International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
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+15878858911
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ARTICLE TITLE	PREVENTION OF SURGICAL SITE INFECTIONS: A COMPREHENSIVE REVIEW OF GUIDELINES AND SCIENTIFIC EVIDENCE (2017–2025)
DOI	https://doi.org/10.31435/ijitss.1(49).2026.4575
RECEIVED	23 November 2025
ACCEPTED	09 January 2026
PUBLISHED	16 January 2026
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PREVENTION OF SURGICAL SITE INFECTIONS: A COMPREHENSIVE REVIEW OF GUIDELINES AND SCIENTIFIC EVIDENCE (2017–2025)

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ABSTRACT

Surgical site infections (SSIs) remain one of the most significant challenges in modern medicine, representing a major cause of patient morbidity, prolonged hospitalization, and increased healthcare costs in medical institutions. This issue deserves particular attention due to the possibility of preventing adverse outcomes through the implementation of standardized, evidence-based preventive measures approved by international health authorities. This narrative review examines recommendations aimed at reducing the incidence of SSIs based on publications indexed in major scientific databases, along with guidelines issued by the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), European Centre for Disease Prevention and Control (ECDC), and the National Institute for Health and Care Excellence (NICE). The article focuses on perioperative recommendations, categorized as preoperative, intraoperative, and postoperative, while considering both the strength of evidence and areas of consistency or divergence among these guidelines. Researchers worldwide generally agree on the most essential preventive strategies, including proper timing of antimicrobial prophylaxis, the use of chlorhexidine-based antiseptics, maintenance of normothermia and glycemic control, and avoidance of unnecessary hair removal. However, differences persist in certain preventive components, such as the use of advanced wound dressings, intraoperative oxygen supplementation, and mechanical barriers, highlighting the need for further discussion and harmonization of global standards. The review emphasizes the importance of implementing these guidelines in clinical practice and identifies unresolved issues requiring additional research. Strengthening education among healthcare professionals and ensuring adherence to correct perioperative practices under expert supervision will undoubtedly contribute to improved surgical outcomes and reduced infection-related complications worldwide.

KEYWORDS

Surgical Site Infections, SSI Prevention, Clinical Guidelines, Perioperative Infection Control, Antimicrobial Prophylaxis, Evidence-Based Recommendations

CITATION

Jakub Tomasz Latos, Katarzyna Anna Kowalska, Franciszek Szweda, Tomasz Poczwardowski, Adrianna Kaczmarek, Marcin Chwalczuk, Olivia Grygorcewicz, Marta Koneczna, Karolina Alicja Krystyniak, Kinga Augustyniak, Klaudia Leszto, Natalia Smuniewska (2026) Prevention of Surgical Site Infections: A Comprehensive Review of Guidelines and Scientific Evidence (2017–2025). *International Journal of Innovative Technologies in Social Science*. 1(49). doi: 10.31435/ijitss.1(49).2026.4575

Introduction

Surgical site infections (SSIs) are among the most serious and common problems in hospital-based patient care. They often carry significant health consequences and postoperative complications for affected individuals. Statistics show that SSIs account for approximately 20–30% of all infections reported in surgical wards. In addition to the obvious discomfort experienced by patients, SSIs also present a growing challenge due to increasing treatment costs and the extended recovery time associated with additional medical interventions. Another important concern is the negative impact on antimicrobial stewardship, as pathogenic microorganisms involved in SSIs may contribute to the development of antibiotic resistance. All these factors collectively affect the quality of surgical treatment and patient safety worldwide, underscoring the ongoing importance of effective infection prevention and control strategies in modern healthcare. The risk of SSI is influenced by multiple patient-, procedure-, and system-related factors, making prevention a multidimensional process requiring standardized, evidence-based protocols. Recognizing the need for global harmonization of clinical practices, several major health organizations such as the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), European Centre for Disease Prevention and Control (ECDC) and the National Institute for Health and Care Excellence (NICE) have released updated sets of guidelines that outline best practices for reducing the incidence of SSI. These recommendations integrate current evidence, epidemiological data, and emerging challenges, including antibiotic resistance and postoperative care variations among countries. In the last decade, numerous updates have been introduced in the field of SSI prevention, reflecting the evolving understanding of perioperative physiology and infection control. Notable areas of emphasis include optimization of patient risk factors, improvements in antimicrobial prophylaxis timing, advancements in preoperative skin preparation, and enhanced strategies for maintaining normothermia, oxygenation, and glycemic stability during surgery. Despite these advancements, differences persist between guidelines regarding the strength of recommendations and the clinical usefulness of specific interventions, such as advanced dressings, mechanical barriers, or routine use of supplemental oxygen. Given the global importance of SSI and the diversity of recommendations available, comprehensive evaluation of existing guidelines is essential. A structured synthesis allows clinicians, policymakers, and hospital administrators to better understand areas of consensus, controversies, and gaps requiring further research.

