Establishing A Culture of Safety: The 7 S Bundle To Prevent Surgical Site Infections

Maureen Spencer, RN, M.Ed., CIC
Infection Preventionist Consultant
Boston, MA

www.7sbundle.com
www.workingtowardzero.com
www.infectionpreventionistconsultants.com

Despite current preventive measures, SSIs remain a significant problem

- In the US (2006) there were ~ 80 million surgical procedures
- Between 2006 -2009 approximately 1.9% developed SSI[1]
- Between 2009-2010 SSIs accounted for 23% of 69,475 HAIs reported to NHSN [2]

TABLE 2. Types of Healthcare-Associated Infections (HAIs) Reported to the National Healthcare Safety Network by HAI Type, by Time Period, 2007–2010

Event	No. (%) of events reported 2007–2008 (n = 47,582)	No. (%) of events reported 2009–2010 (n = 69,475)
CLABSI	18,651 (39.2)	27,766 (40.0)
CAUTI	11,863 (24.9)	19,058 (27.4)
VAP	6,290 (13.2)	6,632 (9.5)
SSI	10,778 (22.7)	16,019 (23.1)

1. Mu Y et al. Improving risk-adjusted measures of surgical site infections for the national healthcare safety network. *Infection control and hospital epidemiology*. Oct 2011;32(10):970-986.

2. Sievert DM at al Antimicrobial resistant pathogens associated with healthcare associated infections. Summary of data reported to the Centers for Disease Control and Prevention 2009-2010 . *Infection control and hospital epidemiology*. 2013;34(1):1-14.

2

TABLE 4. Distribution of Procedure-Associated Infections Reported to the National Healthcare Safety Network, by Type of Surgery, 2009–2010

Type of surgery	No. (%) of SSIs
Orthopedic[a]	6,486 (40.5)
Abdominal[b]	3,598 (22.5)
Cardiac[c]	3,508 (21.9)
Ob/gyn[d]	1,543 (9.6)
Neurological[e]	386 (2.4)
Vascular[f]	245 (1.5)
Transplant[g]	160 (1.0)
Breast[h]	64 (0.4)
Neck[i]	14 (0.1)
Other[j]	15 (0.1)
Total	16,019 (100)

Sievert DM at al Antimicrobial resistant pathogens associated with healthcare associated infections. Summary of data reported to the Centers for Disease Control and Prevention 2009-2010 . *Infection control and hospital epidemiology*. 2013;34(1):1-14.

Special Risk Population: Orthopedic Implants

- Hip or Knee aspiration
- If positive – irrigation and debridement
- Removal of hardware may be necessary
- Insertion of antibiotic spacers
- Revisions at future date
- Long term IV antibiotics in community or rehab
- Future worry about the joint
- In other words – **DEVASTATING FOR THE PATIENT AND SURGEON**

4

Pathogen Involved with SSIs	No (%) of SSI Pathogens	Rank
Staph aureus (includes MRSA)	6415 (30.4)	1
Coagulase neg staph	2477 (11.7)	2
E.Coli	1981 (9.4)	3
Enterococcus faecalis	1240 (5.9)	4
Pseudomonas aerug	1156 (5.5)	5
Enterobacter spp	849 (4.0)	6
Klebsiella spp	844 (4.0)	7
Enterococcus spp	685 (3.2)	8
Proteus spp	667 (3.2)	9
Enterococcus faecium	517 (2.5)	10
Serratia spp	385 (1.8)	11
Candida albicans	367 (1.3)	12
Acinetobacter baum	119 (0.6)	13
Other Candida spp	96 (0.5)	14
Other organisms	3399 (16.1)	
Total	21,100 (100)	

Sievert DM at al Antimicrobial resistant pathogens associated with healthcare associated infections. Summary of data reported to the Centers for Disease Control and Prevention 2009-2010 . *Infection control and hospital epidemiology*. 2013;34(1):1-14.

Mortality risk is high among patients with SSIs

- A patient with an SSI is:
  - **5x** more likely to be readmitted after discharge[1]
  - **2x** more likely to spend time in intensive care[1]
  - **2x** more likely to die after surgery[1]
- The mortality risk is higher when SSI is due to MRSA
  - A patient with MRSA is **12x** more likely to die after surgery[2]

1. *WHO Guidelines for Safe Surgery 2009.*
2. Engemann JJ et al. *Clin Infect Dis*. 2003;36:592-598.

6

HAI	Est Annual %	Est Direct Cost	Avg Length of Stay	Attributable Mortality
Surgical Site Infection (SSI)	33.7%	$20 785	~11.days	~4%
➢ MRSA SSI		$42 300	~23 days	
Central Line Associated Bloodstream Infection (CLABSI)	18.9%	$45 814	~10 days	~26%
➢ MRSA CLABSI			~16 days	
Ventilator Associated Pneumonia (VAP)	31.6%	$40 144	~13 days	~24%
Catheter Associated Urinary Tract Infection (CAUTI)	<1%	$896	< 1 day	<1%
Clostridium difficile Infection (CDI)	15.4%	$11 285	~ 3 days	~4%

Zimlichman. Et al: "Health Care–Associated Infections A Meta-analysis of Costs and Financial Impact on the US Health Care System" *JAMA Intern Med. September 2013*

Cost of Surgical Site Infections

➢Cost of an SSI in a prosthetic joint implant can exceed $90,000[1,2]

➢Cost of an SSI can exceed more than $90,000 if it involves MRSA [3]

Bozick KJ et al. The impact of infection after total hip arthroplasty on hospital and surgeon resource utilization. The Journal of bone and join surgery. American Volume. Aug 2005;87(8):1746-1751.

Kurtz SM et al. Economic burden of periprosthetic joint infection in the United States. The Journal of Arthroplasty. Sep 2012;27(8 Suppl):61-65 e61.

Engemann JJ et al. Adverse clinical and economic outcomes attributable to methicillin resistance among patients with Staphylococcus aureus surgical site infection. Clinical Infectious Disease: an official publication of the Infectious Diseases Society of America. March 1 2003;36(5):592-598.

Pathogens survive on surfaces

Organism	Survival period
Clostridium difficile	35- >200 days.[2,7,8]
Methicillin resistant *Staphylococcus aureus* (MRSA)	14- >300 days.[1,5,10]
Vancomycin-resistant enterococcus (VRE)	58- >200 days.[2,3,4]
Escherichia coli	>150- 480 days.[7,9]
Acinetobacter	150- >300 days.[7,11]
Klebsiella	>10- 900 days.[6,7]
Salmonella typhimurium	10 days- 4.2 years.[7]
Mycobacterium tuberculosis	120 days.[7]
Candida albicans	120 days.[7]
Most viruses from the respiratory tract (eg: corona, coxsackie, influenza, SARS, rhino virus)	Few days.[7]
Viruses from the gastrointestinal tract (eg: astrovirus, HAV, polio- or rota virus)	60- 90 days.[7]
Blood-borne viruses (eg: HBV or HIV)	>7 days.[5]

1. Beard-Pegler et al. 1988.. *J Med Microbiol.* **26**:251-5.
2. BIOQUELL trials, unpublished data.
3. Bonilla et al. 1996. *Infect Cont Hosp Epidemiol.* **17**:770-2
4. Boyce. 2007. *J Hosp Infect.* **65**:50-4.
5. Duckworth and Jordens. 1990. *J Med Microbiol.* **32**:195-200.
6. French et al. 2004. *ICAAC.*
7. Kramer et al.. 2006. *BMC Infect Dis.* **6**:130.
8. Otter and French. 2009. *J Clin Microbiol.* **47**:205-7.
9. Smith et al. 1996. *J Med.* **27**: 293-302.
10. Wagenvoort et al. 2000. *J Hosp Infect.* **45**:231-4.
11. Wagenvoort and Joosten. 2002. *J Hosp Infect.* **52**:226-7.

