Surgical Site Infection Prevention: An Interdisciplinary Review for Nursing, Operating Room, Social Work, Medical Records, and Environmental Health Professionals

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Abstract

Background: Surgical site infections (SSIs) remain among the most common healthcare-associated infections and continue to impose a significant burden on patients and healthcare systems through increased morbidity, prolonged hospitalization, higher treatment costs, and greater postoperative complications. Despite substantial advances in surgical techniques, aseptic practices, and antimicrobial therapy, SSIs remain a persistent challenge requiring coordinated multidisciplinary prevention and management.

Aim: This review aimed to summarize current evidence regarding the epidemiology, classification, risk factors, prevention, early recognition, and management of surgical site infections while highlighting the collaborative roles of nursing, operating room personnel, social workers, medical records professionals, and environmental health specialists in reducing SSI incidence and improving patient outcomes.

Methods: A comprehensive narrative review of contemporary evidence and international clinical guidelines was conducted. The review synthesized findings related to SSI classification, wound classification, clinical manifestations, traditional and emerging risk factors, multimodal prevention strategies, conventional treatment approaches, and recent technological innovations relevant to multidisciplinary surgical practice.

Results: Surgical site infections develop through complex interactions among patient characteristics, operative factors, microbial contamination, environmental conditions, and healthcare system performance. Early identification, accurate wound classification, optimized perioperative care, timely antimicrobial prophylaxis, strict aseptic practice, environmental infection control, and standardized surgical bundles substantially reduce infection rates. Emerging technologies, including negative pressure wound therapy, antimicrobial photodynamic therapy, electrically active biodegradable sutures, and micropore particle technology, offer additional therapeutic opportunities. Effective surveillance through accurate medical documentation and multidisciplinary collaboration strengthens infection prevention and quality improvement initiatives.

Conclusion: Prevention and management of SSIs require coordinated interdisciplinary practice integrating evidence-based clinical care, infection prevention, environmental safety, comprehensive documentation, and patient-centered support. Continuous surveillance, standardized protocols, and collaborative healthcare delivery remain fundamental for improving surgical outcomes and enhancing patient safety.

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Keywords: Surgical site infection; infection prevention; perioperative care; operating room; nursing; social work; medical records; environmental health; multidisciplinary care; antimicrobial stewardship.

Introduction

Surgical site infections (SSIs) continue to represent one of the most significant complications of surgical care despite substantial advances in operative techniques, aseptic practices, antimicrobial therapy, and perioperative patient management. These infections remain a persistent challenge for healthcare systems worldwide because of their considerable impact on patient safety, postoperative recovery, healthcare resource utilization, and overall clinical outcomes. By definition, a surgical site infection is an infection that develops at or adjacent to a surgical incision within 30 days following an operative procedure or within one year when prosthetic material or an implant has been inserted during surgery [3]. As one of the most frequently encountered healthcare-associated infections (HAIs), SSIs account for approximately 14–16% of all hospital-acquired infections and nearly 38% of infections occurring among surgical patients, highlighting their substantial contribution to postoperative morbidity and healthcare burden [2]. Beyond their clinical implications, SSIs are associated with prolonged hospitalization, increased rates of hospital readmission, additional surgical interventions, delayed functional recovery, and markedly elevated healthcare expenditures, making their prevention a critical objective of contemporary surgical practice [1,2]. Although significant improvements in infection prevention strategies have been achieved through enhanced sterilization protocols, perioperative antibiotic prophylaxis, evidence-based surgical techniques, and improved postoperative surveillance, surgical site infections continue to occur across healthcare settings worldwide. Their persistence reflects the multifactorial nature of disease development, involving complex interactions among patient-related characteristics, microbial virulence, surgical factors, environmental conditions, and healthcare system performance. A comprehensive systematic review incorporating data from 43 studies conducted across 29 countries estimated a pooled global SSI incidence of approximately 2.5%. However, the burden is disproportionately greater in low- and middle-income countries (LMICs), where reported infection rates may reach 11.8% of surgical procedures. These disparities are largely attributable to variations in healthcare infrastructure, limited availability of infection prevention resources, inconsistent adherence to evidence-based guidelines, shortages of trained personnel, and constrained microbiological surveillance systems [1,2].

