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Surgical care improvement project and surgical site infections: can integration in the surgical safety checklist improve quality performance and clinical outcomes?[1]

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ABSTRACT

Introduction: The World Health Organization Surgical Safety Checklist (SSC) has been shown to decrease surgical site infections (SSI). The Surgical Care Improvement Project (SCIP) SSI reduction bundle (SCIP *Inf*) contains elements to improve SSI rates. We wanted to determine if integration of SCIP measures within our SSC would improve SCIP performance and patient outcomes for SSI.

Methods: An integrated SSC that included perioperative SCIP *Inf* measures (antibiotic selection, antibiotic timing, and temperature management) was implemented. We compared SCIP *Inf* compliance and patient outcomes for 1-y before and 1-y after SSC implementation. Outcomes included number of patients with initial post-anesthesia care unit temperature $<98.6^\circ$F and SSI rates according to our National Surgical Quality Improvement Program data.

Results: Implementation of a SCIP integrated SSC resulted in a significant improvement in antibiotic infusion timing (92.7% [670/723] *versus* 95.4% [557/584]; $P < 0.05$), antibiotic selection (96.2% [707/735] *versus* 98.7% [584/592]; $P < 0.01$), and temperature management (93.8% [723/771] *versus* 97.7% [693/709]; $P < 0.001$). Furthermore, we found a significant reduction in number of patients with initial post-anesthesia care unit temperature $<98.6^\circ$F from 9.7% (982/10,126) to 6.9% (671/9676) ($P < 0.001$). Institutional SSI rates decreased from 3.13% (104/3319) to 2.96% (107/3616), but was not significant ($P = 0.72$). SSI rates according to specialty service were similar for all groups except colorectal surgery (24.1% [19/79] *versus* 11.5% [12/104]; $P < 0.05$).

Conclusion: Implementation of an integrated SSC can improve compliance of SSI reduction strategies such as SCIP *Inf* performance and maintenance of normothermia. This did not, however, correlate with an improvement in overall SSI at our institution. Further investigation is required to determine other factors that may influence SSI at an institutional level.

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1. Introduction

Surgical site infections (SSI) complicate up to 5% of all operations in the US and are the most frequent nosocomial infection among surgical patients [1]. With over 15 million surgical procedures performed in the US annually, an estimated 750,000 SSI will occur, resulting in additional direct and indirect cost to both the patient and the healthcare systems [1–4]. It has been reported that SSI can increase the postoperative length of stay by 7 to 10 dand hospital costs by 300% [5,6]. Furthermore, mortality rates can exceed 10% with certain infections [7]. Although effective prevention strategies exist, compliance is poor and outcomes are difficult to track [8,9]. Therefore, national programs for surgical quality performance and perioperative outcomes have been introduced as strategies to improve patient care and reduce complications [10–12].

The Surgical Care Improvement Project (SCIP) was developed by the Centers for Medicare and Medicaid Services to reduce SSI rates by 10% [10,12]. SCIP measures for SSI prevention (SCIP *Inf*) involve a multi-disciplinary approach including the proper timing of antibiotic infusion (SCIP *Inf1*), antibiotic selection (SCIP *Inf2*), appropriate discontinuation of prophylactic antibiotics (SCIP *Inf3*), appropriate hair removal method (SCIP *Inf6*), and maintenance of perioperative normothermia (SCIP *Inf10*), and euglycemia (SCIP *Inf4*). Compliance with SCIP quality performance measures is publicly reported and is tied to hospital reimbursement. [11,13] The National Surgical Quality Improvement Program (NSQIP) is a validated program used for improving surgical care through outcome measurement and direct provider feedback. Participation in NSQIP has shown to improve surgical outcomes in both low and high performing hospitals [14], and has been used to track outcomes of quality performance measures including SCIP [14–17]. While adherence to SCIP measures has controversial effects on patient outcomes [15,16,18–22], there is a growing incentive for compliance through pay-for-performance and pay-for value initiatives [11,13,23].

