Exploratory Research and Hypothesis in Medicine **2023** vol. 000(000) | 000–000 Epub
DOI: 10.14218/ERHM.2023.00010

Review Article

Surgical Site Infections: Prevalence, Economic Burden, and New Preventive Recommendations

Gülseren Maraş and Yeliz Sürme*

Faculty of Health Sciences, Department of Surgery Nursing, Erciyes University, Kayseri, Turkey

Received: January 02, 2023 | **Revised:** February 01, 2023 | **Accepted:** March 27, 2023 | **Published online:** April 24, 2023

Abstract

Surgical site infections are the most common and significant epidemiological burden worldwide. Despite implementing modern surgical techniques, appropriate antibiotic prophylaxis, sterilization techniques, and aseptic and antiseptic practices, surgical site infections continue to pose a significant challenge. As a result, patients who experience these infections may require increased antibiotic use, extended hospital stays, and higher treatment costs. This is particularly concerning given that such infections are largely preventable. The financial and social burden imposed by the costs of surgical site infections remains a significant problem for many countries. Evidence-based preventive practices should be integrated into the preoperative, intraoperative, and postoperative periods to prevent these infections. It is estimated that approximately half of all surgical site infections can be prevented by applying evidence-based practices.

Introduction

Healthcare-associated infections (HAIs) are among the most common worldwide adverse events affecting patient safety. Surgical site infections (SSIs), also known as surgical wound infections, occur in the incision site, deep tissues, organs, or cavities within 30 to 90 days following a surgical procedure or as a result of surgical intervention.[1] The World Health Organization (WHO) states that surgical site infections are the most commonly investigated and observed type of HAI in low- and middle-income countries and affect one-third of patients who undergo surgical procedures. SSIs are the second most frequently reported complication among HAIs worldwide.[2] Although preventable as HAIs, SSIs continue to pose a considerable global problem, impacting patient morbidity and mortality, healthcare systems, and additional costs.[3]

Various risk factors are associated with SSIs before, during, and after surgery. According to the Centers for Disease Control and Prevention (CDC) 2018 guidelines, SSI risk factors vary depending on the patient, the surgery, and pre-, intra-, and postoperative processes. Patient-related risk factors include age, chronic diseases such as diabetes, nutrition, smoking, steroid and immunosuppressive drug use, other skin diseases in the patient, infections outside the surgical area, prolonged hospitalization, and perioperative blood transfusion. Preoperative risk factors include antiseptic bath/shower, hair removal, management of infected or colonized personnel, wound classification, nasal decolonization, and antimicrobial prophylaxis. Intra-operative risk factors are the architectural structure and ventilation of the operating room, environmental cleaning and disinfection, microbiological examination, sterilization of surgical instruments, flash sterilization of surgical instruments, surgical hand washing, skin preparation in the operating room, surgical clothing and drapes, asepsis and surgical technique, use of invasive equipment, operation time, suture materials, drains, maintaining normothermia, ensuring glycemic control, oxygenation and hemostasis. The risk factors for the postoperative period are the continuation of surgical dressing and wound care.[1]

The Asia Pacific Society of Infection Control (APSIC) emphasizes concise and practical recommendations to achieve high standards in perioperative practices in healthcare institutions. Preoperative, perioperative, and postoperative risk factors for the APSIC Guidelines for the prevention of SSI published in 2019 are given in Table 1.[4]

Bacterial infections are often responsible for the occurrence of surgical site infections. Bacterial infections are classified as gram-positive and gram-negative (such as spirochetes, rickettsia, chlamydia, and mycoplasma), and other microorganisms cause infections. Bacterial infections include streptococci and staphylococci, which are often gram-positive bacteria. 60–80% of isolated bacteria are gram-positive cocci. Then, respectively, staphylococci

Keywords: Surgical site infections; Economic burden; Evidence-based recommendations.

Abbreviations: ACS/SIS, American College of Surgeons/Surgical Infection Society; APSIC, The Asia Pacific Society of Infection Control; CDC, Centers for Disease Control and Prevention; FiO2, fraction of inspired oxygen; HAIs, healthcare-associated infections; JSSI, Japan Society for Surgical Infection; MRSA, Methicillin-resistant *Staphylococcus aureus*; NICE, National Institute for Health and Care Excellence; SSIs, surgical site infections; WHO, World Health Organization.

