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SPECIAL REPORT

# SSI Prevention: Back to Basics

This report summarizes the basics of surgical site infection (SSI) prevention and control, including reviewing the burden of SSIs, risk factors and risk management, components of SSI prevention, plus current recommendations from clinical guidelines.

***By Kelly M. Pyrek***

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# SSI Prevention: Back to Basics

By Kelly M. Pyrek

The Centers for Disease Control and Prevention (CDC) defines a surgical site infection (SSI) as "an infection that occurs after surgery in the part of the body where the surgery took place."

## The Burden of SSIs

The CDC notes that "While advances have been made in infection control practices, including improved operating room ventilation, sterilization methods, barriers, surgical technique, and availability of antimicrobial prophylaxis, SSIs remain a substantial cause of morbidity, prolonged hospitalization and death. SSI is associated with a mortality rate of 3 percent, and 75 percent of SSI-associated deaths are directly attributable to SSIs."

According to the *National and State Healthcare-Associated Infection Progress Report*, released in January of this year by the CDC, some progress has been made in the effort to eliminate infections, including a 19 percent decrease in SSIs related to the 10 select procedures tracked in the report between 2008 and 2013.

In a point prevalence survey in 10 geographically diverse states published in the *New England Journal of Medicine* in March of this year, Magill, et al. (2014) found that SSIs tied with pneumonia as the most common infection type, and that SSIs constituted 21.8 percent of all HAIs in the survey. The data indicated that there were an estimated 157,500 SSIs in the U.S. in 2011. Estimates are based on an overall estimate of 648,000 patients with at least one healthcare–associated infection (HAI) in 2011. To calculate the numbers of estimated infections, the point estimate of the percentage of patients with a particular type of infection was multiplied by the point estimate of the overall number of patients with HAIs. As Magill, et al. note, surveys were conducted in 183 hospitals. Of 11,282 patients, 452 had one or more HAIs.

In terms of SSI impact on patient outcomes, Anderson, et al. (2014) point out that:

- Patients with an SSI have a 2- to 11-times higher risk of death compared with operative patients without an SSI.
- Seventy-seven percent of deaths in patients with SSI are directly attributable to SSI.
- Attributable costs of SSI vary depending on the type of operative procedure and the type of infecting pathogen.
- SSIs are believed to account for $3.5 billion to $10 billion annually in healthcare expenditures using the CPI (consumer price index for inpatient hospital services with all cost estimates adjusted for 2007 dollars).

## Risk Factors and Risk Management

Uçkay, et al. (2010) outline the risk factors for SSI development that have been shown to be independent determinants by multivariate analysis: "Among the most frequently cited are diabetes mellitus, age, obesity and incorrect or lack of antibiotic prophylaxis … Data on the clinical impact related to both endogenous and exogenous independent risk factors reveal risk indices oscillating between 1.3 and 4.5. Approximately half of all identified risk factors are endogenous and difficult to modify in the immediate preoperative and perioperative phase."

Anderson, et al. (2014) explain that the pathogenesis and likelihood of developing an SSI involves a complex relationship among the following:

- Microbial characteristics (degree of contamination, virulence of pathogen)
- Patient characteristics (immune status, comorbid conditions)
- Surgical characteristics (type of procedure, introduction of foreign material, amount of damage to tissues

Anderson, et al. (2014) add that risk factors for SSI can be separated into intrinsic patient-related characteristics and extrinsic procedure-related characteristics. Implement policies and practices to reducing modifiable risk factors, including the following:

- Optimal preparation and disinfection of the operative site and the hands of the surgical team members.
- Adherence to hand hygiene, including non-surgeon members of the operating team.
- Reduce unnecessary traffic in operating rooms.
- Appropriate care and maintenance of operating rooms, including appropriate air handling and optimal cleaning and disinfection of equipment and the environment.

There is an added imperative for SSI prevention and control. In accordance with the Deficit Reduction Act of 2005, hospitals that are paid by Medicare under the Acute Care Inpatient Prospective Payment System receive their full Medicare annual payment update only if they submit required quality measure information to the Centers for Medicare and Medicaid Services (CMS). As Anderson, et al. (2014) explain, "CMS now requires hospitals to submit data on seven SCIP

## National Healthcare Safety Network Criteria for Defining a Surgical Site Infection

***Superficial incisional SSI:*** Occurs within 30 days postoperatively and involves skin or subcutaneous tissue of the incision and at least one of the following: (1) purulent drainage from the superficial incision, (2) organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision, (3) at least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat, and superficial incision is deliberately opened by surgeon and is culture-positive or not cultured (a culture-negative finding does not meet this criterion), and (4) diagnosis of superficial incisional SSI by the surgeon or attending physician.