The aim of this review is to summarize, compare, and critically analyze current guidelines for SSI prevention published between 2017 and 2025, with emphasis on evidence-based recommendations and their applicability in routine clinical practice. By identifying consistent practices and highlighting discrepancies, this review intends to support the development of standardized protocols and improve perioperative patient safety worldwide.

Materials and Methods

This article was developed as a narrative literature review aimed at summarizing and critically analyzing current recommendations and scientific evidence on the prevention of surgical site infections (SSI). The review focused on international guidelines and peer-reviewed studies published between January 2017 and October 2025, with particular attention to interventions applied in the preoperative, intraoperative, and postoperative phases of surgical care. The literature search was conducted using reputable medical and scientific databases, including PubMed, Scopus, ScienceDirect, Web of Science, and the Cochrane Library. Additionally, official documents and recommendations were sourced from international health authorities such as the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), European Centre for Disease Prevention and Control (ECDC), and the National Institute for Health and Care Excellence (NICE). The review included articles published in English, focused on adult surgical populations, and consisting of reviews, randomized controlled trials, meta-analyses, or clinical guidelines related to SSI prevention. Materials that were not peer-reviewed, including editorials, commentaries, letters to the editor, case reports, as well as studies involving pediatric or veterinary populations, were excluded. The selection of publications was based on their relevance to the research question and thematic alignment with infection prevention practices. Sources were grouped according to the stage of surgical care and type of intervention. Due to the narrative nature of the review, no quantitative synthesis or statistical analysis was performed. Instead, a descriptive and thematic analysis was used to identify patterns, consistencies, and discrepancies across the included guidelines and scientific publications.

Results

1. Identified Risk Factors for Surgical Site Infection

In the reviewed literature, a wide range of factors have been described as contributing to an

increased likelihood of surgical site infections. Across the publications and guidelines examined, these factors are commonly grouped into three main categories: patient-related, procedure-related, and environmental:

a) patient-related factors

Several sources including studies by Rezaei et al. (2025), Jin et al. (2025), and Meijs et al. (2019) describe advanced age (≥65), obesity (BMI >30), diabetes mellitus, smoking, immunosuppression (such as corticosteroid therapy or HIV infection), malnutrition (particularly hypoalbuminemia), and prolonged preoperative hospitalization as noteworthy contributors to SSI risk. For example, Jin et al. noted that patients with hypoalbuminemia exhibited a markedly higher likelihood of postoperative infection compared with individuals presenting normal serum albumin levels.

b) procedure-related factors

Factors related to the surgical procedure itself are also frequently discussed in the literature. These include extended operative duration (beyond 180 minutes), operations performed in contaminated or clean-contaminated fields (such as colorectal surgery), the use of open rather than minimally invasive techniques, inadequate methods of hair removal (e.g., shaving with razors), the use of drains or implants, and intraoperative hypothermia. Both the CDC (2017) and ECDC (2020) highlight these elements as potential contributors to microbial contamination and impaired wound healing.

c) environmental factors

Environmental aspects of the surgical setting are likewise described as influencing SSI risk. Various authors point to increased operating room traffic, suboptimal ventilation, improper sterilization or the use of dull instruments, as well as insufficient hand hygiene as conditions that may compromise intraoperative sterility. Rezaei et al. (2025) further observed that even appropriately sterilized instruments may become re-contaminated during the procedure due to exposure to the patient's skin flora or the surrounding environment.

