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Point prevalence survey for healthcare-associated infections within Canadian adult acute-care hospitals☆,☆☆

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Healthcare-acquired infections; Infection control; Prevalence; Cross-transmission

Summary A survey of adult patients 19 years of age and older was conducted in February 2002 in hospitals across Canada to estimate the prevalence of healthcare-associated infections (HAIs). A total of 5750 adults were surveyed; 601 of these had 667 HAIs, giving a prevalence of 10.5% infected patients and 11.6% HAIs. Urinary tract infections (UTI) were the most frequent HAI, shown by 194 (3.4%) of the patients surveyed. Pneumonia was found in 175 (3.0%) of the patients, surgical site infections (SSI) in 146 (2.5%), bloodstream infections (BSI) in 93 (1.6%) and *Clostridium difficile*-associated diarrhoea (CDAD) in 59 (1%). In this first national point prevalence study in Canada, the prevalence of HAI was found to be similar to that reported by other industrialized countries.

Introduction

Surveillance of healthcare-associated infections (HAIs) is an important component of comprehensive infection prevention and control programme.[1] The gold standard for surveillance is prospective active surveillance. Although not as accurate as the traditional prospective method, prevalence surveys can provide baseline information about the occurrence and distribution of HAI within a healthcare institution and help to establish priorities for infection prevention and control departments.

Repeated prevalence surveys have been used for the evaluation of infection control programmes, to follow trends in HAI rates, determine rates of device utilization and antibiotic usage, for intra-hospital comparisons, to measure adverse effects of HAI, and to measure the costs associated with these infections.[2–7] Large multicentre prevalence surveys have been conducted in Europe during the past decade and have shown an overall prevalence of HAI infections of 4–10%.[7–19] To date, there have been no published reports of prevalence surveys for HAI in adults hospitalised in Canadian acute care facilities.

We conducted a cross-sectional population survey of adult patients 19 years of age and older admitted to hospitals participating in the Canadian Nosocomial Infection Surveillance Program (CNISP) to determine the prevalence of HAIs within these institutions.

Methods

CNISP is a collaborative effort of the Canadian Hospital Epidemiology Committee, a subcommittee of the Association of Medical Microbiology and Infectious Disease Canada and the Public Health Agency of Canada (PHAC). Twenty-five acute-care CNISP member hospitals in eight provinces participated in a one-day HAI point prevalence survey occurring on any day between 5 and 8 February 2002. We have previously reported the results in paediatric age-group patients.[20]

Eligible patients were those 19 years of age and older who had been admitted for at least 48 h on the day of the survey. Patients were identified by a ward census list obtained at 08:00 on the day the survey was conducted. Patients admitted to the ward after 08:00 were not included, and no patient was enrolled more than once during the surveillance period. The primary outcome was the presence of an HAI, which was identified as an infection not present on admission and with onset at least 72 h after admission. The study was limited to the following infections: pneumonia, urinary tract infection (UTI), bloodstream infection (BSI), surgical site infection (SSI) and *Clostridium difficile*-associated diarrhoea (CDAD). Centers for Disease Control and Prevention (CDC) definitions for nosocomial definitions were used for all HAIs except central venous catheter-associated BSI.[21] The Canadian surveillance definitions for central venous catheter-associated BSI were used: confirmation of septic thrombophlebitis with a single positive blood culture; or a single positive blood culture and a positive culture of the catheter segment with the identical organism; or a $>$10-fold colony count difference in the blood cultures drawn from the device and the peripheral blood; or a single positive blood culture and a positive culture from the discharge or aspirate from the exit site, tunnel or pocket, with the identical organism.[22]

Patient information was collected on manually completed data forms and included: date of admission, the admitting medical or surgical service, antimicrobial agents received on the day of

the survey, the presence of indwelling devices including urinary catheters, central venous catheters and endotracheal tubes, and isolation precautions in place. All patient units and wards were surveyed except for psychiatry, rehabilitation and day or overnight surgery.