***Deep incisional SSI:*** Occurs within 30 days after the operative procedure if no implant is left in place or within one year if implant is in place and the infection appears to be related to the operative procedure, involves deep soft tissues (e.g., fascial and muscle layers) of the incision, and the patient has at least one of the following: (1) purulent drainage from the deep incision but not from the organ/space component of the surgical site, (2) a deep incision spontaneously dehisces or is deliberately opened by a surgeon and is culture-positive or not cultured and the patient has at least one of the following signs or symptoms: fever (>38 °C) or localized pain or tenderness (a culture-negative finding does not meet this criterion), (3) an abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination, and (4) diagnosis of a deep incisional SSI by a surgeon or attending physician.

measures as a part of the Hospital Inpatient Quality Reporting (IQR) system. Three of these measures focus on prevention of SSI (antimicrobial prophylaxis provided within one hour of incision, antimicrobial selection, and cardiac surgery perioperative glucose control). In addition, CMS now requires hospitals to report SSI rates for patients undergoing abdominal hysterectomy and colorectal surgery through NHSN. Actual rates of performance on SCIP measures now impacts hospital payment under the Value-Based Purchasing (VBP) program. Current benchmarks identified for the VBP score that is used to modify a hospital's base operating diagnosis-related group payment are at or near 100 percent."

An SSI risk assessment can be performed by members of a multidisciplinary team (e.g., surgical leadership, hospital administration, quality management services, and infection prevention and control) to identify gaps, improve performance, measure compliance, assess impact of interventions, and provide feedback. This team can determine baseline SSI rates by surgical specialty, procedure, and/or surgeon to better target your evaluation and interventions. Another strategy is to observe and review operating room personnel and the environment of care in the operating room.

As Anderson, et al. (2014) suggest, "Perform direct observation audits of operating room personnel to assess operating room processes and practices to identify infection control lapses, including but not limited to adherence to process measures (antimicrobial prophylaxis choice, timing and duration protocols, hair removal, etc.), surgical hand antisepsis, patient skin preparation, operative technique, surgical attire (wearing and/or laundering outside the operating room), and level of operating room traffic. Perform remediation when breaches of standards are identified. Perform direct-observation audits of environmental cleaning practices in the operating room, instrument processing (sterilization), and storage facilities. Review instrument processing and flash sterilization logs. Review maintenance records for operating room heating, ventilation, and air conditioning system, including results of temperature and relative humidity testing, and test for maintenance of positive air pressure in the operating room(s).Provide feedback and review infection control measures with operating room and environmental personnel."

*Organ/space SSI:* Involves any part of the body, excluding the skin incision, fascia, or muscle layers, that is opened or manipulated during the operative procedure. Specific sites are assigned to organ/space SSI to further identify the location of the infection (e.g., endocarditis, endometritis, mediastinitis, vaginal cuff, and osteomyelitis). Organ/space SSI must meet the following criteria: (1) infection occurs within 30 days after the operative procedure if no implant is in place or within 1 year if implant is in place and the infection appears to be related to the operative procedure, (2) infection involves any part of the body, excluding the skin incision, fascia, or muscle layers, that is opened or manipulated during the operative procedure, and (3) the patient has at least one of the following: (a) purulent drainage from a drain that is placed through a stab wound into the organ/ space, (b) organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/ space, (c) an abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination, and (d) diagnosis of an organ/space SSI by a surgeon or attending physician.

Source: Bratzler, et al. (2013)

## Guidance on SSI Prevention and Control

Anderson, et al. (2014) point out that up to 60 percent of SSIs have been estimated to be preventable by using evidence-based guidelines. A new CDC and Healthcare Infection Control Practices Advisory Committee (HICPAC) guideline for the prevention of surgical site infection is scheduled for publication soon, and will replace the previous *Guideline for Prevention of Surgical Site Infection, 1999*. In the meantime, there are several other sources for guidance.

