Reducing Surgical Site Infections by Bundling Multiple Risk Reduction Strategies and Active Surveillance

VIRGINIA LEIGH LIPKE, RN, MHA, ACRN, CIC; **ANTHONY S. HYOTT,** MHA

ABSTRACT

Postoperative surgical site infections (SSIs) are serious health care-associated infections that contribute to higher rates of mortality. Methicillin-resistant *Staphylococcus aureus* (MRSA) is an increasingly common cause of SSIs. A quality improvement intervention was developed to identify surgical patients with nasal colonization of MRSA, treat them with mupirocin, and introduce a new preoperative skin antisepsis protocol using 2% chlorhexidine gluconate cloths. The total number of SSIs was reduced by 63%, and MRSA SSIs decreased by 78%. Preoperative MRSA screening and treatment and the preoperative skin antisepsis protocol were smoothly integrated into the facility workflow and well accepted by patients. This intervention saved two community hospitals an estimated $240,000. *AORN J* 92 (September 2010) 288-296.
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Key words: *chlorhexidine gluconate, 2% CHG cloths, preoperative skin preparation, surgical site infection, health care-associated infection, methicillin-resistant* Staphylococcus aureus.

Postoperative surgical site infections (SSIs) are serious health care-associated infections[1] that develop in up to 4.5% of patients who undergo surgery.[2] In addition to contributing to morbidity, SSIs lead to higher rates of mortality. Mortality is three times higher in surgical patients with SSIs caused by *Staphylococcus aureus*[3] and is five times higher in older adult surgical patients who develop SSIs caused by *S aureus* than in patients who do not develop SSIs.[4] Surgical site infections caused by methicillin-resistant *S aureus* (MRSA) are associated with even greater mortality (ie, a rate that is 12 times higher than for surgical patients who do not develop SSIs).[3]

Medical costs also are greater for patients who develop SSIs. Median hospital costs were estimated to be $53,625 more for older adult patients with SSIs caused by *S aureus* compared with uninfected older adult patients.[4] The costs of infection with MRSA are even greater, with median hospital charges approximately $40,000 greater for patients with MRSA infections than for patients with SSIs caused by methicillin-susceptible

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S aureus.[3] This increase in cost may be caused in part by increased morbidity, which leads to longer stays in the intensive care unit (ICU) after surgery.[3,4]

Staphylococcus aureus is reported to be the most common etiologic factor of SSIs.[5] Strains of MRSA are becoming more common in teaching hospitals and in community hospitals.[5-9] One community hospital reported that MRSA was isolated in 4.5% of SSIs between 2003 and 2004, accounting for 17.4% of *S aureus* infections.[5] In the past, MRSA was acquired in the health care setting, but community-acquired strains of MRSA (CA-MRSA) are now common and often associated with SSIs. Community-acquired MRSA is now the predominant source of MRSA strains in SSIs in some populations. In a study of a community hospital patient population, more than 50% of the MRSA isolates in health care-associated infections were CA-MRSA isolates.[6] In another study reported by a community hospital, 57% of MRSA SSIs were caused by community-acquired strains.[8] The potential for CA-MRSA SSIs is of concern in the obstetric population, given that MRSA colonization rates in pregnant women appear to be consistent with colonization rates for the general population.[9]

QUALITY IMPROVEMENT INITIATIVE

Annual increases in reported MRSA skin and soft tissue infections in the emergency departments of two community hospitals in Kentucky suggested that MRSA was becoming a community problem. In 2005, no MRSA SSIs were reported to the infection control department; however, seven were reported in 2006. To reduce the rate of SSIs, personnel in the infection control and quality improvement departments created a quality improvement initiative that included identifying patients who were nasally colonized with MRSA and introducing a preoperative skin antisepsis protocol that involved the use of 2% chlorhexidine gluconate (CHG), alcohol-free, no-rinse cloths.

