ORIGINAL RESEARCH

Methods matter: Comparison of two post-arthroplasty surgical site infection surveillance methodologies

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ABSTRACT

Background: This study compared post-total hip arthroplasty (THA) and total knee arthroplasty (TKA) surgical site infection (SSI) rates calculated using two surveillance methodologies to assess their reliability as quality indicators in a community hospital. SSI rates from the National Surgical Quality Improvement Program (NSQIP) were compared with those from an independent Infection Prevention and Control (IPAC) SSI surveillance program based on National Healthcare Safety Network (NHSN) guidance.

Methods: The study period ranged from April 1, 2021, to March 31, 2023. The IPAC program actively reviewed all THA and TKA cases for 90 days post-operatively, while NSQIP followed a subset of patients for 30 days. Both methodologies applied the same NHSN case definitions to identify complex SSI cases, and SSI rates were calculated. All identified cases were reviewed and shared with stakeholders. The IPAC program audited compliance with SSI preventive measures beginning in April 2022.

Results: In the first fiscal year, IPAC surveillance identified six complex SSI cases (THA: 3; TKA: 3), with SSI rates of 0.71 for THA and 0.54 for TKA. NSQIP identified one case (THA: 1; TKA: 0), with SSI rates of 0.87 for THA and 0 for TKA. In the second fiscal year, IPAC identified six additional complex SSI cases (THA: 3; TKA: 3), with SSI rates of 0.58 for THA and 0.36 for TKA, while NSQIP identified no cases. Using IPAC surveillance, SSI rates decreased by 18% for THA and 33% for TKA over the study period. Of the 12 SSI cases identified by IPAC, five (41.2%) were detected beyond 30 days post-operatively and would not have been captured by NSQIP. Improvements in preventive practices were observed, including normothermia compliance increasing from <20% to 80% and appropriate hair removal education improving from 60% to 93%.

Conclusion: The IPAC SSI surveillance program provided a more accurate and sensitive indicator for detecting changes in SSI rates.

KEYWORDS:
Surgical Site Infections, hip and knee arthroplasty, surveillance, national surgical quality improvement program, national healthcare safety network

INTRODUCTION

Total Hip Arthroplasty (THA) and Total Knee Arthroplasty (TKA) are surgical procedures in which parts of a joint are removed and replaced with a metal, plastic or ceramic device called a prosthesis. Post arthroplasty surgical site infection (SSI), a procedure-related healthcare-associated infection is a severe complication resulting in increased morbidity and mortality, particularly from complex SSI as a result of deep incisional and organ/space infection. At least half of SSIs can be prevented through improved application of evidence-based basic preventive measures (Umscheid et al., 2011).

In order to implement and assess evidence-based infection prevention strategies, regular monitoring of the rate and trend of SSI events is imperative. SSI monitoring requires active, prospective surveillance including concurrent and post-discharge surveillance methods. But the results of the surveillance may vary depending on the surveillance methodologies (Rennert-May et al., 2018), (Ellison et al 2022).

A successful surveillance program includes the use of epidemiologically sound definitions for both numerators and denominators. Meanwhile, the surveillance methods include surveillance period, time frame of SSI elements, and feedback.

The aim of the current study involves a comparison of two post-arthroplasty surgical site infection surveillance methodologies. Surveillance for SSIs that involve Infection Control Professionals (ICPs) and feedback to stakeholders has been shown to be associated with reductions in rates of SSIs (Brandt et al., 2006).

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METHODS

The study was conducted at a 309-bed community hospital which is a participant of the National Surgical Quality Improvement Program (NSQIP). This program collects data on pre-operative risk factors, intra-operative variables, and 30-day post-operative outcomes for major surgical procedures. Cases are selected utilizing a systematic sampling process. From the NSQIP data, a report was generated exclusively for SSI events post THA and TKA.

In 2021, the Infection Prevention and Control (IPAC) program initiated a parallel SSI surveillance program for THA and TKA, to identify complex SSI rates (deep incisional and organ/space) in alignment with the CDC-NHSN and Canadian Nosocomial Infection Surveillance Program (CNISP) guidelines.

