Device-associated infections in Canadian acute-care hospitals from 2009 to 2018

Canadian Nosocomial Infection Surveillance Program[1]*

Abstract

Background: Healthcare-associated infections (HAIs) pose a serious risk to patient safety and quality of care. The Canadian Nosocomial Infection Surveillance Program (CNISP) conducts national surveillance of HAIs at sentinel acute-care hospitals across Canada. This report provides an overview of 10 years of Canadian data on the epidemiology of select device-associated HAIs.

Methods: Over 40 hospitals submitted data between 2009 and 2018 for hip and knee surgical site infections (SSIs), cerebrospinal fluid shunt SSIs, paediatric cardiac SSIs and/or central line-associated bloodstream infections (CLABSIs). Counts, rates, patient and hospital characteristics, as well as pathogen distributions and antimicrobial susceptibilities are presented.

Results: A total of 4,300 device-associated infections were reported. Central line-associated bloodstream infections were the most common device-associated HAI reported (n=2,973, 69%) and hip and knee arthroplasty infections were the most common SSIs reported (66% of SSIs). Our findings show decreasing CLABSI rates in neonatal intensive care units (4.2 to 1.9 per 1,000 line-days, $p<0.0001$) and decreasing knee SSI rates (0.69 to 0.30 infections per 100 surgeries, $p=0.007$). Rates of device-associated HAIs have remained relatively consistent over the 10-year surveillance period. Overall, 4,599 pathogens were identified from device-associated HAI; 70% of these were related to CLABSIs. Coagulase-negative staphylococci (29%) and *Staphylococcus aureus* (14%) were the most frequently reported pathogens. Gram-positive pathogens represented 68% of identified pathogens, gram-negative pathogens represented 22% and fungi represented 9%.

Conclusion: Understanding the national burden of device-associated HAIs is essential for developing and maintaining benchmark rates for informing infection and prevention control and antimicrobial stewardship policies and programs.

Affiliation

[1] Public Health Agency of Canada, Ottawa, ON

***Correspondence:**
phac.cnisp-pcsin.aspc@canada.ca

Suggested citation: Canadian Nosocomial Infection Surveillance Program. Device-associated infections in Canadian acute-care hospitals from 2009 to 2018. Can Commun Dis Rep 2020;46(11/12):387–97. https://doi.org/10.14745/ccdr.v46i1112a05

Keywords: hospital-associated infection, acute-care, surveillance, antimicrobial resistance, device-associated, surgical site infections, Canada

Introduction

Healthcare-associated infections (HAIs) pose a serious risk to patient safety and quality of care and contribute to prolonged hospital stays, increased antimicrobial resistance, costs to the health system and unnecessary deaths (1). Risk factors for HAIs include the use of invasive devices, surgical procedures and inappropriate antibiotic use (2). In Canada, surgical site infections (SSIs) affect an estimated 26,000 to 65,000 patients annually (3). In a 2017 Canadian point prevalence study at sentinel hospitals, device-associated infections accounted for 35.6% of all HAIs reported. Of the device-associated infections, SSIs associated with a prosthetic implant accounted for 19.4% and central line-associated bloodstream infections (CLABSIs) accounted for 21.2% (4).

Device-associated HAI antimicrobial susceptibility information has important implications for antibiotic resistance (5); impacting length of stay and healthcare costs (6). Cumulative antibiograms are a valuable resource for clinical decision-making while sensitivity results are pending (7). The risk of device-associated HAIs varies among patient populations and hospital types; patients admitted to the intensive care unit (ICU) are at higher risk of developing an HAI (8).

Understanding the trends in device-associated HAIs is essential to effective infection prevention and control. Drawing on a decade of HAI data (2009–2018) from over 40 sentinel acute-care hospitals across Canada participating in the Canadian Nosocomial Infection Surveillance Program (CNISP), this report provides an epidemiological overview of select device-associated HAIs.

Methods

Design

Established in 1994, the CNISP, a collaboration between the Public Health Agency of Canada, the Association of Medical Microbiology and Infectious Disease Canada and sentinel hospitals across Canada, conducts national HAI surveillance at sentinel acute-care hospitals across Canada. This report presents data on device-associated HAIs for the following infections: hip and knee SSIs; cerebrospinal fluid shunt SSIs (CSF-shunt-SSIs); paediatric cardiac surgical site infections (paediatric-cardiac-SSIs); and CLABSIs.

Case definitions

Device-associated HAIs were defined according to standardized protocols and expert-reviewed case definitions (**Appendix 1**). Only CLABSIs identified in ICU settings were included in surveillance. Only complex infections, defined as deep incisional and organ space, were included in hip and knee SSI surveillance.

Data source

Participating hospitals submitted epidemiological data on CSF-shunt-SSIs and CLABSIs occurring between January 1, 2009 and December 31, 2018. Paediatric-cardiac-SSI surveillance started in January 2010. Hip and knee SSI surveillance started in January 2011. Data submission and case identification were supported by annual training sessions and continuous evaluations of data quality.

Statistical analysis

CLABSI rates were calculated by dividing the number of cases by line-day denominators. Hip and knee SSI, CSF-shunt-SSI and paediatric-cardiac-SSI rates were calculated by dividing the number of cases by surgery denominators. Proportions of pathogens were calculated by dividing the number of pathogens by the total number of pathogens identified. Missing and incomplete data were excluded from analyses, therefore denominators may vary. Interquartile ranges (IQR) were calculated. The Mann-Kendall test or negative binomial regression was used to test trends over time. Significance testing was two-tailed and differences were considered significant at p-value ≤ 0.05. Analyses were conducted using Excel and SAS 9.4.

Results

Between 2009 and 2018, over 40 hospitals contributed device-associated HAI data to CNISP, most of which were medium (201–499 bed) adult hospitals (**Table 1**). Overall, 4,300 device-associated infections were reported. CLABSIs were the most common device-associated HAI (n=2,973, 69%). Hip and knee SSI were the most common type of SSI reported (66% of SSIs, n=871/1,327).