In 2013, four professional organizations representing physicians and pharmacists collaborated to publish new clinical practice guidelines to help prevent infections from surgery. The American Society of Health-System Pharmacists (ASHP), the Infectious Diseases Society of America (IDSA), the Surgical Infection Society (SIS), and the Society for Healthcare Epidemiology of America (SHEA) worked together to develop these guidelines (Bratzler, et al. 2013). These guidelines reflect major updates to current clinical practice and were developed to help clinicians determine the best antimicrobial usage to help prevent infections in patients undergoing surgery. The guidelines were developed through an interprofessional panel using an evidence-based approach and included consideration for the validity, reliability, and clinical applicability of current literature. New sections added to the guidelines address: Preoperative screening and decolonization of microbes, such as methicillin-resistant Staphylococcus aureus (MRSA); optimal time for administration of pre- and intra-operative doses (for lengthy procedures); weight-based dosing for obese patients; common principles of antimicrobial prophylaxis for all types of surgical procedures; and guidance specifically for surgery involving the small intestine, colon, rectum, cardiovascular system, and breast; as well as hernia repair and plastic surgery.

As the infection prevention and control community awaits updated SSI guidance from HICPAC there is new thought on SSIs from the 2014 updated *Compendium of Strategies to Prevent Healthcare-Associated Infections in Acute Care Hospitals*, a collaborative effort led by the Society for Healthcare Epidemiology of America (SHEA), the Infectious Diseases Society of America (IDSA), the American Hospital Association (AHA), the Association for Professionals in Infection Control and Epidemiology (APIC) and the Joint Commission. The 2014 release updates the initial 2008 Compendium publication, and both endeavor to help practitioners in infection prevention and healthcare epidemiology identify and implement HAI prevention interventions.

The following are key SSI prevention strategies included in the Compendium:

- Antimicrobial pre- and post-operative therapy: Healthcare professionals should adhere to appropriate antimicrobial prescribing practices before and after the surgery to optimize outcomes.
- Preparation and monitoring protocols: Following protocols for proper hair removal, preoperative skin disinfection, and control of blood glucose levels in cardiac patients provides additional methods to help reduce SSIs.
- Post-operative surveillance: Because the indirect method of SSI surveillance is both reliable and specific, healthcare professionals are urged to use this approach and review microbiology reports, patient medical records, surgeon and patient surveys, and screen for readmission or return to the operating room in an effort to prevent SSIs.

The updated guidelines include a special section on implementation, emphasizing a team-based approach to prevention. These activities include engaging a multidisciplinary team that includes senior leadership and a champion physician in a culture of safety; educating surgical teams, senior leadership, and patients and families on prevention techniques; executing with a focus on reducing barriers and improving adherence with evidence-based practices to lower the risk of SSIs; and evaluating tools, practices and long-term SSI rates.

The Compendium presents the following strategies to prevent SSI:

**I. Basic practices for preventing SSI: recommended for all acute care hospitals**

**1.** Administer antimicrobial prophylaxis according to evidence-based standards and guidelines.

**2.** Do not remove hair at the operative site unless the presence of hair will interfere with the operation. Do not use razors.

**3.** Control blood glucose during the immediate postoperative period for cardiac surgery patients and non-cardiac surgery patients.

**4.** Maintain normothermia (temperature of 35.5 degrees C or more) during the perioperative period.

**5.** Optimize tissue oxygenation by administering supplemental oxygen during and immediately following surgical procedures involving mechanical ventilation.

**6.** Use alcohol-containing preoperative skin preparatory agents if no contraindication exists.

**7.** Use impervious plastic wound protectors for gastrointestinal and biliary tract surgery.

**8.** Use a checklist based on the WHO checklist to ensure compliance with best practices to improve surgical patient safety.

**9.** Perform surveillance for SSI.

**10.** Increase the efficiency of surveillance through utilization of automated data.

**11.** Provide ongoing feedback of SSI rates to surgical and perioperative personnel and leadership.

**12.** Measure and provide feedback to providers regarding rates of compliance with process measures.

**13.** Educate surgeons and perioperative personnel about SSI prevention.

**14.** Educate patients and their families about SSI prevention as appropriate.

**15.** Implement policies and practices aimed at reducing the risk of SSI that align with evidence-based standards (e.g., CDC, Association of periOpeative Registered Nurses (AORN), and professional organization guidelines.