In addition to tracking SSI rates, the IPAC program audited compliance with SSI prevention practices based on Canadian Patient Safety Institute (CPSI) guidance.

Study period

The study period included two fiscal years (April 1, 2021 to March 31, 2022, and April 1, 2022 to March 31, 2023).

The two surveillance programs (NSQIP and IPAC SSI Surveillance program) for SSI post-hip and knee arthroplasty ran in parallel during this period independently. Cases meeting the CDC-NHSN definitions (Centers for Disease Control and Prevention [CDC], 2025) of complex SSI events were identified in both methodologies.

National Surgical Quality Improvement Program (NSQIP)

The NSQIP picked a random sample every month from the total cases who underwent total hip and knee arthroplasties during that month through a systematic sampling process. These sampled cases were followed for 30 days to identify those meeting the definitions of superficial and complex SSI events (Centers for Disease Control and Prevention [CDC], 2025).

The quarterly post-THA and TKA complex SSI rates were calculated using the formula below:

> Complex SSI identified during the 30 days post procedure/ Number of THA and TKA cases reviewed among the THA and TKA performed during that quarter X 100.

The superficial SSI rates obtained through the NSQIP were not compared as the IPAC SSI surveillance program only reviewed for complex SSIs.

Table 1: Surgical site infections (SSI) identified through IPAC surveillance among total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures, fiscal years 2021–2022 and 2022–2023

Outcomes	FY 2021–2022			FY 2022–2023		
	Total	THA	TKA	Total	THA	TKA
Number of surgeries	977	421	556	1,330	511	819
SSI rate (%)	0.61	0.71	0.54	0.45	0.58	0.36
SSI cases (n)	6	3	3	6	3	3
Organ/space SSI	4	1	3	5	2	3
Deep incisional SSI	2	2	0	1	1	0
SSI identified >30 days	3	1	2	2	1	1

Footnote: SSI definitions were based on National Healthcare Safety Network (NHSN) criteria. Surveillance was conducted by the Infection Prevention and Control (IPAC) program.
Abbreviations: SSI: surgical site infection; THA: total hip arthroplasty; TKA: total knee arthroplasty.

IPAC Surgical Site Infection Surveillance Program

All patients undergoing THA and TKA every month, were reviewed from April 1, 2021, to March 31, 2023. Revision surgeries were excluded.

As per CDC-NHSN recommendation for surgeries with implants, all the cases were followed for 90 days through chart reviews using Electronic Health Record (EHR) platform, including all post-discharge hospital visits, admissions, and investigations to identify complex SSI cases. The quarterly post-THA and TKA complex SSI rates were calculated using the formula below:

Complex SSI identified during the 90 days post procedure/ total Number of TKA or THA procedures performed during that quarter X 100.

The post-THA and TKA complex SSI rates collected through the IPAC SSI Surveillance program for the first fiscal year (April 1, 2021 to March 31, 2022) was considered as the baseline for comparison for the subsequent year.

Table 2: Surgical site infections (SSI) identified through National Surgical Quality Improvement Program (NSQIP) among total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures, fiscal years 2021–2022 and 2022–2023

Outcomes	FY 2021–2022			FY 2022–2023		
	Total	THA	TKA	Total	THA	TKA
Number of surgeries reviewed, out of total surgeries performed	221/977	114/421	107/556	205/1,330	102/511	103/819
SSI rate (%)	0.45	0.87	0	0	0	0
SSI cases (n)	1	1	0	0	0	0
Organ/space SSI	0	0	0	0	0	0
Deep incisional SSI	1	1	0	0	0	0
SSI identified >30 days	N/A	N/A	N/A	N/A	N/A	N/A

Footnote: Extracted from NSQIP data.
Abbreviations: SSI: surgical site infection; THA: total hip arthroplasty; TKA: total knee arthroplasty.

CNISP conducts national surveillance of hospital-acquired infections across multiple hospitals throughout Canada. CNISP data for complex SSI post-THA and TKA collected from 28 acute care hospitals (four small, 16 medium and eight large hospitals) between January 1, 2017, and December 31, 2021, were taken as the external benchmark. (Canadian Nosocomial Infection Surveillance Program [CNISP], 2022).