Table 1: Characteristics of acute-care hospitals participating in device-associated HAI surveillance and frequency of device-associated hospital-acquired infections, 2009–2018

Characteristic of hospitals	CSF shunt SSI	Paediatric cardiac SSI	Hip and knee SSI	CLABSI-adult mixed ICU	CLABSI-adult CVICU	CLABSI-PICU	CLABSI-NICU
Years of surveillance	2009–2018	2010–2018	2011–2018	2009–2018	2009–2018	2009–2018	2009–2018
Number of HAIs reported	266	190	871	1,331	192	348	1,102
Total participating hospitals	8–14	3–4	12–25	22–41	5–8	5–10	9–17
Hospital type							
Adult[a]	2–5	NA	8–16	12–27	3–7	NA	2–3
Mixed	2–4	NA	4–9	4–14	1–2	0–4	1–6
Paediatric	4–7	3–4	NA	NA	NA	4–6	4–8
Hospital size							
Small (1–200 beds)	3–7	2–4	1–2	1–4	0–1	3–5	4–7
Medium (201–499 beds)	4–8	1	7–15	10–27	2–4	1–5	1–7
Large (500+ beds)	0–1	NA	5–8	5–10	2–3	0	1–3
Total beds (2018)	3,558	693	9,973	16,701 ICU beds	3,570 ICU beds	2,209 ICU beds	5,500 ICU beds

Abbreviations: CLABSI, central line-associated bloodstream infection; CSF-shunt SSI, cerebrospinal fluid shunt surgical site infection; CVICU, cardiovascular surgery intensive care unit; HAIs, healthcare-associated infections; ICU, intensive care unit; NA, not applicable; NICU, neonatal intensive care unit; PICU, paediatric intensive care unit; SSI, surgical site infection
[a] Seven hospitals classified as "Adult" also had a NICU

Overall, 4,599 pathogens were identified from device-associated HAI cases between 2014 and 2018; 69.8% of these were related to CLABSIs. Coagulase-negative staphylococci and *Staphylococcus aureus* were the most frequently reported pathogens (**Table 2**). Gram-positive pathogens represented 68.3% of identified pathogens, gram-negative pathogens represented 22.3% and fungi represented 9.4%.

Central line-associated bloodstream infections

Between 2009 and 2018, there were 2,973 reported CLABSIs; the majority of which occurred in adult mixed ICUs (n=1,331, 44.8%) and NICUs (n=1,102, 37.1%). Among CLABSIs identified in adult ICUs, the median age was 63 years (IQR=52–73 years). Males represented 62% of adult CLABSIs. One-third of adult CLABSI patients died within 30 days following the first positive

Table 2: Distribution and rank of the five most frequently reported[a] gram-negative, gram-positive and fungal pathogens, 2009–2018[b]

Category	Rank	Pathogen	N	% of total pathogens identified
Gram-positive	1	Coagulase-negative staphylococci[c]	1,320	28.7
	2	*Staphylococcus aureus*[d]	653	14.2
	3	*Enterococcus* spp.	519	11.3
	4	*Streptococcus*	137	3.0
	5	Methicillin-resistant *S. aureus*	120	2.6
	Other gram-positive		392	8.5
Gram-negative	1	*Klebsiella* spp.	226	4.9
	2	*Escherichia coli*	197	4.3
	3	*Enterobacter*	170	3.7
	4	*Pseudomonas aeruginosa*	133	2.9
	5	*Serratia*	87	1.9
	Other gram-negative		214	4.7
Fungi	1	*Candida albicans*	210	4.6
	2	Other *Candida* spp.	199	4.3
	Other fungi		22	0.5
Total			**4,599**	**100.0**[e]

[a] Up to four pathogens per device-associated hospital-acquired infection were included in the analysis
[b] Paediatric-cardiac-surgical site infection surveillance started in 2010. Hip and knee surgical site infection surveillance started in 2011
[c] Coagulase-negative staphylococci include *S. lugdunesis*, *S. haemolyticus*, *S. epidermidis* and *S. capitis*
[d] *Staphylococcus aureus* includes methicillin-susceptible *S. aureus* and unspecified *S. aureus*
[e] Percentage rounded to the nearest whole number

culture (32.3%, n=482/1,492). Among CLABSIs identified in paediatric intensive care units (PICUs), the median age was six months (IQR=2–22 months). Males represented 51% of PICU cases and within 30 days of positive culture, 11% of infected patients had died (n=37/342). Among CLABSIs identified in the neonatal intensive care unit (NICU), the median age at first positive culture was 20 days (IQR=10–45 days). Males represented 57% of NICU cases and within 30 days of positive culture, 8% of infected patients had died (n=88/1,077).

Overall, NICUs had higher rates of CLABSIs (2.7 cases per 1,000 line-days, on average) than PICUs (1.9/1,000 line-days), adult mixed ICUs (1.1/1,000 line-days) and adult cardiovascular surgery ICUs (0.7/1,000 line-days). While rates remained relatively constant for adult ICUs and PICUs, a 54.8% decrease was observed among NICUs (from 4.2 to 1.9/1000 line-days, 2009 to 2018, $p<0.0001$) (**Table 3**).

Hip and knee surgical site infections

Between 2011 and 2018, 871 complex hip and knee SSIs were reported; the majority of which were hip surgeries (n=530, 60.8%). Fifty-two percent (n=455) were organ space infections and 47.8% (n=416) were deep incisional infections (**Table 4**).

Table 3: Rate of central line-associated bloodstream infection per 1,000 line days by intensive care unit type, 2009–2018

Year	CLABSI rate per 1,000 line-days			
	Adult mixed ICU	Adult CV-surgery ICU	NICU	PICU
2009	1.4	0.8	4.2	2.0
2010	1.1	0.9	3.9	1.7
2011	0.9	1.0	4.1	1.6
2012	1.0	1.3	3.5	1.4
2013	1.1	0.5	2.8	1.3
2014	0.9	0.5	2.1	2.0
2015	1.1	0.7	2.3	2.4
2016	1.0	0.5	2.3	1.7
2017	1.2	0.4	1.8	2.0
2018	1.2	0.9	1.9	2.1
Overall	**1.1**	**0.7**	**2.7**	**1.9**

Abbreviations: CLABSI, central line-associated bloodstream infection; CV, cardiovascular; ICU, intensive care unit; NICU, neonatal intensive care unit; PICU, paediatric intensive care unit

Median patient age was 69 and 67 years for hip and knee SSIs, respectively. Median time from procedure to infection was 20 days for hip infections and 22 days for knee infections. Upon collection of additional data beginning in 2018, the median length of stay for hip and knee surgeries was four and three days, respectively. Ninety-one percent of patients with a surgical site infection were readmitted following hip or knee arthroplasty (hip, n=83/91, 91.2%; knee, n=33/37, 89.1%) and 64.8% (n=83/128) required a revision surgery. At 30 days post-surgery, one death was reported in 2018 among the hip-SSI patients.