Prior room occupancy increases risk

Study	Healthcare associated pathogen	Likelihood of patient acquiring HAI based on prior room occupancy (comparing a previously 'positive' room with a previously 'negative' room)
Martinez 2003[1]	VRE – cultured within room	2.6x
Huang 2006[2]	VRE – prior room occupant	1.6x
	MRSA – prior room occupant	1.3x
Drees 2008[3]	VRE – cultured within room	1.9x
	VRE – prior room occupant	2.2x
	VRE – prior room occupant in previous two weeks	2.0x
Shaughnessy 2008[4]	*C. difficile* – prior room occupant	2.4x
Nseir 2010[5]	*A. baumannii* – prior room occupant	3.8x
	P. aeruginosa – prior room occupant	2.1x

1. Martinez *et al. Arch Intern Med* 2003; 163: 1905-12.
2. Huang *et al. Arch Intern Med* 2006; 166: 1945-51.
3. Drees *et al. Clin Infect Dis* 2008; 46: 678-85.
4. Shaughnessy. ICAAC/IDSA 2008. Abstract K-4194.
5. Nseir et al. Clin Microbiol Infect 2010 (in press).

A 7 S BUNDLE APPROACH TO PREVENTING SURGICAL SITE INFECTIONS

7 "S" Bundle to Prevent SSI

- **SAFETY –** is your OPERATING ROOM safe?
- **SCREEN –** are you screening for risk factors and presence of MRSA & MSSA
- **SHOWERS –** do you have your patients cleanse their body the night before and morning of surgery with CHLORHEXIDINE (CHG)?
- **SKIN PREP –** are you prepping the skin with alcohol based antiseptics such as CHG or Iodophor?
- **SOLUTION** - are you irrigating the tissues prior to closure to remove exogenous contaminants? Are you using CHG?
- **SUTURES –** are you closing tissues with antimicrobial sutures?
- **SKIN CLOSURE –** are you sealing the incision or covering it with an antimicrobial dressing to prevent exogenous contamination?

#1 – Safe Operating Room

- ✓ traffic control, number staff in room
- ✓ air handling systems, filtration, grills
- ✓ SCIP: hair clipping, warmers, oxygenation, surgical prophylaxis, foley catheter removal 48 hrs
- ✓ room turnover and terminal cleaning
- ✓ surgical technique and handling of tissues
- ✓ instrument cleaning/sterilization process, biological indicators
- ✓ storage of supplies, clean supply bins, carts, tables, stationary equipment

Follow AORN Recommended Practices

- Preoperative Patient Skin Antisepsis. AORN, 2008:537-553.
- Environmental Cleaning in the Perioperative Setting. In: AORN, 2014
- Surgical Tissue Banking. In: AORN, 2008:599-613.
- Surgical Hand Antisepsis. In: AORN 2013
- Cleaning and Care of Instruments and Powered Equipment: AORN, 2008:421-445.
- High Level Disinfection. AORN 2014
- Cleaning and Processing Anesthesia Equipment AORN
- Sterilization in the Perioperative Setting. AORN
- Hand Hygiene in the Perioperative Setting. AORN 2013
- Recommended Practices for Prevention of Transmissible Infections in the Perioperative Practice Setting 2014
- AORN Surgical attire 2013
- AORN Guidance Statement: The Role of the Health Care Industry Representative in the Perioperative Setting 2013
- Recommended Practices for Cleaning and Processing Flexible Endoscopes and Endoscope Accessories 2013
- Recommended Practices for Cleaning and Care of Surgical Instruments and Powered Equipment 2013
- Recommended Practices for Sterilization in the Perioperative Practice Setting 2014
- Recommended Practices for Sterile Technique 2014
- Recommended Practices for Sharps Safety 2014

Antimicrobial prophylaxis

- Performance measures include the antibiotic being
  - given within 60 minute before incision
  - consistent with current published recommendations
  - re-dosed if the time since administration exceeds two half-lives of the medication
  - dose per BMI
  - discontinued within 24 hours of conclusion of procedure

Hair removal

- Shaving increases risk for SSI
- Hair removal should be performed
  - using a clipper
  - on the day of surgery
  - in a location **outside** of the procedure room
  - Assure clipper is cleaned between use
- Only interfering hair should be removed

Hair left on clipper from previous patient

Clipper mounted in OR

Environmental strategies

- HVAC
  - HVAC systems dilute and remove contaminants
  - Air quality
  - Air volume exchanges
  - Airflow direction
  - Humidity should be maintained between 20% and 60%
    - Low humidity increases potential for dust
    - High humidity increases microbial growth
  - Temperature should be maintained between 68° F to 73° F

AORN RP: Environmental Cleaning in the Perioperative Setting 2012

Environmental cleaning

- Evaluate between room cleaning procedures
- Terminal cleaning procedures on evening/night shift
- sufficient staff to terminally clean all OR rooms?

AORN RP: Environmental Cleaning in the Perioperative Setting 2012

New Technology for Operating Room Terminal Cleaning Being Used in Some Operating Rooms

Ultraviolet C lights

Disinfectant surface sprays

Vaporized Hydrogen Peroxide Room Decontaminator

Surgical attire

- Normal individuals shed more than 10 million particles from their skin every day.
- Approximately 10% of skin squames carry viable microorganisms and it's estimated that individuals shed approximately 1 million microorganisms from their bodies each day.
- AORN "Recommended practices for surgical attire" section IV.a. states that:

> *"a clean, low-lint surgical head cover or hood that confines all hair and covers scalp skin should be worn. The head cover or hood should be designed to minimize microbial dispersal. Skullcaps may fail to contain the side hair above and in front of the ears and hair at the nape of the neck."*

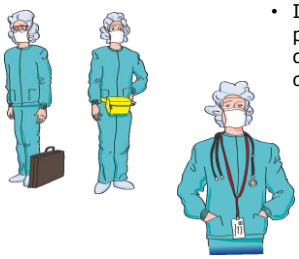
Boyce, Evidence in Support of Covering the Hair of OR Personnel AORN Journal ● Jan 2014

Laminar Flow and Exhaust Suits

No data to support reduction in SSIs

- Lipsett PA. Do we really need laminar flow ventilation in the operating room to prevent surgical site infections? Ann Surg 008;248:701
- Der Tavitian J, Ong SM, Taub NA, et al. Body-exhaust suit versus occlusive clothing. A randomised, prospective trial using air and wound bacterial counts. J Bone Joint Surg Br 2003;85:490.
- Pasquarella C, Pitzurra O, Herren T, et al. Lack of influence of body exhaust gowns on aerobic bacterial surface counts in a mixed-ventilation operating theatre. A study of 62 hip arthroplasties. J Hosp Infect 2003;54:2.
- Brown AR, Taylor GJ, Gregg PJ. Air contamination during skin preparation and draping in joint replacement surgery. J Bone Joint Surg Br 1996;78:92.