The challenge posed by surgical site infections is particularly evident within India, where SSIs remain a major cause of postoperative complications and healthcare utilization. Across the country, infection rates demonstrate considerable geographical and institutional variability, reflecting differences in hospital infrastructure, surgical case complexity, infection prevention practices, and patient populations [4,5]. Evidence from a four-year surveillance study conducted at a private tertiary-care hospital in Mumbai reported an SSI incidence of 1.6% among 24,355 patients undergoing clean and clean-contaminated surgical procedures, indicating that favorable outcomes can be achieved through comprehensive infection control measures [5,6]. Microbiological analyses identified Gram-negative bacilli, particularly *Escherichia coli* and *Klebsiella* species, as the predominant pathogens responsible for these infections, with a substantial proportion demonstrating extended-spectrum β-lactamase production, thereby presenting additional therapeutic challenges because of increasing antimicrobial resistance [6]. Conversely, investigations from other regions of India have documented substantially higher infection rates, emphasizing the ongoing need for standardized preventive strategies. A teaching hospital in Ujjain, Madhya Pradesh, reported an SSI incidence of 5% among 720 surgical patients, identifying disease severity, prolonged operative duration, and surgical drain placement as important determinants of postoperative infection [7]. Similarly, a cross-sectional study conducted in Trichy, Tamil Nadu, demonstrated an SSI prevalence of 5.6% among 2,076 patients, with abdominal surgery, emergency surgical procedures, and diabetes mellitus emerging as major risk factors [8]. Even higher infection rates approaching 11% have been documented in tertiary healthcare institutions in Mumbai, where advanced age, diabetes, and emergency surgery significantly increased susceptibility to postoperative infection [9]. These findings collectively demonstrate substantial heterogeneity in SSI occurrence across healthcare institutions and reinforce the importance of implementing uniform infection prevention protocols supported by continuous surveillance and quality improvement initiatives [4].

Recognizing the global burden imposed by surgical site infections, the World Health Organization has developed comprehensive evidence-based recommendations aimed at minimizing SSI occurrence through standardized perioperative care. These guidelines emphasize meticulous hand hygiene, appropriate timing and selection of antimicrobial prophylaxis, maintenance of sterile operative environments, optimal surgical techniques, and continuous adherence to infection prevention practices throughout the perioperative period [3][10]. Implementation of these recommendations has consistently demonstrated reductions in postoperative infection rates while improving patient safety and healthcare quality. Understanding the determinants of surgical site infection requires consideration of both established and emerging risk factors that influence postoperative outcomes. Traditional risk factors, including diabetes mellitus, contaminated wound classification, prolonged operative duration, obesity, advanced age, and emergency surgery, have been consistently identified across decades of clinical research. More recently, emerging determinants have gained increasing attention, including antimicrobial resistance patterns, perioperative glycemic variability, environmental contamination, technological factors related to surgical equipment, and healthcare system characteristics that influence compliance with infection prevention protocols [1,2]. Examination of these factors within the Indian healthcare context is particularly valuable because the country's diverse healthcare infrastructure, high surgical volume, and variability in infection control practices closely reflect challenges encountered throughout many low- and middle-income countries. Consequently, evidence generated from this setting provides important insights that may be broadly applicable to similar healthcare environments worldwide, contributing to the development of effective multidisciplinary strategies for reducing the global burden of surgical site infections [2].

Classification of Surgical Site Infections

Surgical site infections (SSIs) are defined as infections that develop at or adjacent to the site of a surgical incision within 30 days following an operative procedure or within one year when prosthetic material or an implant has been inserted during surgery. These infections may involve the skin and subcutaneous tissues or extend into deeper anatomical structures, including fascial layers, muscle, body cavities, organs, or implanted devices manipulated during the surgical procedure [11]. Accurate classification of SSIs is essential because the depth of tissue involvement directly influences disease severity, therapeutic decision-making, antimicrobial selection, surgical intervention requirements, prognosis, and surveillance reporting. Standardized classification also facilitates consistent epidemiological monitoring, comparison of infection rates across healthcare institutions, and implementation of targeted infection prevention strategies. The Centers for Disease Control and Prevention (CDC) classifies surgical site infections into three principal categories: superficial incisional surgical site infections, deep incisional surgical site infections, and organ/space surgical site infections [12]. This internationally recognized classification system provides a standardized framework for diagnosing, documenting, reporting, and managing postoperative infections while supporting quality improvement initiatives and infection surveillance programs within healthcare organizations [12].

