiency in surgical patients to improve outcomes, so the nutritional state of a patient is also considered while determining ASA ratings (14).

1.5.7 Immunocompromised patient

Patients who are immunocompromised are described as follows (57):

1. Congenital diseases (disorders of the T- or B-cells, dysfunctions of the macrophages, frequently in infants and adolescents but also in adults).
2. Acquired conditions:
   a. Affected by HIV infection and subsequently developing acquired immunodeficiency syndrome (AIDS).
   b. Hematologic cancer.
   c. Immunodeficient patients with intrinsic immunological diseases that fall under the category of "solid malignancy or solid organ transplanted patients or inflammatory disease/rheumatologic disease," as well as those who are receiving chemotherapy or immunomodulatory medications at the same time.
   d. Individuals with pathological or physiological conditions that include immunodeficiency of any kind.

Deficiencies in Innate Immunity: The first line of defense against pathogens is the innate immune system. Phagocytic cells (such as neutrophils and macrophages) are frequently compromised in immunocompromised people, which lessens the body's capacity to identify and eliminate infections. This raises the possibility of infection at the surgical site.

SSIs are more common in immunocompromised patients because of their lowered immune systems and delayed wound healing. These people frequently have compromised innate and adaptive immune responses, which lessens the body's capacity to fend off infections. Chronic illnesses, immunosuppressive drugs, and inadequate nutrition all contribute to an increased risk of infection. To reduce SSI risks and enhance results in this susceptible population, preventive treatments such as perioperative antibiotics, nutritional and metabolic status optimization, and close post-surgery monitoring are crucial.

1.5.8 ASA score

The American Society of Anesthesiologists created the ASA score to track the severity of a patient's underlying illness. The anesthesiologist's inconsistencies in age and obesity ratings have been discovered to impact the accuracy of the ASA score in predicting SSI risk in elderly patients. This highlights the importance of considering multiple factors when assessing infection risk in this population (14).

The definition of the ASA score is based on a scale of I to VI, with higher scores indicating more severe systemic disease:

I: a patient in normal health
II: Individual with a minor systemic illness
III: A patient with severe systemic condition that is not incapacitating.
IV: A patient with a life-threatening, incapacitating systemic condition
V: Moribund patient, with or without surgery, who is not anticipated to live for 24 hours
VI: A deceased individual who donates their organs.

In clean-contaminated and dirty operations, the incidence of SSI was considerably greater in patients with (ASA) ratings II and II than in those with ASA score I. (58) The definition of the ASA score is based on a scale of I to VI, with higher scores indicating more severe systemic disease, as shown in Table 3.

Pre-operative procedure

1.5.9 Bathing with chlorhexidine before surgery

Bathing using antibacterial chemicals like chlorhexidine before surgery has been found to minimize bacterial colonization on the skin (59). Several studies have looked into the effectiveness of preoperative showers, but few have conclusively proven that they reduce the incidence of SSI.

A prospective, randomized clinical trial at six university-affiliated hospitals in the United States, between April 2004 and May 2008 compared chlorhexidine-alcohol use versus povidone-iodine for preoperative skin preparation and found that chlorhexidine-alcohol was more effective in preventing SSIs (60). Nevertheless, the World Health Organization (WHO) recommends bathing with chlorhexidine gluconate as a strategy to prevent SSIs, as it mentioned in its guidelines for the prevention of SSIs (61).

1.5.10 Hair removal

If hair removal is absolutely necessary, then methods of hair removal prior to surgery are critical in preventing SSIs. It is better to use electric clippers to trim hair right before surgery rather than shaving with a razor since clipping minimizes the probability of skin irritation and microcuts, which can lead to an increased risk of infection.

It's critical to adhere to sterile procedures when shaving hair in order to avoid contaminating the surgery site with microorganisms. Aseptic methods should be used for preoperative hair removal, in accordance with recommendations from the Centers for Disease Control and Prevention (CDC) and WHO (58).

Intra-operative procedure

1.5.11 Normothermia and blood loss

During the perioperative period, maintaining a temperature of 35.5°C or above is essential to prevent SSI. Even slight hypothermia can raise the risk of SSI. Hypothermia can either directly or indirectly decrease neutrophil activity by causing subcutaneous vasoconstriction and consequent tissue hypoxia. It can also increase blood loss by about 500 mL in surgical patients, resulting in wound hematomas or the requirement for transfusion, all of which can raise the risk of SSI. (62) Preoperative and intraoperative warming have been demonstrated to reduce SSI rates and intraoperative blood loss in randomized controlled trials (63).

1.5.12 Type of surgical procedure

When it comes to emergency surgeries, the risk of SSIs is much higher than it is for elective (planned) surgeries. These causes include patient condition, inadequate preoperative preparation, contamination concerns, and improper scheduling of antibiotic prophylaxis.

The risk of SSIs is increased by the fact that emergency procedures are sometimes more complicated, involve compromised tissues, and are carried out in an urgent manner.

Elective surgeries, on the other hand, have lower overall infection risk because of improved planning, patient optimization, and controlled surroundings (64). Many previous studies have pointed to higher infection rates in emergencies—23.8% compared to 7.4% for elective cases (65).

This increase in SSIs during emergency procedures can often be traced back to shorter recovery times, limited preparation for both patients and surgeries, and the nature of certain injuries, like those from road traffic accidents. (64) For example, a study by Dessie et al. reported SSI rates of 38.3% for elective cases and 61.7% for emergencies, reinforcing this concern (66).

When compared to open surgery, laparoscopic surgery often carries a lower risk of operative site infections.

Laparoscopic operations have a lower risk of infection because they include smaller incisions, less tissue stress, and shorter hospital stays. However, there are increased chances for bacterial contamination and subsequent infection during open procedures due to their larger wounds and longer recuperation periods.

While laparoscopic procedures, when practical, offer substantial benefits in lowering the risk of SSIs, open surgery may still be required in some complicated instances (67,68).

1.5.13 Wound classification.

Four classes of wound status were defined by the CDC: (1, clean; 2, clean/ contaminated; 3, contaminated; and 4, dirty) (52).

Postoperative risk of SSI for each class with scores of 1% to 5% for clean surgeries, 3% to 11% for clean-contaminated surgeries, 10% to 17% for contaminated surgeries, and more than 27% for dirty surgeries (69).

- Class 1: clean wounds, these wounds are often closed, absent of inflammation and infection signs. If drainage is required, a closed draining approach is recommended. It is crucial to keep in mind that Class 1 wounds do not impact the respiratory, alimentary, vaginal, or urinary systems. Clean wounds include inguinal hernia surgery and thyroid
- Class 2: clean-contaminated, suggesting a low level of contamination. Only under certain circumstances can these wounds enter the pulmonary, urinary, vaginal, or alimentary tracts.
- Class 3: contaminated, typically the result of a gastrointestinal leak or a lapse in sterile protocols. Acute or non-purulent inflammatory incisions are also classified as Class 3 wounds.
- Class 4: dirty or infected, these wounds are typically caused by obvious infections, excessive purulence, high purulence and inadequate traumatic wound care. Tissues that have lost their strength can cause class 4 wounds. This is usually caused by surgery or infections discovered in organs that have been pierced. (70)

1.5.14 Duration of operation

The longer a surgery takes, the higher the chance of SSI because of things like increased bacterial colonization, prolonged tissue exposure, immune suppression from prolonged anesthesia, and longer hospital stays. Longer procedures are frequently more difficult and involve greater tissue stress, leading to delayed wound healing and a higher risk of infection. To reduce the incidence of SSIs during lengthy procedures, preventive measures such as maintaining normothermia, using appropriate antibiotic prophylaxis, and using efficient surgical techniques are crucial (71).

After the first 60 minutes of anesthesia, wound infection rates rise by 0.5% each minute. This means that for every extra hour of anesthesia, there is a 30% higher chance of postoperative infection (71).

The mean duration of surgeries was 2.6 hours, with a median of 2.2 hours. So, we studied the possibility of infection at the study for a duration more than two hours.

Post-operative procedure

1.5.15 Antibiotic prophylaxis

The WHO provides comprehensive guidelines on antibiotic prophylaxis to reduce SSIs. The purpose of these guidelines is to encourage evidence-based procedures that maximize patient safety and reduce the possibility of SSIs.

The main suggestions are to guarantee sufficient tissue levels at the time of surgery that provide the prophylactic antibiotics within 60 minutes of the surgical incision. Local epidemiology and susceptibility patterns should be taken into consideration when choosing antibiotics, with the goal of using narrow-spectrum medications to minimize collateral damage to normal flora and reduce the risk of resistance (61).

Prophylactics should be administered for as short a period as possible, usually no more than 24 hours after surgery. Redosing antibiotics after the surgical incision is not recommended, unless the duration of surgery or significant blood loss necessitates additional doses.

Adherence to national or local guidelines is essential, and surveillance systems should be in place to monitor adherence and track SSIs for quality improvement. These evidence-based recommendations promote appropriate antibiotic use, optimize patient safety, and support antimicrobial stewardship in surgical practice (61).

Additionally, antibiotic prophylaxis is recommended for surgeries involving clean-contaminated or contaminated wounds to reduce the risk of SSIs, and it is justified in any surgical procedure involving an implant because it decreases the infection rate from 5% to 1%. These evidence-based recommendations are crucial for maximizing patient outcomes and encouraging antimicrobial stewardship in surgical settings (7).