2. Preoperative Skin Preparation and Decolonization

Across the reviewed literature, various preoperative strategies aimed at reducing the microbial burden on the skin are emphasized as important components of SSI prevention. Many sources describe routine preoperative cleansing with chlorhexidine-based solutions as more effective than iodine-based preparations in lowering bacterial counts and improving overall skin antisepsis. Studies in different surgical fields, including orthopedic, abdominal, and obstetric procedures, such as those by Mastrocola et al. (2021) [8], Hasegawa et al. (2022) [9], and Luwang et al. (2021) [11], describe favorable outcomes with chlorhexidine–alcohol formulations compared with povidone–iodine. Extended preoperative preparation with chlorhexidine-impregnated cloths is also discussed in several publications. Seidelman and Anderson (2021) [1] and the WHO guidelines (2018) [3] note that repeated applications of chlorhexidine in the days leading up to surgery can help reduce the microbial load on the skin prior to incision. Preoperative nasal decolonization protocols have also been widely addressed. Multiple studies report that intranasal mupirocin used twice daily, in combination with whole-body chlorhexidine cleansing, contributed to reduced Staphylococcus aureus colonization. Screening-based strategies targeting MRSA carriers, described by Gillespie et al. (2021) [4] and Almottowa et al. (2025) [30], are characterized as feasible and effective approaches in reducing preoperative MRSA carriage. Several sources also highlight the value of multimodal SSI-prevention bundles that integrate preoperative bathing, skin antisepsis, and decolonization. Publications by Lohsiriwat (2021) [24], Nouh et al. (2025) [23], and Cunha et al. (2025) [21] describe improved surgical outcomes when such bundled interventions are implemented compared with standard preoperative care.

a) Preoperative Hair Removal Practices

Preoperative hair removal practices have been widely discussed in the literature due to their potential influence on surgical site infection rates. Multiple sources have emphasized that the method of hair removal may significantly impact skin integrity and postoperative outcomes.

Tanner and Melen (2021) examined a range of randomized and quasi-randomized studies and observed that shaving with a razor was associated with a greater risk of infection compared to leaving the surgical site unshaved. In contrast, alternative methods such as clipping or the use of depilatory creams did not appear to increase the risk of SSI when compared to no hair removal. Omolabake et al. (2020), in a randomized controlled study conducted among patients undergoing clean surgical procedures, found that the use of clippers

was associated with a lower incidence of skin injury and postoperative infection when compared to traditional razor shaving. The authors also reported differences in hair removal effectiveness between the two techniques, although the clinical implications of this finding remain subject to further discussion. A more recent review by Aleid et al. (2023), focusing on multiple randomized trials, further reinforced concerns about razor shaving, which was consistently linked to higher infection rates. The findings supported the idea that avoiding hair removal altogether may be preferable in many cases, and when removal is necessary, clippers or depilatory creams may be safer alternatives.

b) Nutritional Optimization and Metabolic Conditioning

Numerous publications emphasize the importance of preoperative nutritional and metabolic optimization in reducing the risk of surgical site infections, particularly among malnourished or metabolically unstable patients. Several authors have described associations between targeted nutritional support and improved postoperative outcomes. Wang et al. (2025) [46] explored surgical outcomes in patients undergoing gastrointestinal cancer procedures and noted that malnourished individuals were more prone to postoperative infections compared to those who received nutritional support before surgery. Similarly, Jin et al. (2025) [43] identified low serum albumin as a risk factor for SSI in liver transplant patients, highlighting the benefits of preoperative nutritional correction in reducing infection rates. Glycemic control also emerged as a key theme in the reviewed studies. Lai et al. (2022) [54] discussed the implementation of structured blood glucose management protocols, suggesting that tighter control of perioperative glucose levels may be beneficial in minimizing infection risk. In addition to nutritional interventions, modifiable lifestyle-related risk factors such as smoking and obesity were frequently mentioned. Some studies, including those by Fuglestad et al. (2021) [37], recommended smoking cessation at least four weeks prior to surgery, citing improvements in immune function and tissue oxygenation. While not all publications provided quantitative SSI outcomes, there was general agreement regarding the clinical value of this intervention. Structured prehabilitation programs, which incorporate nutritional guidance, physical conditioning, and metabolic assessment, were also described as contributing to improved wound healing and reduced postoperative complications. Although the precise impact on SSI rates varied among studies, the overall evidence supports integrating such strategies into preoperative care, particularly for high risk patients.

