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Reconceptualizing Surgical Site Infection Prevention: An Interdisciplinary Care Continuum Across Pre-Hospital to Post-Discharge Phases – A Narrative Review

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Abstract

Background: Surgical Site Infections (SSIs) represent a significant burden of healthcare-associated harm, contributing to increased morbidity, mortality, and healthcare costs. Traditional prevention strategies have focused narrowly on the intraoperative period, yet contemporary understanding recognizes SSI risk as a continuum influenced by care delivered long before and after the surgical incision. **Aim:** This narrative review aims to synthesize evidence on a comprehensive, interdisciplinary SSI prevention pathway, analyzing contributions and integration points across Emergency Medical Services (EMS), Surgical teams, Nursing, Pharmacy, Epidemiology, and Health Administration from the pre-hospital setting through post-discharge monitoring. **Methods:** A comprehensive search of PubMed, CINAHL, Scopus, and Web of Science databases (2010-2024) was conducted. Keywords included "surgical site infection," "prevention bundle," and terms related to each professional domain. The included literature comprised systematic reviews, clinical trials, observational studies, and guidelines. **Results:** The review identifies critical, often overlooked interventions in the pre-hospital phase (EMS wound management) and post-discharge phase (patient self-monitoring). It reveals significant gaps in the coordination of SSI prevention efforts across professional silos and varying alignment between quality metrics, reimbursement structures, and evidence-based practices. Two original frameworks are presented: an Interdisciplinary SSI Prevention Continuum and a Systems Alignment Matrix for SSI Metrics. **Conclusion:** Effective SSI reduction requires a paradigm shift from episodic, intraoperative-focused prevention to a cohesive, patient-centered continuum of care. This demands standardized interdisciplinary protocols, integrated data systems, and financial models that incentivize collaborative prevention across all domains of the surgical journey.

Keywords: surgical site infection, care bundles, interdisciplinary care, quality metrics, antimicrobial stewardship

Introduction

Surgical Site Infections (SSIs) persist as a formidable challenge in modern healthcare, constituting approximately 20% of all healthcare-associated infections and affecting an estimated 1-3% of patients undergoing inpatient surgery in high-income countries. The consequences extend beyond individual patient suffering—prolonged hospitalization by an average of 9.7 days, a 2-11 times higher risk of mortality, and substantially increased healthcare costs—to impact entire health systems through regulatory penalties, reputational damage, and resource diversion. For decades, prevention efforts have orbited the sterile field of the operating room, emphasizing surgeon technique, operating room ventilation, and timely antibiotic prophylaxis. While these intraoperative measures remain indispensable, a growing body of evidence illuminates a more complex reality: the genesis and prevention of SSIs span a far broader temporal and professional landscape.

The surgical patient's journey is intrinsically interdisciplinary, beginning potentially with traumatic injury management by Emergency Medical Services (EMS), progressing through preoperative optimization, the surgical procedure itself, postoperative inpatient care, and concluding with

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recovery in the community. At each phase, multiple professional domains exert influence on SSI risk. An EMS provider's initial wound management in the field can introduce contaminants or compromise tissue viability. A pharmacist's stewardship of prophylactic antibiotics influences microbial selection pressure. A nurse's postoperative glycemic control and wound monitoring detect early signs of infection. Epidemiologists track patterns to identify outbreaks or procedural risks, while health administrators design reimbursement models that may incentivize or inadvertently discourage comprehensive prevention efforts. Despite this interconnectedness, prevention strategies have historically been developed and implemented in professional silos, creating gaps and inconsistencies along the care continuum.

This narrative review adopts a systems perspective to map the complete SSI prevention pathway. We synthesize contemporary evidence across seven critical domains: EMS pre-hospital care, Surgical protocols, Nursing perioperative practice, Pharmacy antimicrobial stewardship, Epidemiology surveillance, and Health Administration policy and finance. By examining the interfaces between these domains, we identify both synergistic opportunities and persistent barriers to implementing truly comprehensive SSI prevention. The ultimate aim is to propose an integrated framework that transforms SSI prevention from a series of disjointed tasks into a coherent, patient-centered continuum of care, thereby reducing a significant source of preventable patient harm.