Multi-disciplinary checklists including the World Health Organization (WHO) Surgical Safety Checklist (SSC) have been shown to decrease SSI, complications and mortality rates [24,25]. These improved patient outcomes are achieved, in part, through standardized steps during the checklist process that achieve error reduction and improve compliance with process-of-care measures. Haynes and colleagues showed that implementing a 19-item checklist in the perioperative period increased appropriate timing of antibiotic infusion from 56% to 83% with a significant reduction in SSI from 6.2% to 3.4% [24]. However, this study did not report other core SCIP *Inf* performance measures targeting SSI reduction. The purpose of this study was to determine if implementation of a standardized SSC (1) improved surgical team perceptions of SCIP *Inf* SSI reduction strategies, and (2) how implementation affected SCIP *Inf* quality performance measures and patient outcomes.

2. Methods

Scott and White Memorial Hospital is a 636 bed tertiary care hospital that actively participates in SCIP and NSQIP data bases and quality performance reporting. On September 1, 2010, we implemented a SSC with integration of SCIP *Inf* quality performance metrics in effort to improve patient safety and reduce complications, including SSI. The implementation process included a multidisciplinary team for development, validation through focused and limited SSC trial, surgical team training and education (including on-line CME activity with post-test), and monitoring and coaching of surgical teams post implementation [26]. SSI reduction strategies were focused on performance measures that could be verified through direct verbal communication during completion of the sections from our SSC (Table 1). These included (1) timing of antibiotic infusion (SCIP *Inf1*), (2) appropriate antibiotic selection (SCIP *Inf2*), and (3) appropriate perioperative temperature management (SCIP *Inf10*).

A survey of surgical team members (nursing, surgeon and anesthesia provider) perceptions regarding the SSC was distributed 1-mo before (baseline) and 1-y after (follow-up) SSC implementation. This was an anonymous electronic survey carried out through survey monkey (www.surveymonkey.com), and participants were recruited through repeated e-mail invitations over a 1-mo period. No incentives were provided for participation. Follow-up surveys were offered only to those who were invited at baseline. Survey data results reported in this study (three questions) are focused only on SSI reduction strategies integrated in the SSC that are outlined in Table 1, and are not detailed in a separate study of 33 survey questions, which focuses on surgical team communication, teamwork, operating room efficiency, and patient care [26]. The survey questions reported are included to show how implementation of a SSC affected surgery team perceptions of SCIP *Inf* performance metrics and how that related to actual performance and patient outcomes. The questions include (1) *When preoperative antibiotics (excluding vancomycin) have been ordered, using incision time as a reference, to your knowledge, when*

Table 1 – SCIP *Inf* performance measures verbally addressed in the Scott and White surgical safety checklist.

SSC section	SCIP *Inf* performance measures	Verbal verification by surgical team
Check in	*Inf*-10 perioperative temperature management	Estimated time for procedure
Sign in	*Inf*-10 perioperative temperature management	Risk of hypothermia (operation >1 h)
Time out	*Inf*-2 antibiotic selection	Appropriate antibiotic ordered
Time out	*Inf*-1 antibiotic timing	Antibiotic given within 60 min of incision (except vancomycin 120 min)

are the antibiotics to be initiated? (2) *Are you always aware in advance when the patient is at risk of hypothermia?* and (3) *After the surgical procedure has begun, how often do you adjust the temperature in the room or put on a patient warming device because of concern of patient hypothermia?*

This study was performed in effort to determine effect and outcome of an institutional quality and safety improvement initiative. This study was submitted and approved as a retrospective review by the Scott and White Memorial Hospital Institutional Review Board. To determine the impact of our SSC on quality performance and patient outcomes we compared data for 1-y before (PRE) and 1-y after (POST) SSC implementation. Data for compliance of SCIP performance measures and NSQIP were collected prospectively and reported to their respective regulatory bodies. All SCIP measures designed to specifically reduce SSI (SCIP *Inf*) were evaluated, except for euglycemia in cardiac patients (SCIP *Inf4*) as this performance measure does not impact all patients reported in this study. The American College of Surgeons NSQIP database was used to evaluate our institutions surgical outcomes data for SSI and mortality. SSI included superficial, deep, and organ space as defined by NSQIP. Data reported include institutional composite, cardiac surgery, colorectal surgery, general surgery (non-colorectal non-vascular), gynecologic surgery, orthopedic surgery, thoracic surgery, and vascular surgery. These specialties were chosen as they correlate best with defined SCIP *Inf* operative case subcategories. Patient core temperature data in the perioperative period was obtained through DOCUSYS Merge AIMS (Merge Healthcare, Chicago, IL), an electronic anesthesia information management system. All patients evaluated and reported in this study had an operation with general anesthesia lasting >1 h with a documented first operatiang room (OR) temperature (after induction) and first post-anesthesia care unit (PACU) temperature (within 15 min of arrival). Patients who were hypothermic (temperature <96.8°F) at first PACU temperature were identified.