In addition to SSI rates, the IPAC SSI surveillance program also collected data on the category of SSI and causative microorganisms. Auditing compliance to SSI preventive measures was initiated in October 2021. Charts of 20% of patients undergoing TKA and THA were randomly selected and reviewed for compliance with SSI preventive measures and monthly compliance rates were calculated.

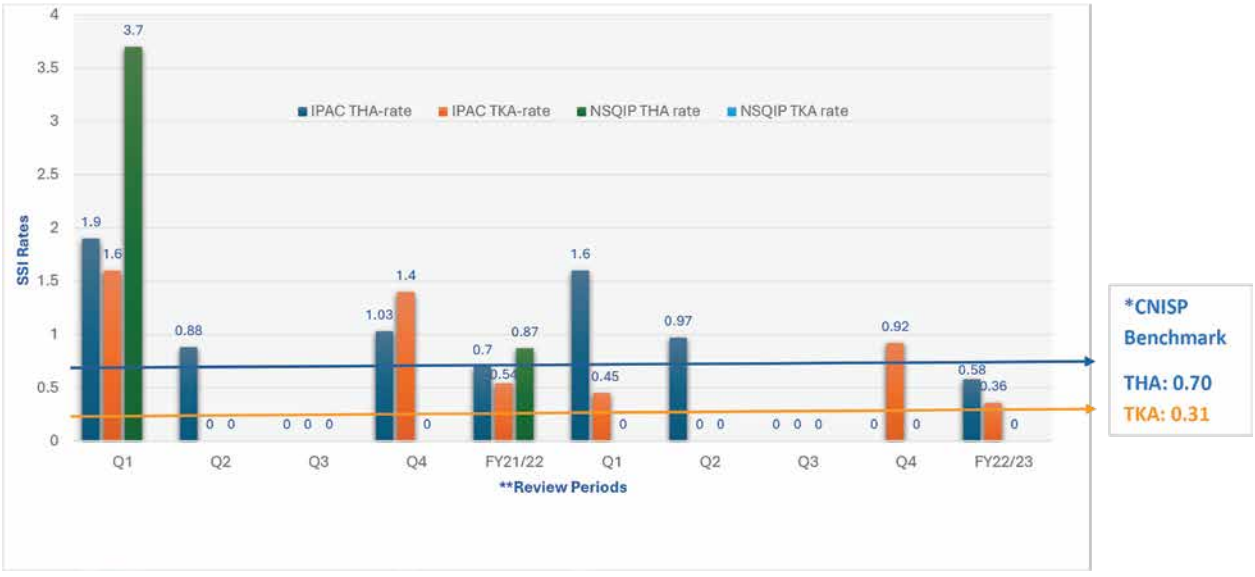

Figure 1: Quarterly surgical site infection (SSI) rates for Total Hip Arthroplasty (THA) and Total Knee Arthroplasty (TKA) procedures over two fiscal years, as determined by Infection Prevention and Control (IPAC) and National Surgical Quality Improvement Program (NSQIP) surveillance methods.

Using the IPAC surveillance methodology, the post -THA SSI rates calculation per quarter for the first fiscal year based on a total count of **421** was [Q1:1/51 (1.9%), Q2: 1/113 (0.88%), Q3: 0/160 and Q4: 1/97 (1.03%) and the post -TKA based on a total count of **556** was [Q1: 1/60 (1.6%), Q2: 0/155, Q3: 0/202 and Q4: 2/139 (1.4%)].
The post -THA SSI rates per quarter for the second fiscal year based on a total count of **511** was [Q1: 2/124 (1.6%), Q2: 1/103 (0.97%), Q3: 0/150 and Q4: 0/134) and the post -TKA based on a total count of **819** was [Q1: 1/221 (0.45%), Q2: 0/168, Q3: 0/213 and Q4: 2/217 (0.92%)].

For the NSQIP methodology, the THA SSI rate calculation per quarter for the first fiscal year based on a total count of **114** was (Q1: 1/27(3.7%), Q2: 0/25, Q3: 0/29 and Q4: 0/33).