Methodology

This narrative review was conducted to provide a comprehensive synthesis of literature on interdisciplinary SSI prevention across the care continuum. A systematic search strategy was employed across four major electronic databases: PubMed/MEDLINE, CINAHL, Scopus, and Web of Science. The search timeframe was limited to January 2010 – December 2024 to capture contemporary practices, guidelines, and research findings. The search strategy utilized a combination of Medical Subject Headings (MeSH) and keywords structured around core concepts: (1) SSI terminology ("surgical site infection," "wound infection," "postoperative infection"); (2) prevention terminology ("prevention," "bundle," "care pathway"); and (3) domain-specific terms for each professional field (e.g., "prehospital care," "emergency medical services," "perioperative nursing," "antimicrobial stewardship," "infection surveillance," "value-based purchasing"). Boolean operators (AND, OR) were used to combine concepts.

Inclusion criteria encompassed: peer-reviewed original research (randomized controlled trials, cohort studies, case-control studies), systematic reviews and meta-analyses, published clinical practice guidelines from recognized professional societies (e.g., WHO, CDC, ACS, SHEA), and substantial quality improvement reports. Exclusion criteria included: editorials, commentaries, case reports (<10 patients), studies not published in English, and studies focused exclusively on pediatric populations due to distinct pathophysiology and prevention considerations.

Data extraction was organized thematically according to the phases of care (pre-hospital, preoperative, intraoperative, postoperative, post-discharge) and the responsible professional domains. Key information extracted included: intervention descriptions, outcome measures, implementation strategies, barriers and facilitators, and evidence of interdisciplinary collaboration. Given the narrative design, a thematic synthesis rather than statistical meta-analysis was performed to identify overarching themes, evidence gaps, and opportunities for integration across the surgical pathway.

The Pre-Hospital Phase: EMS as the Unrecognized First Defender

The prevention timeline for many surgical patients, particularly those undergoing surgery for trauma, begins not in the preoperative clinic but at the scene of injury, with Emergency Medical Services (EMS) personnel serving as inadvertent first-line defenders against SSI. Pre-hospital wound management practices significantly influence the microbial burden and tissue environment that the surgical team later encounters. Despite this, EMS protocols for wound care are highly variable and rarely informed by surgical site infection prevention principles.

Contaminated traumatic wounds managed in the field represent a high-risk scenario. Traditional EMS training emphasizes hemorrhage control and rapid transport, often with minimal aseptic technique during wound packing or dressing application. Studies indicate that up to 40% of pre-hospital wound dressings are applied with non-sterile gloves or directly from storage compartments contaminated with multi-drug resistant organisms (Dominado & Tabuñar, 2022). The timing and choice of irrigation are equally critical. While surgical guidelines recommend low-pressure irrigation with sterile saline, EMS providers often lack both the equipment and protocol direction to perform adequate irrigation in the field. The use of non-sterile water or delayed irrigation until emergency department arrival can allow bacterial adherence and biofilm formation to commence well before surgical debridement (Prada et al., 2022).

Emerging evidence supports specific pre-hospital interventions. The use of chlorhexidine-impregnated dressings for open fractures in the field has shown promise in reducing early bacterial contamination in several pilot studies (Lack et al., 2019). Furthermore, standardized EMS protocols that include hand hygiene before wound contact, the use of sterile gloves and dressings from sealed packages, and documentation of the wound's initial condition and any pre-hospital antibiotics administered can provide crucial information to the receiving surgical team

(Mould-Millman et al., 2019). This represents a critical interdisciplinary handoff: EMS documentation of wound characteristics and initial management must be effectively communicated to emergency department and trauma surgery teams to guide intraoperative strategy and postoperative antibiotic selection. Currently, this handoff is often informal and incomplete, representing a significant missed opportunity in the SSI prevention chain (Brown et al., 2014).

The Preoperative Phase: Optimization and Protocol Initiation

The preoperative period sets the physiological and microbial stage for the impending surgical insult. Effective prevention requires coordination between surgical, nursing, and pharmacy teams to address modifiable risk factors and initiate evidence-based protocols.

Patient Optimization and Risk Stratification

Surgical teams are increasingly responsible for preoperative optimization, moving beyond simple clearance. Key modifiable risk factors for SSI include glycemic control, nutritional status, smoking cessation, and nasal decolonization (Jalalzadeh et al., 2022). For diabetic patients, preoperative HbA1c levels >7.5% are associated with a 2.3-fold increased SSI risk. Structured programs involving endocrinology consultation, nursing education, and pharmacist-managed insulin protocols can significantly improve preoperative glycemic control (Berríos-Torres et al., 2017). Smoking cessation, even if initiated 4-6 weeks before surgery, reduces SSI risk by mitigating tissue hypoxia and impaired immune function. Systematic preoperative screening for methicillin-resistant *Staphylococcus aureus* (MRSA) and subsequent decolonization protocols (e.g., mupirocin ointment and chlorhexidine bathing) have demonstrated significant SSI reduction in cardiac and orthopedic procedures, though implementation requires coordination between preoperative nursing, pharmacy for medication access, and patients for compliance (Schweizer et al., 2013).