***Correspondence to:** Yeliz Sürme, Faculty of Health Sciences, Department of Surgery Nursing, Erciyes University, Turkey. ORCID: https://orcid.org/0000-0002-0851-0254. Tel: 05532051130, Email:yelizcucuk@hotmail.com

How to cite this article: Maraş G, Sürme Y. Surgical Site Infections: Prevalence, Economic Burden, and New Preventive Recommendations. *Explor Res Hypothesis Med* 2023;000(000):000–000. doi: 10.14218/ERHM.2023.00010.

Table 1. APSIC preoperative, perioperative, and postoperative risk factors

Perioperative Risk Factors	Preoperative Risk Factors	Intraoperative Risk Factors	Postoperative Risk Factors
Procedure-related: Emergency and more complex surgery; Higher wound classification; Open surgery. Facility risk factors: Inadequate ventilation; Increased operation theatre traffic; Inappropriate/inadequate sterilization of instruments/equipment. Patient preparation-related: A pre-existing infection; Inadequate antiseptic skin preparation; Preoperative hair removal; Wrong antibiotic choice, administration, and/or duration.	Unmodifiable: Increasing age until age 65 years; Recent radiotherapy and history of skin or soft tissue infection. Modifiable: Uncontrolled diabetes; Obesity, malnutrition; Current smoking; Immunosuppression; Preoperative albumin <3.5 mg/dL; Total bilirubin >1.0 mg/d; Preoperative hospital stay of at least two days.	Long operating time; Blood transfusion; Asepsis and surgical technique; Hand/forearm antisepsis and gloving techniques; Hypoxia; Hypothermia; Poor glycaemic control.	Hyperglycaemia and diabetes; Postoperative wound care; Transfusion.

APSIC, The Asia Pacific Society of Infection Control.

(*Staphylococcus epidermidis* (*S.epidermidis*), *Staphylococcus aureus* (*S. aureus*)), and streptococci. *Escherichia coli* (*E. coli*) and *Klebsiella pneumoniae* (*K. pneumoniae*) are isolated in gram-negative bacteria. For microorganisms that cause surgical site infections and progression, the CDC has identified *S. aureus* as the most common organism. Apart from *S. aureus*, *E. coli*, Coagulase-Negative Staphylococci, *Pseudomonas aeruginosa* (*P. Aeruginosa*), *Enterecocus spp*., *Enterobacter spp*., and *K. pneumonia* have been noted as common infectious agents.[5] In a study examining the pathogens commonly responsible for the formation of SSIs, 26.16% *E.coli*, 20% *S. aureus,* and *K. pneumonia*, 13.33% *Proteus* and 6.66% *Pseudomonas* were found.[6] Another study reported that the infectious agents were 26.16% *E.coli*, 22.53% *Acinetobacter*, 14.63% *Staphylococcus*, 11.78% *Enterococcus*, 8.16% *Klebsiella*, 7.64% *Pseudomonas*, 1.68% *Candida,* 1.42% *Proteus* and 2.59% other microorganisms.[7]

In the study of Lakoh *et al.*, 49 isolates belonging to 14 different bacteria were detected, including 41 gram-negative (83.7%) and 8 gram-positive (16.3%) isolates.[8] Of these, 65.3% were Enterobacteriaceae, 18.4% were unfermented gram-negative bacilli, and 12.2% were Enterococci. The most common isolates were *E. coli* (12%), *K. pneumoniae* (10%), *Acinetobacter baumannii* (10.2%), *Klebsiella oxytoca* (4%), and *Enterococcus faecalis* (4%). Of the isolates belonging to the Enterobacteriaceae family, 4% were carbapenem-resistant, and 29% were extended-spectrum beta-lactamase-producing organisms.[8]

The prevalence of surgical site infections

Healthcare-associated infections are an important public health problem. High-income countries have a lower incidence of SSI; however, in Europe and the USA, SSI is the second most common type of HAI.[2] SSI is the most common healthcare-associated infection in low- and middle-income countries, and surgery can affect up to one-third of patients, according to WHO.[9] According to the National Health Service Associated Infections Surveillance Network 2017 data, the overall SSI rate in Türkiye is 0.72 %. Of the 617,745 HAI reported to the National Health Service Associated Infections Surveillance Network in 2017, 8,194 were associated with SSI. The fact that the SSI rate was >1.0 in 25 of the 60 types of surgeries followed in Türkiye in 2017 proves that SSI still maintains its importance.[10]