Note: Benchmark data are derived from pooled *Canadian Nosocomial Infection Surveillance Program (CNISP) data. Comparisons are descriptive and are not risk-adjusted.
** Q stands for quarter. Q 1: April-June, Q2: July- Sep, Q3: Oct-Dec, Q4: Jan-Mar, FY21/22: April2021-March 2022, FY22/23: April 2022- March 2023.

Table 3: Preventive strategies % compliance

	Preventive strategies	Oct '21	Nov '21	Dec '21	Jan '22	Feb '22	Mar '22	April '22	May '22	June '22	July '22	Aug '22	Sept '22	Oct '22	Nov '22	Dec '22	Jan '23	Feb '23	Mar '23
1	Antibiotic Prophylaxis	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2	Antiseptic wash night before	97	89	89	91	92	96	95	96	96	91	96	100	98	96	100	95	100	100
3	Proper operative site prep	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
4	Peri-operative normothermia (36°C-38°C)	10	12	11.6	15	11	45	59	48	49	33	58	58	66	70	90	77	85	80
5	Appropriate hair removal												100	100	98	85	100	100	100
6	Education on hair removal												60	67	71	76	91	89	93

SSI preventive measures reviewed for compliance during the period of October 2021 to August 2022 included:

1. Percentage of patients with Appropriate Antibiotic Prophylaxis.
a) Percentage of patients receiving prophylactic antibiotic infused prior to incision.
b) Percentage of patients with timely prophylactic antibiotic administration.
2. Percentage of patients having anti-septic wash, night before surgery.
3. Percentage of patients with proper operative site preparation.
4. Percentage of patients with normothermia (36ºC-38ºC) within 15 minutes prior to skin closure or on arrival in the post-anaesthetic care unit.

In September 2022, two further preventive measures were added to the compliance review.

5. Percentage of patients with appropriate hair removal.
6. Percentage of patients who received education on appropriate hair removal.

The compliance rates were presented quarterly to the surgical quality committee team, gaps were identified, and improvement strategies applied throughout the course of the study. A surgical quality improvement plan (SQIP) was created through collaboration between the surgical clinical reviewer, the perioperative professional practice leader and the clinical leader of the surgical admission and discharge unit. Change ideas and strategies were developed to improve compliance to identified gaps in SSI preventive measures including patient questionnaires and education of patients and staff.

RESULTS

Surgical Site Infection Cases

IPAC surveillance methodology

In the first fiscal year (April 1, 2021 to March 31, 2022), a total of 977 total hip and knee arthroplasties were performed (THA: 421 TKA: 556). The IPAC SSI Surveillance program, during the 90-day surveillance period, identified six complex SSI with three among THA cases (two deep incisional, and one organ/space) and three among TKA cases (all organ/space) (Table 1).

In the second fiscal year, (April 1, 2022- March 31, 2023) a total of 1,330 total hip and knee arthroplasties were performed (THA: 511 and TKA: 819). The IPAC SSI Surveillance program, during the 90-day surveillance period, identified another six complex SSI with three among THA cases (one deep incisional and two organ/space) and three among TKA cases (all organ/space) (Table 1 and Figure 1).

It should be noted that 41% of complex SSI cases identified through the IPAC SSI Surveillance program occurred after day 30 (between day 31 and day 90) post-surgery.

During the first fiscal year, 50% (3/6) of the complex SSI were identified after 30 days, while in the second fiscal year 33% (2/6) of the complex SSI were identified after 30 days (Table 1 and Figure 1).

National Surgical Quality Improvement Program (NSQIP) Methodology

During the first fiscal year, 22.6% of the total THA and TKA performed were reviewed (THA: 114 out of 421 cases and TKA: 107 out of 556 cases). One complex SSI (deep incisional) was identified among THA cases and zero complex SSI identified among TKA cases in the 30 days post-surgery. The single identified case of SSI by NSQIP, was also identified by the IPAC SSI surveillance methodology (Table 2).

In the second fiscal year, NSQIP reviewed 15.4% of total THA and TKA performed (THA: 102 out of 511 cases and TKA: 103 out of 819 cases) with no identified complex SSI in the 30 days post-surgery (Figure 1 and Table 2).