Superficial incisional surgical site infections represent the least extensive form of SSI and are confined to the skin and subcutaneous tissues surrounding the surgical incision [12,13]. These infections generally become apparent within 30 days after surgery and commonly present with localized inflammatory manifestations, including erythema, pain, tenderness, swelling, increased local temperature, and purulent wound drainage. Diagnosis is established when purulent exudate is present, pathogenic microorganisms are isolated from aseptically obtained wound cultures, characteristic clinical signs of infection are identified, or when the operating surgeon or attending physician confirms the diagnosis based on clinical evaluation [12,13]. Although superficial infections are generally associated with lower morbidity than deeper infections, delayed recognition or inadequate treatment may allow progression into deeper anatomical tissues. Deep incisional surgical site infections involve the deeper soft tissue structures beneath the surgical incision, including the fascial planes and muscle layers [12,13]. These infections may develop within 30 days after surgery in procedures without implanted material or within one year when prosthetic devices or implants remain in situ [12]. Deep incisional SSIs typically present with purulent drainage originating from the deep tissues, spontaneous wound dehiscence or deliberate reopening of the incision accompanied by fever, localized pain, or tenderness, and radiological or intraoperative evidence of abscess formation. Confirmation may also be established through direct clinical assessment by the surgeon or attending physician [13]. Compared with superficial infections, deep incisional SSIs are associated with substantially greater morbidity because they frequently require prolonged antimicrobial therapy, surgical debridement, repeated operative interventions, and extended hospitalization.

Organ/space surgical site infections constitute the most severe category of SSI because they involve anatomical structures manipulated during surgery other than the incision itself, including internal organs, body cavities, or surgically created spaces [13]. Similar to deep incisional infections, these infections may occur within 30 days after surgery or within one year when an implant has been placed [13]. Diagnosis is based on the presence of purulent drainage from drains positioned within the affected organ or body space, microbiological isolation of pathogenic organisms from aseptically collected specimens, radiological or operative evidence of abscess formation, or confirmation by the responsible surgeon or attending physician [13]. Organ/space infections frequently result in severe systemic illness, prolonged hospitalization, increased rates of intensive care admission, additional surgical procedures, and significantly higher healthcare costs, underscoring the importance of early recognition and prompt multidisciplinary management. The CDC classification system remains the international standard for categorizing surgical site infections because it promotes uniform diagnostic criteria, facilitates accurate surveillance, enables meaningful comparison of infection rates across healthcare institutions, and supports the development of evidence-based infection prevention strategies. Furthermore, standardized classification provides an essential framework for clinical research, quality assurance programs, antimicrobial stewardship initiatives, and continuous monitoring of postoperative outcomes, thereby contributing to improved patient safety and enhanced quality of surgical care [12,13].

CLASSIFICATION OF SURGICAL WOUNDS AND SSI RISK

Classification of surgical wounds is a fundamental component of perioperative risk assessment and serves as an essential predictor of the likelihood of developing surgical site infections (SSIs). Standardized wound classification enables healthcare professionals to estimate postoperative infection risk, determine appropriate antimicrobial prophylaxis, guide intraoperative infection prevention strategies, and facilitate postoperative surveillance.

Furthermore, wound classification provides a consistent framework for benchmarking surgical outcomes, monitoring institutional infection rates, and evaluating the effectiveness of infection prevention programs. Because the microbial burden present at the operative site varies considerably according to the nature of the surgical procedure and the degree of tissue contamination, accurate wound classification plays a pivotal role in evidence-based perioperative management and quality improvement initiatives [13]. The Centers for Disease Control and Prevention (CDC) categorizes surgical wounds into four distinct classes according to the degree of microbial contamination encountered during surgery. These classifications include Class I (Clean), Class II (Clean-Contaminated), Class III (Contaminated), and Class IV (Dirty or Infected) wounds [14]. Each category reflects progressively increasing levels of bacterial exposure and corresponding postoperative infection risk, thereby providing clinicians with valuable guidance for clinical decision-making before, during, and after surgery. Class I, or clean wounds, represent operative procedures performed under sterile conditions in which no evidence of infection or inflammation is present and the respiratory, gastrointestinal, genital, or uninfected urinary tract is not entered during the operation [14]. These procedures typically involve primary wound closure without significant contamination of the operative field and therefore carry the lowest probability of postoperative infection. Common examples include hernia repair, thyroidectomy, mastectomy, and many orthopedic procedures performed under strict aseptic conditions. Although the risk of SSI in clean wounds remains relatively low, strict adherence to sterile surgical technique, meticulous skin preparation, and appropriate perioperative infection prevention measures remain essential to maintain favorable outcomes [14].