Allengeranzi and his colleagues reported in their cohort studies involving 4,322 surgical procedures that, based on a 30-day patient follow-up, 44.0% were classified as clean wounds, 48.5% as clean-contaminated, 6.1% as dirty, and 1.4% as either dirty or infected based on the surgical wound classification.[9] Zhou *et al.* conducted a meta-analysis in 2020, which detected 603 cases of SSI among 22,475 patients, with an incidence rate of 3.1%. Their findings indicate that superficial SSI occurred in 1.4% of patients, while deep SSI occurred in 1.7%.[11] In another meta-analysis, 2,326 articles covering 17 735 patients were reviewed, and the incidence of SSI was reported as 12.1%.[12]

The economic burden of surgical site infections

Surgical site infections are a significant economic burden globally, and with an estimated cost of US$20,785 per patient, they rank as the third most costly infection.[13] Surgical site infections are the most common HAI in low- and middle-income countries, affecting one-third of surgical patients. Europe and the USA rank second among regions with the highest incidence of healthcare-associated infections. SSI, which threatens the lives of millions of patients every year, leads to the development of antibiotic resistance. These infections are estimated to contribute an additional US$10 billion per year in costs in the United States, resulting in more than 400,000 extra days of hospitalization.[14]

Surgical site infections impose a significant economic burden due to various direct medical costs, including extended hospital stays, rehospitalization, use of medical resources, re-operation, intensive care unit stays, and surgical technique. These factors are also attributed to expenses for diagnostic tests, fees for qualified surgical teams, costs associated with surgical procedures, and expenditures for antibiotic prophylaxis and treatment. SSI-related indirect costs are estimated to be 2–11 times higher than for uninfected patients. The increase in morbidity and mortality risk, decrease in patients' quality of life, and financial losses caused by patients' inability to continue working are significant issues. It has been stated that the most crucial factor in the length of hospital stay for SSI is the type of surgery, especially prosthetic surgery, the age of the patient, and the number of comorbidities.[13] SSIs lead to more advanced surgical procedures and greater demand for critical postoperative care. As a result, SSIs impose a significant financial burden on surgical procedures and can negatively impact national health spending.[15]

The study of Behnke *et al.* determined that the prevalence of SSI ranks first among HAI, with a rate of 24.3%.[16] Another study shows that patients who develop SSI have a significantly more extended hospital stay with 16 additional days, resulting in higher case costs for institutions. According to the study, patients who developed SSI had a significantly more extended hospital stay (28 days) than those without SSI (12 days). In contrast, the intensive care unit admission rate was statistically significantly higher among patients with SSI, with 55.2% requiring admission, compared to 30.9% of patients without SSI. The SSI group had a statistically significantly higher mortality rate (9.3%) than the non-SSI group (4.5%). The incidences of sepsis (3.3% compared to 17.7%) and peritonitis (2.8% compared to 11.9%) were also significantly higher in the SSI group. Patients with SSI have significantly higher case costs than those without SSI, with reported costs of €9,040 and €19,008, respectively.[15] According to O'Hara *et al.*, patients with SSI have double the risk of mortality and a 60% higher likelihood of requiring intensive care.[17] They are five times more likely to be readmitted to the hospital than patients without SSI. SSIs are responsible for significant hospital overhead, and the average cost per infection ranges from about $5,000–13,000. The SSI accounts for US$3.5–10 billion in annual healthcare spending. The study suggests that with the appropriate implementation of evidence-based strategies, approximately 55% of SSIs can be prevented.[17]

Review of guidelines

Surgical site infections represent a significant challenge for healthcare providers worldwide, and their prevention is a top priority for the global healthcare community. Implementing evidence-based practices is critical in preventing SSIs, and multiple factors must be considered in this regard. While there may be some variations in the implementation of these practices depending on the healthcare facility or patient's condition, the basic features of the preventive measures remain largely similar. A comprehensive set of preventative measures must be integrated before, during, and after the surgical procedure to prevent SSIs effectively. Evidence suggests that nearly half of all SSIs are preventable by using evidence-based strategies.[18] To compare and contrast the various guidelines for SSI prevention, we analyzed the guidelines provided by CDC, the Japan Society for Surgical Infection (JSSI), the National Institute for Health and Care Excellence (NICE), the American College of Surgeons/Surgical Infection Society (ACS/SIS), and WHO.