**II. Special approaches for preventing SSI**

**1.** Screen for S. aureus and decolonize surgical patients with an anti-staphylococcal agent in the preoperative setting for high-risk procedures, including some orthopedic and cardiothoracic procedures.

**2.** Perform antiseptic wound lavage.

**3.** Perform an SSI risk assessment.

**4.** Observe and review operating room personnel and the environment of care in the operating room.

**5.** Observe and review practices in the post-anesthesia care unit, surgical intensive care unit (ICU), and/or surgical ward.

## Components of SSI Prevention and Control

A broad array of patient and procedural factors affect the risk of SSI, so a multi-factorial and multi-disciplinary approach is needed for SSI prevention. SSI prevention strategies should be designed to target the entire continuum of a surgical procedure: the pre-operative period, the intra-operative period and the post-operative period, as well as address intrinsic, patient-related factors and extrinsic, procedural factors.

As the IHI (2012) confirms, "A review of the medical literature shows that the following care components reduce the incidence of surgical site infection: appropriate use of prophylactic antibiotics; appropriate hair removal; controlled postoperative serum glucose for cardiac surgery patients; and immediate postoperative normothermia for colorectal surgery patients. These components, if implemented reliably, can drastically reduce the incidence of surgical site infection, resulting in the nearly complete elimination of preventable surgical site infection in many cases."

The IHI emphasizes that any improvement process to address SSIs "should be driven by leadership, with a commitment to providing adequate resources and attention to the initiative. It is also imperative to involve a multidisciplinary team in the surgical site infection improvement process. Successful teams set clear aims for their work, establish baseline measurements of performance, regularly measure and study the results of their work, and test various process and systems changes over a variety of conditions in order to find the ones that lead to improvement in their particular setting."

Uçkay, et al. (2010) say that four preventive measures are considered as having a high level of evidence (grade IA) according to major evidence-based guidelines: surgical hand preparation; appropriate antibiotic prophylaxis; and postponing of an elective operation in the case of active remote infection. Although hair clipping before surgery was considered grade IA evidence in the 1999 CDC guidelines, this high grading is now a matter of debate."

Let's take a look at the most common evidence-based recommendations for SSI prevention and control.

### *Surgical hand antisepsis*

Uçkay, et al. (2010) say that "Surgical hand preparation is probably the most important SSI prevention strategy, although there is no strict randomized study comparing surgery with and without previous hand antisepsis preparation sensu strictu. Its importance is supported by expert opinion, experimental studies and success stories of SSI reduction via mere hand hygiene promotion campaigns. However, owing to their multimodal design, most hand hygiene campaigns cannot distinguish between SSI reduction due to improved antisepsis in the operating theater versus better patient and wound care on the ward … A Cochrane review also addressed the issue of preoperative surgical hand preparation. Hand rubbing with an alcohol-based formulation was considered as effective as scrubbing, for which the ideal duration remains unknown, although it is probable that the minimum duration is 2–3 minutes for both techniques. Either alcohol-based handrubs or aqueous antiseptic scrubs can then be subsequently used between patients, provided hands are not visibly soiled."

### *Preoperative patient bathing/showering*

Some studies have shown that this practice reduces skin colonization. The CDC recommends that patients shower or bathe with an antiseptic agent prior to surgery, while NICE (National Institute for Health and Clinical Excellence in the United Kingdom) recommends the use of soap only. A Cochrane review including six trials with 10,000 participants found no evidence for the superiority of preoperative bathing and showering versus placebo.

Anderson, et al. (2014) observe that "Preoperative bathing with agents such as chlorhexidine has been shown to reduce bacterial colonization of the skin. Several studies have examined the utility of preoperative showers, but none has definitively proven that they decrease SSI risk. A Cochrane review evaluated the evidence for preoperative bathing or showering with antiseptics for SSI prevention. Six randomized controlled trials evaluating the use of 4% chlorhexidine gluconate were included in the analysis, with no clear evidence of benefit noted. It should be noted that several of these studies had methodological limitations and were conducted several years ago. Thus, the role of preoperative bathing in SSI prevention is still uncertain. To gain the maximum antiseptic effect of chlorhexidine, adequate levels of CHG must be achieved and maintained on the skin. Typically, adequate levels are achieved by allowing CHG to dry completely. New strategies for preoperative bathing with chlorhexidine, such as preimpregnated cloths, have shown promise, but data are currently insufficient to support this approach."