LITERATURE REVIEW—SSI RISK AND PREVENTION

Cheadle[10] reported that prolonged procedures, trauma, shock, blood transfusions, hypothermia, hypoxia, and hyperglycemia can increase the risk of SSI. Neumayer et al[2] found that patients who developed an SSI were more likely to be older and male, have diabetes and disseminated cancer, consume alcohol, and smoke. Adequacy of preoperative surgical skin preparation[1] and nasal colonization with MRSA[11] are other factors that influence the risk of SSI. Risk of SSI with MRSA is greater in patients who are colonized with MRSA. The most common health care-associated MRSA infections in MRSA carriers include SSIs and bloodstream infections.[1]

Significant obesity appears to increase the risk of health care-associated infections, which is of concern given the increasing frequency of bariatric surgery. In patients undergoing bariatric surgery, increasing weight was associated with an increased risk of several complications, including sepsis.[12] In a retrospective study, patients who were severely overweight had significantly more health care-associated infections than did patients of normal weight ($P < .05$).[13] These wound infections may be caused by local changes in the surrounding tissues (eg, increased adipose tissue), increased tissue trauma from retracting the abdominal wall during surgery, and increased surgical time.[13] Fat tissue mass expands without developing a concomitant increase in blood flow per cell, which leads to speculation on the presence of tissue hypoxia from relative hypoperfusion, which increases the risk of SSI.[14] Kabon et al[14] found that during intraoperative monitoring, patients who were obese had significantly lower subcutaneous oxygen tension than did patients who were not obese ($P = .002$). Given the known association between tissue hypoxia and increased risk of infection, this hypoxia may explain, at least in part, the increased risk of SSI in patients who are obese.[14]

The Institute for Healthcare Improvement's 5 Million Lives Campaign is an organized effort

to reduce harm to patients in the health care setting, including reducing SSI rates.[15] To achieve this goal, the Institute for Healthcare Improvement recommends that health care practitioners identify patients with nasal carriage of MRSA and comply with expert recommendations on reducing bacterial colonization.[15] The Centers for Disease Control and Prevention recommends that patients shower or bathe the night before surgery and use an appropriate skin antiseptic, such as CHG, before surgery to reduce the risk of SSI.[1]

Chlorhexidine gluconate in a 2% solution without alcohol is a commonly used skin antiseptic that is effective against a wide variety of skin-borne pathogens.[1] Residual CHG persists on the skin, which permits continued antiseptic action after application.[16] Chlorhexidine gluconate in a 2% no-rinse cloth formulation has been shown to be an effective antimicrobial agent against *Acinetobacter baumannii* and *S aureus*, specifically MRSA. In one study, the 2% alcohol-free CHG preparation resulted in a 99.9% reduction in *S aureus* on the skin of the abdomen and groin within three minutes of exposure.[17] Cleansing with a 2% CHG no-rinse cloth also has been shown to reduce colonization of other pathogens, such as vancomycin-resistant enterococci.[18]

One study showed that preoperative skin preparation with 2% CHG cloths 12 and three hours before surgery significantly lowered microbial counts compared with skin preparation with triclosan soap.[19] In the study, 126 adult participants were assigned to six antisepsis combinations in a crossover design. All participants underwent two total body cleansing regimens—2% CHG cloths or triclosan soap—and another cleansing three hours before surgery with 2% CHG cloths, 0.7% tincture of povidone-iodine, or 10% povidone-iodine. The combination of using a 2% CHG cloth at both 12 and three hours preoperatively led to significantly lower skin microbial counts than did the other regimens.[19] Use of the advance multiple preoperative skin preparation protocol with 2% CHG cloths resulted in significantly lower numbers of microorganisms on both potential surgical sites than did the control triclosan soap ($> 1 \log_{10}$, $P < .001$). Although not consistently significant, the reduction in microorganisms after the final preoperative surgical site preparation with all three products was $\sim 0.5 \log_{10}$ greater for participants whose skin was prepared with 2% CHG rinse-free cloths than for participants who showered with triclosan.[19]

Chlorhexidine gluconate in a 2% solution is a commonly used skin antiseptic that is effective against a wide variety of skinborne pathogens, but few studies have directly examined the ability of chlorhexidine gluconate skin antisepsis to reduce surgical site infections.