Centers for Disease Control And Prevention (CDC)

In 2017, the Advisory Committee on Healthcare Infection Control Practices of the CDC released a guideline to prevent surgical site infections. Subsequently, an update was published in 2018 that provided further details on the recommended practices to be implemented. According to the updated guidelines, SSI prevention involves several measures during the preoperative phase, including glycemic control, normothermia, oxygenation, antiseptic prophylaxis, non-parenteral antimicrobial prophylaxis, and parenteral antimicrobial prophylaxis.[17]

Japan Society for Surgical Infection (JSSI)

JSSI has issued guidelines for preventing, detecting, and managing SSIs in gastroenterological surgery. The guidelines cover various aspects of SSI prevention, including the definition, epidemiology, and risk factors of SSIs, diagnostic criteria, surveillance and causal bacteria of SSIs, preoperative management, prophylactic antibiotics, intra-operative management, perioperative management, and wound management. In the preoperative stage, measures such as antibiotic prophylaxis, decolonization, evaluation of malnutrition, smoking, and alcohol cessation, management of steroid drugs, mechanical bowel preparation, skin antisepsis with Chlorhexidine gluconate, and hair removal are recommended. During the operation, steps include surgical hand-washing, skin antisepsis with Chlorhexidine gluconate, double gloves, antimicrobial coated sutures, wound-washing, changing dirty and contaminated instruments, and use of drains are emphasized. An early recovery program, carbohydrate loading, blood sugar monitoring, oral care, maintaining normothermia, oxygenation, and early oral and enteral feeding are recommended in perioperative management. Lastly, protective wound dressings and negative pressure wound treatment applications are recommended for wound management.[19]

National Institute for Health and Care Excellence (NICE)

NICE provides guidelines for preventing SSIs. In the preoperative phase, guidelines recommend preoperative showering, nasal decolonization, hair removal, appropriate patient and staff theatre wear, staff leaving the operating area, mechanical bowel preparation, and antibiotic prophylaxis. During the surgical procedure, hand decontamination, incise drapes, sterile gowns, gloves, antiseptic skin preparation, diathermy, maintaining patient homeostasis, wound irrigation, intracavity lavage, antiseptics, antibiotics before wound closure, closure methods, wound-dressings are emphasized. Postoperatively, the guidelines include changing dressings, postoperative cleansing, topical antimicrobial agents for wound healing by primary intention, dressings for wound healing by secondary intention, antibiotic treatment of surgical site infections and treatment failure, debridement, and specialist wound care services.[20]

American College of Surgeons/Surgical Infection Society (ACS/SIS)

ACS/SIS recommend several prehospital interventions, including preoperative bathing and showering, smoking cessation, glucose control, Methicillin-resistant *Staphylococcus aureus* (MRSA) prophylaxis, bowel preparations, and bundling prehospital and hospital interventions. In the hospital setting, interventions such as glucose control, hair removal, skin preparation, surgical hand scrub, surgical attire, prophylactic antibiotics, intraoperative normothermia, wound protectors, antibiotic sutures, glove and instrument wound change for closure, wound classification and closure, topical antibiotic therapy, perioperative supplemental oxygen, postoperative supplemental oxygen, wound management, and postoperative showering are recommended. Post-discharge interventions include wound care and surgical site infection surveillance.[21]

World Health Organization (WHO)

WHO has recently released recommendations for preventing SSIs during the preoperative, intraoperative, and postoperative periods. The preoperative phase involves several measures such as preoperative bathing, nasal decolonization, skin antisepsis using Chlorhexidine gluconate, screening for extended-spectrum beta-lactamase colonization, antibiotic prophylaxis, mechanical bowel preparation, hair removal, surgical site preparation, antimicrobial skin sealants, and surgical hand preparation. Additional measures during the preoperative and/or intra-operative period include enhanced nutritional support, perioperative discontinuation of immunosuppressive agents, perioperative oxygenation, maintaining normal body temperature (normothermia), using protocols for intensive perioperative blood glucose control, maintaining adequate circulating volume control/normovolemia, drapes, and gowns, wound protector devices, incisional wound irrigation, prophylactic negative pressure wound therapy, using surgical gloves, changing surgical instruments, antimicrobial-coated sutures, and laminar airflow ventilation systems in the context of operating room ventilation. Postoperative measures include surgical antibiotic prophylaxis prolongation, advanced dressings, antibiotic prophylaxis in the presence of a drain, and determining the optimal timing for wound drain removal.[22]