The WHO guidelines emphasize the importance of a multidisciplinary approach involving surgeons, anesthesiologists, pharmacists, and infection prevention and control teams to guarantee appropriate antibiotic use and minimize the risk of SSIs. These evidence-based recommendations are crucial for maximizing patient outcomes and encouraging antimicrobial stewardship in surgical settings (61).

1.5.16 Remote site infection

An infection that develops in a body area that is far from the location of a surgery or injury is referred to as a remote site infection. These infections can occur in a patient following surgery even if they have nothing to do with the surgical site or incision. In essence, the infection happens somewhere other than the actual surgery site, which is why it's called "remote." Pneumonia or urinary tract infections in patients who have had appendicectomies are examples of postoperative patient infections (72).

Even though they happen in different places of the body, remote infections can occasionally be linked to SSIs. For instance:

- Sepsis from a surgical wound's bacteremia (bloodstream infection) can impact distant organs.
- Infections in distant locations, such as the heart (endocarditis) or bones (osteomyelitis), may become more likely following surgical procedures involving implants, devices, or prosthesis.
- Systemic infections that impact other organs or tissues can result from surgical equipment contamination or from using inadequate aseptic procedures (73).

Bloodstream infections, medical devices, or a compromised immune system following surgery may all lead to remote infections. Even if they have nothing to do with the actual surgery site, they could still make the patient's recovery more difficult.

Depending on the patient's characteristics and the type of surgery, the exact prevalence of remote infections varies widely. For example:

1. In patients having major surgery, ventilator-associated pneumonia (VAP) is a common distant infection, especially if the patient is intubated or needs mechanical breathing. Although the risk is greater in critically sick patients, the incidence of VAP can vary from 10% to 30% in these situations (73,74).

2. Urinary tract infections linked to catheter use (CAUTIs): According to studies, 5–10% of individuals who have urinary catheters in place for more than 48 hours get a UTI, which is a type of distant infection (73,74).
3. Sepsis (bloodstream infections) following surgery might affect 1–3% of patients overall, but it can be more common in high-risk surgeries (e.g., cardiac, gastrointestinal) (73).
4. Even though they are less common, other distant infections such osteomyelitis and endocarditis can nevertheless be significant in some patient groups (74).

In summary, the occurrence of SSI is multifactorial, involving both intrinsic and extrinsic factors that makes their prevention and control a challenging task for any infection prevention and control program in any institution. To address therefore this preventable but yet very important event, a holistic approach is needed that addresses all these factors simultaneously to achieve the safest care possible for surgical patients. Table 1 and Table 2 summarized these factors and its pathophysiology**.**

Table 1

Summary of SSI risk factors and its pathophysiology"Intrinsic and Extrinsic factors"

Risk factor	The pathophysiology.
Intrinsic factors" non-modifiable patient-related risk factors"	
Age	The immune system of older persons frequently deteriorates, making the body less effective at fighting illnesses, and reduced skin flexibility, hindering wound healing. Common comorbidities like diabetes and malnutrition further increase their susceptibility to SSIs.
Gender	Research suggests that women may have a slightly lower incidence of SSIs due to differences in body fat distribution and immune response. However, men might be at greater risk for certain surgeries, like heart procedures, due to higher comorbidity rates and lifestyle factors
Extrinsic "Modifiable patient-related risk	
Obesity	Excess body fat or obesity impairs healing by reducing blood flow and oxygen supply to tissues, increasing infection risk. Larger incisions and longer procedures associated with obesity further heighten susceptibility to infection and slow recovery from surgery.
Diabetes	High blood glucose damages blood vessels, reducing blood flow and nutrient delivery essential for healing, while also weakening the immune system. These factors, along with increased bacterial growth from elevated sugar levels, significantly raise the SSIs in diabetics.
Smoking	Smoking contributes to SSIs through a variety of mechanisms, including weakened immune systems, decreased oxygen transport to tissues, elevated inflammation, and changes in microbial ecology.
Nutritional status	SSI risk and outcomes can be strongly influenced by nutritional status. The body becomes more vulnerable to infection when its immune system is weakened and wounds are not healed properly due to inadequate nourishment.
Immunocompromised patient	The body is less able to fight off infections when immunological responses are compromised. Immunosuppressive drugs, long-term illnesses, and inadequate nutrition all contribute to an increased risk of infection.

Table 2

Summary of SSI risk factors and its pathophysiology"pre-intra-post procedure"

Risk factor	The pathophysiology.
Pre-operative procedure	
Hair removal	Hair removal before surgery can impact the risk of SSIs, with studies suggesting that clippers are safer than shaving, as shaving can create small skin incisions that promote bacterial growth.
Intra-operative procedure	
Normothermia and blood loss	Maintaining normothermia during surgery reduces the risk of SSIs by supporting immune function, enhancing tissue oxygenation, and promoting effective blood coagulation, all of which facilitate healing.
Type of surgical procedure	In general, SSIs are more likely to occur during emergency procedures because of increased contamination, weakened immune systems, and inadequate preoperative planning. Conversely, planned operations promote better patient optimization and reduce the risk of infection.
Wound classification	The risk of SSIs varies by wound classification, with clean wounds posing the least risk and filthy or infected wounds the highest, emphasizing the importance of proper surgical techniques, infection control, and patient optimization to reduce SSIs across all wound types.
Duration of operation	Longer surgery durations increase the risk SSIs due to greater bacterial exposure and tissue damage, making it crucial to minimize surgery time and maintain optimal patient conditions, such as normothermia, to reduce this risk.
Post-operative procedure	
Antibiotic prophylaxis	Antibiotic prophylaxis reduces bacterial colonization during surgery, which effectively lowers the incidence of SSIs. For best effects, time, dose, and antibiotic selection are crucial, and prudent use helps avoid antibiotic resistance.
Remote site infection	Remote site infections heighten the risk of SSIs by promoting bacterial growth and weakening the immune system, making it essential to treat these infections and enhance patient health before surgery to reduce SSI rates and improve outcomes.

1.6 Pathogens and patterns of resistance

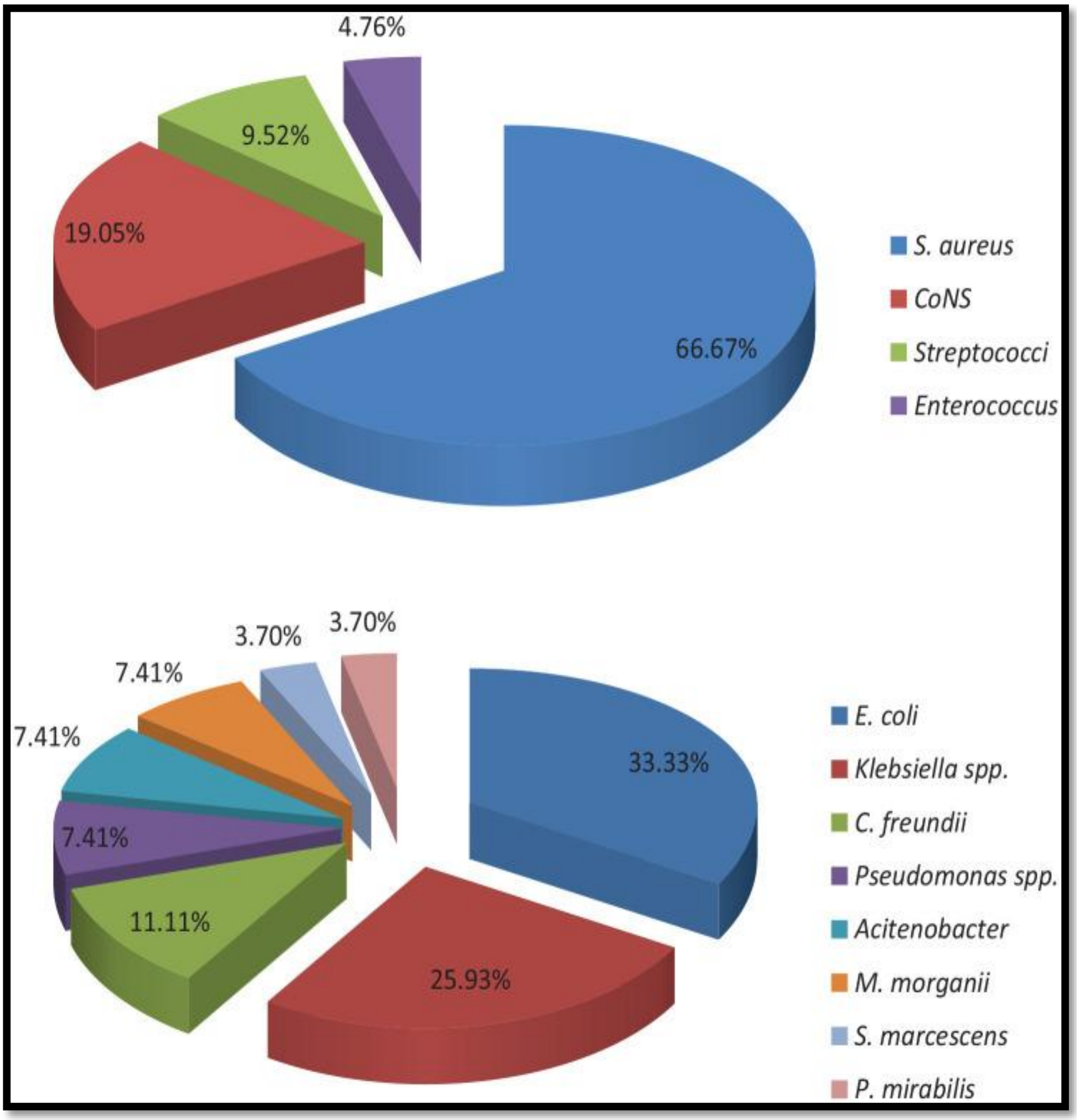
The patient's endogenous flora is the source of infection in most SSIs. The operating room environment, surgical personnel, and any tools, supplies, or equipment introduced into the sterile area are examples of exogenous causes of SSI. Aerobes, particularly gram-positive organisms like *streptococci* and *staphylococci*, make up the majority of external flora. *Staphylococcus aureus* is the species most frequently identified in the literature as causing SSI. (17).