The use of 2% CHG in a no-rinse cloth form has been shown to reduce skin microbial counts more effectively than a 4% CHG bath, which requires rinsing.[20] The greater effectiveness of the 2% CHG cloth may result from its rinse-free formulation or the fact that the gentle exfoliation created by the texture of the cloth allows for a greater reduction in microbial counts.

Few published studies have directly examined the ability of CHG skin antisepsis to reduce SSIs. In a 1983 study, Leigh et al[21] found that total body washing with a 4% CHG solution did not reduce SSI rates. In a systematic review and meta-analysis, there was no clear evidence showing a benefit from using a rinse-off CHG solution to shower or bathe preoperatively.[22] In both studies, rinse-off formulations of CHG were the only CHG products studied.

Some unpublished data on the use of the 2% CHG cloth and SSI reduction support the suggestion that the 2% CHG cloths might be able to reduce SSI rates. In a Veterans Administration hospital setting, rates of SSI decreased from a

historical rate of 0.2% to 0% after the introduction of 2% CHG no-rinse cloths for presurgical skin preparation.[12] Similar results were seen in a community hospital setting in which the incidence of SSI decreased from a historical rate of 2.1% to 0.7% after implementation of the use of 2% CHG no-rinse cloths.[23]

Despite the lack of published data on SSI reduction with 2% CHG cloths, studies have shown that infections other than SSIs are reduced after skin antisepsis or bathing with 2% CHG no-rinse cloths. After the introduction of daily baths with 2% CHG cloths, patients in a medical ICU setting were found to be at lower risk for catheter-associated bloodstream infections: 6.4 versus 16.8 bloodstream infections per 1,000 central line days.[24] In another study in an ICU setting, patients had fewer infections from *Acinetobacter* when they were bathed daily with 2% CHG.[25] These data suggest the possibility that the 2% CHG cloths might be beneficial for preventing other health care-associated infections. None of these studies included all of the interventions chosen for our facility.

Screening for MRSA and preventing contact with carriers reduces the risk of health care-associated MRSA infection.[26] Nicholson and Huesman[27] found that treating MRSA carriers with mupirocin placed in the nares led to a 33% reduction in SSIs and an overall SSI reduction from 1.68% to 0.37% ($P < .006$). Similarly, Carrier et al[28] found that a regimen of nasal screening, preventive isolation, mupirocin ointment application, and vancomycin prophylaxis was effective in controlling MRSA outbreaks and decreased the risk of MRSA mediastinitis in patients undergoing cardiac surgery.

EFFORTS TO REDUCE SSIs

We conducted our quality improvement initiative from February 1, 2006, to January 31, 2007, at two community hospitals with a combined 480-bed capacity. All patients undergoing scheduled cesarean deliveries, hip replacement, knee replacement, gastric bypass surgery and banding, and bone fusions were eligible for inclusion because the infection preventionists at the facilities identified these surgeries as having the highest risk for SSI. Patients were excluded if they had a known allergy to CHG or if their surgeon opted out of the program.

All surgical patients were given a nasal swab during the preoperative screening one to five days before surgery, and obstetric patients underwent screening at their 36-week prenatal examinations. Any patient who had a positive result for MRSA was started on intranasal mupirocin twice daily for five days, with at least one dose administered on the morning before surgery or cesarean delivery. Any patient colonized with MRSA was given an education booklet, *Living with MRSA*,[29] which reviews facts, treatment, and prevention related to MRSA infections.

