Preventing Surgical Site Infections (SSI)
Learning Objectives:

• Discuss risk factors for surgical site infections in healthcare settings.
• Review current strategies and emerging guidelines for SSI prevention.
• Discuss challenges in monitoring and preventing SSIs.
SSI Surveillance: Definitions and Methods
Why focus on SSI detection?

• Growing patient safety focus on preventing healthcare-associated infections, including surgical site infections
• Accurate tracking of infections is an essential foundation for prevention
• Increasing number of states that require mandatory reporting of SSI following select procedures
• Very limited SSI surveillance data available for ambulatory surgery
Why perform surveillance?

- Identify clusters
- Determine baseline risks
- Evaluate prevention measures
- Compare to others
- Identify risk factors
- Satisfy regulators
A Reliable and Useful Surveillance Program Requires . . .

• Meaningful definitions of infection that are...
• Consistently applied...
• To the entire population at risk...
• Without too much effort
Why is it hard?

- Problematic definitions
- Resource intensive
- Much of the action occurs after hospitalization ends
<table>
<thead>
<tr>
<th></th>
<th>NHSN</th>
<th>NSQIP</th>
<th>STS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which infections</td>
<td>Superficial, deep, organ/space</td>
<td>Superficial, deep, organ/space</td>
<td>Deep/organ space</td>
</tr>
<tr>
<td>Surveillance period</td>
<td>30 days (no implant) or 1 year (implant)</td>
<td>30 days</td>
<td>30 days</td>
</tr>
<tr>
<td>Risk adjustment</td>
<td>ASA, wound class, duration in risk model</td>
<td>Many variables in risk model</td>
<td>Many variables in risk model</td>
</tr>
<tr>
<td>What’s reported</td>
<td>SSI rates, observed/expected</td>
<td>Observed/expected</td>
<td>Observed/expected</td>
</tr>
</tbody>
</table>
Defining Surgical Site Infections

**Superficial incisional**
(skin or subcutaneous tissue)

- Infection $\leq 30$ days after procedure and at least 1 of the following:
  - Purulent drainage from superficial incision
  - Organisms isolated aseptically
  - At least 1: pain/tenderness, swelling, redness, heat AND superficial incision deliberately opened by surgeon unless culture-negative
  - SSI diagnosed by surgeon or attending physician

Defining Surgical Site Infections (cont.)

– Deep incisional

– (deep soft tissue at incision site)

– Infection ≤30 days after procedure (no implant) or ≤1 year (with implant) plus at least 1 of the following:
  – Purulent drainage from deep incision but not from organ/space
  – Spontaneous dehiscence or surgical opening of deep incision unless culture-negative AND at least 1: fever or pain or tenderness
  – Abscess or other evidence of infection involving deep incision
  – SSI diagnosed by surgeon or attending physician

Defining Surgical Site Infections (cont.)

Organ/space
(any site other than incision)

- Infection ≤30 days after procedure (no implant) or ≤1 year (with implant) plus at least 1 of the following:
  - Purulent drainage from a drain placed through a stab wound into organ/space
  - Organisms isolated from aseptically obtained culture of fluid or tissue
  - Abscess or other evidence of infection involving the organ/space found by histopathologic examination, X-ray, or reoperation
  - SSI diagnosed by surgeon or attending physician

Data sources used for surveillance

- Microbiology data
- Operative reports
- Readmissions following surgery
- Inpatient antibiotic data
- Discharge diagnosis codes
NHSN risk adjustment (previous)

• 3 equally weighted variables:
  – American Society of Anesthesiologists (ASA) score of $\geq 3$
  – Wound classification of either contaminated or dirty/infecte
  – Length of surgery $>75^{th}$ percentile for the specific operation
NHSN Risk Adjustment (future)

- Measurement System: CDC National Healthcare Safety Network (NHSN)
- Baseline Period: 2006-2008
- Current (CY 2009): SIR = 0.95 = 3,930 / 4,144 SSIs
  - 5% reduction from baseline
  - 946 facilities reporting; 416,341 procedures reported