Table 4: Frequency of hip and knee surgical site infections by type and rate per 100 surgeries, 2011–2018

Year	Deep incisional SSI		Organ/Space SSI		All hip and knee SSI	
	Cases (n)	%	Cases (n)	%	Cases (n)	Rate per 100 surgeries
Hip arthroplasty						
2011	18	43.9	23	56.1	41	0.82
2012	32	66.7	16	33.3	48	0.73
2013	36	57.1	27	42.9	63	0.79
2014	36	50.7	35	49.3	71	0.85
2015	34	51.5	32	48.5	66	0.75
2016	28	41.2	40	58.8	68	0.79
2017	34	41.5	48	58.5	82	0.80
2018	29	31.9	62	68.1	91	0.87
Overall	**247**	**46.6**	**283**	**53.4**	**530**	**0.80**

Table 4: Frequency of hip and knee surgical site infections by type and rate per 100 surgeries, 2011–2018 (*continued*)

Year	Deep incisional SSI		Organ/Space SSI		All hip and knee SSI	
	Cases (n)	%	Cases (n)	%	Cases (n)	Rate per 100 surgeries
Knee arthroplasty						
2011	20	51.3	19	48.7	39	0.69
2012	26	52.0	24	48.0	50	0.65
2013	21	55.3	17	44.7	38	0.41
2014	26	48.1	28	51.9	54	0.56
2015	21	47.7	23	52.3	44	0.43
2016	15	41.7	21	58.3	36	0.35
2017	20	46.5	23	53.5	43	0.36
2018	20	54.1	17	45.9	37	0.30
Overall	**169**	**49.6**	**172**	**50.4**	**341**	**0.47**

Abbreviation: SSI, surgical site infection

From 2011 to 2018, the rate of hip SSI was stable (from 0.82 to 0.87 infections per 100 surgeries, p=0.26), while the rate of knee SSI decreased significantly (from 0.69 to 0.30 infections per 100 surgeries, p=0.007). *S. aureus* and coagulase-negative staphylococci were the most commonly identified pathogens from hip and knee SSI cases (32% and 17% of identified pathogens, respectively).

Cerebrospinal fluid shunt surgical site infections

Between 2009 and 2018, 266 CSF-shunt-SSIs were reported; 143/260 (55%) were identified from new surgeries and 117/260 (45%) were identified from revision surgeries. The median age of cases was 46 years (IQR=29–67 years) for adult patients and 0.6 years (IQR=0.2–6.8 years) for paediatric patients. Females represented 53.4% (n=140/262) of cases. Median days from surgery to infection were 29 days (IQR=14–64 days).

From 2009 to 2018, the overall rate of CSF-shunt-SSI was 3.2/100 surgeries (range: 1.9 to 5.7/100 surgeries, **Table 5**). Infection rates were similar at paediatric hospitals (n=3.3/100 surgeries) and adult/mixed hospitals (n=3.2/100 surgeries). Coagulase-negative staphylococci and *S. aureus* were the most commonly identified pathogens from CSF-shunt-SSIs (41% and 22% of identified pathogens, respectively).

Paediatric cardiac surgical site infections

Between 2010 and 2018, there were 190 paediatric-cardiac-SSIs reported (**Table 6**). Most cases were superficial infections (58.7%) or organ/space infections (32.3%). The average age of patients with a paediatric-cardiac-SSI was 19 days old (IQR=7–213 days). On average, the time from surgery to date of onset of infection was 10 days (IQR=5–19 days). Three deaths were reported within 30 days of onset of infection (1.6% of cases) but all three deaths were unrelated to the paediatric-cardiac-SSI.

Table 5: Cerebrospinal fluid shunt surgical site infection rates per 100 surgeries by hospital type, 2009–2018

Year	Rate/100 surgeries		
	Adult and mixed hospitals	Paediatric hospitals	All hospitals
2009	2.9	2.8	2.9
2010	3.2	3.9	3.5
2011	5.0	6.3	5.7
2012	2.5	3.9	3.2
2013	2.6	2.8	2.7
2014	1.6	2.6	2.0
2015	3.3	2.1	2.7
2016	4.4	2.4	3.3
2017	4.6	3.2	3.9
2018	2.4	2.3	2.4
Overall	**3.2**	**3.3**	**3.2**

Table 6: Paediatric cardiac surgical infection rates by year and infection type, 2010–2018

Year	Superficial		Organ/space		Deep		All paediatric cardiac surgical site infections	
	Cases	% of annual cases	Cases	% of annual cases	Cases	% of annual cases	Cases	Rates/100 surgeries
2010	9	40.9	10	45.5	3	13.6	22	4.1
2011	8	53.3	5	33.3	2	13.3	15	3.1
2012	15	83.3	2	11.1	1	5.6	18	2.9
2013[a]	12	63.2	7	36.8	0	0.0	19	4.6
2014	11	57.9	8	42.1	0	0.0	19	3.5
2015	12	63.2	6	31.6	1	5.3	19	3.5
2016	9	64.3	3	21.4	2	14.3	14	3.0
2017	17	70.8	5	20.8	2	8.3	24	4.4
2018	18	46.2	15	38.5	6	15.4	40	7.5
Overall	**111**	**58.7**	**61**	**32.3**	**17**	**9.0**	**190**	**4.1**

[a] Excludes one site in 2013 with missing denominator data (number of cases=0 in that year). One case missing infection type info

Overall, the average paediatric-cardiac-SSI rate was 4.1/100 surgeries. While rates remained generally consistent (p=0.35), there was a significant increase in 2018 (n=7.5/100 surgeries, p<0.001) compared to the overall rates from 2010 to 2017

(3.6/100 surgeries). *S. aureus* and coagulase-negative staphylococci were the most commonly identified pathogens from paediatric-cardiac-SSIs (43% and 24% of identified pathogens, respectively).

