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Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

Surgical site infection surveillance for elective primary total hip and knee arthroplasty in Winnipeg, Manitoba, Canada

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Key Words:

Infectious complication
Orthopedics
Prospective review
Risk factors
Surgery

Background: Surgical site infections (SSIs) increase morbidity and mortality after primary hip and knee arthroplasty. We evaluated a surveillance program that tracked risk factors associated with infection after primary hip and knee arthroplasty in the Winnipeg Regional Health Authority.

Methods: Surveillance data from April 2010 to March 2015 were reviewed for all 12,636 primary hip or knee arthroplasties, including 1-year follow-up. Procedures were evaluated in earlier (April 2010 to December 2012) and later periods (January 2013 to March 2015). Risk factors for postoperative infection were evaluated.

Results: There were 154 SSIs in 12,636 operations (1.22%) (earlier, 98 infections in 6,613 operations [1.48%]; later, 56 infections in 6,023 operations [0.93%]). The frequency of primary hip arthroplasty deep infection decreased from earlier to later periods; the frequency of primary knee arthroplasty infection was similar between the time periods. Independent risk factors associated with increased SSI risk included higher body mass index. SSI frequency was inversely associated with maintaining immediate postoperative temperature between 36°C and 38°C and surgery in the later period.

Conclusions: Surveillance was effective in decreasing the frequency of deep infection after primary total hip arthroplasties but not after knee arthroplasties. Surveillance of orthopedic surgery with feedback of SSI rates to the front-line staff may result in improvement in surgical outcomes.

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Surgical site infection (SSI) after total joint arthroplasty is an important problem for health systems, especially considering the progressively increasing frequency of these procedures.¹ SSIs may cause poor outcomes such as pain, increased duration of hospital stay, slower recovery, limitations in activities of daily living, decreased quality of life, increased frequency of arthroplasty revision, and death.^{2,3} Additionally, total joint arthroplasty SSIs are an economic burden on a health system. In 2008, the average cost of a hip or knee arthroplasty revision required for infection was \$18,000 Canadian and the total hospital cost (excluding physician costs) for hip and knee arthroplasty revisions due to infection was \$2.8 million Canadian, which is comparable with other

countries.^{4,5} Costs related to SSIs after joint replacement surgery in the United States increased from \$320 million in 2001 to \$566 million in 2009 and are projected to be \$1.62 billion by 2020.⁶ In addition, SSI adds to costs due to additional outpatient visits, pharmacy, radiology, and home care.^{7,8}

In 2012 and 2013, infection was the cause of a substantial frequency of 1-stage (hip, 6.7%; knee, 9.1%) and 2-stage arthroplasty revisions in Canada (hip, 7.8%; knee, 10.5%),² similar to revisions for infection in the other countries: 26.9% for total hip arthroplasties (in England and Wales)⁸ and 25.2% for total knee arthroplasties (in the United States).⁹ Quality improvement interventions including SSI surveillance and the use of a surgical checklist can decrease the frequency of SSI after arthroplasty.¹⁰ In 2016 and 2017, there were 113,632 patients reported to the Canadian Joint Replacement Registry who underwent elective and emergency primary hip and knee arthroplasty surgery. Revisions were also conducted in patients due to a deep postoperative joint infection (22%–44% of all revisions were attributed

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Conflicts of interest: None to report.

to infectious causes, depending on the type of revision completed).⁴

The frequency of SSIs may decrease by using a surveillance program to identify and manage SSI preventive interventions and risk factors, such as preoperative prophylactic antibiotics, skin preparation technique, normothermia during surgery, duration of surgery, and timing of postoperative antibiotics.^{11,12} Surgical outcome including SSI frequency may also be affected by patient-related risk factors such as body mass index (BMI), American Society of Anesthesiologists (ASA) class, type of arthritis, and presence of diabetes mellitus.^{13,14} Surveillance programs may help to decrease SSI frequency by tracking and identifying modifiable risk factors to guide preventive interventions^{15–17} and providing information back to surgical programs indicating where improvements are possible.