Class II, or clean-contaminated wounds, include surgical procedures involving controlled entry into the respiratory, alimentary, genital, or urinary tract without evidence of unusual contamination or active infection [14,15]. Although these anatomical sites naturally contain resident microbial flora, careful operative planning and meticulous surgical technique substantially reduce the risk of bacterial contamination. Representative procedures include elective cholecystectomy, uncomplicated appendectomy without perforation, colorectal procedures performed under controlled conditions, and vaginal hysterectomy [14,15]. Compared with clean wounds, clean-contaminated procedures carry a moderately increased risk of SSI because endogenous microorganisms may contaminate the surgical field despite appropriate infection prevention practices. Consequently, perioperative antimicrobial prophylaxis is frequently recommended to minimize postoperative infectious complications [15]. Class III wounds are categorized as contaminated wounds and are associated with a substantially greater likelihood of postoperative infection [14,16]. This category includes fresh traumatic injuries, operations complicated by major breaches in sterile technique, and procedures involving significant spillage of gastrointestinal contents into the operative field. Examples include penetrating abdominal trauma, bowel surgery complicated by intestinal leakage, and operations during which sterility has been significantly compromised [14,16]. Because bacterial contamination is often considerable and the microbial burden cannot be accurately quantified, contaminated wounds require heightened intraoperative vigilance, appropriate antimicrobial therapy, careful wound management, and intensive postoperative surveillance to reduce the risk of SSI development [16].

Class IV wounds, designated as dirty or infected wounds, represent the highest level of surgical contamination and carry the greatest probability of postoperative infectious complications [14,16]. These wounds include old traumatic injuries containing retained devitalized tissue, procedures performed in the presence of established clinical infection, perforated hollow viscera, abscesses, or extensive tissue necrosis. Common clinical examples include perforated bowel surgery, drainage of intra-abdominal abscesses, and debridement of necrotic soft tissue infections [16]. Patients undergoing procedures classified as dirty or infected frequently require broad-spectrum antimicrobial therapy, extensive surgical debridement, repeated operative interventions, and comprehensive postoperative monitoring because infection is already established or extensive microbial contamination is unavoidable at the time of surgery. The progressive transition from clean to dirty surgical wounds reflects a corresponding increase in microbial contamination, tissue injury, inflammatory response, and overall risk of surgical site infection. Consequently, accurate wound classification provides an indispensable tool for risk stratification, perioperative planning, antimicrobial stewardship, infection surveillance, and quality improvement within surgical practice. Integration of wound classification with patient-specific risk factors, procedural complexity, and institutional infection prevention protocols enables healthcare teams to implement individualized preventive strategies that reduce postoperative complications, improve surgical outcomes, and enhance patient safety across diverse clinical settings [13-16].

CLINICAL PRESENTATION AND EARLY RECOGNITION OF SSI

Early recognition of surgical site infections (SSIs) is essential for minimizing postoperative complications, reducing patient morbidity, and preventing progression to severe local or systemic infection. Prompt identification of clinical manifestations enables timely initiation of appropriate antimicrobial therapy, surgical intervention when indicated, and supportive management, thereby improving patient outcomes and decreasing healthcare utilization. Because the severity of SSIs may range from superficial wound infections to deep tissue involvement and life-threatening organ or space infections, healthcare professionals must maintain a high level of clinical vigilance throughout the postoperative period, particularly during the first few weeks after surgery [17]. The initial manifestations of surgical site infection generally become evident within three to seven days following an operative procedure, although the timing may vary according to the type of surgery, patient-related factors, and the causative microorganism [17,18]. The earliest local signs typically include erythema surrounding the surgical incision, localized swelling, increased warmth, and tenderness at the operative site. These findings reflect the inflammatory response triggered by microbial invasion of the surgical wound and should be carefully differentiated from the normal inflammatory changes associated with uncomplicated wound healing. Progressive or persistent pain that exceeds the expected postoperative course is particularly concerning because it may indicate the development of a deep tissue infection or an underlying abscess requiring further evaluation [18]. Purulent wound drainage remains one of the most characteristic clinical indicators of SSI. The presence of thick, cloudy, or creamy exudate, frequently accompanied by an unpleasant odor, strongly suggests bacterial infection and warrants immediate microbiological investigation and clinical management [19]. Additional local findings may include delayed wound healing, persistent tissue necrosis, excessive slough formation, wound dehiscence, and malodorous discharge, all of which indicate ongoing tissue destruction and impaired healing processes [20,22]. As infection progresses beyond the surgical wound, systemic manifestations may develop, including fever, chills, malaise, tachycardia, and leukocytosis, reflecting dissemination of infection or the onset of systemic inflammatory response syndrome and sepsis [20,21]. Patients with deep incisional or organ/space SSIs may also present with procedure-specific symptoms such as abdominal pain following abdominal surgery, respiratory distress after thoracic procedures, or altered mental status in older adults and immunocompromised individuals [23]. Recognition of these evolving clinical features through comprehensive postoperative assessment is fundamental for early diagnosis, prompt intervention, and prevention of serious postoperative complications.