Antibiogram

Antimicrobial susceptibility testing results for the most frequently identified gram-positive, gram-negative and fungal pathogens from device-associated HAIs are listed in **Table 7**. Oxacillin/cloxacillin resistance was found in 13% (n=38/288) of all *S. aureus* isolates. Meropenem resistance was low among the gram-negative pathogens with 2/36 *Klebsiella* isolates, 1/33 *E. coli* isolates resistant and 0/33 *Enterobacter* isolates resistant to meropenem. Thirty-two vancomycin-resistant *Enterococci* were identified (n=32/187, 17%, *Enterococcus* spp.).

Discussion

This report describes 4,300 device-associated HAIs reported over ten years of surveillance. With the exception of decreasing CLABSI rates in NICUs and decreasing knee-SSI rates, rates of device-associated HAIs have remained relatively consistent. In general, the most frequently reported pathogens among device-associated HAIs in Canada aligned with results from the United States (US): *S. aureus*, *E. coli* and *Klebsiella* ranked in the top five pathogens in our surveillance and in a 2020 US National Healthcare Surveillance Network (NHSN) report of adult HAIs (including CLABSIs, various SSIs, catheter-associated urinary tract infections and ventilator-associated events) (5).

Table 7: Antibiogram results[a] from pathogens identified from device-associated hospital-associated infections, 2014–2018

Antibiotic	Number of resistant/number tested and %															
	Gram-positive						Gram-negative						Fungi			
	Coagulase-negative staphylococci[b]		*S. aureus*[c]		*Enterococcus* spp.		*Klebsiella* spp.		*E. coli*		*Enterobacter*		*C. albicans*		*Candida* spp. other	
	# of resistant	%	# of resistant	%	# of resistant	%	# of resistant	%	# of resistant	%	# of resistant	%	# of resistant	%	# of resistant	%
Ampicillin	5/8	63	2/10	20	61/235	26	76/78	97	56/86	65	51/55	93	NA	NA	NA	NA
Cefazolin	125/154	81	17/158	11	NA	NA	21/58	36	24/76	32	47/48	98	NA	NA	NA	NA
Ceftriaxone	NA	NA	1/11	9	NA	NA	5/62	8	11/54	20	24/50	48	NA	NA	NA	NA
Clindamycin	109/193	56	47/213	22	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ciprofloxacin	1/7	14	2/14	14	NA	NA	6/72	8	23/68	34	0/64	0	NA	NA	NA	NA
Cloxacillin/ Oxacillin	241/308	78	38/238	16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Erythromycin	57/89	64	34/104	33	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gentamicin	15/31	48	2/27	7	7/58	12	6/84	7	11/81	14	1/14	7	NA	NA	NA	NA
Meropenem	NA	NA	NA	NA	NA	NA	2/36	6	1/33	3	0/36	0	NA	NA	NA	NA
Piperacillin-tazobactam	NA	NA	NA	NA	NA	NA	7/60	12	12/60	20	21/48	44	NA	NA	NA	NA
Penicillin	85/87	98	81/86	94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Rifampin	1/59	2	0/33	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trimethoprim-sulfamethoxazole	58/147	39	4/177	2	NA	NA	5/56	9	28/59	47	9/53	17	NA	NA	NA	NA
Tobramycin	NA	NA	NA	NA	NA	NA	6/72	8	3/80	4	2/61	3	NA	NA	NA	NA
Vancomycin	3/293	1	1/140	1	32/187	17	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Amphotericin B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0/11	0	0/9	0
Caspofungin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1/40	3	0/11	0
Fluconazole	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1/55	2	19/59	32

Abbreviation: NA, not available
[a] Antibiotic/organism combinations with fewer than six tests were excluded
[b] Coagulase-negative staphylococci include *S. lugdunesis*, *S. haemolyticus*, *S. epidermidis*, *S. capitis* and *S. warneri*
[c] Includes methicillin-susceptible *S. aureus* and methicillin-resistant *S. aureus*

Surgical site infections

Hip and knee-SSIs were the most common SSI reported in our surveillance. Similar to results from the European Centre for Disease Prevention and Control, a decreasing trend in knee SSI was observed among CNISP hospitals, while hip SSI remained stable (9). In addition, a US point prevalence study observed a significant reduction in the prevalence of complex SSIs between 2011 and 2015 (10). Our findings indicate that the most common pathogens identified among hip and knee-SSIs were *S. aureus* and coagulase-negative staphylococci, consistent with results from other regions (9,11). Frequent identification of *S. aureus* and coagulase-negative staphylococci may be related to the use of implant devices and contamination from the patient's endogenous skin flora (5). Hip and knee-SSIs affect an older population as joint replacements typically occur among older adults (12). As populations age, hip and knee joint replacements are rising and are linked to a rise in surgical complications (i.e. prosthetic joint infections) (12). High observed rates of readmission and revision surgery highlight the financial and resource burden placed on the healthcare system due to hip and knee-SSI (13).

Our overall rate of CSF-shunt-SSIs (n=3.2/100 surgeries) is on the lower end of what is reported internationally; a 2012 review found that reported rates of infection vary from 3% to 12% of shunt operations (14). Stratification of our CSF-shunt-SSI data by paediatric or adult hospital showed little difference in infection rates and in pathogen distributions between paediatric and adult/mixed settings. However, a previous study among CNISP hospitals, conducted between 2000 and 2002, had identified that CSF-shunt-SSIs were more common in children than in adults (15). In this earlier study, the infection rate among paediatric patients was higher than found in this study (4.9% of surgeries in 2000–2002 versus 3.3% 2009–2018) suggesting that SSI rates among paediatric populations have decreased.

Limited literature on paediatric-cardiac-SSI, differences in patient populations and lengths of follow-up makes direct comparisons difficult, but our overall rate of paediatric-cardiac-SSIs (n=4.1/100 surgeries) is similar to the ranges in infection rates reported elsewhere. A 2009–2012 intervention study of neonates undergoing cardiac surgery conducted at a tertiary-care centre in New York found pre and post-intervention paediatric-cardiac-SSI rates of 6.2/100 surgeries and 5.8/100 surgeries, respectively (16). In a 2012–2013 French study of patients younger than one year of age, 19% of patients presented with an SSI (17). A 2010–2012 retrospective study of paediatric patients (younger than 18 years of age) undergoing cardiac surgery at two hospitals in New York found a rate of 1.4 HAIs/100 procedures (18).