2.1. *Statistical analysis*

Data analysis was performed using GraphPad InStat (GraphPad Software, Inc, La Jolla, CA) statistics software. Categorical data are expressed as percentages and quantitative data are presented as mean ± SD. Statistical analysis was performed using *t*-test, χ^2 test, or Fisher's exact test as appropriate. Statistical significance was defined as *P* value <0.05.

3. Results

3.1. *Surgical team perceptions*

Survey invitations were sent to a total of 824 surgical team members (469 baseline and 355 follow-up groups). Although the survey was related to all aspects of the SSC, the results reported in this study represent the surgical teams' perceptions related to SCIP *Inf* performance measures only. The overall response rate was 53% with a total of 210 responses in the baseline group and 227 responses in the follow-up group. There were three questions specific to SCIP *Inf* performance measures, and these included timing of antibiotic infusion (SCIP *Inf1*) and perioperative temperature management (SCIP *Inf10*). For timing of antibiotic infusion (Fig.), 96% of the baseline and follow-up groups chose the correct answer that "*except for vancomycin, antibiotics infusion should start ≤60 min before incision*" ($P = 0.96$). Although perception of antibiotic infusion time did not change after implementation of our SSC, awareness and perception of perioperative temperature management was significantly improved in the follow-up group. First, Table 2 shows a significant improvement in the percentage of surgical team members that affirmatively responded that they were "*aware in advance when the patient is at risk for hypothermia (case lasting >1 h)*" (62.9% *versus* 77.1%; $P < 0.001$). Additionally, Table 3 shows there was also a significant increase in responses that >75% of the time the surgical team member adjusts the temperature in the operating room or puts on a patient warming device because of concern of patient hypothermia (17.2% *versus* 29.5%; $P < 0.001$).

3.2. *Quality performance metrics and temperature management*

Next, we determined whether implementation of our SSC improved perioperative SCIP *Inf* performance measures. Clearly shown in Table 4, the three SCIP *Inf* measures that are specifically addressed in our SSC (*Inf1*, *Inf2*, and *Inf10*) were significantly improved after its implementation ($P < 0.05$). The greatest improvement was in SCIP *Inf10* (perioperative temperature management) that improved nearly 4% (93.8% to 97.7%; $P < 0.001$). SCIP *Inf* data not directly addressed in our SSC also improved, including *Inf3*, appropriate discontinuation of perioperative antibiotics (93.9% *versus* 96.7%; $P < 0.05$). Although there was no significant improvement in SCIP *Inf6* performance (appropriate method of hair removal), both PRE and POST groups achieved a high performance score of >99.5%.

As shown in Tables 2 and 3, the SSC improved perception and awareness of factors affecting perioperative temperature

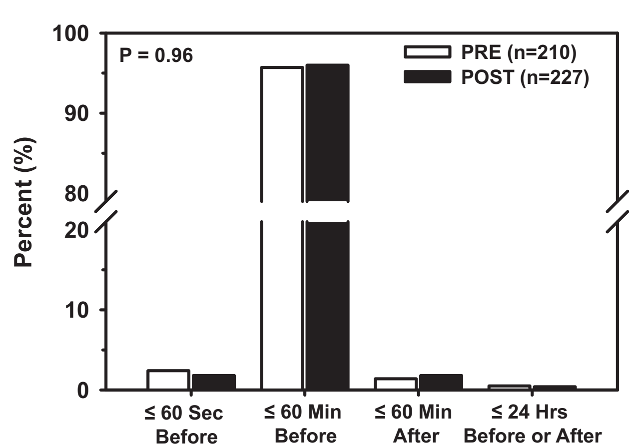

Fig. – Surgical team perception of antibiotic infusion time. Survey question: "When preoperative antibiotics (excluding vancomycin) have been ordered, using incision time as a reference, to your knowledge, when are the antibiotics to be initiated?" There was no difference in PRE *versus* POST group responses.