Patient and Procedure-Related Risk Factors for SSI

The development of surgical site infections (SSIs) is influenced by a complex interaction between patient-related characteristics and procedure-specific factors that affect microbial contamination, host immune defense, and wound healing. Identification of these risk factors is essential for preoperative risk stratification, individualized perioperative planning, and implementation of targeted preventive measures aimed at reducing postoperative infectious complications. Because many of these determinants are modifiable, comprehensive assessment before surgery provides valuable opportunities to optimize patient outcomes and improve the quality of surgical care [24]. Patient-related risk factors significantly influence susceptibility to postoperative infection by impairing immune function, delaying tissue repair, or increasing bacterial colonization. Diabetes mellitus is among the most important independent predictors of SSI because chronic hyperglycemia impairs leukocyte function, compromises microvascular circulation, and delays collagen synthesis, thereby reducing wound healing capacity and increasing vulnerability to infection [26]. Obesity, particularly a body mass index of 30 kg/m^2 or greater, is also strongly associated with postoperative wound infection owing to impaired tissue perfusion, prolonged operative exposure, and reduced oxygen delivery to adipose tissue [27]. Cigarette smoking further increases SSI risk by causing vasoconstriction, reducing tissue oxygenation, impairing immune responses, and delaying wound healing [24,25]. Additional patient-related factors include advanced age, malnutrition, immunosuppression, and nasal or skin colonization with *Staphylococcus aureus*, all of which compromise host defense mechanisms and increase the likelihood of postoperative infection [24,25]. Procedure-related factors also play a critical role in determining SSI risk. Prolonged surgical duration increases exposure of the operative field to environmental microorganisms while contributing to tissue desiccation and surgical fatigue, thereby increasing contamination risk [28]. The complexity of the surgical procedure and the degree of wound contamination are equally important, with contaminated and dirty wounds demonstrating substantially higher infection rates than clean procedures [28,29]. Inadequate preoperative skin antisepsis permits persistence of resident microorganisms at the incision site, while inappropriate selection, timing, or administration of prophylactic antibiotics reduces protection against perioperative bacterial contamination [30]. Furthermore, deficiencies in intraoperative aseptic technique, excessive tissue manipulation, inadequate hemostasis, and technical errors during surgery facilitate microbial invasion and impair wound healing [30]. Recognition and optimization of both patient-related and procedural risk factors remain fundamental components of comprehensive SSI prevention strategies and evidence-based perioperative care.