Surgical site infection rates

IPAC surveillance methodology

During the first fiscal year, the post-THA SSI rate was 0.71% (3/421) and post-TKA was 0.54% (3/556). During second fiscal year, the post-THA SSI rate was 0.58% (3/511) and post-TKA was 0.36% (3/819). A reduction of 18% and 33% in the SSI rates was observed in THA and TKA respectively in the 2nd Fiscal year (Figure1).

National Surgical Quality Improvement Program (NSQIP) Methodology

The post-THA SSI rate during the first fiscal year was 0.87% (1/114) and post-TKA was zero. The SSI rates in the second Fiscal year was zero for both THA and TKA (Figure 1).

Benchmarking

SSI rates obtained through both methodologies were benchmarked with the CNISP pooled data rate (Figure 1). In the first fiscal year, the post-THA SSI rate determined by the IPAC surveillance program (0.71%) was within the CNISP benchmark rate (0.7%) however the SSI rate determined through NSQIP was higher (0.87%). The post-TKA SSI rate determined by the IPAC surveillance program (0.54%) was higher than the benchmark (0.31%). The rate obtained through NSQIP for TKA was zero.

In the second fiscal year, the overall SSI rates determined by the IPAC SSI surveillance program had decreased with the post-THA SSI rate being lower than the benchmark (0.58% vs 0.7%) and the post-TKA SSI rate slightly higher (0.36% vs 0.31%) than the benchmark. No cases were identified through NSQIP methodology and rates for both THA and TKA were zero.

Microbiology

The IPAC SSI surveillance program ascertained the microorganisms implicated in the SSI. Microorganisms were identified in 10 out of 12 complex SSI cases (one culture negative and one specimen was rejected). *Staphylococcus aureus* (Methicillin sensitive) was the most frequent isolate, identified in five cases with one bacteremia. Of note is that 7 of the identified organisms were skin flora commonly associated with SSI (Methicillin-Sensitive *Staphylococcus aureus* and