Personal Items Don't Belong in the OR



- Items may harbor pathogens and be difficult to clean or disinfect adequately
  - Pathogens have been shown to survive on fabrics and plastics
  - Microorganisms may be transported from one location to another

AORN Journal ● January 2012 Vol 95 No 1

Jewelry and Personal Clothing Doesn't Belong in OR

- Wearing jewelry increases bacterial counts on skin surfaces
  - when jewelry is in place
  - after removal
- Removing watches and bracelets allows for more thorough hand washing
- Personal clothing should be completely covered by surgical attire

AORN Journal ● January 2012 Vol 95 No 1

Hot Topic due to recent outbreaks: Cleaning/Sterilization of Instruments

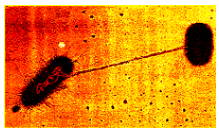
- Inspection of Instruments
  - Lumens, grooves, sorting, hand cleaning, disassembly required – massive kits
  - Many instruments cannot be disassembled
  - Correct use of Biologic Indicators
- Pre-soaking and rinsing of tissue and blood from the instruments in the operating room before sent to decontamination

Tosh et al. Outbreak of Pseudomonas aeruginosa Surgical Site Infections after Arthroscopic Procedures: Texas, 2009 Infect Control Hosp Epidemiol 2011;32(12):1179-1186

24

Most Important Control Measure

- HAND HYGIENE in the operating room
- Wash hands several times a shift – especially if you have had gloves on for more than 20 minutes – organisms multiply every 20 minutes



Communication between organisms to pass resistance factors

Anesthesia Patient Safety Foundation

Section Editor: **Sorin J. Brull**

Hand Contamination of Anesthesia Providers Is an Important Risk Factor for Intraoperative Bacterial Transmission

Randy W. Loftus, MD,* Matthew K. Muffly, MD,* Jeremiah R. Brown, PhD, MS,* Michael L. Beach MD, PhD,* Matthew D. Koff, MD,* Howard L. Corwin, MD,* Stephen D. Surgenor, MD,* Kathryn B. Kirkland, MD,* and Mark P. Yeager, MD*

(Anesth Analg 2011;112:98–105)

Table 2. Baseline Provider Hand Contamination[a]

Organism	Providers N/total (%)
MRSA	12/164 (7%)
MSSA	18/164 (11%)
VRE	4/164 (2%)
Enterococcus (non-VRE)	1/164 (0.6%)
Staph other	164/164 (100%)
Micrococcus	110/64 (67%)
Corynobacterium	14/164 (9%)
Streptococcus	128/164 (78%)
Gram negative[b]	81/164 (49%)

MRSA = methicillin-resistant Staphylococcus aureus; MSSA = methicillin-sensitive Staphylococcus aureus; VRE = vancomycin-resistant Enterococcus.
[a] Samples taken upon entry to the patient environment but before patient contact and after an opportunity to perform hand hygiene.
[b] E. coli, Klebsiella, Serratia, Pseudomonas, and Acinetobacter.

(Anesth Analg 2011;112:98–105)

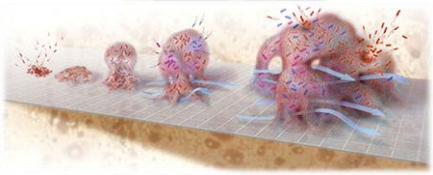
Table 3. Evidence for Intraoperative Transmission of Bacterial Pathogens from Anesthesia Provider Hands to the Anesthesia Environment and Patient IV Catheters

	Case 1			Case 2			
	Before case 1	End case 1		Before case 2		End case 2	
	Provider hands (site B)	Stopcock	Machine APL/D	Machine APL/D	Provider hands (site E)	Stopcock	Machine APL/D
Direction of transmission →							
Organism							
Micro	Attending		X				
S. epi	Attending	X					
S. hae	Attending	X					
S. epi	Attending	X					
S. epi	Attending				Attending[a]		
S. epi	Attending		X			X	X
Micro	Attending		X			X	
S. epi	Attending		X	X			X
Strep	Resident	X					X
Pseudo	Attending						
Pseudo	Resident		X				X
Micro	Resident	X		X		X	X
MRSA	Resident		X	X	Attending[a]		X
MSSA	Resident		X				X
S. auric	CRNA		X	X			
Micro	CRNA			X	Attending[a]		X
S. epi	CRNA			X			
Micro					CRNA[a]	X	X

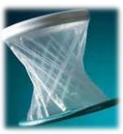
Sites were cultured as described, and pathogens were found at the times and locations noted.
APL = anesthesia machine adjustable pressure limiting valve; D = anesthesia machine inhaled agent concentration dial; X = transmission event confirmed by biotype analysis; S. epi = Staphylococcal epidermidis; S. hae=Staphylococcal haemolyticus; Strep = streptococcus; Pseud = pseudomonas; MRSA = methicillin-resistant Staphylococcal aureus; MSSA = methicillin-sensitive Staphylococcal aureus; S. auric = Staphylococcal auricularis; CRNA = certified registered nurse anesthetist.
[a] Provider was negative at the start of case 1; hands contaminated by bacterial organisms brought in by other providers.

(Anesth Analg 2011;112:98–105)

Contaminated hands have the potential to leave biofilm on stopcocks and other devices



Abdominal Wound Protector/Retractor for Colon Surgery Shown to Reduce SSI



Horiuchi et al: A Wound Protector Shields Incision Sites from Bacterial Invasion SURGICAL INFECTIONS Volume 11, Number 6, 2010

Reid et al: Barrier Wound Protection Decreases Surgical Site Infection in Open Elective Colorectal Surgery: A Randomized Clinical Trial DISEASES OF THE COLON & RECTUM VOLUME 53: 10 (2010)

#2 SCREEN for Risk Factors and MRSA and MSSA Colonization

Evaluate Your Patient Risk Characteristics that might increase risk of SSI

Age	ASA Score
Nutritional status	Obesity
Diabetes mellitus	Blood glucose level
Chronic tobacco use	Corticosteroid use
Drug abuse	Alcoholism
Chronic kidney disease	Chronic lung disease
Chronic liver disease	Malignant disease
Preoperative chemotherapy	Anergy
Nasal colonization	Bacterial colonization
Hypothermia	Hematoma
Preoperative antibiotics	