c) Antimicrobial Prophylaxis: Timing, Dosing, and Antibiotic Selection

The appropriate use of antimicrobial prophylaxis is widely recognized in the literature as a fundamental element of surgical site infection (SSI) prevention. Numerous sources, including CDC and WHO guidelines ([2], [3]), emphasize that both the timing and selection of antibiotics play a key role in minimizing postoperative infection risk. Optimal timing of antibiotic administration is frequently discussed. Several guidelines recommend administering prophylactic antibiotics within a defined time window prior to surgical incision, depending on the pharmacokinetics of the chosen agent ([1], [35]). It is noted that deviations from this timeframe either premature or delayed administration may compromise the prophylactic effect ([29], [35]). Proper dosing is another consistently highlighted factor. According to CDC recommendations and other sources (e.g., Calderwood et al., 2023 [32]), weight-based and renal function–adjusted dosing is crucial, particularly for agents like cefazolin. The importance of intraoperative redosing in prolonged surgeries or those involving considerable blood loss is also a recurring theme in the literature ([1], [32], [35]). Antibiotic selection is typically guided by surgical site and likely pathogens. In most clean or clean contaminated procedures, cefazolin is the preferred agent due to its broad spectrum of activity, favorable pharmacologic profile, and cost-effectiveness ([39], [35]). For patients with β-lactam allergies or those with an elevated risk of MRSA, alternatives such as vancomycin or clindamycin are commonly recommended ([2], [3], [35]). Multiple publications further underline the importance of discontinuing antimicrobial prophylaxis within a limited postoperative period, typically within 24 hours, as extended use is not associated with better outcomes and may increase the risk of antimicrobial resistance or Clostridioides difficile infection ([2], [3], [29], [35]). Variability in adherence to prophylaxis protocols has been observed across institutions. However, facilities demonstrating high compliance with evidence-based guidelines have consistently reported improved infection prevention outcomes ([29], [32], [35]).

3. Intraoperative Strategies

a) General Intraoperative Approaches

The reviewed literature consistently describes intraoperative strategies aimed at reducing the incidence of surgical site infections (SSI) across various surgical disciplines. The most commonly mentioned measures include intraoperative skin antisepsis, surgical site irrigation, the use of wound protectors, antimicrobial sutures, and intraoperative monitoring of physiological parameters. Several sources highlighted the global need for implementing such practices (Mengistu et al., 2023 [38]).

b) Intraoperative Skin Antisepsis

Standard intraoperative antiseptic protocols most often involved the use of chlorhexidine in alcohol (CHG–alcohol) solutions applied immediately prior to skin incision. Comparative studies indicated superior bacterial reduction with CHG–alcohol compared to povidone–iodine, particularly in orthopedic and abdominal surgeries (Mastrocola et al., 2021 [8]; Hasegawa et al., 2022 [9]; Hsieh et al., 2025 [44]). Povidone–iodine was mainly used in patients with contraindications to CHG or in procedures involving mucous membranes.

c) Surgical Site Irrigation

Irrigation of the surgical field before wound closure was frequently reported in clean-contaminated and contaminated procedures. Aqueous povidone–iodine was the most commonly used agent. Antibiotic irrigation was described less frequently, with considerable variation in the type of agents used and application methods (Groenen et al., 2024 [5]; de Jonge et al., 2017 [6]; Thom et al., 2021 [7]).

d) Wound Protection Devices

Intra-abdominal procedures particularly colorectal, gastric, hepatobiliary, and gynecological

Surgeries commonly involved the use of wound protection devices, typically dual-ring plastic retractors. Their use was associated with reduced contamination of the operative field (Kang et al., 2018 [53]).

e) Antimicrobial Sutures

Triclosan-coated sutures were widely reported, particularly in abdominal and gynecologic surgeries. Numerous studies documented reduced bacterial adherence and a lower incidence of SSI compared to standard or uncoated sutures (Olmez et al., 2019 [12]; Uchino et al., 2018 [13]; Jalalzadeh et al., 2025 [15]; Matz et al., 2024 [58]).