<table>
<thead>
<tr>
<th>SCIP Procedure</th>
<th>No. of SSIs</th>
<th>Validated Parameters for Risk Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal aortic aneurysm repair</td>
<td>30</td>
<td>duration of procedure, wound class</td>
</tr>
<tr>
<td>Coronary artery bypass graft</td>
<td>1,644</td>
<td>age, ASA, duration of procedure, gender, med school affiliation, age gender (interaction)</td>
</tr>
<tr>
<td>Cardiac surgery</td>
<td>229</td>
<td>age, duration of procedure, emergency (y/n)</td>
</tr>
<tr>
<td>Colon surgery</td>
<td>1,825</td>
<td>age, ASA, duration, endoscope, med school affiliation, hospital bed size, wound class</td>
</tr>
<tr>
<td>Hip prosthesis</td>
<td>1,183</td>
<td>total/partial/revision, age, anesthesia, ASA, duration of procedure, med school affiliation, hospital bed size, trauma (y/n)</td>
</tr>
<tr>
<td>Abdominal hysterectomy</td>
<td>389</td>
<td>age, ASA, duration of procedure, hospital bed size</td>
</tr>
<tr>
<td>Knee prosthesis</td>
<td>1,108</td>
<td>age, ASA, duration of procedure, gender, med school affiliation, hospital bed size, trauma (y/n)</td>
</tr>
<tr>
<td>Peripheral vascular bypass surgery</td>
<td>176</td>
<td>age, ASA, duration of procedure, med school affiliation</td>
</tr>
<tr>
<td>Rectal surgery</td>
<td>38</td>
<td>duration of procedure, gender, hospital bed size</td>
</tr>
<tr>
<td>Vaginal hysterectomy</td>
<td>122</td>
<td>age, duration of procedure</td>
</tr>
</tbody>
</table>

Courtesy of S Fridkin, CDC
Standardized Infection Ratio (SIR)

SIR = Observed number of infections/Expected number of infections

Not significantly different from benchmark if “1.0” falls between the lower and upper 95% confidence intervals

Hospital A with CABG SIR of 1.6 (95% CI of 0.8, 1.9): not significantly different

Hospital B with CABG SIR of 1.6 (95% CI of 1.2, 1.8): significantly higher SSI rate

Hospital C with CABG SIR of 0.8 (95% CI of 0.5, 0.9): significantly lower SSI rate
CMS Inpatient Prospective Payment System 2011: HAI reporting requirements

- Jan 2011: report CLABSI among ICU and NICU patients
- Jan 2012: SSI rates for some procedures
  - Coronary artery bypass graft?
  - Other cardiac surgery?
  - Hip or knee arthroplasty?
  - Colorectal surgery?
  - Hysterectomy?
  - Vascular surgery?
SSI surveillance outside of the inpatient hospital setting
Methods for post-discharge surveillance

- “Standard” infection prevention surveillance
- Prospective surveillance with post-discharge follow-up
- Self-reporting by patients and surgeons
Limits of hospital based SSI surveillance

• Many procedures have no post-op hospital stay.
• Most infections are identified after discharge.

5,572 procedures. Sands, JID 1996
Limits of hospital based SSI surveillance

• The majority never returned to the hospital.
• These SSIs caused 4-5 additional ambulatory encounters.

5,572 procedures. Sands, JID 1996
Post-discharge SSI surveillance

- Surgeons’ questionnaires miss most infections
- Most infections reported by surgeons aren’t postoperative SSIs

5,572 procedures. Sands, JID 1996; Sands JID 1999;179:434
Post-discharge SSI surveillance

• Surgeons’ questionnaires miss most infections
• Most infections reported by surgeons aren’t postoperative SSIs
• Patients do just as poorly
• Administrative data are much more accurate

5,572 procedures. Sands, JID 1996; Sands JID 1999;179:434
Alternative surveillance methods: Using claims-based SSI indicators