Emerging and Newly Identified Risk Factors for SSI

Recent advances in surgical research have expanded the understanding of surgical site infection (SSI) pathogenesis by identifying several emerging risk factors that extend beyond the traditional patient- and procedure-related determinants. These newly recognized factors reflect the complex interaction between metabolic status, immune function, microbial ecology, perioperative management, and healthcare-associated exposures. Recognition of these evolving contributors is essential for refining preoperative risk assessment, developing individualized prevention strategies, and improving postoperative outcomes in diverse surgical populations [31]. Among the emerging patient-related determinants, metabolic syndrome has gained increasing recognition as an independent predictor of postoperative wound infection because its associated components, including insulin resistance, obesity, hypertension, and dyslipidemia, collectively impair immune function, tissue perfusion, and wound healing. Likewise, anemia and hypoproteinemia have recently been identified as significant independent risk factors, particularly among patients undergoing emergency and major surgical procedures [31]. Reduced hemoglobin levels compromise tissue oxygen delivery, whereas inadequate serum protein concentrations impair collagen synthesis, cellular regeneration, and immune responses, thereby delaying wound repair and increasing susceptibility to infection [32]. Mental health disorders have also been associated with poorer postoperative recovery through their influence on physiological stress responses, treatment adherence, nutritional status, and immune regulation [32]. Furthermore, asymptomatic bacteriuria has emerged as a clinically relevant risk factor, especially in patients undergoing orthopedic joint replacement procedures, where silent bacterial colonization may increase the likelihood of postoperative prosthetic and surgical site infections [33]. Several operative and postoperative factors have likewise emerged as important contributors to SSI development. Although surgical drains are frequently used to prevent fluid accumulation, prolonged drain placement may facilitate bacterial colonization and provide a pathway for microbial entry into deeper tissues [32]. In reconstructive and dermatologic surgery, procedures involving local tissue flaps or skin grafts have demonstrated higher infection rates than primary wound closure because of increased operative complexity and greater tissue manipulation [26,34]. Additionally, the global emergence of multidrug-resistant microorganisms, particularly carbapenem-resistant Enterobacteriaceae, has significantly complicated the prevention and management of SSIs by limiting available antimicrobial treatment options and increasing healthcare-associated transmission [35]. Other important contributors include prolonged hospitalization, delayed wound healing, inadequate postoperative wound care, poor glycemic control, excessive intraoperative blood loss, and previous exposure to antibiotics, all of which increase the risk of microbial colonization and postoperative infection [31,32,35]. These emerging risk factors emphasize the need for comprehensive perioperative assessment and multidisciplinary infection prevention strategies that address patient optimization, antimicrobial stewardship, meticulous surgical practice, and standardized postoperative care.

MULTIMODAL STRATEGIES FOR THE PREVENTION OF SSIs

Prevention of surgical site infections (SSIs) requires a comprehensive multimodal approach that integrates evidence-based interventions throughout the preoperative, intraoperative, and postoperative phases of surgical care. Because SSIs arise from the interaction of patient-related, procedural, microbial, and environmental factors, no single preventive measure is sufficient to eliminate infection risk. Instead, successful prevention depends on the coordinated implementation of standardized infection prevention protocols by a multidisciplinary healthcare team. Effective preventive strategies not only reduce postoperative morbidity and mortality but also shorten hospital stays, decrease readmission rates, improve patient satisfaction, and substantially reduce healthcare expenditures associated with postoperative complications [10,36]. The foundation of SSI prevention begins with meticulous adherence to surgical aseptic principles and optimization of modifiable patient-related risk factors before surgery. Appropriate glycemic control, particularly among patients with diabetes mellitus, smoking cessation, nutritional optimization, and treatment of existing infections contribute significantly to reducing postoperative infectious complications [36]. One of the most effective preventive interventions is the appropriate administration of prophylactic antibiotics. Evidence consistently demonstrates that administering antimicrobial prophylaxis within one hour before surgical incision achieves optimal tissue antibiotic concentrations at the time of microbial exposure, thereby significantly reducing the incidence of postoperative wound infections [37]. Proper antibiotic selection, dosage, and timely redosing during prolonged procedures are equally important components of effective antimicrobial prophylaxis.

Maintenance of physiological homeostasis during surgery further strengthens host defense mechanisms against infection. Preservation of normothermia throughout the perioperative period enhances leukocyte function, improves tissue perfusion, and promotes effective wound healing, while adequate oxygenation increases tissue oxygen availability required for oxidative bacterial killing by neutrophils [38]. Collectively, these physiological optimization strategies improve immune function and reduce susceptibility to postoperative infection. Implementation of standardized surgical care bundles has consistently demonstrated significant reductions in SSI rates across diverse surgical specialties [10,39]. These bundles integrate multiple evidence-based interventions, including appropriate preoperative skin preparation using antiseptic agents such as chlorhexidine-alcohol or povidone-iodine solutions, strict compliance with hand hygiene, use of sterile surgical attire and personal protective equipment, maintenance of aseptic operative technique, and restriction of unnecessary operating room traffic to minimize environmental contamination [38]. Standardization of these practices enhances consistency of care while reducing preventable variations in surgical practice. Optimal postoperative wound management also plays a pivotal role in SSI prevention. Careful wound assessment during the perioperative period facilitates early identification of infection, allowing prompt intervention before complications progress. Avoidance of unnecessary subcutaneous suturing when clinically appropriate, judicious use of wound dressings, and maintenance of a clean, dry wound environment reduce bacterial proliferation and support normal tissue healing [38,39]. Limiting excessive dressing changes minimizes disruption of the healing wound while permitting regular clinical inspection for early signs of infection. Furthermore, timely removal of surgical drains decreases opportunities for bacterial colonization and ascending infection, thereby reducing postoperative infectious risk [39]. Ultimately, effective prevention of surgical site infections depends upon seamless collaboration among surgeons, anesthesiologists, perioperative nurses, infection prevention specialists, environmental health personnel, and other healthcare professionals. Through coordinated implementation of evidence-based preventive measures across the entire continuum of surgical care, multidisciplinary teams can substantially reduce SSI incidence, improve patient safety, and enhance the overall quality and efficiency of surgical services [10].