According to the CDC's and (NHSN) Summary of Data, the most common pathogens were *Staphylococcus aureus* (16%), Enterococcus spp. 14%, *Escherichia coli* 12%, *coagulase-negative staphylococci* 11%, *Candida spp*. 9%, *Klebsiella pneumoniae* (and *Klebsiella oxytoca*; 8%, *Pseudomonas aeruginosa* 8%, and *Enterobacter spp*. 5% (75).

From July 22 to October 25, 2016, a cross-sectional study was carried out in Ethiopia at Dessie Comprehensive Specialized Hospital (DCSH). *S. aureus* (n = 14; 66.67%) was the most common isolation among Gram-positive bacteria, followed by CoNS (n = 4; 19.05%). *E. coli* (9, 33.33%), *Klebsiella species* (7, 25.93%), and *Citrobacter freundii* (3, 11.11%) were the main organisms recovered as Gram-negative rods, which show at figure 4.

Figure 4

Pathogenic microorganism distribution among research participants with SSI at DCSH from July 22 to October 25, 2016



"Adapted from: Ali A, Gebretsadik D, Desta K. Incidence of surgical site infection, bacterial isolate, and their antimicrobial susceptibility pattern among patients who underwent surgery at Dessie Comprehensive Specialized Hospital, Northeast Ethiopia. SAGE Open Med. 2023 Jan 1;11" (76).

According to a systemic review by Jouf University, Sakaka, Saudi Arabia, in 2022, 18 publications reported that *Staphylococcus aureus, Klebsiella pneumonia,* and *E. coli* were the three bacteria that were most frequently reported in the studies. In order to identify the epidemiological characteristics, incidence, etiological agents, and predisposing risk factors for the development of postoperative infections among surgical patients across all six WHO regions, this systemic review was designed (77).

1.7 The significance of the study

SSIs are still a major concern, as evidenced by several studies conducted around the world, despite surgeons' strict adherence to sterility and meticulous patient management before and after procedures (23).

The Study on the efficacy of nosocomial infection control (SENIC) research in the United States looked into the effectiveness of measures to reduce hospital-associated infections. Infection rates were lowered by 32% in hospitals with effective programs.

Organized surveillance and control efforts, an infection control physician, one infection control nurse per 250 beds, and a system for reporting infection rates to practicing surgeons were all part of the successful programs (78).

NNUH has a similar evidence-based infection prevention program, which intended to protect its employees' and patients' health and safety. This program places a strong emphasis on maintaining good hygiene, regularly checking infection control measures, and providing continuous education regarding the significance of infection prevention. Additionally, the program raises awareness through training sessions and workshops, giving the hospital community the skills and knowledge, they need to recognize and reduce any infection risks. An-Najah National University Hospital aims to establish a secure and healthful learning environment by placing a high priority on infection prevention.

NNUH is a tertiary teaching referral hospital with complicated cases, a JCI-certified hospital that has implemented a surveillance program using CDC methodology since 2020. The infection control program has a strong evidence-based structure that complies with WHO and CDC elements for a successful IPC program.

SSIs present a significant challenge in the West Bank, as in many healthcare settings globally. Research indicates that the prevalence of SSIs in this region can be influenced by various factors, including surgical techniques, the conditions in healthcare facilities, and infection control practices (8).

The scarcity of studies in the region underscores the necessity for additional research to evaluate the specific risk factors leading to SSI in low- and middle-income countries as well as provide information about the efficacy of infection prevention initiatives.

This research will be essential for informing healthcare professionals and policymakers and establishing a foundation for future targeted quality improvement programs and investigations.

This study aims at determining the local incidence of SSI and its associated factors, as well as the most common causative species found in infected wounds, at the NNUH teaching referral university hospital in Nablus, Palestine.

1.8 Research Question

What is the incidence of SSIs among patients admitted to NNUH for surgery and associated risk factors during 2018–2020?

1.9 Objectives

1.9.1 Main objective

To determine the incidence of SSIs for patients admitted to surgery at NNUH, and associated risk factors during 2018–2020.

1.9.2 Specific Objectives

1. To assess the risk factors related to SSI at NNUH Hospital
2. To identify the SSIs' causative species.

Chapter Two

Methodology

2.1 Study Design

This is an analytical retrospective cohort study of all patients admitted for surgery between January 2018 and December 2020.

2.2 Study time, setting, and population

The project focused on all patients undergoing surgery who need admission planned/elective or emergency at the wards and clinics of NNUH, a tertiary care teaching referral university hospital in Nablus, Palestine, with 123 beds in patients, 280 total beds, and two operating theaters with four operation rooms.

Patients are usually seen in outpatient clinics, and those who are scheduled for surgery will be included in the study. Those who fulfill the inclusion criteria were enrolled on the day of admission, followed up in the hospital after surgery, and then followed up with clinic visits until the completion of the study period.

Infection presents at the time of surgery, and eligible procedures that are assigned an ASA score of 6 are not eligible for SSI surveillance.

- Numerator: SSI event clinically reported by positive culture or by patient based on specific criteria
- Denominator: data on all procedures included in the selected operative procedure categories

2.3 Inclusion's criteria

1. Inpatient surgeries.
2. Adult patient (age ≥ 18 years) who underwent either elective or emergency surgery.
3. Patient who underwent general, cardiac, orthopedic, and vascular surgeries.

2.4 Exclusion's criteria

1. Day case surgeries.
2. Any patients who, at the time of surgery, have a skin or soft tissue infection.
3. Any patient who has had surgery at another hospital on the same site in the last 30 days.

2.5 Sample size calculation

The minimum sample size desired to achieve a confidence level of 95%, an estimated margin of error of 5%, assuming a large population and using a size effect of 12%, was calculated using the above equation:

$$n= Z^2 *p* (1-p)/E^2 \quad (1)$$

Where,

n= Sample size
Z = z score corresponding to level of confidence of 95% = 1.96
p = percentage of population = 0.12
E = margin of error = 5%

Therefore, the minimal sample size would be 163 patients. Since it is a retrospective study and the data is already available, with no opportunity of loss of follow up during the period of observation, the calculation of sample size using proportion will not require adjustments for loss of follow-up.

Nevertheless, in this study, all patients who met the inclusion criteria were included, accounting for 1157 patients. The final sample size during the study duration was 1157 patients.

2.6 Study variables

The presence or absence of SSI (binary outcome) was the dependent variable in this study. The independent variables that were investigated were as follows:

Gender (male and female), age (in years), duration of surgery (in hours), surgical wound classification (clean, clean-contaminated, contaminated, or dirty/infected), the ASA index (ASA I, ASA II, ASA III, or ASA IV/V), emergency surgery (yes/no), and diabetes mellitus (DM) (yes/no), smoking status (yes or no), as shown in Table 3.

Table 3

The independent variable, operational definition, and the type of measurement

The variable	Operational Definition	Type of measurement
Age	Age at time of surgery	in years (continuous)
Duration of operation	The time from the skin incision to skin closure	Continuous in hours.
Type of operation	A planned operation was recorded as an elective procedure for the patient. There was no emergency operation planned.	Elective/emergency.
Obesity	Body mass index (BMI) of 30 or greater	Yes, No
American Society of Anesthesiologists physical status classification (ASA)	The anesthesiologist's score based on the ASA scoring system	I: a patient in normal health II: Individual with a minor systemic illness III: A patient with severe systemic condition that is not incapacitating. IV: A patient with a life-threatening, incapacitating systemic condition V: Moribund patient, with or without surgery, who is not anticipated to live for 24 hours VI: A deceased individual who donates their organs.
Wound classification	The surgeon's score in accordance with the wound categorization system	1.Clean wounds 2. Clean-Contaminated wounds 3.Contaminated wounds 4. Dirty or infected wounds.
Antibiotic prophylaxes	A patient should be considered to be receiving prophylaxis if; 1. Antibiotics are administered either 24 hours before or 24 hours after surgery. 2. When using antibiotics, there is no history of fever or infections.	Yes, No
Post-operative glucose	Maintain blood glucose level after surgery less than 180 mg/dl	Yes, No
Post-operative normothermia	Maintain temperature between 36.1-37.1	Yes, No.0 +

The following variables: bathing with chlorhexidine before surgery, hair removal, and blood loss, also reported in the literature as potential risk factors for the development of SSI, were not considered due to difficulties in data availability and gathering in a retrospective study.