> "A recent multicenter study evaluated daily bathing of adult ICU patients with chlorhexidine and found a 32% decrease in the acquisition of MRSA colonization, a surrogate for health care-associated transmission of MRSA. VRE acquisition decreased by 30%, and the incidence of all bloodstream infections (BSIs) decreased by 21%.

Milstone, et al. (2008) summarizes recent inquiries into this subject matter: "Whether chlorhexidine baths alone can reduce MRSA infection remains unknown. However, recent evidence suggests that decontaminating ICU patients with daily chlorhexidine baths may reduce transmission of other multidrug-resistant organisms and prevent HAI. Daily bathing of ICU patients with chlorhexidine decreased skin and environmental contamination with VRE and reduced the incidence of VRE acquisition in a comparison of the intervention period with two periods of bathing involving baths that did not contain chlorhexidine. Not only did the intervention lead to decreased colonization of VRE on the skin of patients, but also fewer health care workers' hands were contaminated with VRE. Evidence is mounting that daily bathing of ICU patients with chlorhexidine may also reduce HAI. A recent multicenter study evaluated daily bathing of adult ICU patients with chlorhexidine and found a 32 percent decrease in the acquisition of MRSA colonization, a surrogate for health care-associated transmission of MRSA. VRE acquisition decreased by 30 percent, and the incidence of all bloodstream infections (BSIs) decreased by 21 percent. This study evaluated a before-and-after intervention, and additional studies will be needed to confirm these promising results. Although there is growing literature evaluating the use of chlorhexidine baths for patients with recurrent MRSA abscesses and other infections with community-associated MRSA strains, further research is needed in this important area."

Milstone (2008) adds, "Early studies demonstrated the utility of chlorhexidine-based soaps and hand scrubs; a natural extension of use of this agent lies in the field of preoperative baths and skin preparation for surgical patients. Postoperative surgical site infections are frequently caused by a patient's own skin flora, including those microorganisms that colonize body sites other than the surgical site. Similar to handwashing with chlorhexidine, chlorhexidine whole-body bathing significantly reduces microbial burden on the skin, and repeated baths lead to a progressive reduction of organisms over time. Preoperative bathing and scrubbing with chlorhexidine is superior to preoperative bathing and scrubbing with povidone-iodine in reducing skin colonization at the site of surgical incision. Preoperative baths are widely encouraged in clinical practice. Although we expect that decreasing general skin contamination in preoperative patients will decrease the number of SSIs, a clear cause-and-effect relationship has not been established to date."

"Essentially, surgical antimicrobial prophylaxis comes down to administering the right agent at the right time, in the right dose and for the right duration.

### *Preoperative screening and decolonization*

Bratzler, et al. (2013): "Preoperative screening for S. aureus carriage and decolonization strategies have been explored as means to reduce the rate of SSIs. Anterior nasal swab cultures are most commonly used for preoperative surveillance, but screening additional sites (pharynx, groin, wounds, rectum) can increase detection rates."

Uçkay, et al. (2010) assert that "The rationale behind this approach is to detect MRSA skin carriage before incision, identify carriers and administer glycopeptide prophylaxis in the case of known carriage. However, the results of several outstanding prospective trials in recent years are inconclusive. While some before/after studies report a benefit, other crossover design trials fail to show a reduction in SSI rates (or at least in SSI rates due to MRSA). Therefore the final outcome of this debate remains open."

### *Antimicrobial agents for surgical prophylaxis*

Essentially, surgical antimicrobial prophylaxis comes down to administering the right agent at the right time, in the right dose and for the right duration. The Institute for Healthcare Improvement (IHI, 2012 indicates these measures:

- Prophylactic antibiotic received within one hour prior to surgical incision
- Prophylactic antibiotic selection for surgical patients consistent with national guidelines
- Prophylactic antibiotics discontinued within 24 hours after surgery end time (48 hours for cardiac patients)