In the Canadian province of Manitoba, most total joint arthroplasties (79%) have been organized and delivered in Winnipeg, the capital city, and administered by the Winnipeg Regional Health Authority (WRHA). The remainder of the procedures (21%) are performed at 2 smaller rural regional centers. In 2010, the WRHA established a surveillance program to monitor outcomes, identify risk factors, and establish procedures, with the aim of decreasing SSI occurrence after total joint arthroplasty.

We hypothesized that the implementation of the WRHA SSI surveillance program would be associated with an increased knowledge of infection rates associated with these operations and would result in decreased SSI frequency after primary total joint arthroplasty. The purpose of this study was to evaluate the effects of the surveillance program and its findings on frequency of SSI after primary total hip and knee arthroplasty.

METHODS

Subjects and setting

This retrospective cohort study of a surveillance program included all 12,636 elective primary total hip and knee arthroplasty procedures performed over 5 years from April 2010 to March 2015 at 3 acute care community hospitals (identified as hospitals A, B, and C) in Winnipeg, Manitoba, Canada. These were the only hospitals included in the WRHA elective arthroplasty specialty program.

This study included only patients who underwent elective primary hip or knee arthroplasty and a 12-month postoperative follow-up. A procedure was defined as a primary unilateral arthroplasty operation. When a bilateral arthroplasty was performed, which was infrequently, the procedure was counted as 2 arthroplasties because each side was at risk of developing an SSI. Traumatic and revision hip and knee replacements and arthroplasty procedures for other joints were excluded from the study.

In December 2011, at 1.75 years after the surveillance program began, the orthopedic program for elective primary hip and knee arthroplasties of hospital C was absorbed into the program at hospital B, with the same surgical staff from both hospitals. When possible, the information related to specific hospitals was evaluated separately. Surgeons at hospital A performed surgery only at hospital A, whereas the surgeons at hospitals B and C typically worked at both sites. Hospital A had rotating orthopedic resident physicians who assisted in operations.

Arthroplasty surgery was performed by 20 surgeons during the 5-year study (for a mean of 642 primary arthroplasty procedures per surgeon; range, 86–1,502 primary arthroplasty procedures per surgeon; only 1 surgeon performed <100 primary arthroplasty procedures). The study was approved by the institutional review board of the University of Manitoba, and informed consent was exempted for

inclusion of data because of the quality improvement design of the study.

Surgery and infection prevention and control procedures

Preventive practices to decrease infection risk were similar at all 3 hospitals, including methods of sterilization of surgical instrument packs and other preoperative, intraoperative, and postoperative procedures. During the study period, operating rooms with laminar airflow were used for 80% of the procedures at hospital A, all procedures at hospital B, and none of the procedures at hospital C. However, the use of laminar flow within operating rooms may not be as necessary as previously assumed.¹⁸ Full-body exhaust system surgical suits were used in all facilities. From June–December 2011, all hospitals changed the preoperative skin preparation from povidone-iodine to chlorhexidine gluconate at different times at the 3 hospitals—first at hospital B (June 2011) and later at hospital A (November 2011); hospital C used varied types of skin preparation throughout 2011 until performance of elective hip and knee arthroplasty was discontinued at hospital C at the end of December 2011.

Prophylactic antibiotics were given to all patients before surgery using standardized preoperative drug orders at each hospital. Antibiotic choice was determined by the surgeon based on patient history of antibiotic intolerance and allergies and using standing orders. The timing of antibiotic administration was determined by the anesthesiologist in the operating room. Cefazolin was typically the antibiotic of choice and indicated as such on the standardized order sheets, of which 2 g was the usual dose; however, 1 g was occasionally used depending on the weight of the patient. Initially, there was suboptimal adherence to recommended protocols. During the study, the infusion schedule of preoperative prophylactic cefazolin changed from continuous infusion for 1 hour before surgery to a single intravenous injection (push) in the operating room before skin incision. The use of preoperative prophylactic cefazolin by intravenous injection was adopted earlier at hospital A (August 2011 to March 2014) than hospital B and C (May 2013 to March 2014). When a patient had an allergy to β -lactam antibiotics (penicillin or cephalosporins), vancomycin was typically given during the 2 hours before the skin incision. If there was inadequate time to infuse vancomycin before surgery, on rare occasions clindamycin was used. Antibiotic type and timing of administration were determined from the anesthesia record for cefazolin or clindamycin and the medication administration record for vancomycin. The required administration documentation included drug name, dose, timing, and initials of the individual giving the drug. If this documentation was incomplete, it was recorded as such in the data collected.