f) Maintenance of Normothermia

Many studies described the use of intraoperative warming systems, including forced-air warming devices, warmed intravenous fluids, and thermal blankets. Core temperature monitoring was typically conducted via esophageal or tympanic probes (Chen et al., 2025 [47]).

g) Intraoperative Fluid Management

Numerous anesthesiology and surgical sources reported fluid management strategies based on stroke volume variation, pulse waveform analysis, or Doppler techniques. These approaches aimed to maintain hemodynamic stability and avoid fluid overload (Seidelman & Anderson, 2021 [1]; Almottowa et al., 2025 [30]).

h) Intraoperative Glucose Monitoring

In patients with diabetes or metabolic disorders, intraoperative glucose monitoring was routinely described, along with insulin protocols implemented when glucose levels exceeded institution defined thresholds (Lai et al., 2022 [54]).

i) Operating Room Environmental Factors

Many publications discussed the impact of environmental factors such as ventilation systems, door openings, and staff movement. Laminar airflow was frequently used in orthopedic and cardiac surgeries, though its effectiveness in SSI prevention remained inconclusive (Bao & Li, 2022 [59]; Sadrizadeh et al., 2021 [60]; Ouyang et al., 2023 [61]). Increased foot traffic in the operating room was associated with higher airborne contamination (Caous et al., 2025 [48]).

j) Draping and Surgical Attire

In high-risk procedures such as total joint arthroplasty, disposable nonwoven surgical drapes and gowns were commonly used. The use of adhesive incise drapes varied across institutions. Both single-use and reusable gowns were described, with all studies emphasizing the importance of strict adherence to sterile technique (WHO, 2018 [3]; CDC, 2017 [2]; Seidelman & Anderson, 2021 [1]).

k) Negative Pressure Wound Therapy (NPWT)

Prophylactic negative pressure wound therapy, applied intraoperatively or immediately after skin closure, was reported across various fields including abdominal, obstetric, and bariatric surgery. In obese women undergoing cesarean section, NPWT dressings were associated with reduced SSI rates (Hyldig et al.,

2019 [16]; Tuuli et al., 2020 [17]). Similar outcomes were reported in systematic reviews focusing on abdominal procedures (Gong et al., 2021 [18]; Polomska et al., 2025 [19]).

l) Topical Antibiotic Application

The intraoperative use of topical antibiotics, especially powdered vancomycin, was documented in cardiac and orthopedic surgery cohorts. Application of vancomycin powder to the surgical site was associated with a lower rate of deep wound infections compared to intravenous prophylaxis alone (Kowalewski et al., 2023 [50]). Some sources also described the use of povidone–iodine as a topical antiseptic prior to wound closure, though SSI outcomes were not consistently reported (Monstrey et al., 2023 [51]).

m) Intraoperative Dressing and Wound Management

Several studies compared intraoperative dressings applied at the time of surgical closure. The Bluebelle feasibility study evaluated three types of dressings in abdominal surgery, focusing on wound appearance, material characteristics, and 30-day SSI outcomes (Reeves et al., 2019 [20]). Some publications described protocolized dressing approaches based on wound classification, while others noted variability across institutions. Postoperative wound monitoring and early infection detection strategies were also discussed in relation to remote monitoring tools and standardized scoring systems.

4. Postoperative Strategies

a) Wound Dressing Application and Postoperative Wound Protection

Numerous sources described the application of standard sterile dressings immediately after surgery, with subsequent changes according to institutional protocols. Comparative studies explored the use of advanced dressings, including silver-impregnated, iodine-based, hydrofiber, hydrocolloid, and silicone-coated materials; however, conventional sterile dressings remained the most commonly reported across surgical disciplines (Wormald et al., 2023 [52]). Negative-pressure wound therapy (NPWT) was consistently highlighted in high-risk populations, such as obese patients undergoing cesarean section and individuals undergoing abdominal or vascular procedures. Multiple randomized trials and meta-analyses reported lower SSI rates with NPWT use in these groups (Hyldig et al., 2019 [16]; Tuuli et al., 2020 [17]; Gong et al., 2021 [18]; Polomska et al., 2025 [19]).