As Bratzler, et al. (2013) explain, "Ideally, an antimicrobial agent for surgical prophylaxis should (1) prevent SSI, (2) prevent SSI-related morbidity and mortality, (3) reduce the duration and cost of healthcare (when the costs associated with the management of SSI are considered, the cost-effectiveness of prophylaxis becomes evident), (4) produce no adverse effects, and (5) have no adverse consequences for the microbial flora of the patient or the hospital. To achieve these goals, an antimicrobial agent should be (1) active against the pathogens most likely to contaminate the surgical site, (2) given in an appropriate dosage and at a time that ensures adequate serum and tissue concentrations during the period of potential contamination, (3) safe, and (4) administered for the shortest effective period to minimize adverse effects, the development of resistance, and costs." Bratzler, et al. (2013) add, "The selection of an appropriate antimicrobial agent for a specific patient should take into account the characteristics of the ideal agent, the comparative efficacy of the antimicrobial agent for the procedure, the safety profile, and the patient's medication allergies. There is little evidence to suggest that broad-spectrum antimicrobial agents (i.e., agents with broad in vitro antibacterial activity) result in lower rates of postoperative SSI compared with older antimicrobial agents with a narrower spectrum of activity. However, comparative studies are limited by small sample sizes, resulting in difficulty detecting a significant difference between antimicrobial agents; therefore, antimicrobial selection is based on cost, safety profile, ease of administration, pharmacokinetic profile, and bactericidal activity.

Regarding administration of these antimicrobial agents, Bratzler, et al. (2013) indicate the following considerations:

- Timing of initial dose. "Successful prophylaxis requires the delivery of the antimicrobial to the operative site before contamination occurs. Thus, the antimicrobial agent should be administered at such a time to provide serum and tissue concentrations exceeding the minimum inhibitory concentration (MIC) for the probable organisms associated with the procedure, at the time of incision, and for the duration of the procedure … Overall, administration of the first dose of antimicrobial beginning within 60 minutes before surgical incision is recommended "
- Dosing. "To ensure that adequate serum and tissue concentrations of antimicrobial agents for prophylaxis of SSIs are achieved, antimicrobial-specific pharmacokinetic and pharmacodynamic properties and patient factors must be considered when selecting a dose."

The IHI (2012) says improvement can be achieved by the following actions:

- Use preprinted or computerized standing orders specifying antibiotic, timing, dose and discontinuation.
- Develop pharmacist- and nurse-driven protocols that include preoperative antibiotic selection and dosing based on surgical type and patient-specific criteria (age, weight, allergies, renal clearance, etc.).
- Change operating room drug stocks to include only standard doses and standard drugs, reflecting national guidelines.
- Assign dosing responsibilities to anesthesia or designated nurse (e.g., pre-op holding or circulator) to improve timeliness.
- Involve pharmacy, infection control and infectious disease staff to ensure appropriate timing, selection and duration.
- Verify administration time during –time-out or pre-procedural briefing so action can be taken if not administered.

Bratzler, et al. (2013) say future research is needed: "Additional research is needed in several areas related to surgical antimicrobial prophylaxis. The risks and benefits of continuing antimicrobial prophylaxis after the conclusion of the operative procedure, including dosing and duration, need to be further evaluated. Insight is needed to make specific recommendations for intraoperative repeat dosing, weight-based dosing in obese patients, and timing of pre-surgical antimicrobials that must be administered over a prolonged period (e.g., vancomycin, fluoroquinolones). Additional clarification is needed regarding targeted antimicrobial concentrations and intraoperative monitoring of antimicrobial serum and tissue concentrations to optimize efficacy. The role of topical administration of antimicrobial agents as a substitute for or an adjunct to IV antimicrobial prophylaxis needs to be further evaluated. Additional data are needed to guide the selection of antimicrobial agents for prophylaxis, particularly combination regimens, for patients with allergies to ß-lactam antimicrobials. Data are also needed to devise strategies to optimize antimicrobial prophylaxis in patients and facilities with a high risk or high prevalence of resistant organisms implicated in SSIs (e.g., MRSA). Optimal strategies for screening for S. aureus and decolonization for certain procedures need to be identified. Finally, outcomes studies are needed to assess the impact of using quality measures and pay-for-performance incentives designed to reduce surgical morbidity and mortality."

"Hair removal may not be necessary for many procedures, yet has been–carried over–from years ago when surgical patients commonly received extensive pre-op shaving.