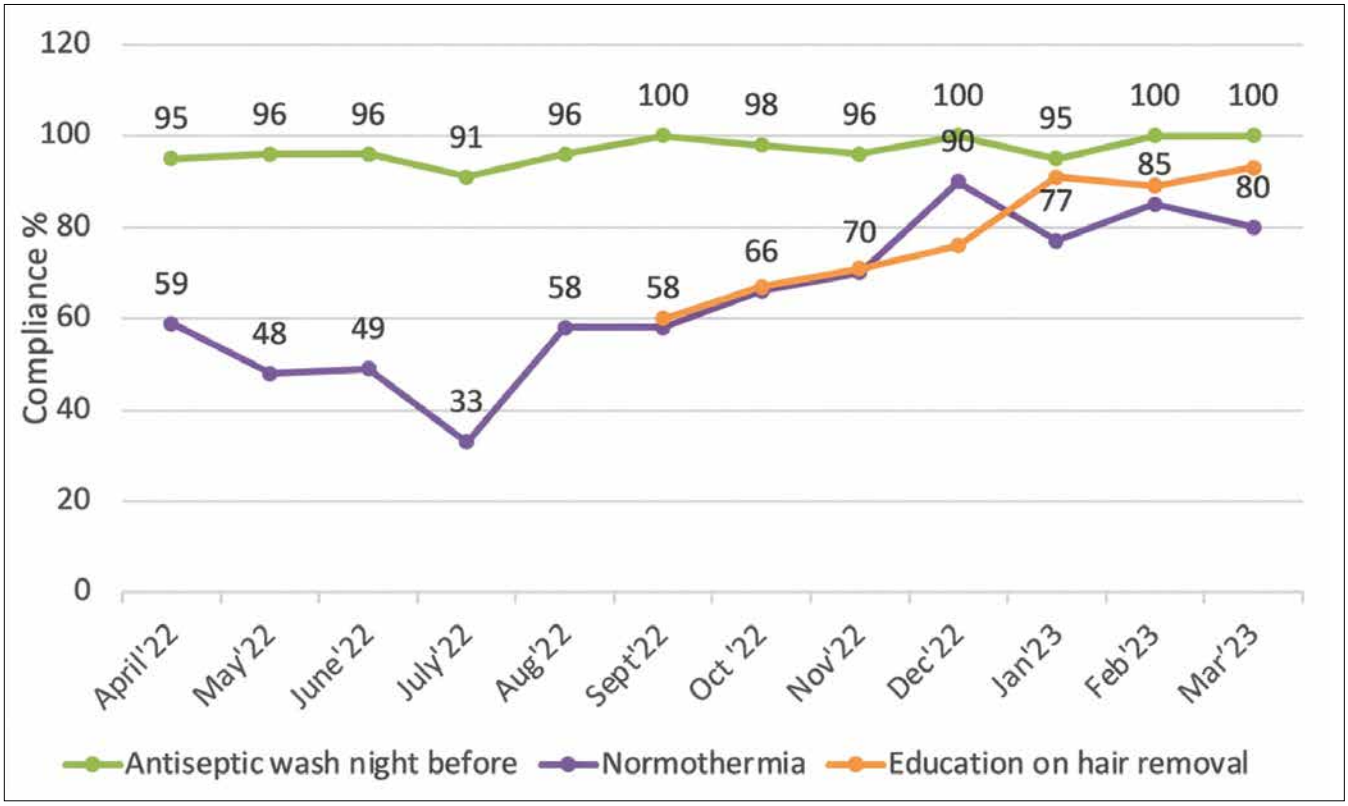

Figure 2: Improvement in the compliance with targeted preventive measures.

coagulase-negative *staphylococci*) (Natividad Benito et al., 2014). Less common pathogens such as *Proteus mirabilis, Candida parapsilosis* and *Streptococcus agalactiae* were identified in three cases.

Preventative measures

Compliance to appropriate prophylactic antibiotic administration and proper operative site preparation was at 100%. Compliance to appropriate hair removal was mostly 100% (Table: 3). An improvement in compliance to other preventive measures was also observed over the study period. Compliance to anti-septic wash the night before improved from 89% to 100%. Compliance to normothermia improved from <20 % to 80%. Compliance to education for hair removal improved from 60% to 93% (Figure 2).

DISCUSSION

Post-Arthroplasty Surgical site infections (SSIs) contribute to significant patient morbidity, mortality, and healthcare costs, emphasizing the importance of robust monitoring and prevention strategies. Also, SSI rates reflect the compliance with evidence-based prevention measures. Therefore, the reliability of the data is critically important as different approaches to monitor SSIs may lead to different results and trending patterns. (Smith et al., 2018; Ellison et al., 2022).

Our study highlighted disparity between the results obtained through the more robust IPAC surveillance program compared to the existing NSQIP methodology. NSQIP identified only 8% (1 out of 12) of the deep incisional or organ space SSIs detected by the IPAC SSI surveillance program. This disparity can be attributed to two main factors: NSQIP's limited review of only 15-20% of patients and its 30-day follow-up period. This study suggests that the data from NSQIP may not provide a reliable representation of SSI rates for arthroplasties at our institution.

The IPAC SSI surveillance program methodology, based on the CDC-NHSN guidance which is widely considered the gold standard provided more accurate and standardized data compared to the existing NSQIP methodology, enabling improved trend analysis and more meaningful benchmarking against pooled data from the Canadian Nosocomial Infection Surveillance Program (CNISP).

SSI rates, individual SSI cases and compliance audits of preventive measures were presented to stakeholders in the Surgical Quality Committee meetings on a regular basis, providing the opportunity for joint review and implementing timely improvement strategies. This led to the development of a multi-disciplinary working group and a Surgical Quality Improvement Plan (SQIP) with regular feedback and education resulting in improved compliance. The initial lower compliance with certain preventive measures, such as normothermia, anti-septic washes the night before, and education on hair removal was addressed through targeted education and audits, leading to improved compliance, possibly contributing to the decrease in SSI rates

observed over the study. This underscores the value of education and regular audits as part of an SSI surveillance program in improving adherence to preventive protocol.

Moreover, the IPAC SSI surveillance program also enabled identification of the microorganisms responsible for SSIs. Most cases involved common pathogens like Methicillin-sensitive *Staphylococcus aureus* and Coagulase-negative *Staphylococci*. Surveillance of the specific organisms causing SSIs can help identify trends, monitor antibiotic resistance, and guide infection control strategies, including choice of prophylactic antibiotic.