- Developed claims-based indicators of CABG SSI to identify hospitals with high SSI rates*
- Applied algorithms to 2005 Medicare claims to rank hospitals into deciles of post-CABG SSI risk
- National validation of cases in top and bottom decile


US Hospitals Performing ≥80 CABGs in Medicare Patients
## Predictors of 60-day CABG SSI Risk

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Odds Ratio (Confidence Interval)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABG Performed in Bottom vs. Top Decile Hospital</td>
<td>2.7 (2.2, 3.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>0.0006</td>
</tr>
<tr>
<td>65-74</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>75-84</td>
<td>0.6 (0.4, 1.0)</td>
<td></td>
</tr>
<tr>
<td>85+</td>
<td>0.7 (0.5, 0.8)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.7 (1.4, 2.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Open vs. Minimally Invasive</td>
<td>1.0 (0.8, 1.2)</td>
<td>0.8</td>
</tr>
<tr>
<td>Comorbidity Score (Romano)</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>1.4 (0.9, 2.2)</td>
<td></td>
</tr>
<tr>
<td>5+</td>
<td>2.5 (1.6, 4.0)</td>
<td></td>
</tr>
</tbody>
</table>

Huang SS, et al. SHEA Annual Meeting (San Diego), 2009
Conclusions (Huang SS, et al)

• Claims-based algorithm can be used to rank US hospitals by CABG SSI risk for Medicare patients
• There is a 3-fold risk of SSIs between top and bottom decile hospitals
• Claims enables adjustment for host-based predictors of SSI, such as gender, age, and comorbidities
• Medicare could use this algorithm to identify outlier hospitals for targeted review and assessment of actual SSI risk
Ambulatory Surgery: The next surveillance frontier

- “Ambulatory surgery” = surgical episode where the patient requires hospital care for <24 hours and no overnight stay.
- Accounts for an increasing proportion of surgeries in the U.S.
- Little data about the risk of infectious complications

Proportion of surgical procedures that are ambulatory surgery

Preventing surgical site infections
Basic Practices

- Perform SSI surveillance for targeted procedures
- Provide ongoing feedback to surgical and perioperative personnel and leadership
- Make use of automated data to increase the efficiency of surveillance
  - Pharmacy data
  - Diagnosis codes
  - Microbiology data
  - OR information
Basic Practices

• Administer antimicrobial prophylaxis in accordance with evidence-based standards and guidelines

“Let’s just start cutting and see what happens.”
Perioperative antimicrobial prophylaxis

What is perioperative antimicrobial prophylaxis?
   - A brief course of an antimicrobial agent initiated just before an operation begins (i.e., before contamination occurs)

What’s the purpose of prophylaxis?
   - To reduce the microbial burden of intraoperative contamination in order to prevent the occurrence of surgical site infections.
Which surgical procedures benefit from prophylaxis?

- High risk for infection
  - Procedure-related risks OR
  - Patient risk factors
- Procedures involving prosthetic implants
- Potential severe sequelae from SSI
**Relative benefit from antimicrobial prophylaxis**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Prophylaxis (%)</th>
<th>Placebo (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colon</td>
<td>4-12</td>
<td>24-48</td>
</tr>
<tr>
<td>Other (mixed) GI</td>
<td>4-6</td>
<td>15-29</td>
</tr>
<tr>
<td>Vascular</td>
<td>1-4</td>
<td>7-17</td>
</tr>
<tr>
<td>Cardiac</td>
<td>3-9</td>
<td>44-49</td>
</tr>
<tr>
<td>Hysterectomy</td>
<td>1-16</td>
<td>18-38</td>
</tr>
<tr>
<td>Craniotomy</td>
<td>0.5-3</td>
<td>4-12</td>
</tr>
<tr>
<td>Spinal operation</td>
<td>2.2</td>
<td>5.9</td>
</tr>
<tr>
<td>Total joint repl</td>
<td>0.5-1</td>
<td>2-9</td>
</tr>
<tr>
<td>Brst &amp; hernia ops</td>
<td>3.5</td>
<td>5.2</td>
</tr>
</tbody>
</table>
Surgical Care Improvement Project (SCIP) recommendations

– Choice of antimicrobial agent

– Start time within 1 hour of incision (2 hrs for vancomycin and fluoroquinolones)

– Discontinuation within 24 hours (48 hours for cardiac surgery)
How should prophylaxis be used?