2.7 Duration of follow-up

Both patients who had elective or urgent operations were monitored for 30 to 90 days afterward. According to the CDC, a superficial or deep SSI is described as an infection that occurs within 30 to 90 days of a surgical procedure.

The follow up was done by either subsequent visits to the clinic after surgery and/or a phone call to ask about signs and symptoms and if they had visited another doctor for any symptom. The follow up included also all reports received from doctors notifying the occurrence of infection as per hospital protocol.

2.8 Data collection

Patient information from the patient's file was used to gather data for the datasheets "case report form of surgical producer denominator's, prevention of surgical site infection. (Appendix 1)."

The data sheets were kept safe and confidential at the researcher's office. At the conclusion of the report, all data introduced–into Excel sheets for easy review by the researcher.

2.9 Data analysis

After data was entered in excel sheet, depurated and completed, descriptive analysis was performed according to the type of variable: categorical ones using frequencies and percentages while continuous variables were analyzed using mean and standard deviation (SD).

Further analytical analysis using an appropriate test: chi-square test, Fisher exact test, or t-test Analysis of Variance test (ANOVA) were applied to study the possible association between sociodemographic characteristics as well as the clinical characteristics of patients or surgery characteristics and the development of SSIs. The level of significance used was 5% (p-value < 0.05).

As the outcome considered in this study is a binary one: SSI (yes, no), a binary logistic regression has been performed to predict the potential development of SSI given the mentioned risk factors. Odds Ratios and their respective 95% Confidence Interval (95%CI) were reported.

IBM SPSS (Statistical Package for the Social Sciences) Version;21 was used to analyze the data.

2.10 Ethical Considerations

To ensure that the study meets the Declaration of Helsinki ethical principles, permission to perform the study was obtained from the Institutional Review Board (IRB) at (Ref: Mas.April.2022/11).

In addition, the appropriate administrative approvals from the Hospital Research Center and the hospital were retrieved.

Confidentiality of data was ensured by the anonymization of the data and removal of potential sensitive identifiers. The researcher was the only person having access to the data.

Chapter Three

Result

3.1 The result of the study

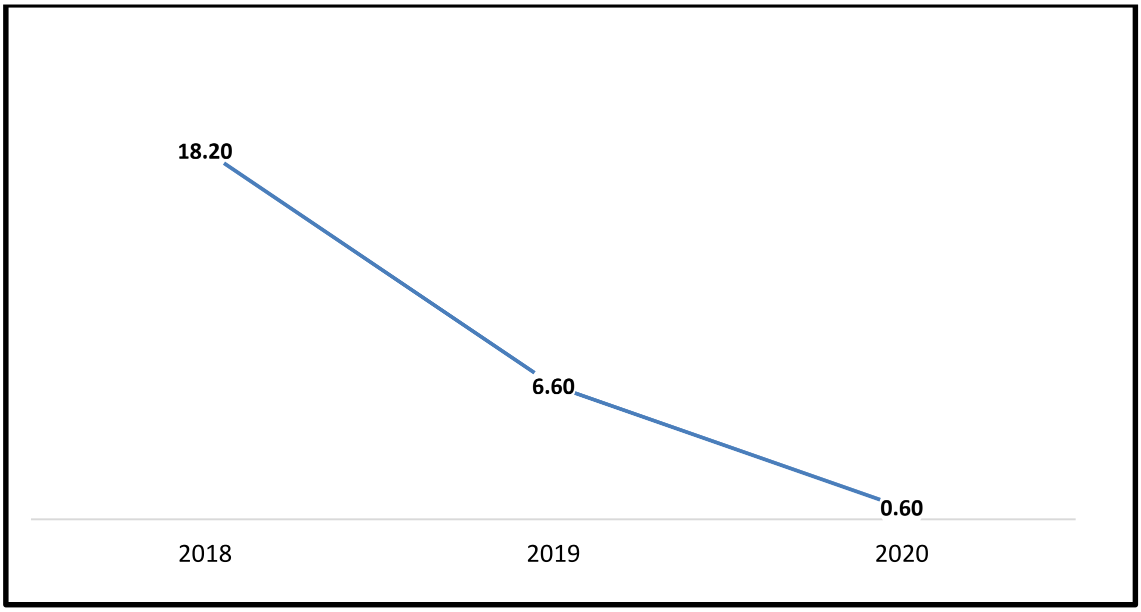
The study involved 1,157 patients who underwent surgical procedures between 2018 and 2020 at NNUH.

During the period of the study, the overall incidence of SSI in this study was 7.65%.

In 2018, the incidence was 18.2%, which dropped to 6.6% in 2019 and further to 0.6% in 2020, as illustrated in Figure 5, showing a consistent decline in incidence over the years.

Figure 5

Surgical site infection rate at NNUH 2018-2020



Among study participants, 675 (58.3%) were male, with an age of 50.2 years (SD 17.8). Regarding the sociodemographic and clinical characteristics of participants, 296 (25.9%) were current smokers, 54 (4.9%) had a history of trauma, and 490 (42.3%) had diabetes, while 31 (3.3%) were classified as normally healthy according to the ASA classification.

Additionally, 60 (5.3%) patients had malnutrition, while 83 (7.2%) were immunocompromised. Obesity was present in 103 (9.3%) of the participants, and prosthesis placement was reported in 75 (6.8%) of the study population. Table 4, summarizes the baseline characteristics of the study population.

Table 4

Sociodemographic and clinical characteristics of study participants. (N=1157)

Variable		n	%
Age group (years)			
	≤30	230	19.9
	31-50	292	25.2
	51-70	488	42.3
	≥71	147	12.4
Gender			
	Male	675	58.3
	Female	482	41.7
Malnutrition			
	Yes	60	5.3
	No	1074	94.7
	Missing	23	2.0
Obesity			
	Yes	103	9.3
	No	1010	90.7
	Missing	44	3.8
Diabetes Mellitus			
	Yes	490	42.3
	No	661	57.4
	Missing	6	0.5
ASA score			
	I: a patient in normal health	31	3.3
	II: Individual with a minor systemic illness	482	50.6
	III: A patient with severe systemic condition that is not incapacitating.	406	42.6
	IV: A patient with a life-threatening, incapacitating systemic condition	34	3.6
	Missing	204	17.6
Smoker			
	Yes	296	25.9
	No	849	74.1
	Missing	12	1.0
Immunocompromised			
	Yes	83	7.2
	No	1067	92.8
	Missing	7	0.6
Trauma			
	Yes	54	4.9
	No	1039	95.1
	Missed	64	5.5
Prosthesis placement			
	Yes	75	6.8
	No	1020	93.2
	Missed	62	5.4

The mean duration of the length of stay was 8.06 (11.9), and the most common type of surgery was programmed for 1096 (94.7%) patients, making up the majority of procedures performed.

Notably, 1,036 (90.8%) received antimicrobial prophylaxis within 24 hours after surgery, while patients with postoperative blood glucose control of less than 180 mg/dL had 92 % of cases.

Additionally, maintaining a temperature post-surgery between 35.5 °C and 36.5 °C also helps reduce the risk of infection, with a total of 93.3% fulfilling these criteria.

The most common surgical category was general surgery, accounting for 491 (42.5%) of all cases. These procedure-related characteristics of the patient are presented in Table 5.

Table 5

Procedure -related characteristics of the patients (N:1157)

Risk factor		n	%
Type of surgical procedure (Access)			
	Laparoscopic	168	15.1
	non-laparoscopic	944	84.9
	Missed	45	3.9
Type of surgery			
	Emergency	61	5.3
	Programmed	1096	94.7
	Missed	2	0.2
Duration of procedure			
	<2 hours	498	43.0
	≥2 hours	659	57.0
Surgical wound classification			
	Clean	963	90.87
	Clean-contaminated	80	7.5
	Contaminated	18	1.7
	Missed	96	8.3
Antimicrobial prophylaxis within24 after surgery			
	Yes	1036	90.8
	No	105	9.2
	Missed	16	1.4
Postoperative blood glucose control			
	Yes	1016	92.0
	No	88	8.0
	Missed	53	4.6
Temperature post-surgery			
	Yes	1030	93.3
	No	74	6.7
	Missed	53	4.6
Surgical category			
	General surgery	491	42.4
	Cardiac surgery	244	21.1
	Orthopedic surgery	228	19.7
	Vascular surgery	193	16.7

Overall, there were (90) 7.65% cases of SSI identified in this study.

SSI was more prevalent in male than in female (8.9% vs. 6.2%). Contaminated wounds had the highest rate of SSIs 44.4%, followed by clean-contaminated 18.8% and clean 6.9% wounds ($p<0.001$).

SSIs were more prevalent in non-laparoscopic surgeries ($p < 0.02$), longer-duration procedures ($p < 0.001$), and patients with prothesis implantation ($p = 0.03$).

Among those with an ASA index of IV or higher, the incidence of SSIs was 14.7% (p<0.001). All characteristics are shown in Table 6 and Table 7.