Preoperative skin preparation with 2% CHG no-rinse cloths was initiated by patients on the morning of surgery according to written instructions we provided. The patients were instructed to use one cloth to wipe down the front of the body, starting at the neck and working downward, ending with the perineum, and to use the second cloth to wipe down the back of the body in a similar fashion and to allow their skin to air dry. This wipe down was extensive, but patients were instructed to avoid contact with mucous membranes. Obstetric patients were instructed to avoid the areolas of the breasts and mucous membranes of the perineum; those admitted to the labor and delivery department were wiped down in the same fashion by a nurse at the time of admission.

KEY MEASURES FOR IMPROVEMENT

As part of the performance improvement process, we analyzed the facility algorithm to add in testing for MRSA (Figure 1). An infection control staff member recorded simple numbers and percentages on all total hip, total knee, gastric bypass and banding, cesarean delivery, and bone fusion procedures. We used historical rates of SSI

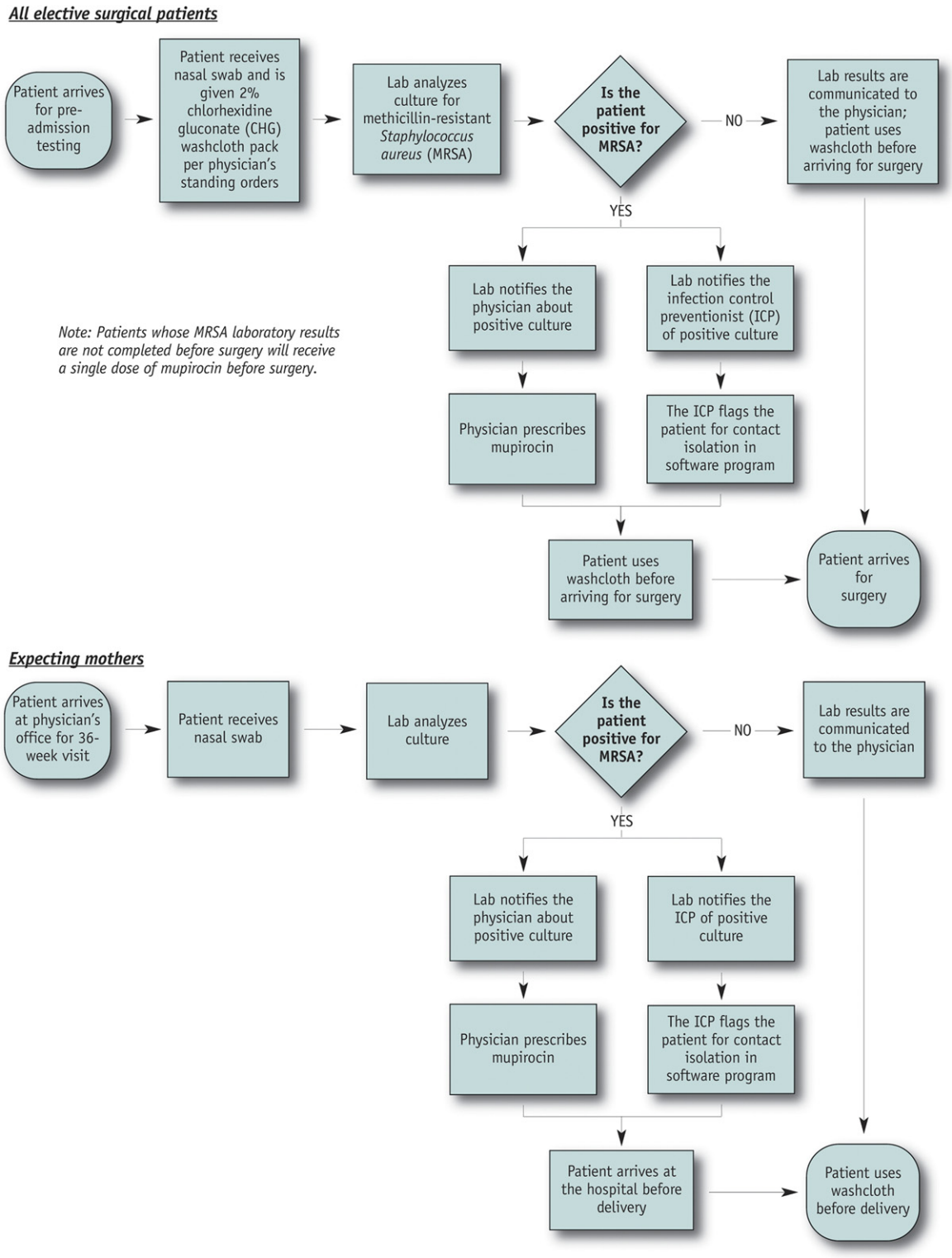

Figure 1. Algorithm used as part of the quality improvement initiative to test for methicillin-resistant *Staphylococcus aureus* (MRSA).

between February 1, 2005, and January 31, 2006, for comparison. We pulled the historical rates of SSIs directly from the infection control SSI reports of the facilities, which were part of ongoing health care-associated infection surveillance. We did not perform data analysis by surgeon or demographics because this quality improvement initiative was intended to evaluate the effects of a change in protocol with no control group. To follow up on discharged patients, staff members in the infection control department queried surgeons via letter by procedure and patient 30 days after surgery, and the surgeons provided their expert opinions of whether the patient had developed an SSI, per Nosocomial Infection Surveillance System criteria.