Pharmacy-Surgical Collaboration

The appropriate administration of surgical antibiotic prophylaxis (SAP) is a cornerstone of prevention, yet errors in timing, selection, and duration remain prevalent. Pharmacists play an indispensable stewardship role. Computerized preoperative order sets, developed collaboratively by pharmacy, surgery, and infectious disease, can standardize drug selection based on procedure type, patient weight, and allergy history (Martinez-Sobalvarro et al., 2022). The critical timing of infusion—within 60 minutes before incision (120 minutes for vancomycin or fluoroquinolones)—requires precise coordination between preoperative nursing (starting the infusion), pharmacy (timely preparation and delivery), and the operating room team (communicating the incision time) (Righi et al., 2023). Despite guidelines, re-dosing guidelines for prolonged procedures or major blood loss are often overlooked. Pharmacy-led monitoring programs that track compliance with timing, selection, and duration (discontinuation within 24 hours for most procedures) have been associated with significant reductions in SSI rates and *Clostridioides difficile* infection (Wolfhagen et al., 2022).

The Intraoperative Phase: The Traditional Core of Prevention

Intraoperative prevention represents the most studied and protocolized phase, involving strict adherence to aseptic technique, environmental controls, and physiologic management.

Aseptic Technique and Environmental Controls

The surgical team's adherence to aseptic principles—surgical hand antisepsis, sterile gowning and gloving, and maintaining the sterile field—is fundamental. However, human factors such as fatigue, case complexity, and team dynamics can lead to breaches (Wang et al., 2023). The use of double-gloving, especially in procedures with high risk for glove perforation, and iodine-impregnated incise drapes provides additional barriers. Operating room environmental controls, including adequate air exchange rates (≥20 air changes per hour), positive pressure ventilation relative to corridors, and minimization of traffic, are engineered controls that reduce airborne particle counts containing microbes (Allegranzi et al., 2016). The role of ultraviolet light disinfection or hydrogen peroxide vapor between cases continues to be evaluated, particularly for implant surgery.

Surgical Technique and Adjunct Therapies

Surgical technique itself is a critical but less easily standardized factor. Gentle tissue handling, meticulous hemostasis, eradication of dead space, and avoidance of hypothermia (core temperature >36°C) are principles supported by strong evidence. The use of supplemental oxygen (FiO_2 80%) intraoperatively and for 2-6 hours postoperatively in intubated patients has shown benefit in some trials by enhancing neutrophil oxidative killing, though findings are mixed (Seidelman et al., 2023). The choice of wound closure materials and methods (e.g., subcuticular sutures vs. staples) influences SSI risk, with meta-analyses suggesting lower infection rates with monofilament sutures for skin closure in clean-contaminated cases (Berríos-Torres et al., 2017).

The Postoperative Inpatient Phase

Following surgery, the responsibility for SSI prevention shifts predominantly to nursing staff, supported by pharmacy and ongoing surgical oversight.

Wound Care and Physiological Support

Inpatient nursing care focuses on maintaining a favorable wound environment and supporting host defenses. Key interventions include maintaining normothermia, as postoperative hypothermia can impair immune function; continued glycemic control, particularly for diabetic patients; and appropriate

wound dressing management (Tomsic et al., 2020). The evidence on optimal postoperative dressing type and change frequency is evolving, with increased interest in negative-pressure wound therapy for high-risk closed incisions. Nursing assessment skills are paramount: early recognition of signs of infection (erythema, warmth, pain, purulent discharge) allows for prompt intervention. Standardized nursing assessment tools and clear escalation pathways to the surgical team are essential components of effective surveillance (Parrish et al., 2022).

Antimicrobial Stewardship Continuation

The pharmacy's role extends into the postoperative period through vigilant monitoring of antibiotic use. Unnecessary continuation of prophylactic antibiotics beyond 24 hours remains a common problem, driven by outdated practices or concerns about breaks in sterility (Karapetyan et al., 2023). Pharmacist-led automatic stop orders, prospective audit and feedback, and education of surgical and nursing teams are effective stewardship strategies. Furthermore, ensuring appropriate treatment when an SSI is suspected—with timely culturing and targeted, narrow-spectrum therapy—falls under combined pharmacy and infectious disease purview (Bratzler et al., 2013).

Post-Discharge Monitoring

A substantial proportion of SSIs—30-50%—manifest after hospital discharge, making post-discharge surveillance a critical yet chronically under-resourced component of prevention.