Table 6

Intrinsic and extrinsic factors distribution of the study population per SSI (n = 1157)

Variable		SSI		
		Yes	No	P-value
Gender				
	Male	60 (8.9%)	615(91.1%)	0.095
	Female	30 (6.2%)	452(93.8%)	
Age				
	≤30	28 (12.2%)	202(87.8%)	
	31-50	15 (5.1) %	277(94.9%)	
	51-70	33(6.8%)	455(93.2%)	0.019
	≥71	14(10.2%)	133(91.1%)	
Malnutrition				
	Yes	3(5%)	57(95%)	0.29*
	No	86(8%)	988(92%)	
Obesity				
	Yes	9(8.7%)	94(91.3%)	0.77
	No	80(7.9%)	930(92.1%)	
Diabetes Mellitus				
	Yes	35(7.1%)	455(92.9%)	0.46
	No	55(8.3%)	606(91.7%)	
ASA score				
	I: a patient in normal health	2(6.5%)	29(93.5%)	
	II: Individual with a minor systemic illness	21(4.4%)	461(95.6)	
	III: A patient with severe systemic condition that is not incapacitating.	37(9.1%)	369(90.9%)	0.01
	IV: A patient with a life-threatening, incapacitating systemic condition	5(14.7%)	29(85.3%)	
Smoker				
	Yes	24(8.1%)	272(91.9%)	0.85
	No	66(7.8%)	783(92.2%)	
Immunocompromised				
	Yes	2(2.4%)	81(97.6%)	0.056
	No	88(8.2%)	979(91.8%)	
Remote site infections				
	Yes	2(11.8%)	15(88.2%)	0.53
	No	87(7.7%)	1044(92.3%)	

Table 7

Producer-risk factor distribution of the study population per SSI (n = 1157)

Prosthesis placement				
	Yes	11(14.7%)	64(85.3%)	0.03
	No	79(7.7%)	941(92.3%)	
Type of surgical procedure (Access)				
	Laparoscopic	6(3.6%)	162(96.4%)	0.020
	non-laparoscopic	84(8.9%)	860(91.1%)	
Type of surgery				
	Emergency	6(9.8%)	55(90.2%)	0.53
	Programmed	84(7.7%)	1012(92.3%)	
Duration of procedure				
	<2 hours	26(5.2%)	472(94.8%)	<0.001
	≥2 hours	64(9.7%)	595(90.3%)	
Surgical wound classification				
	Clean	66(6.9%)	897(93.1%)	
	Clean-contaminated	15(18.8%)	65(81.3%)	<0.001
	Contaminated	8(44.4%)	10(55.6%)	
Antimicrobial prophylaxis within24 after surgery				
	Yes	61(5.9%)	975(94.1%)	<0.001
	No	28(26.7%)	77(73.3%)	
Postoperative blood glucose control				
	Yes	70(6.9%)	946(93.1%)	<0.001
	No	19(21.6%)	69(78.4%)	
Temperature post-surgery				
	Yes	70(6.8%)	960(93.2%)	<0.001
	No	19(25.7%)	55(74.3%)	
Surgical category				
	General surgery	35(7.1%)	456(92.9%)	
	Cardiac surgery	29(11.9%)	215(88.1%)	0.08
	Orthopedic surgery	16(7%)	212(93%)	
	Vascular surgery	10(5.2%)	183(94.8%)	

SSI: Surgical site infection. P-value: Chi-square test. *P-value: Fisher's exact test

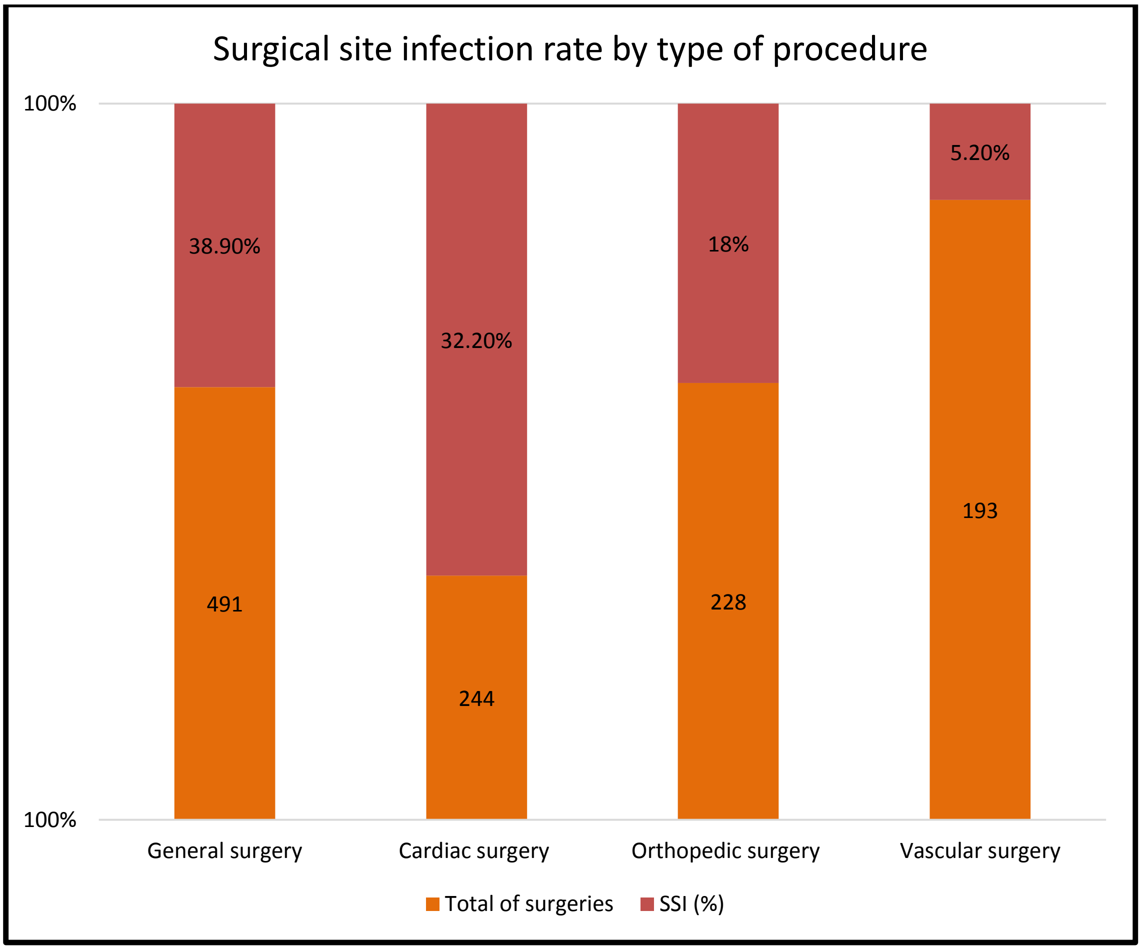
SSIs incidence rates by type of surgery, among cardiac surgery 11.9% had SSI, general surgery 7.1% had SSI, while among orthopedic surgery 7%, and vascular surgery 5.2% had SSI.

General surgery was the most prevalent surgery performed during the period of the study, with total number of general surgeries is 491, of which 15 (44.1%) had superficial SSIs, while 17 (47.2%) had deep SSIs.

Cardiac surgery accounting for a total of 244 surgeries, with 8 (23.5%) having superficial SSIs, 10 (27.2%) having deep SSIs, and none having organ SSIs. Orthopedic surgery had a total of 228 surgeries, with 8 (23.5%) having superficial SSIs, 4 (11.1%) having deep SSIs, and one (100%) having organ/space SSIs. The vascular surgery as well as general surgery both did not present any case with SSI involving deep organs. In fact, out of 193 surgeries, only 3 (8.8%) were reported as superficial SSIs and 5 (13.9%) had deep SSIs. as illustrated in Figure 6

Figure 6

The incidence of SSIs. The number of surgeries and surgical site infections (SSIs) for each category are shown in the bar chart



Overall, the data shows that cardiac surgery had the highest percentage of deep SSIs compared to orthopedic and vascular surgery Table 8.

Table 8

Incidence of SSI based on the surgical type of infection

Surgical site infection rate by surgical type of infection			
Surgical procedure (n)	Type of infection		
	SIP	DIP	Organ
General surgery (491)	15(44.1%)	17(47.2%)	0(0.0%)
Cardiac surgery (244)	8(23.5%)	10(27.8%)	0(0.0%)
Orthopedic surgery (228)	8(23.5%)	4(11.1%)	1(100%)

A total of 77 pathogens were isolated. The most common organism found based on tissue and/or wound cultures was *Klebsiella pneumoniae*, followed closely by *Acinetobacter baumannii* and *Escherichia coli.*, as presented in Table 9.

Table 9

Most common pathogen total N: 77

Most common pathogen total N:77		
Type of micro-organism	No. specimens	Percentage
Staphylococcus epidermidis	11	14.3%
Klebsiella pneumoniae	14	18.2%
Acinetobacter baumannii	12	15.6%
Pseudomonas aeruginosa	3	3.9%
Escherichia coli	11	14.3%
Staphylococcus warneri	1	1.3%
Enterococcus faecium	6	7.8%
pseudomonas putida	1	1.3%
Enterococcus faecalis	4	5.2%
Enterococcus avium	1	1.3%
Methicillin-resistant staphylococcus aureus (MRSA)	1	1.3%
Staphylococcus aureus	5	6.5%
Enterobacter cloacae complex	1	1.3%
Bacteroides fragilis	1	1.3%
Candida albicans	1	1.3%
Citrobacter	1	1.3%
Pseudomonas stutzeri	1	1.3%
Citrobacter freundii	1	1.3%
Stenotrophomonas	1	1.3%

The overall mortality rate among all patients was approximately 16 (11.38%). However, among patients who developed surgical site infections (SSIs), the mortality rate was significantly lower at 3 (0.25%). Further analysis is necessary to identify the specific causes of death and any potential patterns. It is important to closely examine the patient index for those who experienced mortality with SSIs to uncover common factors that may have contributed to their outcomes. This information will be valuable for informing future treatment strategies and interventions aimed at improving patient outcomes.