### *Appropriate hair removal*

As the IHI (2012) explains, "For many years, it has been known that the use of razors prior to surgery increases the incidence of wound infection when compared to clipping, depilatory use, or no hair removal at all. Razors can cause small cuts and nicks to skin, many of which may be microscopic and not visible to the human eye. However, many teams working on this measure find that the use of razors in their own institutions can range from zero to nearly 100 percent. Hair removal may not be necessary for many procedures, yet has been–carried over–from years ago when surgical patients commonly received extensive pre-op shaving. When hair must be removed to safely perform the procedure, it should never occur with a razor. It is preferable to use clippers rather than shaving with a razor as this results in fewer surgical site infections. The use of clippers has been found to be the best method in many hospitals, as depilatory creams can cause skin reactions. Staff must be trained in the proper use of clippers because an untrained user can damage the skin. If hair must be removed preoperatively, it is generally recommended that this not occur in the operating room itself, as loose hairs are difficult to control."

The IHI (2012) says improvement can be achieved by the following actions:

- Ensure adequate supply of clippers and train staff in proper use.
- Use reminders (signs, posters).
- Educate patients not to self-shave preoperatively.
- Remove all razors from the entire hospital.
- Work with the purchasing department so that razors are no longer purchased by the hospital.

### *Maintaining normothermia*

As the IHI (2012) explains, "Anesthesia, anxiety, wet skin preparations, and skin exposure in cold operating rooms can cause patients to become clinically hypothermic during surgery." Uçkay, et al. (2010) affirm that "The intraoperative period is important in terms of SSI prevention and leaves room for measures not targeting the transmission of pathogens, but rather enhancing patient immunity. Perioperative hypothermia is common and is estimated to occur in about half of all surgical patients. Several trials and a systematic review reported the importance of maintaining normothermia during anesthesia (above 36°C). This requires close collaboration with anesthesiologists and is not easy to implement, but the benefits seem to be substantial."

The IHI (2012) says improvement can be achieved by the following actions:

- Prevent hypothermia at all phases of the surgical process.
- Use warmed forced-air blankets preoperatively, during surgery and in PACU.
- Use warmed fluids for IVs and flushes in surgical sites and openings.
- Use warming blankets under patients on the operating table.
- Use hats and booties on patients perioperatively.
- Adjust engineering controls so that operating rooms and patient areas are not permitted to become excessively cold overnight, when many rooms are closed.
- Measure temperature with a standard type of thermometer.

### *Glucose control*

Uçkay, et al. (2010) observe that "Similar to the avoidance of hypothermia, maintaining intraoperative normoglycemia (<200 mg/dl) throughout surgery and some hours beyond is regarded to be of benefit, although the evidence surrounding glycemic control is of mixed opinion in the literature. A Cochrane review identified five randomized trials on this topic. None evaluated strict glycemic control in the immediate preoperative period or outside the intensive care unit. Owing to heterogeneity in patient populations, glycemic target and definitions, a combination of the results into a meta-analysis was not appropriate. Nevertheless, glycemic control is used as a cornerstone of SSI prevention in many trials or settings. This is another area where further research is required."

The IHI (2012) says improvement can be achieved by the following actions:

- Implement one standard glucose control protocol for cardiac surgery.
- Regularly check preoperative blood glucose levels on all patients to identify hyperglycemia; this is best done early enough that assessment of risk can be completed and treatment initiated if appropriate.
- Assign responsibility and accountability for blood glucose monitoring and control.

## Other Best Practices

Spruce (2014) offers the following common-sense recommendations for safe practice in the operating room that can help curb SSIs. Personnel should:

- Clean their hands often with an alcohol-based product and perform appropriate surgical hand scrubs

- Perform surgical skin antisepsis using an appropriate technique and antiseptic
- Wear clean, facility-laundered scrub attire
- Minimize OR traffic
- Follow environmental cleaning protocols
- Engage with a patient who has experienced an SSI or the patient's family member to develop SSI prevention strategies
- Follow a surgical safety checklist
- Implement team training to promote a team-based approach to SSI prevention
- Minimize the use of immediate use steam sterilization
- Clean surgical instruments thoroughly before sterilizing or disinfecting
- Speak up whenever a break in sterile technique is witnessed and correct the break in protocol as soon as possible

There are a number of strategies that healthcare professionals and administrators can use to reduce and prevent SSIs in their institutions. The Joint Commission's Implementation Guide for NPSG.07.05.01 on Surgical Site Infections: The SSI Change Project makes the following recommendations for practices according to hospital stakeholder:

***Effective leadership practices***

- Resources are dedicated to decrease SSI rates
- Support of SSI reduction by top level leadership
- Financial incentives for practitioners to reduce SSIs

***Effective clinician practices***

- Practitioners accept and/or take accountability/responsibility
- Highly engaged physicians are champions to reduce SSIs in their service
- Anesthesia practitioners provide the prophylactic antibiotics

The Joint Commission also suggests the following process improvement practices:

- Preoperative/postoperative order sets are developed/revised to match NPSG.07.05.01 and other evidence-based practices (EBP) used in the hospital
- Decreasing OR traffic
- Direct observation of EBP in the OR by infection prevention and control (IC) staff (MD or RN)
- Using chlorhexadine gluconate for preoperative baths
- Daily SSI vigilance
- One-to-one education of physicians
- Post-discharge surveillance of SSIs with report-back to hospital committees
- Aligned and coordinated education for staff and licensed independent practitioners (LIP)
- Participation in an SSI-focused collaborative (e.g., SCIP, IHI etc.)
- Focus on implementing EBP in the hospital
- Acting on identified SSI issues
- Support of migration of SSI EBP from one surgical service to another
- Use of specific SSI tools for patient education
- Use of performance improvement tools
- Use of multidisciplinary teams

- Use of benchmarking/comparison of SSI rates
- Use of information technologies
- Focus on improving organizational integration

A multi-modal, bundle approach has been recommended by a number of experts. As Uçkay, et al. (2010) explain, "Instead of targeting single risk factors, it is advised to target several at the same time, although they are usually based on pre/post intervention studies and not randomized trials or meta-analyses. Multimodal interventions, sometimes in the form of so-called 'bundles,' have become very popular in recent years. A variant are safety checklists that have been inspired from the airline industry … Multimodal interventions based on bundles or checklists are the strategy with the highest impact in terms of SSI prevention."

Anderson, et al. (2014) recommend the use a checklist based on the World Health Organization (WHO) checklist to ensure compliance with best practices to improve surgical patient safety. The WHO checklist is a 19-item surgical safety checklist to improve adherence with best practices.

The best interventions are useless without education and training of healthcare personnel so they can properly implement these practices. Anderson, et al. (2014) recommend:

- Regularly provide education to surgeons and perioperative personnel through continuing education activities directed at minimizing perioperative SSI risk through implementation of recommended process measures.
- Provide education regarding the outcomes associated with SSI, risks for SSI, and methods to reduce risk to all patients, patients' families, surgeons, and perioperative personnel.
- Education for patients and patients' families is an effective method to reduce risk associated with intrinsic patient-related SSI risk factors.

Anderson, et al. (2014) assert that "Accountability is an essential principle for preventing HAIs. It provides the necessary translational link between science and implementation. Without clear accountability, scientifically based implementation strategies will be used in an inconsistent and fragmented way, decreasing their effectiveness in preventing HAIs. Accountability begins with the chief executive officer and other senior leaders who provide the imperative for HAI prevention, thereby making HAI prevention an organizational priority. Senior leadership is accountable for providing adequate resources needed for effective implementation of an HAI prevention program. These resources include necessary personnel (clinical and nonclinical), education, and equipment."

To foster the four key implementation strategies — engage, educate, execute, and evaluate — Anderson, et al. (2014) make the following recommendations:

***Engage***

- Obtain support for SSI reduction from senior leadership.
- Obtain highly engaged physicians as champions.
- Use multidisciplinary teams.
- Adopt evidence-based practices and guidelines.
- Focus on a culture of safety.

### *Educate*

- Aligned and coordinated SSI education for licensed independent practitioners and staff.
- One-to-one education of the surgeon when an SSI issue is identified.
- Education for senior leadership that describes the value and benefits of SSI reduction.
- Education for the surgical team on safety science.
- Specific SSI education for patients and families.

### *Execute*

- Use a quality improvement methodology.
- Differentiate between adult and pediatric populations.
- Use information technologies (IT).
- Participate in a collaborative.
- Use preoperative/postoperative order sets.
- Act on identified SSI issues.
- Establish a protocol for preoperative testing.

### *Evaluate*

- Use performance improvement tools.
- Perform direct observation of evidence-based practices.
- Use longitudinal evaluation of SSI rates and compliance rates.

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