Definitions

Infections were defined according to the US Centers for Disease Control and Prevention (CDC) definitions used by the National Healthcare Safety Network for ongoing SSI surveillance in 2010.¹⁹ Although the recommended length of follow-up for deep infections was revised by the CDC during the study,¹⁹ the CDC definitions available at the beginning of the study (with 1-year follow-up for deep infections) were used throughout the study. The WRHA functioned with a fiscal year from April 1 to March 30, and the 4 quarters of the year were defined as quarters 1 (Q1, April–June), 2 (Q2, July–September), 3 (Q3, October–December), and 4 (Q4, January–March).

SSI surveillance

Surveillance was performed for 1 year postoperatively for all patients who underwent primary elective hip or knee arthroplasty.

The paper hospital records of all procedures were reviewed by staff of the WRHA Infection Prevention and Control (IPC) program; the hospitals did not use electronic medical records during the study. The infection control professionals received training in methods of chart review for SSI surveillance, and consistent methods were used to identify specific metrics throughout the study. Medical record issues that were discovered during the review were addressed at meetings every 3 months with surgeons, infectious disease physicians, anesthesiologists, and staff members of the IPC, Surgery, and Quality Process Improvement programs.

The initial medical record review of all procedures was performed 3–6 weeks after surgery to determine whether any infections were observed during the arthroplasty hospitalization or later in the emergency departments or cast clinics. Data collection focused on patient demographics, comorbidities such as diabetes and BMI, date of surgery, start time of surgery (time of surgical incision), and type and timing of prophylactic antibiotics and their comparison with *Safer Healthcare Now!* guidelines.^{10,20} *Safer Healthcare Now!* guidelines recommended antibiotics to be given within the 1 hour before incision (except vancomycin) and to maintain normothermia throughout the perioperative period. Surveillance also noted details about surgery, end time of surgery (time the patient was transported from the operating room after surgery was completed), duration of time from operating room to postanesthesia care unit temperature reading, postoperative temperature, details about postoperative treatment, duration of postoperative antibiotic use, and occurrence of a postoperative SSI. For patients who underwent multiple individual elective primary hip or knee procedures during the study, each arthroplasty was evaluated and followed separately for SSI. As the surveillance program evolved, information on infection rates, timing of preoperative antibiotics, and maintenance of normothermia were fed back to the regional orthopedics standards and quality committee, hospital site nursing and surgical leadership, and front-line staff via quarterly reports and semiregular infographics.

After discharge from the hospital, SSI follow-up was performed by the patient's surgeon, community wound clinics, and intravenous clinics. As part of the preoperative assessment, all patients were advised they should contact the primary surgeon immediately when there were any concerns about infection. Infections were reported to IPC staff, who then reviewed the outpatient records.

Infections were identified by (1) the rapid notification form, completed by hospital staff when they observed any signs of infection during the hospitalization for surgery, (2) the hospital record, (3) the outpatient chart for patients who had infection reported by the community wound and intravenous clinics after surgery, and (4) administrative data linkages, determined from a repeat review of medical records at 1 year after surgery (using codes from the ICD-10²¹ and CDC definitions¹⁹), to identify any patient who had an emergency room visit or hospital readmission at any hospital in the health region with a diagnosis of possible infection. Follow-up reviews of the hospital records were performed to confirm whether an SSI had occurred for any patients identified by these methods. Follow-up occurred from the day of surgery to 1 year after surgery. According to CDC definitions of SSIs, a diagnosis of postoperative cellulitis or stitch abscess did not meet the case definition.¹⁹