The primary outcome measures were the number of SSIs and the number of MRSA SSIs. Secondary outcome measures included adverse events caused by either the mupirocin or the application of the CHG product and patient compliance with the skin preparation protocol, which we assessed using an informal survey.

The intervention patients were identified by personnel in the infection control department through the hospital's database of patients coming in through preadmission testing, combined with patients coming in through our large obstetrics/gynecology center housed in the hospital. We queried the database by entering the time period for the intervention and determined the preintervention SSIs based on the results.

ANALYSIS AND INTERPRETATION

We hypothesized that the bundling of active surveillance and presurgical antisepsis intervention would reduce SSI rates. With data from more than 1,000 procedures in each time period, there was adequate statistical power to detect an absolute difference of more than 1% as statistically significant with an alpha level of 5% and a beta level of 20%. We used the chi-square test to assess the change in the SSI rate from 2005–2006 compared with 2006–2007. An assumption of the chi-square test (ie, cells in the contingency table

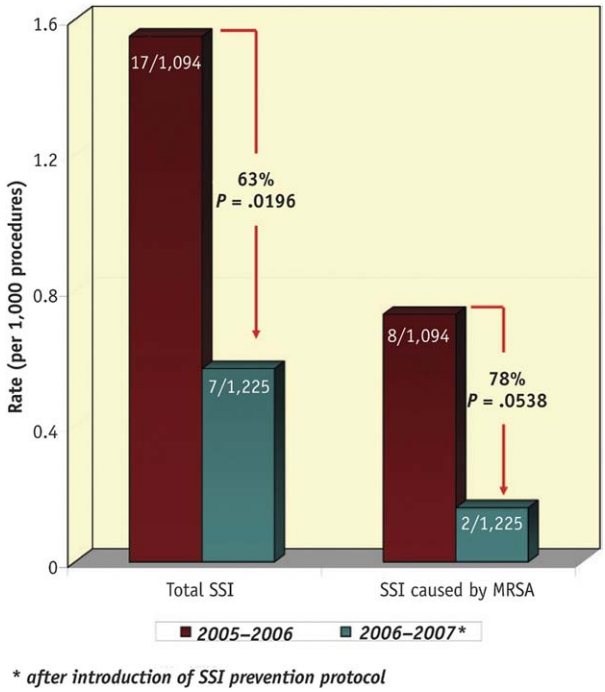

Figure 2. Total surgical site infection (SSI) and methicillin-resistant *Staphylococcus aureus* SSI rates for 2005–2006 and 2006–2007.

with expected counts of < 5) was not met for rates of SSI caused by MRSA, so we used the Fisher exact test instead. Counts per procedures were presented as the SSI rates (per 100 procedure days). In addition, the test statistics and *P* values were reported. A *P* value less than or equal to an alpha level of .05 was considered statistically significant.