Risk Factors for Orthopedic Surgery

Table 4. Infection risk factor

Risk factor	Odds ratio (confidence interval)	p value
Current tobacco use	3.00 (1.78 5.06)	< 0.001
Current or history of bone cancer	12.85 (4.64 35.59)	< 0.001
Diabetes mellitus	2.44 (1.55 3.82)	< 0.001
Hepatitis B	7.34 (0.96 56.1)	0.027
Hepatitis C	5.59 (2.21 14.19)	< 0.001
MRSA colonization or prior infection	7.34 (2.85 18.91)	< 0.001
MSSA colonization or prior infection	8.64 (3.75 19.89)	< 0.001
Staphylococcal colonization or prior infection	6.52 (3.41 12.51)	< 0.001
Underweight (BMI < 18.5 kg/m^2)	1.90 (0.26 13.7)	0.56
Overweight (BMI 25.0 29.9 kg/m^2)	0.60 (0.24 1.50)	0.24
Obese (BMI 30.0 39.9 kg/m^2)	0.84 (0.51 1.41)	0.52
Morbid obesity (BMI 40.0 49.9 kg/m^2)	1.28 (0.61 2.65)	0.51
Super obesity (BMI 50 + kg/m^2)	15.69 (5.97 41.21)	< 0.001
Obesity hypoventilation syndrome	10.2 (1.17 88.5)	0.01

MRSA = methicillin resistant *Staphylococcus aureus*; MSSA = methicillin susceptible *S aureus*; BMI = body mass index.

Everheart JS et al. Medical comorbidities are independent preoperative risk factors for surgical infections after total joint arthroplasty. Clin orthoped relat res. March22, 2013 online pub

MRSA and MSSA Carriage and Infection – Evidence Based Practice

Patients who carry *Staph aureus* in their nares or on their skin are more likely to develop *Staph aureus* SSIs.

This is true for methicillin-resistant as well as methicillin-sensitive *Staph aureus*.

Kluytmans JA, Mouton JW, Ijzerman EP, Vandenbroucke-Grauls CM, Maat AW, Wagenvoort JH, et al. Nasal carriage of *Staphylococcus aureus* as a major risk factor for wound infections after cardiac surgery. *J Infect Dis*. 1995;171:216-9.

Huang SS, Platt R. Risk of methicillin *Staphylococcus aureus* infection after previous infection or colonization. *Clinical Infectious Diseases*. 2003;36(3):281-5.

Rao N, Cannella BA, Crossett LS, Yates AJ, McGough RL, Hamilton CW. Preoperative Screening/Decolonization for Staphylococcus aureus to Prevent Orthopedic Surgical Site Infection. *J Arthroplasty* 2011.

34

Decolonization Protocol – Evidence Based

Staph aureus carriers treated with five days of intranasal mupirocin and CHG washes before surgery have a **60% lower *Staph aureus* SSI rate** than the placebo group

Bode LG, Voss A, Wertheim HF, et al. Preventing surgical-site infections in nasal carriers of *Staphylococcus aureus*. *N Engl J Med*. 2010;362(1):9-17.

Preoperative screening/decolonization was associated with **fewer SSIs** after elective Total Joint Arthroplasty

Rao N, Cannella BA, Crossett LS, Yates AJ, McGough RL, Hamilton CW. Preoperative Screening/Decolonization for Staphylococcus aureus to Prevent Orthopedic Surgical Site Infection. *J Arthroplasty* 2011.

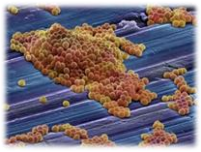
35

Does using mupirocin eradicate *Staph aureus* nasal carriage? – Evidence Based

- ✓ Short-term nasal mupirocin (4-7 days) is an effective method for *Staph aureus* eradication
- ✓ 90% success at one week
- ✓ 1% develop mupirocin resistance

Systematic review (Ammerlaan HS, et al. CID 2009): 8 studies comparing mupirocin to placebo

Implementation of a Screening Program For MRSA and Staph aureus Before Inpatient Orthopedic Surgery



Kim D, Spencer M, Davidson S, et al. J Bone Joint Surg

37

Polymerase Chain Reaction (PCR) for Nasal Screens – Lab Challenges

- Instructing staff on how to obtain a nares specimen with proper swabs
- Lab differentiation of the colonized screens from routine cultures.
- Molecular lab up and running in a short time frame with cross-training of staff of Cepheid's GeneXpert System
- Reporting system for positive results

Implemented Decolonization Protocol

- 5-day application of intranasal 2% mupirocin - applied twice daily - for MRSA ***and*** *Staph aureus* positive patients
  - Prescription called in by Nurse Practitioner in prescreening unit
- Daily body wash with chlorhexidine (purchased by patient)
- MRSA Patients – Unique sticker system to notify Pre-surgery Unit of Vancomycin surgical prophylaxis

39

Institutional Prescreening for Detection and Elimination of Methicillin Resistant Staphylococcus aureus in Patients Undergoing Elective Orthopaedic Surgery

	Control Period 10/2005-6/2006	Study Period 6/2006-9/2007	*p* value
N	5293	7019	
MRSA Infection	10 (0.18%)	**4 (0.06%)**	0.0315
MSSA Infection	14 (0.26%)	**9 (0.13%)**	0.0937
Total SSIs	**24 (0.46%)**	**13 (0.18%)**	**0.0093**

Kim DH, Spencer M, Davidson SM, et al. J Bone Joint Surg Am 2010;92:1820-1826

Pre-op MRSA and *S. aureus* Decolonization

- **Results:** % MRSA and *S. aureus* SSI

Time Period	Inpatient Surgeries	# of Surgical Infections	%MRSA/MSSA
FY06 10/01/05-07/16/06*	5,293* *Historical Controls	24*	0.45%*
FY07 07/17/06-09/30/07	7,019	6	0.08%
FY08 10/01/07-09/30/08	6,323	7	0.11%
FY09 10/01/08-09/30/09	6,364	11	0.17%
FY10 10/01/10-09/30/10	6,437	6	0.09%

41

#3 – Showers with CHG

OR Risk Factors: Bacteria on Patient's Skin

- Pre-op Showers:
  - –Liquid chlorhexidine shower
  - –CHG impregnated washcloths

43

Pre-surgical Skin Preparations as a Pathway to Improving Surgical Outcomes – Evidence Based

- Reducing the risk of *SSI* in orthopaedic surgery
  - Standardized pre-cleansing initiative (CHG cloths) in total joint patients (night before/morning of surgery)
  - SSI rate prior to intervention – 3.2% (N=727)
  - SSI rate post intervention – 1.6% (N=824) **50% reduction** ***p<0.01***

    Eiselt – Orthopaedic Nursing 2009;28:141-145
- Bundling risk reduction strategies – Quality initiative
  - MRSA prescreening in orthopaedic, obstetric, bariatric patients – decolonization
  - Pre-surgical antisepsis (CHG cloths) prior to surgery
  - Pre-intervention SSI rate 1.6% (N=17/1,095) vs post intervention SSI rate 0.57% (N=7/1,225) **>60% reduction**
  - MRSA SSI rate 0.73% vs 0.16% **>75% reduction** ***p<0.01***