Data analysis

Data analysis was performed with statistical software (Epi Info, version 7.1.5.2; CDC, Atlanta, GA), Stata, version 12.1 (StataCorp, College Station, TX) and a spreadsheet program (Excel; Microsoft, Redmond, WA). A descriptive analysis was completed on all arthroplasty operations. Univariate analysis was completed for all risk factors, surgical details, and categorical demographic risk factor data. Risk factors evaluated were age, facility, procedure type (hip or knee), ASA class,

prophylactic antibiotic type and timing, postoperative normothermia, skin preparation type, type of arthritis, diabetes, BMI category, and fiscal year within the study or comparison between a specific earlier period with higher frequency of infection (April 2010 to December 2012; 33 months) and a later time period with lower frequency of infection (January 2013 to March 2015; 27 months).

All patients had a 1-year follow-up after arthroplasty and were included in calculations of frequency of infection. Risk factors were evaluated with the χ^2 test, Fisher exact test, and 2×2 odds ratio calculations (Epi Info; Stata, version 12.1; StataCorp, College Station, TX). Age was included in the logistic regression analysis. Comparisons were made between frequency of infection in the earlier versus later periods because a noticeable change in the frequency of SSIs seemed to occur at this point and was confirmed with analysis at a more granular level. Risk factors that showed significance were included in backward and forward stepwise logistic regression to determine significance after controlling for other variables. Variables used in the model had a statistical significance of $P \leq .10$ for the χ^2 and Fisher exact tests and $P \leq .05$ for regression analysis.

RESULTS

The number of primary elective total hip and knee arthroplasties was similar between hospital A (5,547 procedures) and B (6,066 procedures), and more than hospital C (1,023 procedures) (Table 1). At surgery, the patients undergoing procedures had a mean age of 67 years (range, 17–104 years); 42.5% were aged 65–80 years. The ASA class ranged from 1–4, including 3,784 patients (30%) who had ASA class 2. The mean BMI at surgery was 33.2 kg/m² (range, 15 to >50 kg/m²), and 3,500 patients (31%) had a BMI from 25–29.9 kg/m²; the mean BMI was higher in patients who underwent knee versus hip arthroplasty (hip, 30.9 kg/m²; knee, 34.6 kg/m²; $P \leq .00001$). There were 12,262 procedures on patients (97%) who had noninflammatory arthritis, 240 procedures on patients (2%) who had inflammatory arthritis, and 134 procedures on patients (1%) who had arthritis from congenital or other nontraumatic conditions.

There were 154 SSIs in 12,636 primary hip or knee arthroplasties (1.22%), and the frequency of SSI was greater for knee than for hip arthroplasty ($P < .05$) (Tables 1 and 2). The frequencies of total hip arthroplasty SSIs (both total and deep infection) but not knee arthroplasty SSIs were significantly lower in the later than the earlier period of the study (Tables 2, 3, and 4). Sixteen deep hip infections and 24 deep knee infections occurred in the first period. Six deep hip infections and 14 deep knee infections occurred during the second part of the study.

Cefazolin was used as the prophylactic antibiotic in 10,786 arthroplasties (85%). During the early part of the study, cefazolin was given

Table 1
Surgical site infections reported after primary total joint arthroplasty in Winnipeg, Manitoba, Canada*

Hospital	Time in study (mo)	Joint	No. of arthroplasties (%)	No. of infections (%)
A	60	Hip	2,442	24 (0.98)
		Knee	3,105	47 (1.51)
		Total	5,547	71 (1.28)
B	60	Hip	2,072	19 (0.92)
		Knee	3,994	53 (1.33)
		Total	6,066	72 (1.19)
C	21	Hip	385	4 (1.04)
		Knee	638	7 (1.10)
		Total	1,023	11 (1.08)
Total			12,636	154 (1.22)

*April 2010 to March 2015; n = 154 infections in 12,636 hip or knee procedures. All procedures were elective primary total hip or knee arthroplasties.