FINDINGS

A total of 5,570 patients were included in the intervention: 2,417 at one community hospital and 3,153 at the other hospital. Two surgeons, a cataract surgeon and a pediatric dentist, opted out of the quality improvement program.

The number of SSIs was reduced from 17 before the intervention to seven during the intervention period, which represented a 63% reduction. The incidence of MRSA SSIs decreased from the historical baseline of eight to two after the intervention, as determined by laboratory cultures of the wounds, representing a 78% reduction (Figure 2). Figure 3 shows the combined

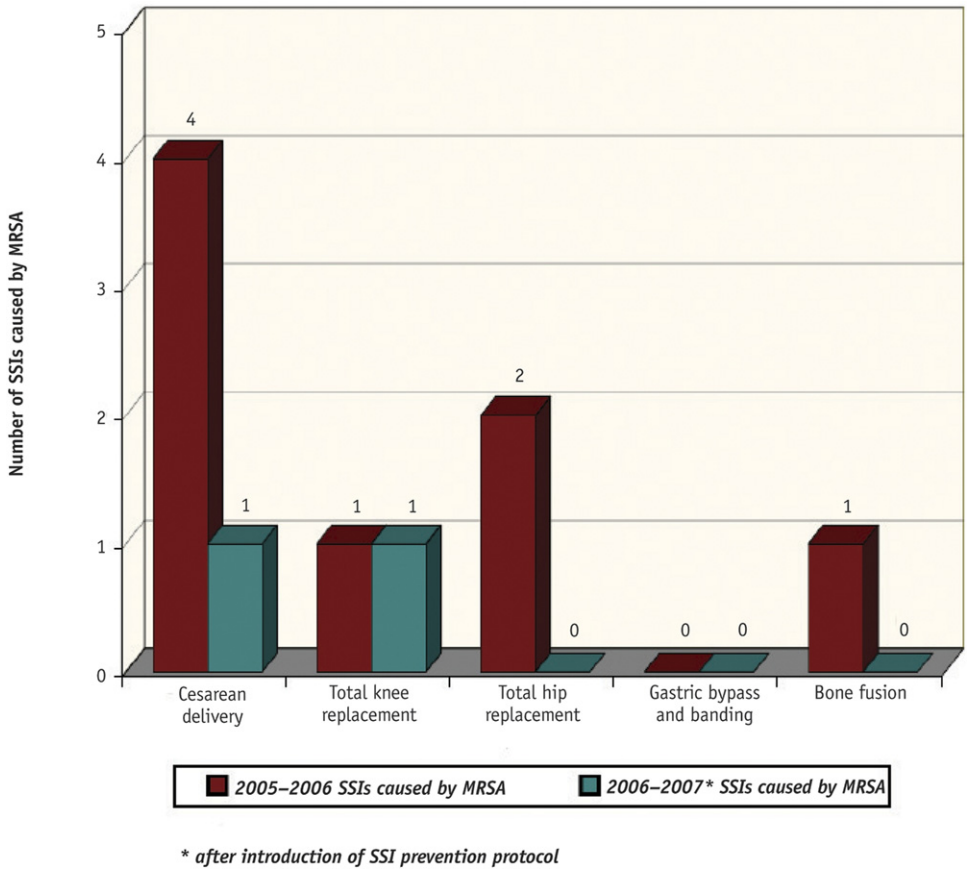

Figure 3. Combined incidence of surgical site infections (SSIs) caused by methicillin-resistant *Staphylococcus aureus* (MRSA) for both hospitals by procedure, 2005–2006 and 2006–2007.

incidence of SSIs caused by MRSA for both hospitals by procedure for 2005–2006 and 2006–2007. No incidents of rash or swelling or signs of allergic reaction or intolerance were reported from the use of the mupirocin or CHG, but some patients reported that the CHG made their skin "tingle" during use. During the informal patient surveys conducted by the staff nurses, the patients reported that the CHG was easy to use and the instructions were easy to understand and follow.