    Lipke VL, Hyott AS. AORNJ 2010';62:288-296

Select Publications of Skin-Friendly, No-Rinse 2% CHG Impregnated CHG Prep Cloth			
Publication	CHG Prep Cloth Applications	Outcome	Significance
Johnson JKS 2012	2	72% SSI reduction	p.021
Kapadia JOA 2012	2	70% SSI reduction	p.05
Lipke AORN 2010	2	62% SSI reduction	p.0196
Eiselt Orthop Nurs 2009	2	50% SSI reduction	
Murray JSES 2011	2	66% reduction of MRSA colonization	p.0001
Thompson AJIC 2013	2 preop + postop	72% SSI reduction	P0.003 (Cardio/Neuro)
Phillips ID Week 2012 Poster of RCT (manuscript submitted)	2	0% SSI reduction	p.05
Kapadia/Mont RCT interim data submitted to FDA hearing on Sterile Preps 12/2012	2	0% SSI reduction	p.05
Bailey ICHE 2011	2	CHG Cloth product is cost effective for routine distribution even low patient compliance.	N/A
Graling AORN 2013	1	77% SSI reduction	p.01

#4 Skin Prep – Alcohol based surgical skin prep

Skin preparation

- FDA requires skin preparation antiseptics are
  - Fast acting (ie, within 10 minutes)
    - Two-log bacterial reduction on abdomen
    - Three-log bacterial reduction on groin
      - ✓One log = microorganisms reduced 10 times
      - ✓Two log = microorganisms reduced 100 times
      - ✓Three log = microorganisms reduced 1000 times
  - Persistent
    - No return to baseline flora at six hours post application

Use an alcohol-containing antiseptic agent for preoperative skin preparation

Two types of preoperative skin preparations that combine alcohol (which has an immediate and dramatic killing effect on skin bacteria) with long-acting antimicrobial agents appear to be more effective at preventing SSI than povidone-iodine (an iodophor) alone:

–Chlorhexidine plus alcohol

– Iodophor plus alcohol

IHI: Prevention of SSI: Institute for Healthcare Improvement 2012

48

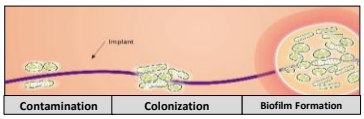
Skin antiseptic agents

Antiseptic agent	Rapidity of action	Persistent activity
Alcohol	Excellent	None
CHG	Moderate	Excellent
PI	Moderate	Minimal
CHG w/alcohol	**Excellent**	**Excellent**
PI w/alcohol	**Excellent**	**Moderate**
PCMX	Moderate	Moderate

5 Sutures – Antimicrobial Plus Sutures

Risk Factor: Bacterial colonization of the suture

- Like all foreign bodies, sutures can be colonized by bacteria:
  - Implants provide nidus for attachment of bacteria[1]
  - Bacterial colonization can lead to biofilm formation[1]
  - Biofilm formation increases the difficulty of treating an infection[2]



On an implant, such as a suture, it takes only 100 staphylococci per gram of tissue for an SSI to develop[3]

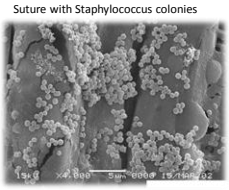
1. Ward KH et al. J Med Microbiol. 1992;36: 406-413.
2. Kathju S et al Surg infect. 2009;10:457-461
3. Mangram AJ et al. Infect Control Hosp Epidemiol.1999;27:97-134..

Why Antimicrobial Sutures? OR Air Current Contamination

- **In teaching hospitals:**
- Surgeon leaves room
- Resident, Physician Assistant or Nurse Practitioner work on incision
- Circulating Nurse counts sponges and starts room breakdown
- Scrub Technician starts breaking down tables and preparing instruments for Central Processing
- Anesthesia move in and out of room
- Instrument representative might leave room and Visitors may leave room

Potential for Contamination of Sutures at End of Case

Suture with Staphylococcus colonies

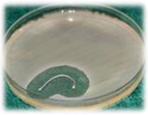


Air settling plates in the operating room at the last hour of a total joint case from the anesthesia cart, bovie cart, computer

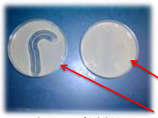
Spencer et al: Reducing the Risk of Orthopedic Infections: The Role of Innovative Suture Technology NAON 2010 Annual Congress - May 15-19, 2010

Antibacterial Suture Challenge

- Studied the "zone of inhibition" around the suture
  - A pure culture—0.5 MacFarland Broth—of *S. aureus* was prepared on a culture plate
  - An antibacterial suture was aseptically cut, planted on the culture plate, and incubated for 24 hrs – held at 5 and 10 days



5 day zone of inhibition



10 day zone of inhibition

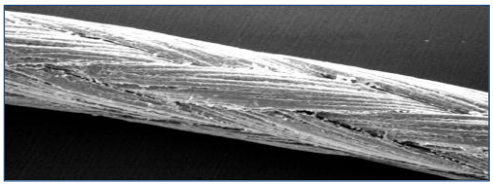
Spencer et al: Reducing the Risk of Orthopedic Infections: The Role of Innovative Suture Technology NAON 2010 Annual Congress - May 15-19, 2010

54

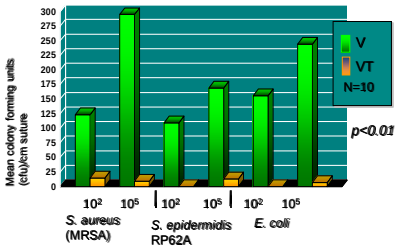
Bacterial Adherence to Surgical Sutures: Can Antibacterial-Coated Sutures Reduce the Risk of Microbial Contamination?

Charles E Edmiston, PhD, Gary R Seabrook, MD, FACS, Michael P Goheen, MS, Candace J Krepel, MS, Christopher P Johnson, MD, FACS, Brian D Lewis, MD, FACS, Kellie R Brown, MD, FACS, Jonathan B Towne, MD, FACS

J Am Coll Surg 2006;203:481-489



Mean Microbial Recovery from Standard Polyglactin 910 Sutures (V) and Triclosan-Coated Polyglactin 910 Braided Sutures (VT)



Exposure Time 2 Minutes

Edmiston et al, J Am Coll Surg 2006;203:481-489

Systematic review and meta-analysis of triclosan-coated sutures for the prevention of surgical-site infection

Z. X. Wang[1,2], C. P. Jiang[1,2], Y. Cao[1,2] and Y. T. Ding[1,2]

[1]Department of Hepatobiliary Surgery, Affiliated Drum Tower Hospital, School of Medicine, Nanjing University, and [2]Jiangsu Province's Key Medical Centre for Liver Surgery, Nanjing, Jiangsu Province, China