Table 2
Surgical site infections reported after primary total joint arthroplasty in Winnipeg, Manitoba, Canada*

Joint	Type of infection	Total (60 mo)		Earlier (33 mo)		Later (27 mo)		P value [†]
		(April 2010 to March 2015)		(April 2010 to December 2012)		(January 2013 to March 2015)		
		No. of procedures	No. of infections (%)	No. of procedures	No. of infections (%)	No. of procedures	No. of infections (%)	
Hip	Deep		22 (0.45)	16 (0.63)		6 (0.25)	≤.05	
	Superficial		23 (0.47)	16 (0.63)		7 (0.30)	NS	
	Undefined		2 (0.04)	2 (0.08)		0 (0.00)	NS	
	Total	4,899	47 (0.96)	2,545	34 (1.34)	2,354	13 (0.55)	≤.005
Knee	Deep		38 (0.49)	24 (0.59)		14 (0.38)	NS	
	Superficial		67 (0.87)	38 (0.93)		29 (0.79)	NS	
	Undefined		2 (0.03)	2 (0.05)		0 (0.00)	NS	
	Total	7,737	107 (1.38)	4,068	64 (1.57)	3,669	43 (1.17)	NS
Hip and knee combined	Deep		60 (0.47)	40 (0.60)		20 (0.33)	≤.05	
	Superficial		90 (0.71)	54 (0.82)		36 (0.60)	NS	
	Undefined		4 (0.03)	4 (0.06)		0 (0.00)	NS	
	Total	12,636	154 (1.22)	6,613	98 (1.48)	6,023	56 (0.93)	≤.005

NS, not significant.

*April 2010 to March 2015 inclusive; n = 154 infections in 12,636 arthroplasties. All patients were followed after surgery for 12 months. At the end of the earlier period, the preoperative preparation solution was changed from povidone-iodine to chlorhexidine gluconate at all 3 hospitals; however, the change occurred gradually at the different hospitals, making it impossible to compare infection frequency with the 2 different solutions.

[†]Comparison of earlier vs later. P > .05 is considered NS.

before surgery at times earlier than the published recommendations of within 1 hour before the skin incision.²⁰ The administration of cefazolin occurred outside of 1 hour of incision in 31 of 85 cases (11/28 hips and 20/57 knees) that developed infections during the first period; during the second period, this occurred in 6 of 49 arthroplasties (0/12 hips and 6/37 knees). Cefazolin prophylaxis timing improved over the surveillance period, and a greater portion of procedures had administration times meeting recommended guidelines. Significant improvements in antibiotic timing corresponded with the same periods in which the frequency of infection decreased (P < 0.001) (Fig 1). Safer Healthcare Now! guidelines recommend the administration of cefazolin and clindamycin within 1 hour and vancomycin within 2 hours before the surgical incision. There was a

significant increase in procedures that satisfied the guidelines from the earlier to later period.

The measurement of postoperative temperature within 15 minutes of arrival to the recovery room and postoperative temperature between 36°C and 38°C was observed in 4,256 of 6,613 patients (64%) during the earlier period; this frequency varied among the different facilities (range, 54%–91%). During the later period, normothermia was reached within 15 minutes of arriving in the recovery room in 5,131 of 6,023 patients (85%).

Higher BMI, presence of diabetes mellitus, and higher ASA class were independently associated with an increased frequency of SSI in unadjusted analysis (Table 5). A temperature between 36°C and 38°C was inversely related to increased SSIs. Backward and forward

Table 3
Hip infections after primary total hip arthroplasty in Winnipeg, Manitoba, Canada*

Year	Months	Superficial SSI		Deep SSI		Procedures
		No.	SSI frequency (%)	No.	SSI frequency (%)	
2010	April-June	2	(0.74)	0	(0.00)	270
	July-September	1	(0.47)	3	(1.41)	213
	October-December	0	(0.00)	0	(0.00)	215
2011	January-March	0	(0.00)	0	(0.00)	221
	April-June	1	(0.42)	2	(0.83)	240
	July-September	1	(0.49)	3	(1.48)	203
2012	October-December	3	(1.30)	0	(0.00)	230
	January-March	2	(0.92)	2	(0.92)	217
	April-June	3	(1.22)	3	(1.22)	246
2013	July-September	2	(0.93)	1	(0.47)	215
	October-December	1	(0.36)	2	(0.73)	275
	January-March	1	(0.38)	1	(0.38)	263
2014	April-June	1	(0.40)	0	(0.00)	249
	July-September	0	(0.00)	0	(0.00)	221
	October-December	0	(0.00)	0	(0.00)	246
2015	January-March	1	(0.35)	2	(0.71)	282
	April-June	0	(0.00)	1	(0.38)	264
	July-September	1	(0.41)	1	(0.41)	246
2015	October-December	1	(0.36)	0	(0.00)	280
	January-March	2	(0.66)	1	(0.33)	303
Total		23	(0.47)	22	(0.45)	4,899

SSI, surgical site infection.