b) Early Postoperative Glycemic Monitoring

Postoperative glucose surveillance was frequently mentioned in the context of care for patients with diabetes or metabolic disorders. Regular monitoring intervals (typically every 4–6 hours during the first 24–72 hours postoperatively) were described, with insulin therapy implemented via intravenous or subcutaneous regimens according to institutional protocols. A meta-analysis by Jiang et al. (2021 [1]) confirmed that intensive perioperative glucose control was associated with a significant reduction in postoperative complications, including SSIs, particularly in diabetic patients. In obstetric surgery, structured glycemic monitoring was integrated into perioperative care bundles, contributing to a reduction in wound infections following cesarean delivery (Erritty et al., 2022 [2]).

c) Postoperative Oxygenation Strategies

Oxygen supplementation in the immediate postoperative phase was commonly administered

through nasal cannula, face masks, or high-flow systems. Continuous oxygen saturation monitoring was described as standard, especially following major abdominal and cardiothoracic surgery. A 2023 systematic review by Kuh et al. concluded that the use of a high fraction of inspired oxygen ($FiO_2 \geq 80\%$) during and after surgery significantly reduced SSI incidence in abdominal procedures. The findings support high FiO_2 delivery as part of perioperative infection prevention bundles, particularly in clean-contaminated surgical settings (Kuh et al., 2023 [3]).

d) Drain Management Practices

Drain use and management were discussed across general, orthopedic, and spinal surgery contexts. Prolonged antibiotic prophylaxis was generally not indicated solely due to the presence of a drain. Removal timing varied by procedure but typically followed clinical indicators such as drainage volume and fluid characteristics. A review by Epstein & Agulnick (2025 [42]) found that subfascial drains used in spinal surgery did not increase SSI risk and may help reduce hematoma-related complications when carefully monitored.

e) Post-Discharge Surveillance

Post-discharge SSI surveillance has increasingly incorporated digital tools between 2019 and 2025. Mobile health (mHealth) platforms, patient-submitted wound images, structured symptom questionnaires, and virtual follow-ups were commonly reported. Macefield et al. (2023 [25]) demonstrated the clinical value of remote wound monitoring in identifying early infection signs and improving outcomes through timely responses. Similarly, Dalcól et al. (2024 [26]) reported improved detection rates and patient engagement using mHealth tools. Advanced informatics approaches were also explored. Quéroué et al. (2019 [57]) presented an

EHR based algorithm for automatic SSI detection, while Agostinho et al. (2025 [63]) proposed a hybrid machine learning and rule-based model to support scalable, real-time infection monitoring beyond hospital discharge.

f) Postoperative Wound Cleaning and Hygiene

Postoperative wound care protocols often included sterile saline cleaning after dressing removal (typically after 24–48 hours). Patient showering was permitted once the wound was sealed. The use of antiseptics was limited to situations involving early contamination signs or wound exudate (Cunha et al., 2025 [21]).

g) Additional Postoperative Care Practices

Enhanced Recovery After Surgery (ERAS) protocols were widely adopted across specialties, incorporating early ambulation, thromboprophylaxis, optimal pain control, and nutritional supplementation. These components were associated with improved wound healing and reduced complications. Integration of these measures into SSI prevention bundles was observed particularly in colorectal and obstetric surgery (Erritty et al., 2023 [22]; Nouh et al., 2025 [23]; Lohsiriwat, 2021 [24]).

Discussion

This narrative review presents a synthesis of current literature from 2017 to 2025 concerning the prevention of surgical site infections (SSIs) through a range of preoperative, intraoperative, and postoperative strategies. The findings support a multidimensional approach, emphasizing that SSI prevention is most effective when based on the integration of evidence-based practices and patient centered care. Recommendations provided by global health authorities including the CDC, WHO, ECDC, and NICE highlight the growing importance of bundled strategies that address risk factors across the entire perioperative continuum (Berríos Torres et al., 2017 [2]; WHO, 2018 [3]; ECDC, 2025 [34]).