Correspondence to: Professor Y. T. Ding, 321 Zhong Shan Road, Nanjing, Jiangsu Province, China 210008 (e-mail: dingyuao@yahoo.com.cn)

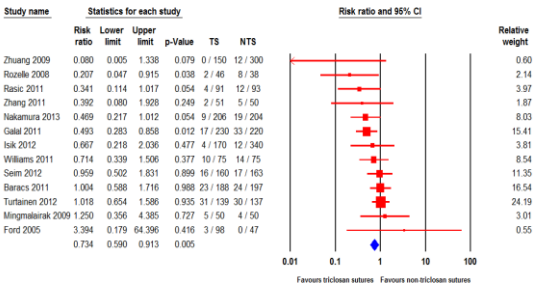
Wang et al: British Journal of Surgery, 2013

Is there an evidence-based argument for embracing an antimicrobial (triclosan)-coated suture technology to reduce the risk for surgical-site infections?: A meta-analysis

Charles E. Edmiston, Jr. PhD,[a] Frederic C. Daoud, MD,[b] and David Leaper, MD, FACS,[c] *Milwaukee, WI, Paris, France, and London, UK*

Edmiston et al: Surgery 2013;154:89-100

Meta-analysis of 13 eligible RCTs



Fixed Effects Pooled Risk Ratio - Number of patients with a surgical site infection

Edmiston et al: Surgery 2013;154:89-100

Evidence-Based Argument for Antimicrobial (Triclosan) Coated Sutures

1. Ford et al. Pediatric surgery- Surg Infect 2005;3:313
2. Rozzelle et al. Cerebro-spinal shunt surgery – J Neurosurg Pediatr 2008;2:111-1117.
3. Mingmalairak et al. Appendectomy – J Med Assoc Thai 2009;92:770-775.
4. Zhuang et al. Abdominal surgery – J Clin Rehab Tiss Eng Res 2009;13:4045-4048.
5. Zhang et al. Radical mastectomy – Chin Med J 2011;124:719-724.
6. Galal et al. General, GI surgery - Am J Surg 2011;202:133-138.
7. Rasic et al. Colorectal surgery – Colleg. Antropologicum 2011;35:439-443.
8. Williams et al. Breast CA surgery – Surg Infect 2011;12:469-474.
9. Barac et al. Colorectal surgery – Surg Infect 2011;12:483-489.
10. Isik et al. Cardiac surgery – Heart Surg Forum 2012;15:E40-E45.
11. Turtainen et al. Lower limb revascularization surgery – World J Surgery 2012;
12. Seim BE et al. Cardiac surgery – Interact Cardiovasc Thorac Surg 2012: June 12
13. Nakamura T, et al. Colorectal surgery – Surgery 2013 [Epub ahead of print].
14. Laas E, et al. Breast surgery – Int J Breast Cancer 2012 [Epub ahead of print].
15. Justinger et al. Abdominal wall closure – 2013 Surgery

#6 Solution – to Pollution is Dilution

Pulsatile Lavage Irrigation

- High-pressure pulsatile lavage and low-pressure pulsatile lavage result in **higher rates of deep bacterial seeding** in bone than does brush and bulb-syringe lavage[1]
- Higher irrigant pressures result in greater **osseous damage** and perhaps impairment of osseous healing[1]
- Kalteis et al. revealed that compared with brush and bulb-syringe lavage high and low-pressure pulsatile lavage resulted in **significantly ($p < 0.001$) higher rates of deep bacterial seeding in bone**[2]
- No evidence that Bacitracin/Polymixin irrigations reduce rate of SSI[2]

1. *Kalteis T, Lehn N, Schroder HJ, Schubert T, Zysk S, Handel M, Grifka J. Contaminant seeding in bone by different irrigation methods: an experimental study. J Orthop Trauma. 2005;19:591-6.*

2. *Fletcher N, et al: Prevention of perioperative infections. J Bone Joint Surg Am. 2007;89:1605-1618*

61

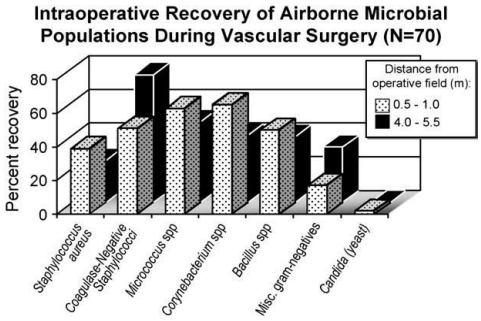
New Chlorhexidine 0.05% Irrigation Solution

- Meets American College of Emergency Physicians (ACEP) guidelines for wound irrigation volume and pressure
- Proprietary SplatterGuard protects healthcare workers, patients and the environment from biohazard contamination
- Chlorhexidine Gluconate 0.05% has demonstrated antimicrobial efficacy and persistence in laboratory testing
- The mechanical action effectively loosens and removes wound debris
- Safe for mucous membranes – approved by FDA
- www.irrisept.com

Why CHG Irrigation: Environmental Contaminants in the Operating Room and at the End of Case

Molecular epidemiology of microbial contamination in the operating room environment: Is there a risk for infection?

Charles E. Edmiston Jr, PhD,[a] Gary R. Seabrook, MD,[a] Robert A. Cambria, MD,[a] Kellie R. Brown, MD,[a] Brian D. Lewis, MD,[a] Jay R. Sommers, PhD,[b] Candace J. Krepel, MS,[a] Patti J. Wilson, BSN,[c] Sharon Sinski, BSN,[a] *and* Jonathan B. Towne, MD,[a] *Milwaukee, Wis, and Roswell, Ga*



Edmiston et al: Surgery 2005;138:573-82

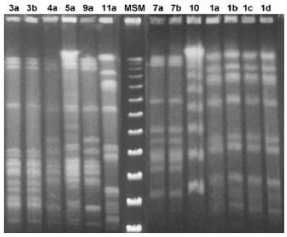


Fig 5. PFGE of clonally related strains of *S epidermidis* and *S aureus* recovered from members of the vascular surgical team and perioperative airborne sampling. *Lanes 3a/3b* and *4a/9a*, *S epidermidis* clonality; *lanes 7a/7b* and *1a/1b/1c/1d*, *S aureus* clonality.

Edmiston et al: Surgery 2005;138:573-82

American Journal of Infection Control 41 (2013) 549–555

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Original research article

Reducing the risk of surgical site infections: Does chlorhexidine gluconate provide a risk reduction benefit?