*The table does not include 2 SSIs that were not documented as superficial or deep.

Table 4
Knee infection after primary total knee arthroplasty in Winnipeg, Manitoba, Canada*

Year	Months	Superficial SSI		Deep SSI		Procedures
		No.	SSI frequency (%)	No.	SSI frequency (%)	
2010	April-June	8	(2.02)	1	(0.25)	396
	July-September	1	(0.33)	2	(0.65)	306
	October-December	1	(0.30)	1	(0.30)	335
2011	January-March	0	(0.00)	0	(0.00)	359
	April-June	4	(1.02)	1	(0.25)	394
	July-September	7	(2.06)	3	(0.88)	339
2012	October-December	6	(1.49)	5	(1.24)	404
	January-March	3	(0.83)	3	(0.83)	363
	April-June	1	(0.23)	4	(0.93)	429
2013	July-September	3	(0.87)	3	(0.87)	344
	October-December	4	(1.00)	1	(0.25)	399
	January-March	2	(0.52)	3	(0.77)	388
2014	April-June	7	(1.46)	4	(0.83)	480
	July-September	9	(2.23)	0	(0.00)	404
	October-December	0	(0.00)	4	(0.97)	411
2015	January-March	3	(0.72)	1	(0.24)	418
	April-June	5	(1.19)	1	(0.24)	421
	July-September	3	(0.86)	1	(0.29)	348
2015	October-December	0	(0.00)	0	(0.00)	372
	January-March	0	(0.00)	0	(0.00)	427
Total		67	(0.87)	38	(0.49)	7,737

SSI, surgical site infection.

*The table does not include 2 SSIs that were not documented as superficial or deep.

stepwise logistic regression showed significant risk factors inversely associated with SSI included lower BMI, maintaining patient intraoperative temperature between 36°C and 38°C, and surgery during the later surveillance period (Table 6).

DISCUSSION

The present study showed that an SSI surveillance program that provided feedback to the surgery program was successful in engaging staff, who then made practice changes where improvements were required. This process in turn decreased the frequency of SSIs after primary elective total hip, but not knee,

arthroplasty. The decreased SSI frequency after hip arthroplasty was associated with improved compliance with the administration of prophylactic antibiotics, primarily because of a change in practice by most anesthesiologists. Early in the study, the antibiotic had been given in an intravenous drip over 1 hour in the preoperative holding area, but later in the study, anesthesiologists typically gave the cefazolin as an intravenous injection during the time-out session just before the incision. Frequency of compliance with the *Safer Healthcare Now!* guidelines ranged from 15%–68% for the 3 hospitals during the first few months of the earlier period, but compliance increased to 89%–98% at all sites during the final 3 months of the study (Fig 1). This finding is consistent

Table 5
Risk factors and frequency of surgical site infection after total joint arthroplasty*