Table 2 – Answer to survey question "*Are you always aware in advance when the patient is at risk of hypothermia?*"

Group	*n*	Yes	No	*P* value
Baseline	210	132 (62.9%)	78 (37.1%)	<0.001
Follow-up	227	175 (77.1%)	52 (22.9%)	

Statistical analysis by Fisher's exact test.

management, and this was associated with improvement in perioperative temperature management (SCIP *Inf10*) performance measure (Table 4). To determine clinical impact, we identified the first OR temperature measured and the first postoperative PACU temperature measured (Table 5). There were a total of 10,126 patients in the PRE group and 9676 patients in the POST group. Although the POST group started with a significantly lower first OR temperature ($P < 0.001$), the first PACU temperature in the POST group was significantly higher ($P < 0.001$), suggesting improved perioperative temperature management by the surgical team. Furthermore, there was a significant reduction in the number of patients who arrived in the PACU hypothermic with temperature <96.8°F (9.7% *versus* 6.9%; $P < 0.001$).

3.3. *NSQIP outcomes for SSI and mortality*

To determine how our SSC associated improvement in SCIP *Inf* performance measures impacted patient outcomes, we determined SSI and mortality rates as measured through our institutional NSQIP data report (Table 6). Overall, our institutional SSI rates decreased from 3.13% to 2.96%, but the result was not significant ($P = 0.72$). The reported NSQIP SSI rates for our institution according to surgical specialty services were similar for all groups except colorectal surgery, which showed a significant decrease in SSI following SSC implementation (24.1% *versus* 11.5%; $P < 0.05$). Although there was no difference in SSI rates for orthopedics, there was a substantial trend to decreased SSI rates (1.7% *versus* 0.7%; $P = 0.06$). Finally, mortality rates were equivalent between groups (0.9% [30/3319] PRE *versus* 1.0% [36/3616]; $P = 0.79$) with no difference seen within surgical specialty services.

4. Discussion

The main findings of our study is that a SSC with integrated SCIP *Inf* quality performance measures improves surgical team perceptions and compliance with these process-of-care measures on an institutional level. Improved perceptions of surgical team communication and intervention for hypothermia resulted in a decrease in number of patients with hypothermia upon arrival to the PACU. These findings did not result in overall improved SSI rates; however, a significant reduction in SSI was seen in colorectal surgery subspecialty group.

SSC have been shown to improve patient outcomes by reducing mortality and SSI rates [24,25]. These beneficial effects are a result of enhanced communication and consistent process-of-care performance [25,27]. Haynes and colleagues [24] showed that use of a SSC was associated with an improvement in timing of antibiotic infusion (56.1% to 82.6%) and resulted in a 42% reduction in overall SSI rates. In our study, we also found a small, but significant incremental improvement in performance of SCIP *Inf1* antibiotic timing; however, we were already performing at a high level (92.7% to 95.4%). This may be why we did not see a significant improvement in overall institutional composite SSI rates (3.1% *versus* 3.0%). Bliss *et al.* [28] reported similar results with antibiotic timing achieving 95.9% with no significant improvement in SSI (6.2% *versus* 5.5%; $P = 0.85$); however, pre-SSC SCIP performance was not reported, SCIP *Inf* measures were not comprehensively evaluated, and hypothermia rates were not reported. Furthermore, the proportion of emergent cases was significantly lower in the SSC group which may account for any improved outcomes. In contrast, our SSC included SCIP *Inf1* appropriate timing for antibiotic infusion, SCIP *Inf2* antibiotic selection, and SCIP *Inf10* perioperative temperature management, and each showed significant improvement. In fact, in all six SCIP *Inf* performance metrics, we achieved 95.4% to 99.6% compliance, indicating that incorporating specific SSI reduction strategies into a standardized SSC can be effective in improving process compliance and quality performance. As healthcare evolves into value-based purchasing, pay-for-performance, and fee-for-value type programs, checklists that integrate performance measures into process-of-care quality initiatives will be an effective tool to assure compliance and improve reimbursement.