Comparison of guidelines

Glycemic control

Hyperglycemia is an undesirable condition that occurs among patients following surgery and trauma and is associated with infection and death rates in critically ill patients. It can adversely affect wound healing, immunity, and vascular function. For glycemic control, it is recommended that CDC blood glucose levels be <200 mg/dL, covering the perioperative period in patients with and without diabetes.[17] JSSI suggests a blood sugar level of less than 150 mg/dL. It recommends close monitoring of blood sugar against the risk of hypoglycemia.[19] NICE recommends targeting fasting plasma glucose levels of 5–7 mmol/liter in adults with type 1 diabetes and 5–8 mmol/liter during surgery or acute illness.[20] The ACS/SIS recommends a target blood glucose level of 110–150 mg/dL and less than 180 mg/dL for cardiovascular surgery.[21] WHO recommends 110–150 mg/dL or less than 150 mg/dL without a firm recommendation.[22]

Antibiotic prophylaxis

Antibiotic prophylaxis is an essential strategy in the prevention of SSI. The CDC recommends administering a single dose of an appropriate antimicrobial agent before incision for antibiotic prophylaxis. It is recommended to consider the administration of an additional dose without making any specific recommendations for the timing of additional dosing when the surgical duration exceeds two half-lives of the antimicrobial agent (*e.g.*, more than three hours for cefazolin) or in the event of significant blood loss (*i.e.*, >1,500 mL).[17] Despite limited evidence, JSSI recommends its administration within 60 minutes before surgical incision. It is stated that intraoperative administration of additional doses of prophylactic antibiotics reduces the incidence of SSI. However, no high-quality studies have been reported in this regard. In patients undergoing elective gastrectomy for gastric cancer, it is recommended to administer an additional intraoperative dose of antibiotics when the surgical duration exceeds three hours.[19] NICE recommends administering a single dose of intravenous antibiotic prophylaxis before prosthetic or implant surgeries, clean-contaminated surgeries, and contaminated surgeries during anesthesia. It is recommended to administer additional doses of antibiotics during surgeries where the surgical duration exceeds the half-life of the antibiotic.[20] ACS/SIS recommends administering prophylactic antibiotics within one hour before incision and two hours for vancomycin or fluoroquinolones. Similar to CDC recommendations, additional doses of prophylactic antibiotics can be administered during surgery to maintain sufficient tissue levels based on the half-life of the agent or every 1,500 mL estimated blood loss. WHO recommends administering antibiotics within 120 minutes before incision, considering the antibiotic's half-life. It has been emphasized that attention should be paid to the half-life when considering administering additional doses during prolonged surgeries.[22]

Normothermia

Hypothermia can lead to surgical site infection by causing vasoconstriction, tissue hypoxia, and neutrophil dysfunction. The CDC recommends the use of pre-warmed blankets or other warming devices.[17] JSSI, ACS/SIS, and WHO recommend maintaining normothermia during the intra-operative period to prevent SSIs by using methods of intra-operative warming.[19,21,22] According to NICE, it is recommended to assess the risk of hypothermia in patients, measure and monitor their temperature, and use devices to keep them warm before, during, and after surgery.[20]

Oxygenation

The occurrence of tissue hypoxia in the surgical incision area can lead to a delay in healing and an increased risk of SSI. A reduction or cessation of blood flow to the tissue can lead to decreased tissue oxygenation in the surgical area. The CDC strongly recommends the administration of an increased fraction of inspired oxygen (FiO2) during intra-operative and post-extubation periods for patients with a normal pulmonary function who undergo general anesthesia and endotracheal intubation.[17] JSSI and WHO suggest that high oxygen concentrations (%80 FiO2) during surgery and in the 2–6 hours following surgery in adult patients under general anesthesia with tracheal intubation may reduce the risk of SSI. However, due to the adverse effects, such as absorption atelectasis and oxygen toxicity, the indication for high FiO2 should be carefully evaluated.[19,22] To maintain optimal oxygenation during surgery, particularly during significant surgeries and recovery, NICE recommends providing patients with adequate oxygen to maintain a hemoglobin saturation of over 95%.[20] The ACS/SIS emphasizes the administration of additional oxygen (80% FiO2) during the intra-operative and postoperative periods for patients under general anesthesia.[21]