• Use an agent that is safe, inexpensive and with an antimicrobial spectrum that is appropriate.
  ✓ Procedures where skin colonizers (e.g., *Staphylococcus aureus*) are the most common pathogens, use an anti-staphylococcal agent: cefazolin
  ✓ Keep spectrum as **narrow** as possible
Draft Therapeutic Guidelines on Antimicrobial Prophylaxis in Surgery

The original Therapeutic Guidelines on Antimicrobial Prophylaxis in Surgery was published in 1999. The American Society of Health-System Pharmacists, Infectious Diseases Society of America, Surgical Infection Society, and Society of Healthcare Epidemiology of America have collaborated to revise this current draft of the therapeutic guideline to reflect the current knowledge on antimicrobial prophylaxis in surgery since 1999.
How should prophylaxis be used?

• Need inhibitory levels in serum and tissues when contamination occurs and maintain therapeutic levels throughout the operation.
  ✓ Initiate prophylaxis before incision
  ✓ Adjust dosing to be appropriate for patient weight
  ✓ Consider repeat intraoperative doses for long procedures
Timing of antimicrobial prophylaxis

- Prophylactic antimicrobials should be started within one hour prior to surgical incision (two hours allowed for vancomycin or quinolones)
Timing of prophylaxis and risk of surgical site infection


Infection Rate (%)

![Bar chart showing the infection rate before and after the incision.](chart.png)
How should prophylaxis be used?

• End prophylaxis within 24 hours after completion of surgery (48 hours for cardiac surgery)
  ➢ No evidence to support extending prophylaxis for devices (e.g., drains, chest tubes, pacing wires)
  ➢ Little evidence to support use of antimicrobial prophylaxis after incision closure
  ➢ Extended prophylaxis may promote antimicrobial resistance
Provide protocols

• Design standard protocols based on surgery type
  ✓ Minimize reliance on individual physician memory
• Include guidance for common exceptions
  ✓ Penicillin/cephalosporin allergy
• Use your own formulary to narrow choices
  ✓ Makes protocol easier and saves costs
Provide a clear process

• Identify owners clearly: who starts it and who documents it
• Take advantage of habits and patterns
  ✓ Dose of antibiotic started at a point that makes sense and is easy to remember
Provide a clear process

• Verify that the antibiotic has been started before the incision

✓ Final check at pre-procedural briefing or time-out
Surgical Safety Checklist

Before induction of anaesthesia
(with at least nurse and anaesthetist)

- Has the patient confirmed his/her identity, site, procedure, and consent?
  - Yes
  - Not applicable

- Is the site marked?
  - Yes
  - Not applicable

- Is the anaesthesia machine and medication check complete?
  - Yes

- Is the pulse oximeter on the patient and functioning?
  - Yes

- Does the patient have a:
  - Known allergy?
    - No
    - Yes
  - Difficult airway or aspiration risk?
    - No
    - Yes, and equipment/assistance available
  - Risk of >500mL blood loss (7mL/kg in children)?
    - No
    - Yes, and two IVs/central access and fluids planned

Before skin incision
(with nurse, anaesthetist and surgeon)

- Confirm all team members have introduced themselves by name and role.
- Confirm the patient's name, procedure, and where the incision will be made.

- Has antibiotic prophylaxis been given within the last 60 minutes?
  - Yes
  - Not applicable

Anticipated Critical Events

To Surgeon:
- What are the critical or non-routine steps?
- How long will the case take?
- What is the anticipated blood loss?