Prevalence ratios were calculated and differences between infected and non-infected patients were assessed using a Wald test for categorical variables and a Student's *t*-test for continuous variables. All tests were two-tailed, and $P < 0.05$ was considered statistically significant. Variables associated with values of $P < 0.25$ in the univariate analysis were included in a multiple logistic regression model in order to assess patient factors associated with the presence of an HAI. Data analysis was performed using SAS version 8.1 (SAS Institute, Cary, NC, USA).

Results

A total of 5750 adults 19 years of age and older were surveyed. The mean age of the patients was 65 ± 17 years (range 19–99 years); 2938 (51%) patients were men. There were 2619 (46%) patients on medical units, 2112 (37%) on surgical units, 462 (8%) in critical care units including intensive care and coronary care, 250 (4%) on oncology/haematology units and 311 (5%) on other units including transplant, trauma and gynaecology. Of these, 1803 (31%) had at least one indwelling device; 1253 (22%) had an indwelling urinary catheter, 896 (16%) had a central venous catheter, 224 (4%) were mechanically ventilated and 100 (2%) had an endotracheal tube but were not mechanically ventilated.

Among the total patients surveyed, 2086 (36%) patients were receiving at least one systemic antimicrobial agent and 812 (14%) were receiving more than one agent. The most commonly prescribed antimicrobial agents were cephalosporins (11.4%), fluoroquinolones (10.6%), metronidazole (6.6%) and penicillins (6.5%). Four per cent of the patients surveyed were on vancomycin (Table I).

Three hundred and ninety (7%) of the patients surveyed were being managed under transmission-based precautions, in addition to standard precautions.[23] The most common type of isolation was contact (360 patients), followed by airborne (17 patients). Only six patients surveyed were on droplet precautions.

On the day of the survey, 601 patients had a total of 667 HAIs for an overall prevalence of 10.5% infected patients and of HAIs of 11.6%. Fifty-six (1%) patients had two HAI; 10 (0.2%) had three HAI. UTIs were the most frequent HAI, found in 194

Table I Antimicrobials used on the day of the point prevalence survey by drug classification and medical unit, $N = 5750$

Drug classification	Medicine $N = 2619$		Surgery $N = 2112$		Critical care $N = 462$		Oncology–haematology $N = 250$		Transplant $N = 82$		Other[a] $N = 225$		Total, $N = 5750$	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Aminoglycosides	41	1.6	35	1.7	11	2.4	16	6.4	0	0.0	5	2.2	108	1.9
Antifungal agents	21	0.8	23	1.1	25	5.5	40	16.0	12	14.6	2	0.9	123	2.1
Antituberculosis agents	32	1.2	10	0.5	6	1.3	4	1.6	0	0.0	0	0.0	52	0.9
Carbapenems	17	0.6	21	1.1	17	3.7	15	6.0	5	6.1	6	2.6	81	1.4
Cephalosporins 1st generation	88	3.4	205	9.7	28	6.1	8	3.2	4	4.9	12	5.2	345	6.0
Cephalosporins 2nd generation	37	1.4	11	0.5	8	1.7	0	0.0	1	1.2	3	1.3	60	1.0
Cephalosporins 3rd/4th generation	122	4.7	59	2.8	35	7.6	23	9.2	10	12.2	4	1.7	253	4.4
Fluoroquinolones	297	11.3	194	9.2	61	13.3	39	15.6	11	13.4	6	2.6	608	10.6
Vancomycin	81	3.1	64	3.0	43	9.4	27	10.8	5	6.1	5	2.2	225	3.9
Clindamycin	29	1.1	38	1.8	12	2.6	2	0.8	1	1.2	1	0.4	83	1.4
Macrolides	41	1.6	11	0.5	13	2.8	2	0.8	0	0.0	1	0.4	68	1.2
Metronidazole	141	5.4	164	7.8	34	7.4	27	10.8	8	9.8	3	1.3	377	6.6
Penicillins	151	5.8	124	5.9	50	10.9	38	15.2	4	4.9	4	1.6	371	6.5
Others[b]	80	3.1	84	4.0	12	2.6	44	17.6	37	45.1	2	0.8	259	4.5

[a] Includes trauma, burn and gynaecology.
[b] Includes tetracycline, urinary tract agents.