Charles E. Edmiston, Jr. PhD [a,*], Benjamin Bruden PharmD [b], Maria C. Rucinski BS [c], Cindy Henen RPh [b], Mary Beth Graham MD [d], Brian L. Lewis MD [a]

[a] Department of Surgery, Medical College of Wisconsin, Milwaukee, WI
[b] Pharmacy Department, Froedtert Hospital, Milwaukee, WI
[c] Florida State University School of Medicine, Tallahassee, FL
[d] Department of Medicine, Medical College of Wisconsin, Milwaukee, WI

Impact of Intraoperative Irrigation on Resolution of Mesh Contaminated Animal Model

Study Group	Irrigation Fluid	Bacterial Isolates	Initial Challenge	Study Population , N = animals at 7 days
1	Saline (Control)	MRSA	~3.7 $\log_{10}$ CFU	8
2	0.05% CHG[a]	MRSA	~3.7 $\log_{10}$ CFU	8

Study Group	Positive Recovery at 7 days ($\log_{10}$ CFU)	Negative Recovery at 7 day ($\log_{10}$ CFU)	Biofilm Formation ($\log_{10}$ CFU)
Saline	8/8, 4.26 $\log_{10}$ CFU	No, 0/8	8/8, 6.3 $\log_{10}$ CFU
0.05% CHG	1/8 ,1.8 $\log_{10}$ CFU *p<0.001*	Yes, 7/8	2/8, 2.6 $\log_{10}$ CFU *p<0.01*

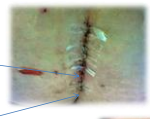
[a] Irrisept®

Edmiston CE, et al., 2013 Am J Infect Control

#7 Skin Adhesive – Care of the Incision

Challenges in the Post-op Patient

- Incision collects fluid – serum, blood - growth medium for organisms – small dehiscences
- Spine fusions -incisions close to the buttocks or neck
- Body fluid contamination from bedpans/commodes
- Heavy perspiration common with obese patients
- Friction and sliding - skin tears and blisters
- Itchy skin - due to pain medications - skin breakdown



70

Cesarean Delivery: Sutures vs Staples

- **Prospective, randomized study of 435 c-section patients**[1]
  - 197 patients: staples
  - 219 patients: 4-0 MONOCRYL™ (poliglecaprone 25) Suture on PS2 needle
    - Wound separation rate: 17% (staples) vs. 5 % (sutures)
    - Wound complication rate: 22% (staples) vs. 9% (sutures)
    - **Staple closure was a significant independent risk factor for wound separation** after adjustment for all other factors (GDM, BMI >30, incision type, etc)
- **Meta-analysis of 6 studies with a total of 1487 c-section patients**[2]
  - 803 patients: staples
  - 684 patients: subcuticular suture closure
    - Staple closure was associated with a **two-fold increase in risk of wound infection or separation**

1. Bash et al. *Am J Obstet Gynecol.* 2010;203:285.e1.
2. Tuuli et al. *Obset Gynecol.* 2011;117:682.

BMJ

RESEARCH

Sutures versus staples for skin closure in orthopaedic surgery: meta-analysis

Toby O Smith, research physiotherapist in orthopaedics, honorary lecturer Debbie Sexton, senior orthopaedic physiotherapist Charles Mann, consultant orthopaedic surgeon Simon Donell, consultant orthopaedic surgeon, honorary professor in musculoskeletal disorders

In orthopaedic surgery the risk of infection after staple closure was three times the risk with suture closure; after hip surgery the risk was four times greater

To minimise wound infection, orthopaedic surgeons should close wounds with sutures rather than staples

March 16 2010 issue of the BMJ

Innovative Technology: Topical Skin Adhesive

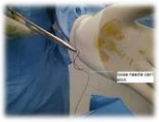
- Wounds are most vulnerable to infection in the **first 48-72 hours**[1]
  - Until the epithelial barrier is complete (usually within 48 hours) wounds are solely dependent on the wound closure device to maintain integrity[1]
- The extent of microbial protection depends on barrier integrity[1]
  - Effective barriers must maintain their integrity for the first 48 hours
- Incisional adhesive provides a **strong microbial barrier** that prevents bacteria from entering the incision site[2]

1. *Fine and Musto. Wound healing. In: Mulholland et al. Greenfield's Surgery: Scientific Principles and Practice. 4th ed. 2005.*
2. *Bhende et al. Surg Infect (Larchmt). 2002;3:251-257.*

73

Topical Skin Adhesive: Benefits Beyond Risk Reduction

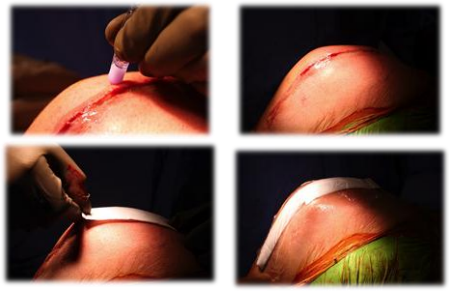
- For Hospital Staff
  - No time spent removing staples or sutures
  - Reduces hospitalization costs
  - Reduces number of suture set ups
  - Simplifies post-op wound checks
  - Reduces number of wound dressings
  - Can reduce staff suture exposures
- For Patients
  - **7 days of wound healing strength in less than one minute** of application
  - Shower immediately
  - Outstanding cosmesis
  - Reduced follow-up
  - Less pain and anxiety



74

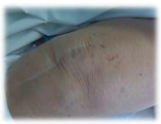
Adhesive Border and Healing 6 Weeks Post-op and Beyond

Incisional Adhesive on Total Knee



Clinical Use of Incisionial Adhesive in Orthopedic Total Joints

Hip: Sealed with adhesive covered with gauze and transparent dressing for incision protection



Healed incision

Knee: Sealed with incisional adhesive, covered with Telfa and a transparent dressing for incision protection

Which Would You Prefer???

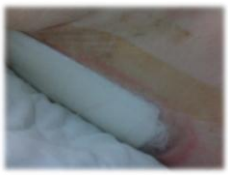
Topical Incisional Adhesive (TSA)
Octyl Cyanoacrylate

OTHER OPTIONS
WHEN ADHESIVES ARE NOT USED

Antimicrobial (PHMB) Dressings with Hypoallergenic Fabric Tape

Spencer et al: The Use of Antimicrobial Gauze Dressing (AMD) After Orthopedic Surgery To Reduce Surgical Site Infections NAON 2010 Annual Congress - May 15-19, 2010

Antimicrobial Silver Dressings



Silver dressing and transparent dressing left on until discharge – seals the incision from exogenous contaminants

NAON – May 2006
Spencer et al: The Use of A Silver Gauze Dressing in Spine Surgery to Reduce the Incidence of MRSA Surgical Site Infections

IN CONCLUSION…..