The data revealed a significant reduction in the SSI rate from 1.55 (17/1,094) in 2005–2006 to 0.57 (7/1,225) in 2006–2007 ($X^2 = 5.45$, $P = .0196$); this reflects a relative reduction of 63%. The MRSA SSI rate also was marginally reduced (ie, from 0.73 [8/1,094] in 2005–2006 to 0.16 [2/1,225] in 2006–2007, Fisher exact test statistic = 4.34, $P = .0538$) (Table 1). Although this represents a relative reduction of 78%, the result had less statistical significance (ie, higher P value than that for the main SSI rate) because with fewer occurrences of an event, there is greater difficulty of statistical detection.

EFFECTS OF CHANGE

In the quality improvement initiative, introducing screening for MRSA with nasal swabs and treatment of carriers with mupirocin combined with

TABLE 1. Surgical Site Infection Rate Reduction Statistics

End point	Year	Count/ procedures (rate)	X^2	P
Surgical site infection	2005–2006 2006–2007	17/1,094 (1.5) 7/1,225 (0.57)	5.45	.0196

presurgical skin preparation with a 2% CHG no-rinse cloth on the morning of surgery led to a 63% reduction in the rate of SSIs and a 78% reduction in the rate of MRSA SSIs compared with historical rates. These results are better than those from studies that evaluated mupirocin alone[27] and are similar to preliminary unpublished data from uncontrolled trials.[12,23] Our results have shown that introduction of a program that includes screening for and treatment of nasal carriage of MRSA combined with preoperative skin antisepsis with 2% CHG cloths can lead to a reduction in SSIs and MRSA SSIs. Patients reported that using the cloth was easy and that the education material[29] was well received, which suggests that the use of skin antisepsis is acceptable to patients. The interventions were smoothly incorporated into the nurse's daily routines after a preintervention inservice program was conducted. The inservice program ensured that the nurses understood the rationale behind the practice changes and helped us garner staff member buy-in.

The cost of implementing the quality improvement program was estimated at $108,000, which included MRSA cultures, 2% CHG cloths, and mupirocin ointment for an annual surgical volume of 6,900 patients. Given the median cost of $40,000 per SSI caused by MRSA,[3] the prevention of six cases of SSI caused by MRSA potentially saved the hospitals $240,000.

PRACTICE IMPLICATIONS

A limitation of these findings is that this was a quality improvement initiative and not a clinical study. Therefore, the results of these efforts are attributed to multiple interventions instead of a single intervention. Research should be conducted using rigorous clinical trial methodology to better examine the effects of the individual interventions on SSI reduction.

Reductions in SSI rates through interventions such as preoperative screening, treatment with mupirocin for MRSA carriers, and the use of 2% CHG cloths offer improved outcomes for surgical patients. Experience suggests that planned, evidence-based interventions can have a positive effect on SSI rates and that the costs of such interventions are more than offset by the savings realized by the prevention of SSIs. AORN

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Virginia Lipke, RN, MHA, ACRN, CIC, is an infection control practitioner and preventionist at the Division of Global HIV/AIDS, Center for Global Health, Centers for Disease Control and Prevention, Atlanta, GA. *Ms Lipke has no declared affiliation that could be perceived as posing a potential conflict of interest in the publication of this article.*

Anthony Hyott, MHA, is the director, planning and program development, at St Elizabeth Healthcare, Edgewood, KY. *Mr Hyott has no declared affiliation that could be perceived as posing a potential conflict of interest in the publication of this article.*