Skin preparation

A preoperative bath is essential in preparing patients for surgery to prevent SSI. It can be concluded that preoperative bathing may reduce the risk of developing SSI since it reduces the overall bacterial load on the skin before surgery. If it is not contraindicated, CDC recommends using an antiseptic solution containing alcohol for skin preparation during the intra-operative period.[17] According to JSSI, preoperative skin cleansing with chlorhexidine gluconate does not affect preventing SSI. According to reports, there is no difference between clipper hair removal, no hair removal, and depilatory lotion for SSI prevention.[19] ACS/SIS recommends using alcohol-based solutions for skin preparation to reduce the risk of SSI unless contraindicated. It has been stated that in the absence of alcohol preparations, chlorhexidine may be more effective than povidone-iodine. There is currently no unmistakable evidence regarding the effectiveness of chlorhexidine gluconate in preoperative bathing practices. There is no significant difference in SSI between taking a shower 12 hours after surgery and delayed showering (>48 hours after surgery).[21] According to NICE, it is recommended that patients take a shower or bath using soap the day before or on the day of surgery. It is stated that they can safely take a shower 48 hours after the surgery. It is not recommended to perform routine shaving for SSI prevention, and in critical situations, clippers are recommended.[20] WHO recommends not removing hair before surgical procedures or, if necessary, only removing it with surgical clippers. Shaving before surgery or in the operating room is not routinely recommended. It is recommended to use alcohol-based chlorhexidine gluconate for skin preparation before surgery.[22]

MRSA decolonization

According to the JSSI guideline, patients with nasal colonization of *S. aureus* may have a high incidence of SSIs. As a result, it is recommended to perform screening and decolonization procedures on nasal carriers before surgery rather than implementing routine applications.[19] NICE recommends the use of nasal mupirocin in situations where there is a potential risk of SSI.[20] ACS/SIS suggests avoiding the routine use of vancomycin prophylaxis and instead recommends MRSA screening and nasal mupirocin decolonization for positive patients and avoiding the routine use of vancomycin prophylaxis for negative patients.[21] The WHO recommends the perioperative use of 2% mupirocin in patients undergoing cardiac-thoracic and orthopedic surgeries who are known carriers of nasal *S. aureus*.[22]

Bowel preparation

The JSSI, ACS/SIS, and WHO guidelines share a common view that preoperative mechanical bowel cleansing alone is not effective in preventing SSIs. However, it is recommended to use mechanical bowel preparation with the addition of oral antibiotics, as it may be effective in preventing SSIs.[19,21,22] NICE does not recommend mechanical bowel preparation to prevent SSIs.[20]

Cigarette-alcohol

According to JSSI and ACS/SIS guidelines, preoperative use of tobacco and alcohol has been identified as a risk factor for SSI. It is recommended to quit alcohol before surgery and smoking at least one month prior.[19,21]

Hand-washing, changing tools, suture material, use of drains

According to JSSI, surgical hand scrubbing and rubbing exhibit the same effectiveness in SSI prevention, but it is recommended that they be performed appropriately. There is insufficient evidence regarding the effectiveness of adhesive drapes. Double-ring and other wound protectors are recommended for reducing SSIs in gastrointestinal system surgery. Double gloves are recommended to reduce surgical site infections, as they protect against perforation and decrease bacterial load in dirty and contaminated operations where instrument changes are required. Antibiotic-containing sutures and high-pressure wound irrigation are recommended to prevent surgical site infections, while drains are not recommended.[19] NICE recommends that the surgical team removes their jewelry and refrains from using artificial nails and nail polish before surgery. Washing hands with a disposable brush and an antiseptic solution is recommended. It is not recommended to use adhesive drapes. Double gloves are recommended for protection against perforation and contamination situations. It does not recommend wound irrigation for reducing SSIs. It is recommended to use triclosan sutures in incision closure and to prefer stitches instead of staples in skin closure.[20] ACS/SIS states that hand rubbing with chlorhexidine without water is as effective as water-based hand rubbing and requires less time. It has been reported that non-permeable plastic wound protectors effectively reduce SSIs in wound protection. Using sutures coated with triclosan is recommended for clean and clean-contaminated abdominal cases. It recommends the use of double gloves but notes that there is insufficient evidence regarding instrument exchange.[21] WHO recommends not using adhesive wound dressings, wound irrigation, negative pressure wound therapy, double gloves, and triclosan-coated sutures in clean and clean-contaminated abdominal cases, noting insufficient evidence on changing surgical instruments.[22]