To Anaesthetist:
- Are there any patient-specific concerns?

To Nursing Team:
- Has sterility (including indicator results) been confirmed?
- Are there equipment issues or any concerns?

- Is essential imaging displayed?
  - Yes
  - Not applicable

Before patient leaves operating room
(with nurse, anaesthetist and surgeon)

- Nurse Verbally Confirms:
  - The name of the procedure
  - Completion of instrument, sponge and needle counts
  - Specimen labelling (read specimen labels aloud, including patient name)
  - Whether there are any equipment problems to be addressed

To Surgeon, Anaesthetist and Nurse:
- What are the key concerns for recovery and management of this patient?

This checklist is not intended to be comprehensive. Additions and modifications to fit local practice are encouraged.

Revised 1 / 2009
©WHO, 2009

http://www.who.int/patientsafety/safesurgery/en/
Table 5. Outcomes before and after Checklist Implementation, According to Site.*

<table>
<thead>
<tr>
<th>Site No.</th>
<th>No. of Patients Enrolled</th>
<th>Surgical-Site Infection</th>
<th>Unplanned Return to the Operating Room</th>
<th>Pneumonia</th>
<th>Death</th>
<th>Any Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>1</td>
<td>524</td>
<td>598</td>
<td>4.0</td>
<td>2.0</td>
<td>4.6</td>
<td>1.8</td>
</tr>
<tr>
<td>2</td>
<td>357</td>
<td>351</td>
<td>2.0</td>
<td>1.7</td>
<td>0.6</td>
<td>1.1</td>
</tr>
<tr>
<td>3</td>
<td>497</td>
<td>486</td>
<td>5.8</td>
<td>4.3</td>
<td>4.6</td>
<td>2.7</td>
</tr>
<tr>
<td>4</td>
<td>520</td>
<td>545</td>
<td>3.1</td>
<td>2.6</td>
<td>2.5</td>
<td>2.2</td>
</tr>
<tr>
<td>5</td>
<td>370</td>
<td>330</td>
<td>20.5</td>
<td>3.6</td>
<td>1.4</td>
<td>1.8</td>
</tr>
<tr>
<td>6</td>
<td>496</td>
<td>476</td>
<td>4.0</td>
<td>4.0</td>
<td>3.0</td>
<td>3.2</td>
</tr>
<tr>
<td>7</td>
<td>525</td>
<td>585</td>
<td>9.5</td>
<td>5.8</td>
<td>1.3</td>
<td>0.2</td>
</tr>
<tr>
<td>8</td>
<td>444</td>
<td>584</td>
<td>4.1</td>
<td>2.4</td>
<td>0.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Total</td>
<td>3733</td>
<td>3955</td>
<td>6.2</td>
<td>3.4</td>
<td>2.4</td>
<td>1.8</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.001</td>
<td>0.047</td>
<td>0.46</td>
<td>0.003</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

* The most common complications occurring during the first 30 days of hospitalization after the operation are listed. Bold type indicates values that were significantly different (at P<0.05) before and after checklist implementation, on the basis of P values calculated by means of the chi-square test or Fisher’s exact test. P values are shown for the comparison of the total value after checklist implementation as compared with the total value before implementation.

Basic Practices

• Do not remove hair at the operative site unless the presence of hair will interfere with the operation; do not use razors
  ✓ Remove all razors from the perioperative suite
  ✓ Provide mechanical clippers with replaceable heads.
Shaving, Clipping and SSI

% Infected

Basic Practices

• Control blood glucose levels during the immediate postoperative period for patients undergoing cardiac surgery
  ✓ Set clear goals: glucose <200 mg/dL measured at 6:00 AM on postoperative days 1 and 2
Other basic prevention practices

- Implement policies and practices that meet regulatory and accreditation requirements and are aligned with evidence-based standards (e.g., HICPAC guidelines)
Intrinsic modifiable risks

- Reduce hemoglobin A1c to <7% \textit{A-II}
- Smoking cessation >30 days prior to surgery \textit{A-II}