There was a significant increase in the rate of paediatric-cardiac-SSI in 2018 to 7.5/100 surgeries. This increase was limited to two hospital sites, where investigations are ongoing. This increase should be interpreted with caution as rates are calculated from a small number of cases and may be sensitive to random fluctuation at individual hospitals.

Central line-associated bloodstream infections

Central line-associated bloodstream infections were the most commonly reported device-associated HAI (69% of included HAIs); however, it is important to note that the number of hospitals participating in the surveillance of each HAI differs and that the surveillance periods for some HAIs were shorter. In a point prevalence study of HAIs, the frequencies of SSIs (19%) and CLABSIs (21%) were very similar (5).

There were no substantive changes in CLABSI rates among surveyed adult ICUs or PICUs; however, there was a 55% decrease in CLABSI rates among NICUs. The methods of measurement differ, but CLABSI rates in NICUs have also decreased in the US; between 2010 and 2016, standardized incidence ratios (defined as the change in relation to the number of CLABSIs per central line days) for CLABSIs in NICUs and rates of central line use in NICUs decreased in the US (19). In addition, CLABSI rates in other ICU types in the US also decreased between 2010 and 2016 (19). Updated NHSN guidelines have been credited for the reduction in rates in the US (20). It is possible that improvements to rates in Canada occurred prior to the study period.

Our overall CLABSI rates in adult ICUs (0.7 and 1.1/1,000 central-line-days for cardiovascular intensive care units and mixed ICUs, respectively) are similar to ranges reported in the US and Australia. In the US, the CLABSI rate in ICUs was estimated to be 0.8/1,000 central-line-days in 2010–2015 (21). In Australia, annual rates of CLABSIs in ICUs ranged between 0.9 and 1.7/1,000 central-line-days in 2010–2013 (22). Higher rates are seen in other regions; a large surveillance study of 703 intensive care units in Latin America, Europe, Eastern Mediterranean, Southeast Asia and Western Pacific reported a CLABSI rate of 4.1/1,000 central-line-days between January 2010 and December 2015 (21).

Antibiogram

The percentage of *S. aureus* isolates that were methicillin-resistant *S. aureus* (MRSA) in this study (13%) is similar to what was reported from a Swiss surveillance network where 8% of *S. aureus* SSI cases were MRSA in 2010–2015 (23). Higher rates of MRSA have been reported elsewhere. In the US, 42% to 48% of *S. aureus* isolates from HAIs (including SSI, CLABSI and others) in NHSN surveillance were MRSA (5). A Japanese study of SSIs at 27 medical centres, found that 72% of *S. aureus* isolates were MRSA in 2010 (24).

Of identified *Enterococcus* spp., 17% were vancomycin-resistant *Enterococci* in our surveillance. In NHSN surveillance in the US, 8.5% of *Enterococcus faecalis* and 84.5% of *Enterococcus faecium* pathogens identified from CLABSIs in ICUs were vancomycin-resistant *Enterococci* in 2015–2017 (5).

Meropenem resistance was low among the gram-negative pathogens with 2/36 (6%) *Klebsiella* isolates and 1/33 (3%) *E. coli* isolates resistant to meropenem. In the US, the percent of carbapenem-resistant *Enterobacteriaceae* among *Klebsiella* spp. ranged from 3.1% (among SSIs) to 6.9% (among expanded list of device-associated infections); the percent of carbapenem-resistant *Enterobacteriaceae* among *E. coli* ranged from 0.6% (among SSIs) to 0.7% (among expanded list of device-associated infections) (5).

Strengths and limitations

The strength of this study lies in the standardized collection of detailed data from a large network of sentinel hospitals over a decade. While the CNISP network extends across Canada, participating hospitals may not be representative of the general Canadian inpatient population; hospitals participating in CNISP tend to be larger, teaching hospitals in urban centres. The CNISP is currently undergoing a recruitment process to increase representativeness and bed coverage, especially in northern, rural and indigenous populations. The CNISP's data, although standardized, may be sensitive to changes in hospital participation, infection prevention and control practices and the application of surveillance definitions. Differences in surveillance protocols and case definitions limit the ability to compare data from other countries. However, the data presented in this report are routinely used by Canadian hospitals for benchmarking.

For CLABSI surveillance, we do not have data on infections occurring outside of ICU settings; however, in the US, CLABSIs outside of the ICU setting represented 55% of all CLABSIs (19)

Conclusion

This report provides an updated summary of rates, pathogen distributions and antimicrobial resistance among select device-associated HAIs and relevant pathogens. Understanding the national burden of device-associated HAIs is essential for developing and maintaining benchmark rates for informing infection and prevention control and antimicrobial stewardship policies and programs.

Authors' statement

Canadian Nosocomial Infection Surveillance Program hospitals provided expertise in the development of protocols in addition to the submission of epidemiological data. Epidemiologists from the Public Health Agency of Canada were responsible for the conception, analysis, interpretation, drafting and revision of this paper.

Competing interests

None.