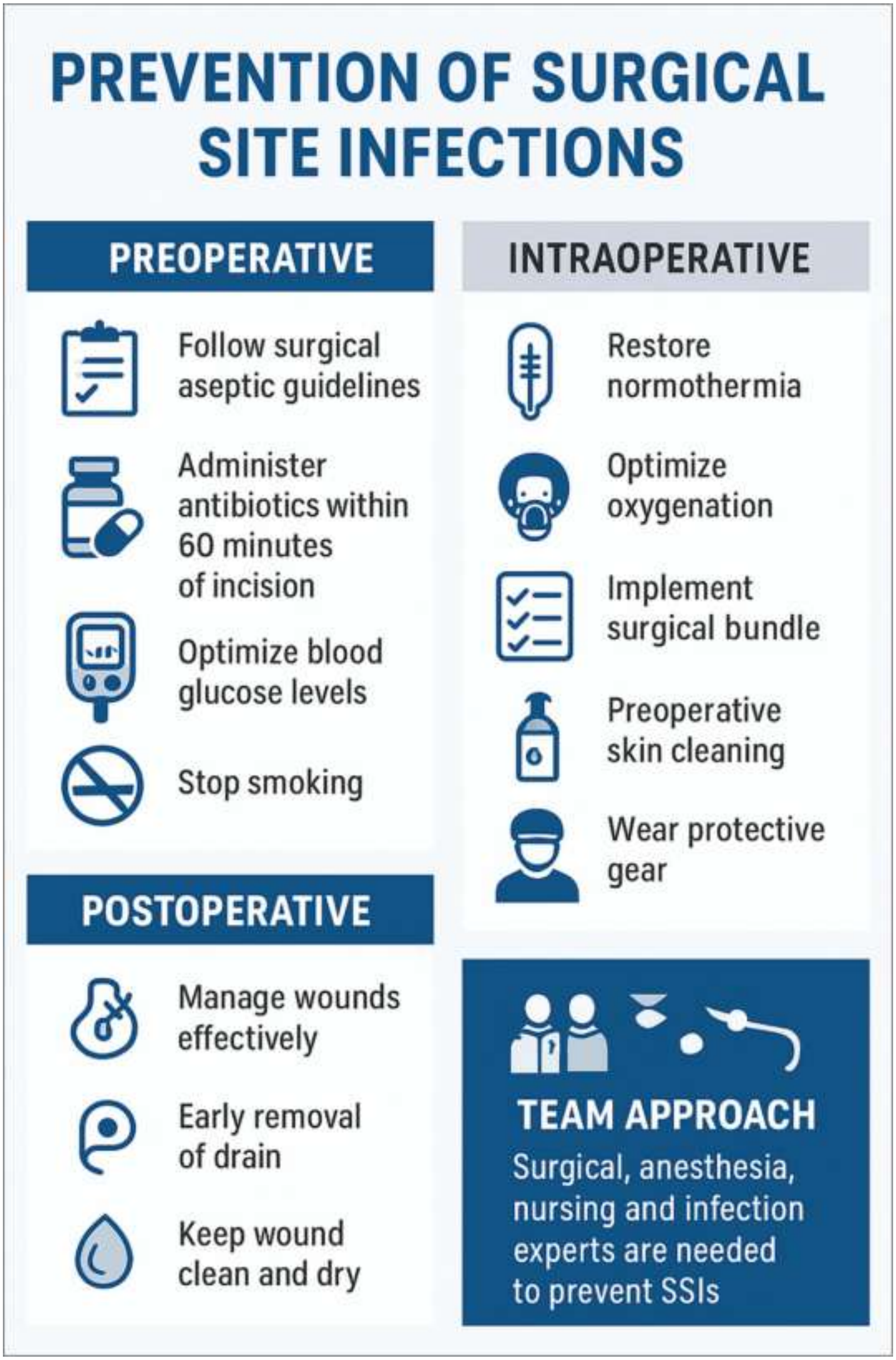

Fig. 1: Prevention strategies of SSI.