Extrinsic risks: Pre-operative

• Treat pre-existing infections at remote sites prior to surgery *A-II*

Extrinsic risks: Peri-operative

- Surgical scrub or alcohol-based surgical hand antiseptic agent *A-II*
- Skin preparation at the operative site *A-II*
- Optimize surgeon technique *A-III*
- Adhere to principles of operating room asepsis *A-III*

Extrinsic risks: Perioperative

- Follow facility guidelines for OR construction and ventilation **C-I**
- Minimize traffic **B-II**
- Optimize sterilization of equipment; minimize use of flash sterilization **B-I**
- Optimize environmental cleaning **B-III**

Unresolved issues

• Pre-operative *Staphylococcus aureus* screening and decolonization
• Maintain normothermia
• Maintain oxygenation
Do CHG bathing and intranasal mupirocin prevent SSIs?

- Theoretical benefit:
- Nasal *S. aureus* carriers may also be colonized at extra-nasal sites
- Combining CHG bathing and intranasal mupirocin may eradicate nares and skin *S. aureus* colonization
CHG bathing plus mupirocin

- Randomized, double-blinded, placebo-controlled multicenter study of 6,771 patients in the Netherlands (Bode *NEJM* 2010)
- Mainly surgical patients
- Rapid screening for MSSA/MRSA on admission
- Carriers randomized to mupirocin/CHG soap vs. placebo/bland soap x 5 days

Bode LGM, et al. *NEJM* 2010;362:9-17
Bode, et al (continued)

- **Results**: CHG bathing/mupirocin group had significantly lower SSI rates than the placebo group

<table>
<thead>
<tr>
<th>Localization of infection</th>
<th>Mupiroc-CHG</th>
<th>Placebo</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep surgical site</td>
<td>4 (0.9)</td>
<td>16 (4.4)</td>
<td>0.21 (0.07-0.62)</td>
</tr>
<tr>
<td>Superficial surgical site</td>
<td>7 (1.6)</td>
<td>13 (3.5)</td>
<td>0.45 (0.18-1.11)</td>
</tr>
</tbody>
</table>

Bode LGM, et al. *NEJM* 2010;362:9-17
**Bode, et al (continued)**

- **Conclusions:** Rapid preoperative identification of *S. aureus* carriers followed by 5 days of intranasal mupirocin plus CHG bathing reduced *S. aureus* SSIs by ~60%  
- **Caveat:** No MRSA carriers or mupirocin resistance were found, patients with expected stay of <4 days were excluded

Bode LGM, et al. *NEJM* 2010;362:9-17
Why not use pre-operative mupirocin for *ALL* surgical patients?

Prevent *S. aureus* SSIs for some patients
Why not use pre-operative mupirocin for *ALL* surgical patients?

- Prevent *S. aureus* SSIs for some patients
- Mupirocin resistance
  - Costs and logistics
Possible implementation strategies

- Target patients known to be *S. aureus* nasal carriers (MSSA and MRSA)
  - Most likely to benefit from decolonization
  - Reduce the risk of promoting mupirocin resistance by focusing on this subgroup
- Target patients scheduled for high risk, non-general surgery
  - Orthopedic surgery involving implants
  - Cardiac surgery
Process measures: SSI

• Compliance with antimicrobial prophylaxis guidelines
  ✓ Choice of antimicrobial agent
  ✓ Start time within 1 hour of incision (2 hrs for vancomycin and fluoroquinolones)
  ✓ Discontinuation within 24 hours (48 hours for cardiac surgery)
• Compliance with hair removal guidelines
• Compliance with perioperative glucose control guidelines
• Look for documentation of the number of procedures in compliance / number of observations x 100
Outcome Measures: SSI

• Perform SSI surveillance
  ✓ Identify high-risk, high-volume operative procedures to target
  ✓ Use NHSN definitions
  ✓ Risk adjustment per NHSN
  ✓ Benchmark against NHSN rates using SIRs
Resources