Acknowledgements

We gratefully acknowledge the contribution of the physicians, epidemiologists, infection control practitioners and laboratory staff at each participating hospital (Vancouver General Hospital (VGH), Vancouver, British Columbia (BC); Richmond General Hospital, Richmond, BC; UBC Hospital, Vancouver, BC; Lion's Gate, North Vancouver, BC; Powell River General Hospital, Powell River, BC; Sechelt Hospital (formerly St. Mary's), Sechelt, BC; Squamish General Hospital, Squamish, BC; Peter Lougheed Centre, Calgary, Alberta (AB); Rockyview General Hospital, Calgary, AB; South Health Campus, Calgary, AB; Foothills Medical Centre, Calgary, AB; Alberta Children's Hospital, Calgary, AB; University of Alberta Hospital, Edmonton, AB; Stollery Children's Hospital, Edmonton, AB; Health Sciences Centre-Winnipeg, Winnipeg, Manitoba (MB); University of Manitoba Children's Hospital, Winnipeg, MB; Children's Hospital of Western Ontario, London, Ontario (ON); Victoria Hospital, London, ON; University Hospital, London, ON; Toronto General Hospital, Toronto, ON; Toronto Western Hospital, Toronto, ON; Princess Margaret, Toronto, ON; Mount Sinai Hospital, Toronto, ON; Bridgepoint Active Healthcare, Toronto, ON; Sunnybrook Hospital, Toronto, ON; Kingston General Hospital, Kingston, ON; Sir Mortimer B. Davis - Jewish General Hospital, Montréal, Québec (QC); The Moncton Hospital, Moncton, New Brunswick (NB); Halifax Infirmary, Halifax, Nova Scotia (NS); Victoria General, Halifax, NS; Rehabilitation Centre, Halifax, NS; Veterans Memorial Building, Halifax, NS; Dartmouth General Hospital, Halifax, NS; IWK Health Centre, Halifax, NS; Hospital for Sick Children, Toronto, ON; Montréal Children's Hospital, Montréal, QC; Royal University Hospital, Saskatoon, Saskatchewan (SK); St. Paul's Hospital, Saskatoon, SK; General Hospital & Miller Centre, St. John's, Newfoundland and Labrador (NL); Burin Peninsula Health Care Centre, Burin, NL; Carbonear General Hospital, Carbonear, NL; Dr. G.B. Cross Memorial Hospital, Clarenville, NL; Janeway Children's Hospital and Rehabilitation Centre, St. John's, NL; St. Clare's Mercy Hospital, St. John's, NL; McMaster Children's Hospital, Hamilton, ON; St Joseph's Healthcare, Hamilton, ON; Jurvinski Hospital and Cancer Center, Hamilton, ON; General Site, Hamilton, ON; Civic Campus, Ottawa, ON; General Campus, Ottawa, ON; University of Ottawa Heart Institute, Ottawa, ON; Hôpital Maisonneuve-Rosemont, Montréal, QC; Victoria General Hospital, Victoria, BC; Royal Jubilee, Victoria, BC; Nanaimo Regional General Hospital, Nanaimo, BC; Children's Hospital of Eastern Ontario (CHEO), Ottawa, ON; BC Women's Hospital, Vancouver, BC; Hôtel-Dieu de Québec, Québec, QC; Montréal General Hospital, Montréal, QC; Royal Victoria Hospital, Montréal, QC; Montréal Neurological Institute, Montréal, QC; North York General Hospital, Toronto, ON; Kelowna General Hospital, Kelowna, BC; Queen Elizabeth Hospital, Charlottetown, Prince Edward Island (PEI); Prince County Hospital, Summerside, PEI; Western Memorial Regional Hospital, Corner Brook, NL; Regina General

Hospital, Regina, SK; Pasqua Hospital, Regina, SK; Sudbury Regional Hospital, Sudbury, ON; University Hospital of Northern BC, Prince George, BC).

Thank you to the staff at Public Health Agency of Canada in the Centre for Communicable Diseases and Infection Control, Ottawa, ON (J Brooks, L Pelude, R Mitchell, W Rudnick, KB Choi, A Silva, V Steele, J Cayen, C McClellan, J Liang, M Hunt and L Sauvé) and the National Microbiology Laboratory, Winnipeg, MB (G Golding, M Mulvey, J Campbell, T Du, M McCracken, L Mataseje, A Bharat and D Boyd).

Funding

This work was supported by the Public Health Agency of Canada.

References

1. Allegranzi B, Nejad SB, Castillejos GG, Kilpatrick C, Kelley EM. WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Celan Care is Safer Care. Chapter 3. The burden of health care-associated infection. Geneva (CH): WHO; 2011. https://www.ncbi.nlm.nih.gov/books/NBK144030/

2. Al-Tawfiq JA, Tambyah PA. Healthcare associated infections (HAI) perspectives. J Infect Public Health 2014;7(4):339–44. DOI PubMed

3. Canadian Patient Safety Institute. Canadian Surgical Site Infection Prevention Audit Month. February 2016. CPSI; 2016. http://www.patientsafetyinstitute.ca/en/toolsResources/Documents/SSI Audit 2016_Recap Report EN.pdf

4. Mitchell R, Taylor G, Rudnick W, Alexandre S, Bush K, Forrester L, Frenette C, Granfield B, Gravel-Tropper D, Happe J, John M, Lavallee C, McGeer A, Mertz D, Pelude L, Science M, Simor A, Smith S, Suh KN, Vayalumkal J, Wong A, Amaratunga K; Canadian Nosocomial Infection Surveillance Program. Trends in health care-associated infections in acute care hospitals in Canada: an analysis of repeated point-prevalence surveys. CMAJ 2019;191(36):E981–8. DOI PubMed

5. Weiner-Lastinger LM, Abner S, Edwards JR, Kallen AJ, Karlsson M, Magill SS, Pollock D, See I, Soe MM, Walters MS, Dudeck MA. Antimicrobial-resistant pathogens associated with adult healthcare-associated infections: Summary of data reported to the National Healthcare Safety Network, 2015-2017. Infect Control Hosp Epidemiol 2020;41(1):1–18. DOI PubMed

6. Zimlichman E, Henderson D, Tamir O, Franz C, Song P, Yamin CK, Keohane C, Denham CR, Bates DW. Health care-associated infections: a meta-analysis of costs and financial impact on the US health care system. JAMA Intern Med 2013;173(22):2039–46. DOI PubMed

7. Nodzo SR, Frisch NB. The Use of Antibiograms in Orthopedic Surgery. Curr Rev Musculoskelet Med 2019;11(3):341–6. DOI PubMed

8. Center for Disease and Prevention Control. National Healthcare Safety Network (NHSN) Overview Patient Safety Component Manual. 2020. https://www.cdc.gov/nhsn/pdfs/pscmanual/pcsmanual_current.pdf

9. European Centre for Disease Prevention and Control. Healthcare-associated infections: surgical site infections - Annual Epidemiological Report for 2017. Solna (Sweden): ECDC; 2019. https://www.ecdc.europa.eu/en/publications-data/healthcare-associated-infections-surgical-site-infections-annual-1