a) Risk Factors for SSI

The literature consistently confirms that both modifiable and non-modifiable factors contribute significantly to the development of SSIs. Patient-related variables such as advanced age, diabetes mellitus, obesity, immunosuppression, smoking, and hypoalbuminemia were repeatedly associated with higher SSI incidence (Meijs et al., 2019 [55]; Jin et al., 2025 [43]; Fuglestad et al., 2021 [37]). In particular, malnutrition and metabolic instability were emphasized as critical in gastrointestinal and transplant surgery settings (Wang et al., 2025 [46]). Procedure-related factors including prolonged operative time, contaminated surgical fields, drain placement, and intraoperative hypothermia were also identified as increasing infection risk (Maemoto et al., 2023 [56]; Chen et al., 2025 [47]). In addition, the quality of the operating room environment, ventilation systems, and personnel movement were cited in systematic reviews as important external contributors to SSI risk (Sadrizadeh et al., 2021 [60]; Caous et al., 2025 [48]). A global estimate of SSI incidence remains high, with a pooled rate of 11.6%, indicating a persistent burden and the need for more consistent prevention strategies (Mengistu et al., 2023 [38]).

b) Preoperative Strategies

Chlorhexidine-alcohol (CHG–alcohol) was found to be the most effective antiseptic for preoperative skin preparation, outperforming povidone–iodine in a variety of surgical specialties (Mastrocola et al., 2021 [8]; Hasegawa et al., 2022 [9]; Hsieh et al., 2025 [44]). The application of CHG over multiple days prior to surgery was further supported by WHO guidelines and clinical data (WHO, 2018 [3]; Seidelman & Anderson, 2021 [1]). Preoperative nasal decolonization using mupirocin, combined with whole-body cleansing using CHG, was especially beneficial for patients colonized with MRSA (Gillespie et al., 2021 [4]; Almottowa et al., 2025 [30]). Combined interventions particularly those integrated into structured SSI prevention bundles were more effective than isolated practices in reducing postoperative infections in high risk surgeries (Lohsiriwat, 2021 [24]; Nouh et al., 2025 [23]; Cunha et al., 2025 [21]). Nutritional and metabolic optimization were central to successful SSI prevention. Hypoalbuminemia and malnutrition were recognized as strong predictors of postoperative infection, and their correction preoperatively was associated with a 30–35% reduction in SSI rates (Wang et al., 2025 [46]). Glycemic control was similarly impactful, with a 33% SSI risk reduction in patients undergoing intensive glucose monitoring and management (Lai et al., 2022 [54]). Antimicrobial prophylaxis remained a fundamental practice. Adherence to guideline-recommended timing administration within 60 minutes of incision, or within 120 minutes for longer infusions was associated with improved outcomes (Calderwood et al., 2023 [32]; Berríos Torres et al., 2017 [2]). Dosing based on body weight, particularly cefazolin 2–3 g depending on weight, and intraoperative redosing were identified as critical factors in reducing infection rates (Eckmann et al., 2024 [39]; Zukowska & Zukowski, 2022 [35]). Prolonged antibiotic use beyond 24 hours was consistently discouraged (Barros dos Santos et al., 2024 [29]).

c) Intraoperative Strategies

Intraoperative infection prevention strategies included CHG–alcohol antisepsis, wound irrigation (commonly with aqueous povidone–iodine), and use of antimicrobial sutures (Groenen et al., 2024 [5]; Uchino et al., 2018 [13]; Jalalzadeh et al., 2025 [15]). Triclosan-coated sutures were particularly effective in reducing SSI risk in abdominal and general surgeries (Kouzu et al., 2024 [33]; Matz et al., 2024 [58]). Negative-pressure wound therapy (NPWT) was found to be effective when applied intraoperatively or immediately after closure, especially in high-risk groups such as obese patients undergoing cesarean delivery or abdominal surgery (Hyldig et al., 2019 [16]; Tuuli et al., 2020 [17]; Gong et al., 2021 [18]; Polomska et al., 2025 [19]). The application of topical antibiotics, especially intrawound vancomycin, demonstrated benefits in cardiac and orthopedic surgeries, with reduced incidence of deep sternal wound infections (Kowalewski et al., 2023 [50]). However, the use of povidone–iodine in this context yielded mixed results (Monstrey et al., 2023 [51]). Environmental interventions, including reduced staff movement and improved ventilation, were widely emphasized, although the benefits of laminar airflow in orthopedic surgery remain inconclusive (Ouyang et al., 2023 [61]; Caous et al., 2025 [48]; Bao & Li, 2022 [59]).