A binary logistic regression was performed to assess potential variables that predict the occurrence of SSI among our patients.

The variables included in the model were the following, based on previous research and clinical expertise: smoking status, immunosuppression, RSI, duration of the procedure, presence of a prosthesis, wound classification, post-operative glucose levels, post-operative temperature, days of stay (DOSS), wound site, significant post-operative symptoms, and type of infection.

The model explained 68.5% (Nagelkerke R^2) of the variance in SSI and correctly classified 92.5 % of the cases.

3.2 Odds ratios for significant variables

The odds ratios provide detailed information about the impact of different variables on the likelihood of developing SSI.

Based on the logistic regression performed, surgeries with longer durations (2 hours or more) are approximately 17 times more likely to result in an SSI ($p<0.001$), patients with a prosthesis are 9 times more likely to develop SSI compared with those who do not have a prothesis or implant ($p = 0.002$), and contaminated wounds are 23 times more likely to lead to an infection ($p = 0.005$).

Moreover, each additional day a patient stays in the hospital increases the odds of developing an SSI by 4.6%.

While the effect size is smaller compared to other variables, it indicates a cumulative risk. All mentioned variables were statistically significant, as shown in Table 10.

Table 10

Multivariate analysis of risk factors associated with surgical site infection

Variables	OR	95%CI	P value
Duration of procedure (< 2hours*)			
≥2hours	17.71	3.71- 124.01	<0.001
Prothesis (No*)			
Yes	9.15	2.12 – 37.33	0.002
Wound classification (Clean wound*)			
Contaminated wound	22.91	2.44 – 214.17	0.005
Days of stay (in days)	1.046	1.02 - 1.07	<0.001

OR= Odds Ratio; 95%CI= Confidence interval 95%; p value significant at 0.05; (*) = Reference category

Chapter Four

Discussion of Results

4.1 Discussion

This study looked at the occurrence of SSI in 1,157 patients admitted to a major referral teaching hospital in the North of the West Bank between 2018 and 2020 and explored the factors linked to it.

We found that 7.65% of patients (90 individuals) developed an SSI during this period. Fortunately, the rate has been declining over the years, mainly due to the implementation of a strong surveillance program using the CDC methodology and enforcement of all evidence-based infection and prevention elements suggested by the WHO program.

Those results are therefore reflecting a better management of risk factors leading to SSI in our health setting, impacting positively patient outcomes and the quality of healthcare provided. It is important to highlight that the incidence rate in our institution, although high at baseline assessment 18%, has significantly dropped over the years and is even better than the reported in the region, such as in Saudi Arabia, where the incidence was of 12% in 2016. (79) The 7.8% is even similar to those reported in studies performed in high income countries (23).

It's also important to mention that the period of study include pandemic (COVID-19), the pandemic has underscored the importance of stringent infection control measures and careful monitoring of surgical patients to minimize the risk of SSIs. A study conducted at 2023 to evaluated how the COVID-19 pandemic affected surgical site infections (SSIs) in several surgical specialties, data collected by American College of Surgeons National Surgical Quality Improvement Program. Researchers compared two cohorts, Cohort A (pre-pandemic, N = 24,060) and Cohort B (pandemic, N = 3,698), using data from the American College of Surgeons National Surgical Quality Improvement Program from January 1, 2015, to April 1, 2021. With rates of 2.8% in Cohort B against 4.5% in Cohort A, the findings showed a decrease in the overall incidence of SSI during the pandemic ($p < 0.001$). Prior to the pandemic, multivariable analysis revealed a declining trend in SSIs, which continued to decline by 39% at the start of the epidemic (80).

The study concludes that although overall SSI incidence decreased, the most noticeable effect was seen in general surgical patients, indicating a positive influence of enhanced infection control measures, known as the "COVID bundle," on SSI rates. Notably, SSI rates trended downward significantly in general surgical patients at the beginning of the pandemic (80).

Our findings also showed that patients over the age of 70 year were more likely to develop SSIs. Many of these individuals had underlying health conditions like diabetes or other co-morbid diseases, which can weaken the immune system and make them more susceptible to infections. This trend aligns with previous research, such as the studies conducted by Owens et al. (81) and Bharatnur et al. (82) ,which also found that older age groups—particularly those between 36 and 50—had a higher risk of SSIs compared to the younger individuals.

In our study, we found that males had a higher rate of SSIs 8.9% compared to females 6.2%, though this difference wasn’t statistically significant. This mirrors findings from a 2005 study in Peru, where Hernandez et al. also reported that men experienced more SSIs 65.6% (83). Also, the results from the German National Nosocomial Infections Surveillance System that analyzed more than 438,050 surgical procedures showed that there are gender differences in the occurrence of SSI, as males were more prone to have a weaker immune system, to have skin colonization, more comorbidities, and even present higher infection rates after certain surgeries (84,85).

Obesity is a significant risk factor for developing SSIs, as highlighted by numerous studies. The increased risk is largely attributed to greater tissue trauma, impaired wound healing, and the presence of other health issues, such as diabetes, that are common in obese patients (50, 81). In our study, 9 of the 90 patients with SSIs 8.7% were obese, while the majority 7.9% were not. This may be due to the fact that more non-obese patients underwent surgeries, and it’s worth noting that BMI data was missing for about 44 patients, which is a limitation of our findings. Research from the Dutch national surveillance network PREZIES indicates that the risk of SSIs rises steadily as BMI increases, from normal weight to morbid obesity. This underscores the need to pay closer attention to SSI risks in overweight and obese individuals and highlights the importance of addressing obesity at the community level (86).

Patients with comorbidities exhibit an elevated risk of SSIs relative to those without such conditions. Diabetes mellitus, although a known risk factor for the development of SSI as it interferes with wound healing and weakens immunity was not identified as such in our study. This contrasts with a study by Mohan et al. from Trichy, Tamil Nadu, India, which reported a higher rate of SSIs among diabetics, approaching 50% (87).

Similarly, currently smoking was not found to be statistically significant in our study. In fact, 26.7% of smokers developed SSIs, which is a considerable proportion but this wasn't statistically significant. This contrasts with other research that has clearly shown smoking as a major risk factor for infections. For example, a study by Sorensen et al. (88) found that smokers were 2-3 times more likely to develop wound infections, while Hawn et al. also reported a much higher infection rate among smokers compared to non-smokers (89).

The difference between our findings and those studies could be due to several factors, like the smaller sample size or the fact that other risk factors, like the patient’s overall health or the type of surgery, may have played a bigger role in our cases.

Despite the fact that our results have not shown a statistically significant association with the increased risk of developing SSI, both factors are still recognized by most available research as plausible risk factors and therefore are elements included in our surveillance system.

Patients with a higher ASA index were found to have a greater incidence of SSIs, which was statistically significant. Several studies have identified the ASA index as a significant risk factor for these infections, likely due to the fact that elevated ASA scores reflect an increased severity of systemic disease and comorbidities, potentially impairing immune response and wound healing (58,90).

In our study, 1,157 patients underwent a variety of surgeries. Among them, 38.9% (491 patients) had general procedures like appendectomies, hernia repair, and exploratory laparotomies. Orthopedic surgeries, such as open reduction and internal fixation (ORIF) and hip or knee replacements, were performed on 228 patients, with 17.8% of those developing SSIs. Additionally, 193 patients 11.1% had vascular surgeries, and (244) 32.2% underwent cardiac procedures.

When looking at abdominal surgeries, our study also echoes findings from a systematic review and meta-analysis, which showed that SSI rates are higher in low- and middle-income countries—23.2% and 14%, respectively—compared to 9.4% in high-income countries. These surgeries tend to have higher infection rates overall, with reported rates ranging from 3.0% to 58.2%, highlighting the importance of improving infection prevention in these procedures across different healthcare settings (91). A recent study in India shows that abdominal surgery has the highest SSI rates among all surgical procedures (92).

Patients who have cardiac surgery are especially vulnerable to SSI and hospital infections, which lead to extra procedures and higher expenses for the hospital. The mortality rate from these causes can exceed 25%, while SSI rates can range from 3.5% to 21%. Longer operating times, invasive procedures like sternotomies, and common patient comorbidities like diabetes and obesity are all variables that raise the risk of SSIs following cardiac surgery (93).

These findings are consistent with other researches. For instance, a 2019 study published in 2015 by Andrew J. et al. found that orthopedic surgeries, particularly joint replacements, have a higher risk of SSIs. Factors like the use of implants, longer surgeries, and underlying health conditions in patients all contribute to this increased risk (94). Similarly, a study by Maksimović et al. conducted at the teaching hospital in Belgrade in 2007 found that orthopedic procedures were more frequently associated with SSIs, especially when prosthetic devices were involved (95).

We looked at 1,096 elective procedures and 61 emergency procedures, finding that (84) 7.1% of the elective surgeries and (6) 3.6% of the emergency surgeries resulted in SSIs. While the analysis showed that the risk of SSIs from emergency surgeries was not statistically significant ($p = 0.53$).