10. Magill SS, O'Leary E, Janelle SJ, Thompson DL, Dumyati G, Nadle J, Wilson LE, Kainer MA, Lynfield R, Greissman S, Ray SM, Beldavs Z, Gross C, Bamberg W, Sievers M, Concannon C, Buhr N, Warnke L, Maloney M, Ocampo V, Brooks J, Oyewumi T, Sharmin S, Richards K, Rainbow J, Samper M, Hancock EB, Leaptrot D, Scalise E, Badrun F, Phelps R, Edwards JR; Emerging Infections Program Hospital Prevalence Survey Team. Changes in prevalence of health care-associated infections in U.S. Hospitals. N Engl J Med 2018;379(18):1732–44. DOI PubMed

11. Public Health England. Surveillance of surgical site infections in NHS hospitals in England, 2017 to 2018. London (UK): PHE; 2018. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765967/SSI_annual_report_NHS_hospitals_2017_18.pdf

12. Kandel CE, Jenkinson R, Daneman N, Backstein D, Hansen BE, Muller MP, Katz KC, Widdifield J, Bogoch E, Ward S, Sajja A, Jeldes FG, McGeer A. Predictors of Treatment Failure for Hip and Knee Prosthetic Joint Infections in the Setting of 1- and 2-Stage Exchange Arthroplasty: A Multicenter Retrospective Cohort. Open Forum Infect Dis 2019;6(11):ofz452. DOI PubMed

13. Springer BD, Cahue S, Etkin CD, Lewallen DG, McGrory BJ. Infection burden in total hip and knee arthroplasties: an international registry-based perspective. Arthroplast Today 2017;3(2):137–40. DOI PubMed

14. Wong JM, Ziewacz JE, Ho AL, Panchmatia JR, Bader AM, Garton HJ, Laws ER, Gawande AA. Patterns in neurosurgical adverse events: cerebrospinal fluid shunt surgery. Neurosurg Focus 2012;33(5):E13. DOI PubMed

15. Langley JM, Gravel D, Moore D, Matlow A, Embree J, MacKinnon-Cameron D, Conly J; Canadian Nosocomial Infection Surveillance Program. Study of cerebrospinal fluid shunt-associated infections in the first year following placement, by the Canadian Nosocomial Infection Surveillance Program. Infect Control Hosp Epidemiol 2009;30(3):285–8. DOI PubMed

16. Murray MT, Corda R, Turcotte R, Bacha E, Saiman L, Krishnamurthy G. Implementing a standardized perioperative antibiotic prophylaxis protocol for neonates undergoing cardiac surgery. Ann Thorac Surg 2014;98(3):927–33. DOI PubMed

17. Macher J, Gras Le Guen C, Chenouard A, Liet JM, Gaillard Le Roux B, Legrand A, Mahuet J, Launay E, Gournay V, Joram N. Preoperative Staphylococcus aureus Carriage and Risk of Surgical Site Infection After Cardiac Surgery in Children Younger than 1 year: A Pilot Cohort Study. Pediatr Cardiol 2017;38(1):176–83. DOI PubMed

18. Turcotte RF, Brozovich A, Corda R, Demmer RT, Biagas KV, Mangino D, Covington L, Ferris A, Thumm B, Bacha E, Smerling A, Saiman L. Health care-associated infections in children after cardiac surgery. Pediatr Cardiol 2014;35(8):1448–55. DOI PubMed

19. Centers for Disease Control and Prevention. Data Summary of HAIs in the US: Assessing Progress 2006-2016. CDC; 2017. https://www.cdc.gov/hai/data/archive/data-summary-assessing-progress.html

20. Bell T, O'Grady NP. Prevention of Central Line-Associated Bloodstream Infections. Infect Dis Clin North Am 2017;31(3):551–9. DOI PubMed

21. Rosenthal VD, Al-Abdely HM, El-Kholy AA, AlKhawaja SA, Leblebicioglu H, Mehta Y, Rai V, Hung NV, Kanj SS, Salama MF, Salgado-Yepez E, Elahi N, Morfin Otero R, Apisarnthanarak A, De Carvalho BM, Ider BE, Fisher D, Buenaflor MC, Petrov MM, Quesada-Mora AM, Zand F, Gurskis V, Anguseva T, Ikram A, Aguilar de Moros D, Duszynska W, Mejia N, Horhat FG, Belskiy V, Mioljevic V, Di Silvestre G, Furova K, Ramos-Ortiz GY, Gamar Elanbya MO, Satari HI, Gupta U, Dendane T, Raka L, Guanche-Garcell H, Hu B, Padgett D, Jayatilleke K, Ben Jaballah N, Apostolopoulou E, Prudencio Leon WE, Sepulveda-Chavez A, Telechea HM, Trotter A, Alvarez-Moreno C, Kushner-Davalos L; Remaining authors. International Nosocomial Infection Control Consortium report, data summary of 50 countries for 2010-2015: device-associated module. Am J Infect Control 2016;44(12):1495–504. DOI PubMed

22. Spelman T, Pilcher DV, Cheng AC, Bull AL, Richards MJ, Worth LJ. Central line-associated bloodstream infections in Australian ICUs: evaluating modifiable and non-modifiable risks in Victorian healthcare facilities. Epidemiol Infect 2017;145(14):3047–55. DOI PubMed

23. Abbas M, Aghayev E, Troillet N, Eisenring MC, Kuster SP, Widmer AF, Harbarth S; SwissNoso. Temporal trends and epidemiology of Staphylococcus aureus surgical site infection in the Swiss surveillance network: a cohort study. J Hosp Infect 2018;98(2):118–26. DOI PubMed

24. Takesue Y, Watanabe A, Hanaki H, Kusachi S, Matsumoto T, Iwamoto A, Totsuka K, Sunakawa K, Yagisawa M, Sato J, Oguri T, Nakanishi K, Sumiyama Y, Kitagawa Y, Wakabayashi G, Koyama I, Yanaga K, Konishi T, Fukushima R, Seki S, Imai S, Shintani T, Tsukada H, Tsukada K, Omura K, Mikamo H, Takeyama H, Kusunoki M, Kubo S, Shimizu J, Hirai T, Ohge H, Kadowaki A, Okamoto K, Yanagihara K. Nationwide surveillance of antimicrobial susceptibility patterns of pathogens isolated from surgical site infections (SSI) in Japan. J Infect Chemother 2012 Dec;18(6):816–26. DOI PubMed

Appendix 1: Case definitions

Central line-associated bloodstream infection (CLABSI)

Only central line-associated bloodstream infections (BSIs) related to an intensive care unit (ICU) admission were included in surveillance.