What to DO? Establish a Multidisciplinary Team

The team representatives
- OR nursing, CSS, Surgeons & Anesthesia, Managers from infection control, healthcare quality, facilities and environmental services

Evaluate
- Procedures and Practices
- Facility design and Environment of Care Issues
- Patient Risk Factors
- Infection Rates
- Innovative Infection Prevention Products and Practices

- *Spencer M, et al. A Multidisciplnary Team Working Toward Zero Infection Rate. Poster presented AORN 2006; March 19-23, 2006; Washington DC*
- *Spencer M., et al. A Multidisciplinary Team working toward Zero Orthopedic Infection Rate. Global Infectious Disease Conference, Tufts Medical School, Boston, MA October 2009*

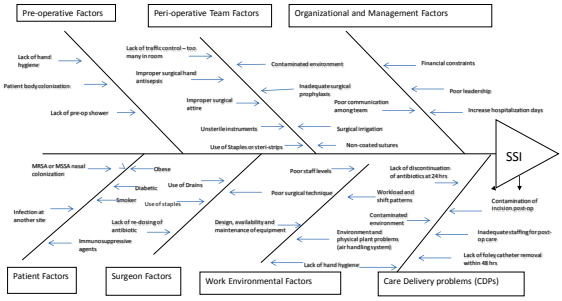
83

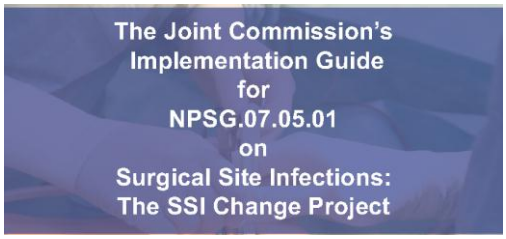
Working Toward Zero Teams

- Senior leadership and surgeons – must be involved and lead the effort
- Clear goals
  - Structured program with clearly defined goal of zero tolerance for HAIs
- Communication – effective and consistent
- Ongoing and creative education
- Financial support to Infection Prevention program
- Use process improvement tools (fishbone, pareto, mind-mapping)

84

Risk is a Myriad Event
SSI Fishbone Diagram





	Elements of Performance
1.	Educate staff and licensed independent practitioners involved in surgical procedures about surgical site infections and the importance of prevention. Education occurs upon hire, annually thereafter, and when involvement in surgical procedures is added to an individual's job responsibilities.
2.	Educate patients, and their families as needed, who are undergoing a surgical procedure about surgical site infection prevention.
3.	Implement policies and procedures aimed at reducing the risk of surgical site infections. These policies and procedures meet regulatory requirements and are aligned with evidence-based guidelines (for example, The Centers for Disease Control and Prevention (CDC) and/or other professional organizational guidelines).
4.	As part of the effort to reduce surgical site infections: - Conduct periodic risk assessments for surgical site infections in a time frame determined by the hospital. - Select surgical site infection measures using best practices or evidence-based guidelines. - Monitor compliance with best practices or evidence-based guidelines. - Evaluate the effectiveness of prevention efforts. Note: Surveillance may be targeted to certain procedures based on the hospital's risk assessment.
5	Measure surgical site infection rates for the first 30 days following procedures that do not involve inserting implantable devices and for the first year following procedures involving implantable devices. The hospital's measurement strategies follow evidence-based guidelines. Note: Surveillance may be targeted to certain procedures based on the hospital's risk assessment.*
6.	Provide process and outcome (for example, surgical site infection rate) measure results to key stakeholders.
7.	Administer antimicrobial agents for prophylaxis for a particular procedure or disease according to evidence-based practices.
8.	When hair removal is necessary, use a method that is cited in the scientific literature or endorsed by professional organizations.

Unit Based Champions: Role Models, "Positive Deviance" Empowerment at Staff Level

- Role Models and Responsibilities enhance self-efficacy
- Participate in educational activities
- Hand hygiene observations
- Precaution Carts and direct care observations
- Communicate information to staff
- Assist in implementing practice change
- "Call-out" breaks in techniques
- Attend monthly meetings
- Contribute to an annual "Bug Beat Fair"
- Participate in Performance Improvement Studies
- Clinical ladder for professional advancement

National Association of Orthopedic Nurses (NAON), May 2006 Poster Presentation:
The Bug Beat Fair: An Innovative Infection Control Educational Campaign in An Orthopedic Specialty Hospital

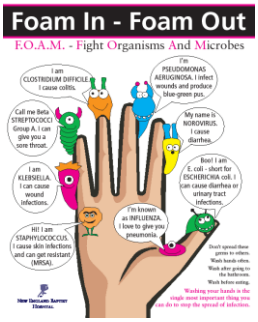
Engage Your Staff: *Got Soap?*

- Engaged the OR staff in a *Got Soap?* Campaign
  - OR Nurses
  - Surgeons
  - Administration
- Used shaving cream for soap and used medical photographer

www.creativehandhygiene.com

89

Creative Themes and Posters



www.creativehandhygiene.com

90

References

1. National Quality Safety Forum. (February 2012). Reducing surgical site infections.
   http://www.npsf.org/updates-news-press/reducing-surgical-site-infections/ Accessed September 10, 2012/
1. Centers for Disease Prevention and Control. (January 2012). Types of health care-associated infections. http://www.cdc.gov/HAI/infectionTypes.html Accessed September 10, 2012.
2. Centers for Disease Prevention and Control. (December 2009). Surgical site infection toolkit. http://www.cdc.gov/HAI/pdfs/toolkits/SSI_toolkit021710SIBT_revised.pdf. Accessed September 10, 2012.
3. Centers for Disease Prevention and Control. (August 2012). Stopping *C. difficile* infections. http://www.cdc.gov/vitalsigns/hai/ . Accessed September 10, 2012.
4. Fry DE. Fifty ways to cause surgical site infections. *Surgical Infections*. 2011;12(6): 497-500.
5. Umscheid CA, Mitchell MD, Doshi JA, et al. Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. *Infection Control and Hospital Epidemiology*. February 2011;32(2):101-114.
6. Mangrum AJ, Horal TC, Pearson ML, Silver LC, Jarvis WR. Hospital Infection Control Practices Advisory Committee. Guidelines for prevention of surgical site infection, 1999. *Infection Control and Hospital Epidemiology*. 1999;20(4):247-278.
7. Simmons BP. Guideline for prevention of surgical wound infections. *American Journal of Infection Control*. 1983;11(4):133-143.
8. Van Wicklin, S. A. (2012, January). Venous thromboembolism prophylaxis in pediatric patients. The Centers for Disease Control and Prevention surgical wound classification system. Using the surgical wound classification decision tree tool. Using cotton surgical masks. Using povidone-iodine solution for surgical skin antisepsis before thyroid procedures. *AORN Journal, 95(1)*, 155-164.
9. Recommended practices for preoperative patient skin antisepsis. In: Perioperative Standards and Recommended Practices. Denver, CO: AORN, Inc; 2012:445-463.
10. Fry DE. Surgical site infections and the surgical care improvement project (scip): evolution of national quality measures. *Surgical Infections*. 2008;9(6):579-584.
11. Specifications Manual for National Hospital Inpatient Quality Measures. Discharges 01-01-13 (1Q13) through 06-30-13 (2Q13). SCIP-Inf-2-5.
12. Recommended practices for a safe environment of care. In: Perioperative Standards and Recommended Practices. Denver, CO: AORN, Inc; 2012:215-236.
13. Recommended practices for environmental cleaning. In: Perioperative Standards and Recommended Practices. Denver, CO: AORN, Inc; 2012:237-250.
14. Boyce JM. Environmental contamination makes an important contribution to hospital infection. *Journal of Hospital Infection*. June 2007;65(Suppl 2):S50-54.

The End