If SSIs are higher in elective surgeries compared to emergency procedures, several factors may explain this. Elective surgery numbers in our settings are relatively low compared to the programmed ones, which may have affected the results. Besides, they often involve more complex procedures and longer operation times, increasing infection risk. Additionally, patients undergoing elective surgeries may have underlying health issues that are less common in emergency cases. The surgical techniques used can also differ, and elective patients typically spend more time in the hospital, potentially increasing exposure to infections. These factors underscore the need for tailored infection prevention strategies for both types of surgeries.

When comparing laparoscopic and open surgeries, open procedures showed a higher risk of SSIs, which was found in our study to be statistically significant. This aligns with previous research. Laparoscopic surgery often involves less exposure to the external environment, reduced immune system impact, the use of carbon dioxide pneumoperitoneum, and better visibility for dissection and hemostasis, all of which may contribute to a lower occurrence of SSIs (67, 68).

When moving from clean to dirty wound operations, a trend toward increased rates of postoperative SSIs was seen. (52,53,70) However, the postoperative SSI rate at our study for the clean, clean/contaminated, and contaminated wound classes was 6.9%, 18.8%, 44.44 respectively which consistent with other studies. According to a 2019 systematic review and meta-analysis, SSI was much more common in clean and clean-contaminated procedures across a wide range of developing-nation countries. In every country examined, the prevalence of SSI in elective clean and clean-contaminated procedures was 6% (95% CI 5–7%) (96).

In fact, in our study, we found that longer surgeries (> 2 hours) were linked to a higher incidence of SSIs. A Brazilian study from 2017 reported that the risk of developing an SSI increased by 34% for each additional hour of surgery after the first hour. (97) Similar patterns have been observed in developed countries like France (90) and Italy. (98) Cheng et al. provided insights, as mentioned before, into why this might be the case, explaining that extended surgical times expose wounds to the environment for longer, which raises the risk of infection. Additionally, longer procedures can lead to dryness around incisions, and the effectiveness of prophylactic antibiotics may diminish over time, especially if the dose isn’t repeated. All of these factors together contribute to a greater risk of SSIs (71).

Additionally, managing postoperative blood glucose levels and temperature is crucial for further reducing the risk of SSIs. Our data showed a strong relationship between these factors and the development of infections, with 19 cases 21.6% of SSIs linked to poor management of blood glucose; the results were statistically significant ($p<0.001$) (52).

On the other hand, antimicrobial prophylaxis played a significant role in reducing the incidence of SSIs, with 28 cases 26.7% recorded. However, unnecessarily prolonged use of antibiotics can lead to issues like superinfections (such as Clostridium difficile), increased antimicrobial resistance, longer hospital stays, and higher medical costs (7).

Hence, targeted antimicrobial prophylaxis can play a key role in reducing the incidence of SSIs while avoiding the risks associated with unnecessary prolonged antibiotic use, such as superinfections and antimicrobial resistance. It is also important to focus on managing postoperative blood glucose levels and temperature, as these factors have a strong connection to the development of infections. In our institution, all mentioned parameters are within the protocol of SSI prevention and control and are managed according to WHO recommendations. Besides, the implementation of the antibiotic stewardship program in the hospital since 2020 is also contributing to the follow up of the antibiotic prophylaxis during and after the surgical procedures performed.

The microbiological analysis of infected tissues and/or wounds revealed that S*taphylococcus aureus*, *Klebsiella pneumoniae*, and *Escherichia coli* were the most common pathogens, which aligns with findings from similar studies that point to the significance of superficial infections (75). *Acinetobacter baumannii* also stood out as the second most prevalent microorganism at NNUH hospital, raising concerns given that our setting is a tertiary referral hospital in a region where multidrug-resistant organisms (MDROs) are common (99).

The International Wound Journal article by Rose A. Cooper et al. emphasizes the microbiological and epidemiological components of SSIs in orthopedic and trauma surgery (100). It could have, however, covered opportunistic fungi implicated in SSIs in greater detail (100). The incidence of fungal surgical site infections (SSIs) in intensive care units is 4/1000 admissions, according to data from Kasturba Hospital in Manipal, Karnataka. Common pathogens include Candida albicans, Candida tropicalis, Candida glabrata, and Rhodotorula glutinis, while environmental molds include Aspergillus flavus and Fusarium solani (100).

While bacterial infections dominate, Candida infections should also be considered, particularly in immunocompromised patients, as these fungi can readily colonize and invade when the skin barrier is impaired (101). The article also discusses how treatment choices are made more difficult by the evolution of azole resistance in Candida species, namely as a result of C. glabrata's altered ERG11 gene. It might be required to use alternative treatments such liposomal amphotericin B. Additionally, prosthetic devices are at danger because to Candida species' capacity to produce biofilms (101).

The logistic regression results showed a clear connection between higher risks SSIs and factors like longer procedures (over two hours), contaminated wounds, the use of prostheses, and longer hospital stays. Each of these factors significantly increases the chance of developing an infection, reinforcing what other studies have also found. This emphasizes the importance of addressing these risks during surgery and focusing on reducing hospital stays after surgery to help lower the chance of infections in our patients.

This situation emphasizes the need for continues enforcement of effective infection control protocols and focused antimicrobial treatments, as research shows that mismanagement of these pathogens can lead to increased complications and longer hospital stays. Continuous monitoring of antimicrobial resistance is crucial for shaping effective treatment strategies and ensuring patient safety.

To sum up, this study provides valuable insights into SSIs at a major referral teaching hospital in the north of the West Bank. With an SSI rate of 7.65% that is gradually declining, we see encouraging progress in patient outcomes. However, the higher incidence among older patients and those with underlying health issues highlights the need for careful monitoring and targeted interventions.

The common presence of *Staphylococcus aureus, Klebsiella pneumoniae*, and *Escherichia coli*, along with *Acinetobacter baumannii*, emphasizes the importance of effective antimicrobial stewardship and robust infection prevention measures. Moving forward, prioritizing improved surgical techniques and patient health management will be essential for further reducing SSI rates and enhancing patient safety.

4.2 Strengths and limitations of the study

This study does have some limitations. It was conducted at a single center and focused only on adult patients, meaning pediatric cases weren't included. The retrospective design led to some missing data from medical records, which could influence the overall findings. Additionally, the lack of a structured antibiotic stewardship program during the study period may have affected the observed rates of SSIs.

Nevertheless, this research sheds light on SSI rates and their associated risk factors for adult patients in our hospital. Given the scarcity of similar studies in our country, these findings add important knowledge to the field at both the national and regional levels. By honing in on the local context, this study lays the groundwork for future research and potential improvements in infection control practices.

4.3 Conclusions

The prevalence of SSI among adult patients who underwent surgeries at NNUH was 7.65%. SSIs were more common in general surgeries. Patients who have prothesis placement, have a high ASA index (2 or 3), are not controlled in glucose or temperature after surgery, have a duration of antibiotic prophylaxis of more than 24 hours, have a longer surgical duration of more than two hours, and have a clean wound classification are at higher risk of developing SSIs after surgery. The most common organism encountered as SSI was Klebsiella pneumoniae, followed by Acinetobacter.

Strict adherence to infection control protocols and additional precautions for high-risk patients are necessary to avoid infections. To thoroughly investigate the risk factors, pathogens, complications, and outcomes of SSIs, long-durational cohorts should be carried out.

4.4 Recommendations

To effectively tackle SSIs , it's essential to embrace a multi-faceted approach that aligns with the CDC's recommendations for surveillance and prevention.

First, reinforce the robust SSI surveillance system in place that will help identify trends and risk factors specific to our patient population. This data can guide tailored interventions in our institution.

Improving preoperative assessments is vital, especially for patients with higher ASA scores or existing comorbidities. Proper management of glucose levels and body temperature can greatly lower the risk of infections. Moreover, minimizing surgical duration and following established antibiotic prophylaxis protocols can also help reduce SSIs. Achieving these goals requires collaboration among surgeons and surgical staff throughout all phases of care—preoperative, intraoperative, and postoperative—ensuring that patient care aligns with the latest scientific research.

Education plays a key role; healthcare staff should receive regular training on infection prevention measures and the importance of maintaining sterile techniques during surgeries.

Finally, fostering a culture of safety that encourages open communication about infection control practices among all team members can lead to better outcomes for our patients.

By prioritizing these recommendations, we can work towards reducing SSI rates and improving overall surgical outcomes, making a meaningful difference in patient care.

List of Abbreviations

Abbreviation	Meaning
ASA	American Society of Anesthesiologists physical status.
BMI	Body Mass Index.
CAUTI	Catheter-associated urinary tract infection.
CDC	Center for Disease Control and Prevention.
DIP	Deep incisional SSI.
HAI	Healthcare-associated infection.
INICC	The International Nosocomial Infection Control Consortium.
IRB	Institutional Review Board.
LIC	Low-Income Countries.
LMICS	Low-Middle-Income Countries.
MRSA	Methicillin-resistant Staphylococcus aureus
NHSN	National Healthcare Safety Network.
NNIS	The National Nosocomial Infection Surveillance
NNUH	An-Najah National University Hospital.
RSI	Remote site infection.
SD	Standard deviation.
SENIC	Study on the Efficacy of Nosocomial Infection Control.
SIP	Superficial incisional SSI.
SPSS	Statistical Package for Social Sciences.
SSI	Surgical Site Infections.
VAP	Ventilator-associated pneumonia.
WHO	World Health Organization

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Appendices

Appendix A

Institutional Review Board (IRB) approval

An-Najah National University
Faculty of Medicine & Health Sciences
Institutional Review Board

جامعة النجاح الوطنية
كلية الطب وعلوم الصحة
لجنة اخلاقيات البحث العلمي

Ref: Mas. April. 2022/11

IRB Approval Letter

Title of Research:

Epidemiology, Characteristics, and Risk Factors of Surgical Site Infections in a tertiary care hospital in West Bank2018 -2020

Submitted by :
Rawan Jeetawi

Supervisor:
Souad Belkebir

Approved:
19th April, 2022

Your Study Title "**Epidemiology, Characteristics, and Risk Factors of Surgical Site Infections in a tertiary care hospital in West Bank2018 -2020**" reviewed by An-Najah National University IRB committee and was approved on 19th April, 2022.