BSI case definition:

BSI is **NOT** related to an infection at another site and it meets one of the following criteria:

Criterion 1: Recognized pathogen cultured from at least one blood culture, unrelated to infection at another site.

OR

Criterion 2: At least one of: fever (>38°C core), chills, hypotension; if aged <1 year: fever (>38°C core), hypothermia (<36°C core), apnea, or bradycardia **AND** common skin contaminant (see list below) cultured from ≥2 blood cultures drawn on separate occasions, or at different sites, unrelated to infection at another site. Different sites may include peripheral veins, CVCs, or separate lumens of a multilumen catheter. Different times include two blood cultures collected on the same or consecutive calendar days via separate venipunctures or catheter entries. The collection date of the first positive blood culture is the date used to identify the date of positive culture. Two positive blood culture bottles filled at the same venipuncture or catheter entry constitute only one positive blood culture.

CLABSI case definition:

A laboratory-confirmed bloodstream infection where a central line catheter (CL) or umbilical catheter (UC) was in place for >2 calendar days on the date of the positive blood culture, with day of device placement being Day 1. If admitted or transferred into a facility with a CL/UC in place (e.g. tunneled or implanted central line), day of first access is considered Day 1.

AND

A CL or UC was in place on the date of the positive blood culture or the day before. If a CL or UC was in place for >2 calendar days and then removed, the BSI criteria **must be fully met** on the day of discontinuation or the next day. If the patient is admitted or transferred into the ICU with a CL in place, the day of first access is considered Day 1. "Access" is defined as line placement, infusion or withdrawal through the line.

ICU-related case definition:

CLABSI onset during ICU stay and the CL has been in place >2 calendar days. The CLABSI would be attributable to the ICU if it occurred on the day of transfer or the next calendar day after transfer out of the ICU.

Common skin contaminants:

Diphtheroids, *Corynebacterium* spp., *Bacillus* spp., *Propionibacterium* spp., coagulase-negative staphylococci (including *S. epidermidis*), viridans group streptococci, *Aerococcus* spp., *Micrococcus* spp. and *Rhodococcus* spp.

Hip and knee surgical site infection (SSI)

Only complex surgical site infections (deep incisional or organ/space) following hip and knee arthroplasty were included in surveillance.

A deep incisional SSI must meet the following criterion:

Infection occurs within 90 days after the operative procedure and the infection appears to be related to the operative procedure and involves deep soft tissues (e.g. facial and muscle layers) of the incision and the patient has at least **ONE** of the following:

1. Purulent drainage from the deep incision but not from the organ/space component of the surgical site.
2. Deep incision that spontaneously dehisces or is deliberately opened by the surgeon and is culture-positive or not cultured when the patient has at least one of the following signs or symptoms: fever (>38°C), or localized pain or tenderness. A culture-negative finding does not meet this criterion.
3. An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of a deep incisional SSI by a surgeon or attending physician.

An organ/space SSI must meet the following criterion:

Infection occurs within 90 days after the operative procedure and the infection appears to be related to the operative procedure and infection involves any part of the body, excluding the skin incision, fascia, or muscle layers, that is opened or manipulated during the operative procedure and patient has at least **ONE** of the following:

1. Purulent drainage from a drain that is placed through a stab wound into the organ/space.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space.

3. An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of an organ/space SSI by a surgeon or attending physician.

Cerebrospinal fluid shunt surgical site infection

Only patients who underwent a placement or revision of a cerebrospinal fluid (CSF) shunting device and the infection occurred within one year of surgery were included in surveillance.

CSF shunt-associated surgical site infection case definition:

A patient is identified as having CSF shunt SSI if the patient meets the following criteria:
Criterion 1: An internalized CSF shunting device is in place

AND

Criterion 2: A bacterial or fungal pathogen(s) is identified from the cerebrospinal fluid

AND

Criterion 3: The pathogen is associated with at least **ONE** of the following:
1. Fever (temperature ≥38°C)
2. Neurological signs or symptoms
3. Abdominal signs or symptoms
4. Signs or symptoms of shunt malfunction or obstruction

Paediatric cardiac surgery surgical site infection

Only surgical site infections following open-heart surgery with cardiopulmonary bypass among paediatric patients (<18 years of age) were included in surveillance.

A **superficial incisional SSI** must meet the following criterion:

Infection occurs within 30 days after the operative procedure and involves only skin and subcutaneous tissue of the incision and at least **ONE** of the following:
1. Purulent drainage from the superficial incision.
2. Organisms isolated from an aseptically-obtained culture of fluid or tissue from the superficial incision.
3. At least **ONE** of the following signs or symptoms of infection:
    - Pain or tenderness, localized swelling, redness, or heat and the superficial incision is deliberately opened by surgeon, and is culture-positive or not cultured. A culture-negative finding does not meet this criterion
    - Diagnosis of superficial incisional SSI by the surgeon or attending physician

A **deep incisional SSI** must meet the following criterion:

Infection occurs within 90 days after the operative procedure and the infection appears to be related to the operative procedure **AND** involves deep soft tissues (e.g. facial and muscle layers) of the incision **AND** the patient has at least **ONE** of the following:
1. Purulent drainage from the deep incision but not from the organ/space component of the surgical site.
2. Deep incision spontaneously dehisces or is deliberately opened by the surgeon and is culture-positive or not cultured when the patient has at least one of the following signs or symptoms: fever (>38°C), or localized pain or tenderness. A culture-negative finding does not meet this criterion.
3. An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of a deep incisional SSI by a surgeon or attending physician.

An **organ/space SSI** must meet the following criterion:

Infection occurs within 90 days after the operative procedure and the infection appears to be related to the operative procedure **AND** infection involves any part of the body, excluding the skin incision, fascia, or muscle layers, that is opened or manipulated during the operative procedure **AND** patient has at least **ONE** of the following:
1. Purulent drainage from a drain that is placed through a stab wound into the organ/space.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space.
3. An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of an organ/space SSI by a surgeon or attending physician.