d) Postoperative Strategies

Postoperative wound care was dominated by the use of standard sterile dressings, though several studies also evaluated advanced dressing materials (Wormald et al., 2023 [52]). NPWT was commonly extended into the postoperative period, continuing to demonstrate favorable outcomes. Glycemic control continued to play a central role in the postoperative phase, particularly in diabetic and obstetric populations, where structured surveillance protocols contributed to improved wound healing (Jiang et al., 2021 [45]; Erritty et al., 2023 [22]). The role of high-concentration oxygen delivery ($FiO_2 \geq 80\%$) in the immediate postoperative phase was highlighted in several randomized studies, particularly in abdominal surgery, where it contributed to reduced SSI risk (Kuh et al., 2023 [3]). Management of surgical drains varied by specialty, but there was consensus that prophylactic antibiotics should not be extended solely due to their use. In spinal surgery, drains did not increase SSI risk and were potentially beneficial for hematoma prevention (Epstein & Agulnick, 2025 [42]). A major development in postoperative infection control involved the implementation of digital surveillance systems. Remote tools such as mobile apps, wound photography, structured questionnaires, and machine learning algorithms demonstrated high utility in early SSI detection and patient follow-up (Macefield et al., 2023 [25]; Dalcól et al., 2024 [26]; Quéroué et al., 2019 [57]; Agostinho et al., 2025 [63]). These tools represent an evolution in postoperative care, extending SSI surveillance beyond the hospital and supporting patient-centered recovery.

e) Implications, Strengths, and Limitations

This review reinforces the importance of comprehensive, stage-specific strategies for SSI prevention. The synthesis of international guidelines and peer-reviewed studies allows clinicians and healthcare institutions to align perioperative practices with current evidence and global recommendations. Emphasizing consistency in antimicrobial prophylaxis, preoperative decolonization, intraoperative asepsis, and digital postoperative surveillance may lead to measurable improvements in patient safety and healthcare efficiency.

A key strength of this narrative review lies in its broad scope, incorporating multidisciplinary perspectives from surgery, anesthesiology, infectious disease, and public health. The inclusion of guidelines from leading authorities (CDC, WHO, ECDC, NICE) and a wide range of clinical studies published between 2017 and 2025 ensures both relevance and depth of analysis.

However, the narrative nature of this review introduces certain limitations. Unlike systematic reviews or meta-analyses, no quantitative synthesis or statistical evaluation of outcomes was performed. Variability in study design, surgical populations, and SSI definitions may have influenced the interpretation of results. Furthermore, only English-language publications were included, potentially omitting relevant findings from non-English sources. Despite these limitations, this review provides a valuable overview of contemporary SSI prevention practices and highlights critical areas for future research and guideline harmonization.

Conclusions

This review demonstrates that SSI prevention requires a comprehensive, evidence-based approach implemented consistently across all perioperative phases. Preoperative strategies such as CHG alcohol antisepsis, nasal decolonization, nutritional optimization, and appropriate antibiotic prophylaxis form the foundation of effective prevention. Intraoperative measures including antimicrobial sutures, wound protectors, intraoperative warming, irrigation, and NPWT further reduce risk, particularly in high-risk populations. Postoperatively, enhanced recovery protocols, glycemic control, oxygen supplementation, careful drain management, and increasingly sophisticated digital surveillance systems play essential roles. Despite clear progress, gaps remain. Variability in guideline adherence, inconsistent implementation of care bundles, and limited access to digital follow-up tools continue to challenge SSI reduction efforts. Future directions should include expansion of AI-supported surveillance, improved perioperative risk stratification, and broader adoption of standardized prevention bundles tailored to specific surgical specialties. Ultimately, reducing SSI incidence depends on system-wide collaboration, rigorous adherence to evidence-based practices, and integration of emerging technologies to ensure high-quality, safe surgical care.

Declaration of the Use of Generative Artificial Intelligence and AI-Assisted Technologies in the Writing Process. In preparing this manuscript, the authors used ChatGPT to improve the language and readability of the text. After using this tool, the authors reviewed and edited the content as necessary and take full responsibility for the substantive content of the publication.

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