Hasan Fitian, MD
IRB Committee Chairman

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Appendix B

Case report form of surgical producer denominator's, prevention of surgical site infection and surgical site infection.

www.INICC.org
Comunidad Científica Internacional de Control de Infecciones Nosocomiales

Case Report Form of Surgical Procedure Denominators, Prevention of Surgical Site Infections, and Surgical Site Infections

Patient Data

Hospital:	
Initials	
Medical record	
Date of admission	/ /
Date of readmission	/ /
Date of Surgical Procedure	/ /

Patient Characteristics

Date of birth	/ /
Age	
Sex	M ( ), F ( )
Weight	Kg
Height	Meters

Patient's Risk Factors

Malnutrition	Yes ( ), No ( )
Obesity	Yes ( ), No ( )
Diabetes	Yes ( ), No ( )
ASA Score	1 ( ), 2 ( ), 3 ( ), 4 ( ), 5 ( )
Smoker	Yes ( ), No ( )
Immunocompromised	Yes ( ), No ( )
Remote site infection	Yes ( ), No ( )

Surgical Procedure

Type of Surgical Procedure	Yes ( ), No ( )
Time of beginning of the surgical procedure	
Time of end of the surgical procedure	
Name of Surgical Procedure	

Risk factors for the surgical procedure

Trauma	Yes ( ), No ( )
Prosthesis placement	Yes ( ), No ( )

Type of surgery: Emergency ( ); Programmed ( )
Surgical Wound Classification:
Clean ( ), Clean Cont ( ), Cont ( ), Dirty ( )
Surgeon's name: ______________________________

Antimicrobial prophylaxis

Drug used for antimicrobial prophylaxis	
Dose administered (mg)	
Time of drug administration	

SSI Prevention

		With?
Preoperative bath	Yes ( ), No ( )	
Preoperative shaving	Yes ( ), No ( )	
Preoperative skin preparation	Yes ( ), No ( )	
Antimicrobial prophylaxis interrupted within 24 hours after surgery (48 hours only for cardiac surgery)	Yes ( ), No ( )	
Postoperative glucose control management on days 1 and 2 after surgery (11,11 mmol / L- 200 mg / dL)	Yes ( ), No ( )	
Postoperative maintence of normothermia (36, 1- 37, 1)	Yes ( ), No ( )	

Surgical Site Infection

Presence of SSI	Yes ( ), No ( )
Date of surgical site infection	
Type of surgical site infection	
Microorganism	

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Case Report Form of Surgical Procedure Denominators, Prevention of Surgical Site Infections, and Surgical Site Infections

Patient Discharge

Date of discharge	/ /
Date of discharge in readmission	/ /

Condition at hospital discharge	Alive ( ), Dead ( )

Antibiogram

	S or R
Amikacin	
Amoxicillin/Clavulanic	
Ampicillin	
Ampicillin/sulbactam	
Amphotericin B	
Aztreonam	
Caspofungin	
Cefepime	
Cefazolin	
Cefoperazone	
Cefoxitin	
Cefotaxime	
Ceftazidime	
Ceftriaxone	
Cefuroxime	
Ciprofloxacin	
Clindamycin	

Colistin	
Daptomycin	
Doripenem	
Echinocandin	
Erythromicin	
Ertapenem	
Fluconazole	
Flucytosine (5-FC)	
Gentamicin	
Imipenem	
Itraconazole	
Levofloxacin	
Linezolid	
Meropenem	
Methicilin	
Metronidazole	
Minocycline	
Moxifloxacin	

Mupirocin	
Nitrofurantoin	
Norfloxacin	
Ofloxacin	
Oxacillin	
Penicillin G	
Piperacillin	
Piperacilin-Tazobactam	
Posaconazole	
Polymyxin B	
Quinupristin/dalfopristin	
Rifampicin	
Teicoplanin	
Tigecycline	
Trimethoprim/sulfamethoxazole	
Vancomycin	
Voriconazole	

جامعة النجاح الوطنية

كلية الدراسات العليا

الانتشار الوبائي، مواصفات وخصائص والعوامل المؤدية لالتهابات وعدوى الموضع الجراحي في مستشفى الرعاية الثالثية في الضفة الغربية : دراسة بأثر رجعي

إِعداد

روان خليل موسى جيتاوي

إشراف

د. سعاد بلكبير

قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في مكافحة وضبط العدوى، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس – فلسطين.

2024

الانتشار الوبائي، مواصفات وخصائص والعوامل المؤدية لالتهابات وعدوى الموضع الجراحي في مستشفى الرعاية الثالثية في الضفة الغربية : دراسة بأثر رجعي

إِعداد
روان خليل موسى جيتاوي
إشراف
د. سعاد بلكبير

الملخص

خلفية البحث: تعد التهابات الموقع الجراحي (SSIs) من المضاعفات الكبيرة بعد الجراحة، مما يؤثر على تعافي المريض وزيادة تكاليف الرعاية الصحية. يمكن أن تؤدي الالتهابات الجراحية إلى دخول المستشفى لفترة طويلة، ونفقات طبية باهظة، وحتى الموت. يعد تحديد عوامل الخطر وتنفيذ استراتيجيات الوقاية الفعالة أمرًا ضـــروريًا لتحسين سلامة المرضى. إن حدوث مثبطات مباحث أمن الدولة أعلى بشكل ملحوظ في الدول الناميـــة، حيـــث يتراوح من 2.5% إلى 41.9%. ومع ذلك، فإن البيانات الواردة من فلسطين نادرة. تهدف هذه الدراســـة إلـــى تحديد نسبة حدوث SSI بين المرضى في مستشفى النجاح الوطني الجامعي من عـــام 2018 إلـــى عـــام 2020 وتحديد عوامل الخطر المرتبطة بها.

منهجية البحث: شملت هذه الدراسة التحليلية بأثر رجعي 1157 مريضًا خضعوا لعملية جراحيـــة بـــين ينـــاير 2018 وديسمبر 2020 في مستشفى النجاح الوطني الجامعي. تم جمع وتحليل البيانات الاجتماعية والديموغرافية والسريرية باستخدام الأساليب الوصفية والتحليلية، بما في ذلك الانحدار اللوجستي الثنائي لتقييم عوامل الخطـــر المحتملة. تم تطبيق مستوى أهمية قدره 5%، وتم استخدام برنامج التحليل الاحصـــائي الإصـــدار 21 لتحليـــل البيانات.

النتائج: وجدت الدراسة معدل حدوث SSI إجماليًا قدره 7.65% بين 1,157 مريضًا جراحيًا. انخفض المعـــدل من 18.2% في عام 2018 إلى 6.6% في عام 2019، ثم إلى 0.6% في عام 2020. وقد لوحظت معـــدلات أعلى لـــ التهاب الموقع الجراحي في المرضى الذين يخضعون لزراعة الأطراف الاصـــطناعية، والإجـــراءات

الجراحية الأطول، والعمليات الجراحية غير بالمنظار ($P \geq 0.05$). بالإضافة إلى ذلك، كان المرضى الذين لديهم مؤشر ASA IV أو أعلى لديهم خطر متزايد بشكل ملحوظ ($P < 0.001$). أشار الانحدار اللوجستي إلى أن العمليات الجراحية التي استمرت لأكثر من ساعتين كانت أكثر احتمالية أن تؤدي إلى مباحث أمن الدولة بحوالي 17 مرة ($P < 0.001$)، في حين أن أولئك الذين لديهم غرسات اصطناعية كانوا أكثر عرضة بتسعة مرات ($P = 0.002$). زادت الجروح الملوثة من خطر العدوى بنسبة 23 مرة (ع = 0.005)، وكل يوم إضافي في المستشفى رفع احتمالات التهاب الموقع الجراحي بنسبة 4.6٪ (ع <0.001).

الاستنتاجات: يؤكد برنامج مراقبة التهاب الموقع الجراحي في مستشفى النجاح الوطني الجامعي على أهمية تقليل مدة الجراحة، وإدارة نسبة الجلوكوز في الدم ودرجة الحرارة بعد الجراحة، والالتزام بسياسات مكافحة العدوى للحد من حدوث التهابات الجرح. هناك حاجة إلى مزيد من البحث لتقييم فعالية هذه الاستراتيجيات عبر البيئات الجراحية المتنوعة والتركيبة السكانية للمرضى.

الكلمات المفتاحية: التهابات الموقع الجراحي، عوامل الخطر، العدوى المرتبطة بالرعاية الصحية (HAIs)، الجراحة النظيفة