Future direction

There are three main reasons why standard and digital care systems are necessary for future applications in preventing SSIs. First, SSIs are an unwanted condition that causes significant patient morbidity and mortality and a severe economic burden, accounting for approximately 20% of HAIs in the community. Second, healthcare systems use different systems for preventing and managing SSIs. Third, SSIs have many independent risk factors, and there are deficiencies in pre- and post-hospitalization monitoring of patients. A systematic and standard method needs to be developed to calculate the financial burden of SSIs. It is essential for healthcare workers to have adequate knowledge of evidence-based practices and guidelines and to provide leadership in preventing SSIs. Interprofessional and interdisciplinary teams should collaborate to integrate existing guidelines into clinical practice. The deficiencies in post-hospitalization practices for preventing SSIs need to be addressed. It is recommended that countries' SSI surveillance studies be managed using up-to-date technologies and mapping methods, particularly for the first 30 days after surgery.

Conclusion

Surgical site infections represent a significant worldwide public health challenge with medical, social, and economic implications. Preventing the development of SSIs is a crucial responsibility of healthcare organizations, and evidence-based guidelines can help reduce their incidence by up to 50%. Thus, it is imperative to identify risk factors and implement evidence-based interventions during the perioperative process. Healthcare providers must be familiar with evidence-based recommendations to ensure accurate and efficient SSI prevention and provide quality care. To ensure the safety of surgical patients, checklists based on guideline recommendations should be developed and implemented, and clinical compliance should be ensured. Policies to reduce the risk of SSIs should be established, and practices should conform to clinical standards based on evidence-based guidelines. In resource-limited settings, process improvement approaches should be utilized to demonstrate the cost-effectiveness of SSI prevention measures.

Acknowledgments

None.

Funding

The authors have no receipt of the financial support for the research, authorship, and/or publication of this article.

Conflict of interest

The authors have no conflict of interests related to this publication.

Author contributions

Study concept and design (GM), acquisition of data (GM), analysis and interpretation of data (GM), drafting of the manuscript (GM), critical revision of the manuscript for important intellectual content (GM, YS), and study supervision (GM, YS). All authors have contributed significantly to this study and approved the final manuscript.

References

[1] Borchardt RA, Tzizik D. Update on surgical site infections: The

new CDC guidelines. JAAPA 2018;31(4):52–54. doi:10.1097/01.JAA.0000531052.82007.42, PMID:30973535.

[2] Leaper DJ, Edmiston CE. World Health Organization: Global guidelines for the prevention of surgical site infection. J Hosp Infect 2017;95(2):135–136. doi:10.1016/j.jhin.2016.12.016, PMID:28139389.

[3] Bischoff P, Kubilay NZ, Allegranzi B, Egger M, Gastmeier P. Effect of laminar airflow ventilation on surgical site infections: a systematic review and meta-analysis. Lancet Infect Dis 2017;17(5):553–561. doi:10.1016/S1473-3099(17)30059-2, PMID:28216243.

[4] Ling ML, Apisarnthanarak A, Abbas A, Morikane K, Lee KY, Warrier A, *et al*. APSIC guidelines for the prevention of surgical site infections. Antimicrob Resist Infect Control 2019;8:174. doi:10.1186/s13756-019-0638-8, PMID:31749962.

[5] Çelik S. Current Applications in the Surgery nurse. Adana: Chocolate Nobel Medical Library; 2021:217–249.

[6] Bashir J, Sahito RA, Abbasi MA, Jabeen A. Surgical site infection: Evaluation of causative organisms involved. Prof Med J 2015;22(2):181–185. doi:10.29309/TPMJ/2015.22.02.1367.

[7] Aslaner H, Akıncı E, Ayşe BUT, Kanyılmaz D, Baştuğ A, Aypak A, *et al*. A third step evaluation of the effects of a surgical field detected in a hospital. Turkish Hyg Exp Biol J 2018;75(3):265–276. doi:10.5505/TurkHijyen.2018.77150.

[8] Lakoh S, Yi L, Sevalie S, Guo X, Adekanmbi O, Smalle IO, *et al*. Incidence and risk factors of surgical site infections and related antibiotic resistance in Freetown, Sierra Leone: a prospective cohort study. Antimicrob Resist Infect Control 2022;11(1):39. doi:10.1186/s13756-022-01078-y, PMID:35189952.