Risk factor	No. of procedures	No. of total infections (%)	$P \leq^{\dagger}$	No. of deep infections (%)	P^{\dagger}
Body mass index (kg/m ²)			.005		$\leq .008$
15–19.9	124	2 (1.6)		0	
20–24.9	1343	13 (1.0)		4 (0.3)	
25–29.9	3503	44 (1.3)		16 (0.5)	
30–34.9	3321	24 (0.7)		12 (0.4)	
35–39.9	2023	26 (1.3)		7 (0.3)	
40–44.9	1068	19 (1.8)		11 (1.0)	
45–49.9	510	6 (1.2)		1 (0.2)	
≥50	427	15 (3.5)		7 (1.6)	
Unknown	317	5 (1.6)		2 (0.6)	
Diabetes mellitus			.05		$\leq .08$
Present	2,282	38 (1.7)		16 (0.7)	
Absent	10,354	116 (1.1)		44 (0.4)	
American Society of Anesthesiologists class			.005		$\leq .005$
1	419	3 (1.5)		2 (0.5)	
2	6,407	60 (0.9)		20 (0.3)	
3	4,475	76 (1.7)		33 (0.7)	
4	63	1 (2.6)		1 (1.6)	
Undefined	1,272	14 (1.1)		4 (0.3)	
SHN! antibiotic timing guidelines			NS		NS
Satisfied SHN!	8,542	102 (1.2)		38 (0.4)	
Did not satisfy SHN!	4,094	52 (1.3)		22 (0.5)	
Total	12,636	154 (1.2)		60 (0.5)	

NS, not significant; SHN!, *Safer Healthcare Now!*

*April 2010 to March 2015; n = 12,636 arthroplasties (hip and knee arthroplasty combined).

[†] $P > .05$ is considered NS.

Table 6
Logistic regression for risk factors associated with surgical site infection after total joint arthroplasty

Variable	Individual odds ratio <i>P</i> value*	Stepwise logistic regression, final model <i>P</i> value*	Final odds ratio	95% Confidence limits
Facility B	NS	.31 (NS)	—	—
Facility C		.07 (NS)		
ASA 2 [†]	≤.005	.92 (NS)	—	—
ASA 3		.44 (NS)		
ASA 4		.60 (NS)		
Preoperative antibiotic (A/B) type	NS	.89 (NS)	—	—
Skin preparation	NS	.57 (NS)	—	—
Type of arthritis	NS	.47 (NS)	—	—
Diabetes	≤.04	.19 (NS)	—	—
Body mass index	—	≤.007	1.02	1.01–1.04
Satisfied <i>Safer Healthcare Now!</i> guidelines in A/B timing [‡]	NS	.61 (NS)	—	—
Age	—	.86 (NS)	—	—
Temperature between 36°C and 38°C	≤.03	≤.005	0.54	0.34–0.83
Surgery during later period of surveillance (January 2013 to March 2015)	≤.005	≤.002	0.55	0.37–0.81

ASA, American Society of Anesthesiologists classification; NS, not significant.

**P* > .05 is considered NS.

[†]ASA classes were tested individually in logistic regression models.

[‡]A/B timing when earlier vs later periods were compared.

with other published studies that show a decrease in SSIs when an antibiotic is given within 59 minutes before the incision.²²

Decreased SSI frequency was associated with improved compliance with measures toward postoperative hypothermia prevention. Use of patient warming devices (Bair Hugger; 3M, St Paul, MN) during surgery to prevent hypothermia may have been a primary reason for this successful compliance, including maintaining patient temperature between 36°C and 38°C upon arrival to the recovery room. These changes were facilitated with the use of practice guidelines to address risk factors for SSI.

The present study included data for the entire population in a major geographic region who underwent elective total joint arthroplasty. These regional data were available because of the organization of provincial health care into regional health authorities that delivered care and monitored quality and cost parameters. The present results are consistent with previous results from Europe and the United States that surveillance programs for SSI may decrease the

frequency of infection after primary total joint arthroplasty.^{16,17} Documentation of infection frequency may provide a baseline from which programs may initiate and evaluate the effects of preventive interventions to decrease the frequency of SSI.¹⁵

Surgical factors that may affect the frequency of SSI include preoperative antiseptic skin cleansing, use of laminar flow in the operating room, and postoperative wound care.^{23,24} Chlorhexidine (2% solution) combined with isopropyl alcohol (70%) may be more effective than povidone-iodine (10%) in preventing SSI after clean-contaminated surgery.²⁵ The change to chlorhexidine occurred at all 3 sites during the study, but the effect on the outcomes is unknown; it is possible that this change explains some of the difference in infection rates between the 2 time periods because the change occurred near the end of the first study period. The use of laminar airflow and routine postoperative wound care was consistent throughout the study.