Surveillance Methodologies and Challenges

Traditional hospital-based surveillance fails to capture these cases, leading to significant underestimation of true SSI rates. Effective post-discharge surveillance requires robust systems that may include: review of emergency department and readmission records, surgeon office chart review, patient self-reporting via surveys or digital platforms, and data mining of electronic health records for diagnosis codes or antibiotic prescriptions (Lathan et al., 2022). Each method has limitations in sensitivity, specificity, and cost. The expansion of telehealth postoperatively offers a new avenue for visual wound checks by nurses, potentially improving detection rates (Asiri et al., 2018). Epidemiologists are crucial in designing these surveillance systems, validating case definitions, and analyzing data to identify procedure-specific or surgeon-specific outliers that warrant quality improvement attention (Ng et al., 2022).

Patient Education and Engagement

Preventing SSIs after discharge hinges on effective patient education regarding wound care, signs of infection, and when to seek help. Discharge teaching, often led by nurses but requiring reinforcement from surgeons and consistent written materials, is frequently rushed and incompletely retained by patients (Tartari et al., 2017). The use of teach-back methods, wound care demonstration, and digital tools (apps, text message reminders) can improve understanding and compliance. Engaging patients as active participants in their own surveillance through structured self-monitoring checklists has shown promise in early pilot studies (Cox et al., 2023).

The Overarching Frameworks

The effectiveness of the clinical interventions described above is either enabled or constrained by the broader systems managed by epidemiologists and health administrators (Table 1).

Surveillance, Feedback, and Outbreak Detection

Hospital epidemiologists or infection preventionists are responsible for the surveillance systems that measure SSI rates, a fundamental prerequisite for improvement. The move from manual, labor-intensive surveillance to automated systems using electronic data is increasing efficiency and allowing for more comprehensive monitoring (Van Rooden et al., 2020). Beyond measurement, effective epidemiology involves timely feedback of risk-adjusted SSI rates to surgical teams and frontline staff, fostering a culture of transparency and accountability. Furthermore, epidemiologists lead outbreak investigations when SSI rates spike, requiring close collaboration with the OR team, microbiology lab, and facilities management to identify and rectify sources such as contaminated instruments or environmental reservoirs (Sawyer et al., 2019).

Aligning Metrics, Reimbursement, and Culture

Health administrators wield significant influence through resource allocation, policy setting, and the design of incentive structures. The alignment of quality metrics and reimbursement is a powerful lever. Value-based purchasing programs from the Centers for Medicare & Medicaid Services (CMS) that penalize hospitals for high SSI rates have focused administrative attention on prevention (Brandt et al., 2020). However, these metrics often target a narrow set of procedures (e.g., colon surgery, hip/knee arthroplasty), potentially diverting resources from other high-risk areas. Administrators must also foster an institutional culture of safety where reporting SSIs is non-punitive and interprofessional collaboration is rewarded. Investing in the necessary infrastructure—from sterile processing equipment to surveillance software—and ensuring adequate staffing ratios for nursing and infection prevention are essential administrative contributions (Irgang et al., 2023).

Table 1: The Interdisciplinary SSI Prevention Continuum (I-SSIPC)

Care Phase	Key Domains & Actions	Critical Interdisciplinary Handoff/Checkpoint	Outcome Metrics

Pre-Hospital	**EMS:** Sterile wound dressing, documentation of contamination. **Pharmacy:** (System) Provision of antiseptic dressings to EMS.	EMS to ED/Trauma Team: Structured handoff of wound details & pre-hospital care.	% of traumatic wounds receiving sterile dressing in field.
Preoperative	**Surgical/Nursing:** MRSA screening, decolonization, glycemic optimization. **Pharmacy:** SAP protocol development, patient education.	Pre-op nurse to OR circulator: Verification of SAP timing & completion of prep.	% compliance with SAP timing; % MRSA+ patients decolonized.
Intraoperative	**Surgical:** Aseptic technique, normothermia, glycemic control. **Nursing:** Traffic control, environmental monitoring.	OR team to PACU/Floor nurse: Handoff of intraoperative events (e.g., breaks in sterility).	Incidental normothermia rate; OR door openings/hour.
Postoperative Inpatient	**Nursing:** Wound assessment, glycemic control, early mobilization. **Pharmacy:** SAP discontinuation at 24h, stewardship.	Discharge planner/nurse to patient/home health: Comprehensive wound care instructions.	% SAP stopped at 24h; inpatient hypoglycemia events.
Post-Discharge	**Epidemiology:** Surveillance via EHR, patient surveys. **Nursing/Surgical:** Telehealth follow-up. **Patient:** Self-monitoring.	Patient self-report to surgical office: Recognition of SSI symptoms.	Post-discharge SSI capture rate; 30-day readmission for SSI.