The more comprehensive IPAC SSI Surveillance program based on the CDC-NHSN standard detected more SSIs and facilitated quality improvements in prevention measures. However, the resource-intensive nature poses a challenge in resource-limited settings. A potential solution for such settings is to implement a rotational surveillance model, (World Health Organization [WHO], 2018) where a more comprehensive SSI surveillance program alternates between different types of surgeries. The WHO recommends surveillance for a six-month to one-year period allowing reliable, albeit intermittent monitoring of the SSI rates across diverse surgical types.

This study although meticulously conducted, has several limitations. It was conducted at a single community hospital which may limit generalizability. Although standardized NHSN definitions were applied, IPAC case ascertainment relied on active surveillance and documentation, introducing potential detection bias. The small number of events limits statistical precision, and the observational design precludes causal inference. Although SSI reductions coincided with improved preventive practices, other factors may have contributed. Finally, some post discharge SSIs may have been missed if patients presented to external institutions.

Applying a reliable SSI surveillance method contributes to improved patient safety, better clinical outcomes, and more efficient resource allocation.

REFERENCES

Umscheid, C. A., Mitchell, M. D., Doshi, J. A., Agarwal, R., Williams, K., & Brennan, P. J. (2011). Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. *Infection Control & Hospital Epidemiology, 32*(2), 101–114. https://doi.org/10.1086/657912

Rennert-May, E., Manns, B., Smith, S., Puloski, S., Henderson, E., Au, F., Bush, K., & Conly, J. (2018). Validity of administrative data in identifying complex surgical site infections from a population-based cohort after primary hip and knee arthroplasty in Alberta, Canada. *American Journal of Infection Control, 46*(10), 1123–1126. https://doi.org/10.1016/j.ajic.2018.03.018

Ellison, J. J. R., Boychuk, L. R., Chakravorty, D., et al. (2022). A comparison of surgical site infections following total hip replacement and total knee replacement surgeries identified by Infection Prevention and Control and the National Surgical Quality Improvement Program in Alberta, Canada. *Infection Control & Hospital Epidemiology, 43*(4), 435–441. https://doi.org/10.1017/ice.2021.159

Brandt, C., Sohr, D., Behnke, M., Daschner, F., Rüden, H., & Gastmeier, P. (2006). Reduction of surgical site infection rates associated with active surveillance. *Infection Control & Hospital Epidemiology, 27*(12), 1347–1351. https://doi.org/10.1086/509843

American College of Surgeons. (n.d.). *National Surgical Quality Improvement Program*. https://www.facs.org/quality-programs/data-and-registries/acs-nsqip/

Canadian Nosocomial Infection Surveillance Program. (2022). HK-SSI surveillance protocol – revised January 2022. Public Health Agency of Canada. https://ammi.ca/wp-content/uploads/2023/02/CNISP-2023-HK-SSI-protocol_EN.pdf

Safer Healthcare Now! (2010). *Prevent surgical site infections: Getting started kit*. https://picnet.ca/wp-content/uploads/SSI-Getting-Started-Kit_SaferHealthcareNow.pdf

Centers for Disease Control and Prevention. (2026). *Surgical site infection (SSI) event: Chapter 9, NHSN patient safety component manual*. https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf

Canadian Nosocomial Infection Surveillance Program. (2022). Device and surgical procedure-related infections in Canadian acute care hospitals from 2011 to 2020. *Canada Communicable Disease Report, 48*(7/8), 325–339. https://doi.org/10.14745/ccdr.v48i78a04

Benito, N., Franco, M., Coll, P., Gálvez, M. L., & Jordán, M. (2014). Etiology of surgical site infections after primary total joint arthroplasties. *Journal of Orthopaedic Research*. https://doi.org/10.1002/jor.22581

World Health Organization. (2018). *Global guidelines for the prevention of surgical site infection (2nd ed.)*. https://iris.who.int/server/api/core/bitstreams/5c422323-5c27-4e6a-812e-dbd76023ba48/content