These results showed that increased BMI and the presence of a postoperative temperature outside of normothermia were associated with a higher frequency of SSI, consistent with the results of previous studies.^{7,15} The frequency of deep SSI decreased for hip arthroplasties from the earlier to the later period. However, the frequency of SSI after knee arthroplasty was uniform despite changes in prophylactic antibiotic timing, hypothermia control, and skin preparation introduced during the 5 years of the study (Table 2). The changes in practice and increased awareness of the ongoing surveillance may have contributed to the decrease in frequency of deep hip infection from the earlier to the later period. The factors associated with increased odds of having an SSI was a higher BMI, whereas maintaining the patient's body temperature between 36°C and 38°C was associated with decreased odds of having an SSI (Table 6).

Limitations of the present study included the absence of controlled variables because the study was an ongoing surveillance program. Superficial infections may have been underreported in patients who lived in rural locations far from Winnipeg because these patients were unlikely to travel from home to Winnipeg for the evaluation and treatment of superficial infections. During follow-up of rural patients, the presence of symptoms or signs of an SSI usually prompted communication between the IPC staff at the rural follow-up and urban surgical centers, but failure of such communication might have contributed to underreporting of SSIs. Underreporting of SSIs also might have occurred for patients who had follow-up only with their family physician and not the surgeon. Deep infections were not likely missed because all would have required readmission to a regional facility where orthopedic programs were available.

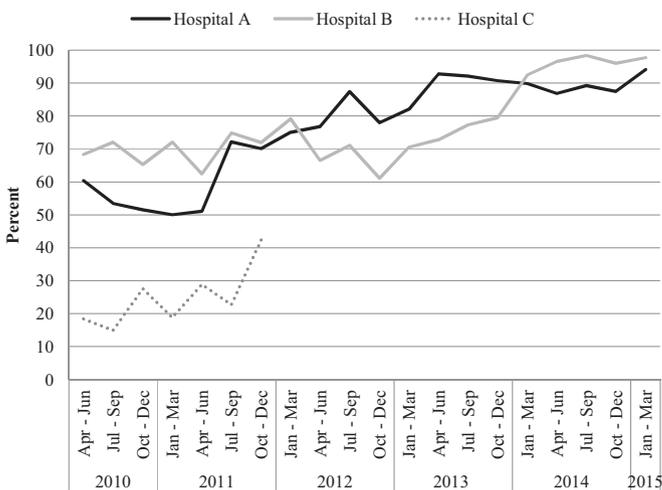


Fig 1. Cefazolin and clindamycin prophylaxis that satisfied *Safer Healthcare Now!* guidelines. Antibiotic administration took place within 1 hour of surgery. The difference for antibiotic prophylaxis timing meeting guidelines between the earlier (April 2010 to December 2012) and the later period (January 2013 to March 2015), *P* < .00001, is shown. The arthroplasty program at hospital C was merged into hospital B after December 2011.

Most orthopedic programs in Manitoba are situated in Winnipeg facilities. Admissions for all reasons to these facilities within 1 year of surgery were reviewed to determine whether SSI was a cause for admission. Controlling for sex in the final analysis was not possible, because sex was not captured in this surveillance program. Transfusion rates decreased during the study, possibly accounting for part of the decrease in the frequency of SSIs.

CONCLUSIONS

This review of an orthopedic SSI surveillance program showed that positive changes were made during the 5 years under study, including a significant decrease in the frequency of primary hip arthroplasty SSI. The risk factors that affected outcomes included BMI and maintenance of normothermia, similar to those of other studies that have shown decreases in SSI during a surveillance program.^{16,17}

Acknowledgments

The authors thank Molly Blake, RN, director of Winnipeg Regional Health Authority's Infection Prevention and Control program, for support of this surveillance program and for providing feedback on the manuscript. The authors also thank Craig Doerksen, divisional director for facility management, and D. James Vernon for additional support. The surveillance program results used for this article would never have been possible without the manual chart reviews completed on all patients undergoing hip and knee arthroplasties by the infection control professionals of Winnipeg Regional Health Authority's Infection Prevention and Control program.

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