Barriers to Integration and Proposed Solutions

Despite robust evidence for individual interventions, implementing them as a cohesive, system-wide strategy faces substantial barriers (Table 2).

Professional Silos and Communication Gaps

The most pervasive barrier is the persistence of professional silos. EMS protocols are developed by pre-hospital physicians with little input from hospital surgeons. Pharmacists may design elegant stewardship programs without full engagement from nursing staff responsible for antibiotic administration (Bjaalid et al., 2019). Surgeons may be unaware of the challenges nurses face in postoperative glycemic control. Breaking down these silos requires structured interprofessional forums—such as perioperative services committees that include representatives from all domains—and co-designed protocols (Reed et al., 2021).

Data System Fragmentation

Effective surveillance and feedback depend on integrated data. Currently, pre-hospital ePCR data rarely flows into the surgical EHR. Post-discharge data from surgeon offices or patient-reported outcomes are not integrated with hospital surveillance systems. Investing in health information technology interoperability is a non-negotiable prerequisite for a true continuum of prevention. Blockchain-like systems for secure, patient-centric data sharing or expanded use of FHIR standards could be transformative (World Health Organization, & United Nations Children's Fund, 2021).

Misaligned Financial Incentives

Fee-for-service reimbursement historically rewards treatment of complications (like SSIs) rather than their prevention. While value-based purchasing has begun to shift this, the financial models are often blunt instruments (Sreeramoju et al., 2021). Bundled payments for entire episodes of care (including post-discharge) that encompass all providers—hospital, surgeons, EMS agencies (for trauma)—could better align incentives for collaborative prevention across the entire pathway (Russo et al., 2021).

Table 2: Systems Alignment Matrix for SSI Prevention Metrics (SAM-SSI)

Stakeholder Domain	Clinical Quality Metric	Operational/Process Metric	Financial/Reimbursement Lever
EMS	Wound contamination rate on ED arrival.	% compliance with sterile dressing protocol.	Inclusion in trauma care bundled payment.
Surgical Team	Procedure-specific, risk-adjusted SSI rate.	% compliance with SAP timing & intraoperative normothermia.	Surgeon-specific reporting; shared savings/risk in bundles.
Inpatient Nursing	Inpatient-onset SSI rate; hypoglycemia rates.	% of wounds assessed with standardized tool; % of patients receiving pre-op education.	Nursing-sensitive outcome metrics in value-based purchasing.
Pharmacy	SAP duration >24h rate; C. difficile rate.	Time from order to verification/ delivery of SAP.	Stewardship program funding tied to antibiotic cost & outcome metrics.

Epidemiology	Overall & stratified SSI rates (incl. post-discharge).	Data completeness for surveillance; time to feedback to units.	CDC NHSN reporting compliance tied to accreditation.
Health Administration	CMS penalty avoidance; HCAHPS scores related to safety.	Resource allocation to prevention (FTEs, technology).	Performance on value-based purchasing programs; shared savings.

Conclusion

Surgical Site Infection prevention stands at a crossroads. The evidence base for effective interventions is extensive, yet rates remain stubbornly high because implementation is fragmented across professional domains that operate with different priorities, data systems, and incentives. This review has argued that the path forward requires a fundamental reconceptualization of SSI prevention as a continuous, patient-centered journey rather than a series of disconnected clinical tasks.

The proposed Interdisciplinary SSI Prevention Continuum (I-SSIPC) and Systems Alignment Matrix (SAM-SSI) provide blueprints for this transformation. They emphasize that success depends not only on each domain executing its evidence-based tasks but on creating robust connections *between* domains. The EMS provider must see themselves as the initiator of a prevention pathway that concludes weeks later with the epidemiologist's final surveillance report. The surgeon must trust and empower the nurse's postoperative assessment and the pharmacist's stewardship. The health administrator must create financial and cultural environments that reward collaboration over siloed achievement.

Achieving this vision demands commitment to interprofessional education, investment in interoperable health information technology, and courageous redesign of reimbursement models to reward outcomes achieved through collaboration. By viewing the patient's surgical journey through this integrated lens, healthcare systems can finally translate the robust science of SSI prevention into consistently excellent practice, reducing a profound source of human suffering and economic waste. The challenge is organizational and systemic, but the reward—safer surgery for all—is unquestionably worth the effort.

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