TREATMENT STRATEGIES IN SSI MANAGEMENT

Management of surgical site infections (SSIs) requires an individualized, evidence-based approach that is determined by the depth of infection, extent of tissue involvement, microbiological findings, and the patient's overall clinical condition. The primary objectives of treatment are eradication of infection, preservation of tissue viability, promotion of wound healing, prevention of systemic complications, and restoration of normal function. Superficial surgical site infections are frequently managed with meticulous local wound care, including regular wound irrigation, appropriate dressing changes, and close clinical monitoring to evaluate healing progression and detect signs of deterioration [40,41]. When localized abscess formation occurs, prompt incision and drainage are essential to evacuate purulent collections, reduce bacterial burden, and facilitate tissue recovery, followed by continued wound care using evidence-based dressing techniques [41]. In contrast, deep incisional and organ/space infections often require surgical debridement to remove necrotic tissue, decrease microbial contamination, and establish conditions favorable for tissue regeneration and wound healing [42]. Systemic antimicrobial therapy remains a cornerstone of SSI management, particularly in patients with deep infections or systemic manifestations. Initial empirical antibiotic therapy should target the most likely causative microorganisms while considering local antimicrobial resistance patterns and institutional epidemiological data [43]. Once microbiological culture and antimicrobial susceptibility results become available, treatment should be adjusted to provide targeted therapy with the narrowest effective antimicrobial spectrum. This strategy enhances therapeutic efficacy while supporting antimicrobial stewardship and reducing the emergence of multidrug-resistant organisms [43,44]. Patients with infections caused by resistant pathogens or those presenting with complex clinical conditions may benefit from consultation with infectious disease specialists to optimize antimicrobial selection and treatment duration [43,44]. Adjunctive therapies, including negative pressure wound therapy, have demonstrated substantial benefits by promoting granulation tissue formation, improving tissue perfusion, reducing edema, and removing excess wound exudate [45]. Comprehensive management should also include optimization of glycemic control, nutritional support, smoking cessation, and correction of modifiable systemic risk factors that impair wound healing and immune function [41]. Recent technological innovations have introduced promising adjunctive approaches for SSI treatment and prevention. Electrically active biodegradable sutures generate therapeutic electrical stimulation through the triboelectric effect, enhancing cellular proliferation, accelerating wound repair, and inhibiting bacterial growth without requiring external power sources [46]. Antimicrobial photodynamic therapy utilizes light-activated photosensitizing agents to generate reactive oxygen species capable of selectively destroying pathogenic microorganisms, offering an effective non-antibiotic strategy that has demonstrated encouraging outcomes in orthopedic and spinal surgery [47,48]. Additionally, micropore particle technology has emerged as an innovative wound management modality by rapidly absorbing wound exudate, disrupting bacterial biofilms, and supporting local immune responses, thereby creating a favorable environment for tissue repair while reducing microbial proliferation [49]. Collectively, these emerging technologies complement conventional surgical and antimicrobial therapies, expanding the therapeutic options available for managing complex surgical site infections while addressing the growing challenges associated with antimicrobial resistance and improving overall patient outcomes [49].

Conclusion

Surgical site infections continue to represent a major challenge in modern surgical practice because of their substantial impact on patient recovery, healthcare utilization, and clinical outcomes. Their development results from a complex interaction between patient-related conditions, operative factors, microbial characteristics, environmental contamination, and adherence to evidence-based infection prevention practices. Successful reduction of SSI rates depends on comprehensive perioperative assessment, meticulous aseptic technique, timely antimicrobial prophylaxis, standardized surgical bundles, effective postoperative wound monitoring, and early recognition of infection. Appropriate management requires individualized treatment that combines wound care, surgical intervention when indicated, targeted antimicrobial therapy, and optimization of modifiable patient risk factors. Emerging technologies offer promising adjunctive approaches that may further improve healing and reduce antimicrobial dependence. Equally important is the integration of multidisciplinary expertise involving nurses, operating room professionals, surgeons, infection prevention specialists, environmental health personnel, medical records professionals, and social workers. Accurate clinical documentation supports surveillance and quality improvement, while social support enhances patient education, treatment adherence, and continuity of care following discharge. Through sustained interdisciplinary collaboration, continuous surveillance, adherence to international guidelines, and implementation of evidence-based practices, healthcare organizations can significantly reduce the burden of surgical site infections, improve patient safety, optimize resource utilization, and achieve better long-term surgical outcomes across diverse healthcare settings.

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