The basis for individual SCIP *Inf* performance measures is compelling and has recently been reviewed [12]. Studies have shown that SSC and other perioperative checklist tools can be effective in enhancing process-of-care measures [24,25]; however, in these studies, the pre-existing level of compliance was low and evaluation of SCIP was not comprehensive. Individual SCIP *Inf* performance measures have inconsistent

Table 3 – Answer to survey question "*After the surgical procedure has begun, how often do you adjust the temperature in the room or put on a patient warming device because of concern of patient hypothermia?*"

Group	*n*	Answer categories				*P* value
		<25%	25 to 50%	50 to 75%	>75%	
Baseline	210	110 (52.4%)	40 (19.0%)	24 (11.4%)	36 (17.2%)	<0.001
Follow-up	227	130 (57.3%)	19 (8.4%)	11 (4.8%)	67 (29.5%)	

Statistical analysis by χ^2 test.

Table 4 – SCIP performance measures for 1-y before (PRE) and 1-y after (POST) implementation of the Scott and White surgical safety checklist.

SCIP Performance measures		SSC		P value
		PRE	POST	
Inf-1	Antibiotic timing	670/723 (92.7%)	557/584 (95.4%)	<0.05
Inf-2	Antibiotic selection	707/735 (96.2%)	584/592 (98.7%)	<0.01
Inf-3	Antibiotic end	636/677 (93.9%)	528/546 (96.7%)	<0.05
Inf-6	Hair removal	1039/1044 (99.5%)	914/918 (99.6%)	0.99
Inf-10	Perioperative temperature	723/771 (93.8%)	693/709 (97.7%)	<0.001

Statistical analysis by Fischer's exact test.

results on SSI reduction, and a high degree of performance (75% to 90%) in composite SCIP *Inf* measures did not affect SSI rates [15,19,21,29]. Our study included a comprehensive SCIP *Inf* bundle analysis, and we found no difference in SSI rates with a significant improvement in five of six SCIP *Inf* measures and all measures achieving greater than 95% compliance. This indicates that there is a law of diminishing returns where a plateau for SSI reduction using SCIP *Inf* performance is reached and improvements are more difficult to achieve. As national SCIP performance reaches 90% and higher, it will be more difficult to differentiate between high and low performing hospitals, and SCIP may not be an effective program to distinguish hospital quality [19,29]. National SCIP compliance rates reached 96.4% in 2010 [30], and our data suggest that we may have reached capacity for improvement using SCIP. Thus, to justify the investment of resources into tracking and reporting quality of patient care, we must evaluate and direct how to continue with future quality improvement initiatives.

NSQIP is a validated national database to track and improve surgical outcomes and has been effectively used to assess impact of SCIP and SSC implementation on patient outcomes [14,28]. In our study, unadjusted SSI rates from NSQIP were used as the time frame for PRE and POST groups did not correspond with standard semiannual reporting. Although composite SSI rates remained unchanged, there was a greater than 50% reduction in SSI rates in the colorectal surgery group (24.1% *versus* 11.5%; $P < 0.05$). To ensure our findings were not related to disproportionate risk factors, we verified our findings with risk adjusted SSI data for colorectal surgery according to the semiannual report. The dramatic improvement in observed/expected ratio from 1.6 (July 2009–June 2010) to 1.1 (January 2011–December 2011) indicates that the improvements found in our study using unadjusted data is meaningful, and we must focus on specialty specific needs and variables.