[9] Allegranzi B, Aiken AM, Zeynep Kubilay N, Nthumba P, Barasa J, Okumu G, *et al*. A multimodal infection control and patient safety intervention to reduce surgical site infections in Africa: a multicentre, before-after, cohort study. Lancet Infect Dis 2018;18(5):507–515. doi:10.1016/S1473-3099(18)30107-5, PMID:29519766.

[10] Bakanlığı S. National Health Services Relational Influences Swiss Network Special Report 2018. Available from: https://infline.saglik.gov.tr. Accessed April 15, 2023.

[11] Zhou J, Wang R, Huo X, Xiong W, Kang L, Xue Y. Incidence of Surgical Site Infection After Spine Surgery: A Systematic Review and Meta-analysis. Spine 2020;45(3):208–216. doi:10.1097/BRS.0000000000003218, PMID:31464972.

[12] Jalalzadeh H, Groenen H, Buis DR, Dreissen YE, Goosen JH, Ijpma FF, *et al*. Efficacy of different preoperative skin antiseptics on the incidence of surgical site infections: a systematic review, GRADE assessment, and network meta-analysis. Lancet Microbe 2022;3(10):e762–e771. doi:10.1016/S2666-5247(22)00187-2, PMID:35985350.

[13] Iskandar K, Sartelli M, Tabbal M, Ansaloni L, Baiocchi GL, Catena F, *et al*. Highlighting the gaps in quantifying the economic burden of surgical site infections associated with antimicrobial-resistant bacteria. World J Emerg Surg 2019;14:50. doi:10.1186/s13017-019-0266-x, PMID:31832084.

[14] World Health Organization. Preventing surgical site infections: implementation approaches for evidence-based recommendations. Avaible from: https://apps.who.int/iris/bitstream/handle/10665/273154/9789241514385-eng.pdf. Accessed April 15, 2023.

[15] Eckmann C, Kramer A, Assadian O, Flessa S, Huebner C, Michnacs K, *et al*. Clinical and economic burden of surgical site infections in inpatient care in Germany: A retrospective, cross-sectional analysis from 79 hospitals. PLoS One 2022;17(12):e0275970. doi:10.1371/journal.pone.0275970, PMID:36576894.

[16] Behnke M, Aghdassi SJ, Hansen S, Diaz LAP, Gastmeier P, Piening B. The Prevalence of Nosocomial Infection and Antibiotic Use in German Hospitals. Dtsch Arztebl Int 2017;114(50):851–857. doi:10.3238/arztebl.2017.0851, PMID:29271343.

[17] O'Hara LM, Thom KA, Preas MA. Update to the Centers for Disease Control and Prevention and the Healthcare Infection Control Practices Advisory Committee Guideline for the Prevention of Surgical Site Infection (2017): A summary, review, and strategies for implementation. Am J Infect Control 2018;46(6):602–609. doi:10.1016/j.ajic.2018.01.018, PMID:29525367.

[18] Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, *et al*. Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017. JAMA Surg 2017;152(8):784–791. doi:10.1001/jamasurg.2017.0904, PMID:28467526.

[19] Ohge H, Mayumi T, Haji S, Kitagawa Y, Kobayashi M, Kobayashi M, *et al*. The Japan Society for Surgical Infection: guidelines for the prevention, detection, and management of gastroenterological surgical site infection, 2018. Surg Today 2021;51(1):1–31. doi:10.1007/s00595-020-02181-6, PMID:33320283.

[20] Natioanl Insititute for Health and Care Excellence. Surgical site infections: prevention and treatment. Avaible from: https://www.nice.org.uk/guidance/ng125/resources/surgical-site-infections-prevention-and-treatment-pdf-66141660564421. Access April 15, 2023.

[21] Ban KA, Minei JP, Laronga C, Harbrecht BG, Jensen EH, Fry DE, *et al*. American College of Surgeons and Surgical Infection Society: Surgical Site Infection Guidelines, 2016 Update. J Am Coll Surg 2017;224(1):59–74. doi:10.1016/j.jamcollsurg.2016.10.029, PMID:27915053.

[22] World Health Organization. Global guidelines for the prevention of surgical site infection, 2nd ed. Avaible from: https://www.who.int/publications/i/item/global-guidelines-for-the-prevention-of-surgical-site-infection-2nd-ed. Accessed April 15, 2023.