Colorectal operations have higher rates of SSI compared with other surgical subspecialties, with reported rates as high as 26% [31], and provides the opportunity for optimization of SSI reduction bundles to improve outcomes. SSI reduction bundles including SCIP *Inf* performance measures, wound management in patients with body mass index >25, and change in operative decision-making has been shown to reduce SSI by up to 40% following colorectal operations [32,33]. We found similar results with over 50% reduction in SSI following colorectal surgery with implementation of a SCIP *Inf* integrated SSC. During the study period, we have not made significant changes to our practice, including antibiotic selection or use of preoperative bowel preparation. Normothermia has been associated with significant reduction in SSI rates in colorectal surgery, and is the basis for SCIP *Inf*10 recommendation [12,34]. In our study, incorporating communication of patient risk for hypothermia in the SSC improved surgical team awareness, perceived patient care action, and was associated with a 30% reduction in PACU hypothermia rates. Although we do not have specific data on maintenance of hypothermia in colorectal patients specifically, our data includes all patients recovered in the PACU

Table 5 – Surgical patient temperature measurements and rate of hypothermia PRE and POST implementation of the Scott and White surgical safety checklist.

	SSC		P value
	PRE	POST	
Total patients to PACU	$n = 10,126$	$n = 9676$	
Temperature results			
First OR temperature	97.0 ± 1.4°F	96.9 ± 1.2°F	<0.001
First PACU temperature	97.7 ± 0.9°F	97.8 ± 0.8°F	<0.001
Temperature change	0.7 ± 1.4°F	0.9 ± 1.2°F	<0.001
PACU temperature <96.8°F	982 (9.7%)	671 (6.9%)	<0.001

Statistical analysis by *t*-test or Fischer's exact test.

Table 6 – NSQIP data for surgical site infection rates for PRE and POST implementation of the Scott and White surgical safety checklist.

NSQIP SSI (%)	SSC		P value
	PRE	POST	
Composite	104/3319 (3.13%)	107/3616 (2.96%)	0.72
Cardiac surgery	6/81 (7.4%)	12/86 (13.9%)	0.22
Colorectal surgery	19/79 (24.1%)	12/104 (11.5%)	0.03
General surgery	52/838 (6.2%)	55/907 (6.1%)	0.92
Gynecologic surgery	5/241 (2.1%)	7/260 (2.7%)	0.77
Thoracic surgery	1/41 (2.4%)	3/43 (7.0%)	0.62
Vascular surgery	3/121 (2.5%)	6/129 (4.7%)	0.50
Orthopedic surgery	16/960 (1.7%)	7/1031 (0.7%)	0.06

whose operation was over 1 h. To our knowledge, all colorectal cases tracked by NSQIP take greater than 1 h to complete, and should be comprehensively included in our data.

Given the study design and quality improvement focus, there are limitations to our study that must be discussed. First, SCIP and NSQIP do not report on all cases, but these programs are a validated snapshot of surgical patient outcomes on an institutional and surgical specialty level [12,14–16]. It would be of benefit to directly link SCIP to individual patient outcome performance on NSQIP, but this is beyond the scope of our study. Second, we actively educate surgical team members and residents on SCIP measures, definitions, and identified SCIP failures. This, however, is a part of our continued surgical quality improvement initiative and is designed to maintain our SCIP awareness and performance. Finally, our study was a single institution experience with SSC implementation and impact on SCIP *Inf* quality measures and patient outcomes. Effective SSC use and compliance is dependent on multiple factors, including physician culture. It would be important to determine these barriers and how they might affect the success of SSC implementation on quality performance and outcomes.

Implementation of our quality integrated SCC improved awareness and action of surgical teams to SSI reduction strategies (SCIP *Inf* bundle). The use of standardized communication tools such as checklists ensure a high standard of quality of care and will be a valuable tool to effectively participate in pay-for-value and value-based purchasing programs. Achieving a high level of quality performance in SCIP *Inf* bundle improved SSI rates in colorectal surgery; however, this did not correlate with institutional or non-colorectal surgical subspecialties. Further investigation is required to determine other factors that may influence SSI across varied surgical specialties. Our data suggest that there is a plateau performance level where institutions will start to see diminishing returns for resources utilized for SCIP. Quality improvement assessment and program sustainability requires that quality performance measures be directly tied to improved patient outcomes to ensure an improvement in delivery of care.

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