Table II Distribution of all types of healthcare-associated infection (HAI) by medical unit

Medical unit	All HAIs		UTI		Pneumonia		SSI		BSI		CDAD	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
All units, $N = 5750$	667	11.6	194	3.4	175	3.1	146	2.5	93	1.6	59	1.0
Critical care, $N = 462$	153	33.2	20	4.3	72	15.6	22	4.8	34	7.4	5	1.1
Trauma and burn, $N = 97$	17	17.6	4	4.1	5	5.2	5	5.2	3	3.1	0	0.0
Transplant, $N = 82$	12	14.7	3	3.7	5	6.1	1	1.2	3	3.7	0	0.0
Surgery, $N = 2112$	247	11.7	79	3.7	39	1.9	99	4.7	13	0.6	17	0.8
Oncology—haematology, $N = 250$	28	11.2	6	2.4	7	2.8	0	0.0	9	3.6	6	2.4
Gynaecology—oncology, $N = 118$	13	11.0	5	4.2	0	0.0	4	3.4	4	3.4	0	0.0
Medicine, $N = 2619$	197	7.5	77	2.9	47	1.8	15	0.6	27	1.0	31	1.2
Other, $N = 10$	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

UTI, urinary tract infection; SSI, surgical site infections; BSI, bloodstream infections; CDAD, *Clostridium difficile*-associated diarrhoea.

(3.4%) of the patients surveyed. Pneumonia was found in 175 (3.0%) of the patients; SSI in 146 (2.5%); BSI in 93 (1.6%), and CDAD in 59 (1%) (Table II). Sixty-three (68%) of the 93 BSIs were central venous catheter-related and 69 (39%) of the 175 pneumonias were ventilator-associated. Gram-negative organisms accounted for the majority of cases of pneumonia and UTI while most SSIs and BSIs were caused by Gram-positive cocci (staphylococci and enterococci). The prevalence of HAI in critical care units was over three times higher than the prevalence on all other units combined (33.2 vs 9.7%, $P < 0.0001$). In contrast, the prevalence of HAI on medical units was half that on the other units (7.5 vs 15%, $P < 0.0001$).

In univariate analysis the following factors were associated with infection: being in a critical care unit (OR 3.6, 95% CI 2.9—4.5, $P < 0.0001$), having any indwelling device (OR 3.7, 95% CI 3.1—4.4, $P < 0.0001$), being in isolation precautions (OR 4.1, 95% CI 3.2—5.2, $P < 0.0001$), and receiving systemic antimicrobials (OR 25.3, 95% CI 18.9—34.0, $P < 0.0001$) (Table III). When compared to patients on all other units, patients on medical units were less likely to have an HAI (OR 0.5, 95% CI 0.4—0.6, $P < 0.0001$). In the multivariate logistic regression model for HAI, the following characteristics were all independently associated with HAI: extended hospital stays of more than 7 days prior to the day of the survey, having a central venous catheter, an indwelling urinary catheter or an endotracheal tube with or without mechanical ventilation (Table IV). Being in a critical care unit was not independently associated with HAI.

Discussion

This paper represents the first reported hospital-wide prevalence survey for HAI in adults hospitalised at large, university-affiliated acute-care hospitals across Canada. Since this study represents more than 85% of such hospitals, it provides a robust estimate of HAI in hospitals of this type in Canada. We found an overall prevalence of patients with HAI of 10.5%, with infections most common in patients on surgical wards. These results are in the range reported in large European multicentre prevalence surveys with their overall prevalence of HAI ranging from 4 to 10%.[2,5,9—14,16] According to these reported studies, the most common HAIs were urinary tract, lower respiratory tract and surgical site. Similar results were found in this Canadian survey with UTI being the most common HAI in 3.4% of patients followed by pneumonia (3%) and SSI (2.5%).

The present prevalence survey shows other important results. The prevalence of HAI in critical care units (33.2%) or trauma/burn units (17.6%) was much higher than the overall prevalence of HAI (11.6%), an expected finding since the severity of illness and susceptibility to HAI in such units is by definition higher than that in patients in general units. In addition, more patients in these units had multiple HAIs than patients on other units such as medicine or surgery. Neither residency on critical care units nor trauma/burn units were independently associated with HAI on multivariate logistic regression. However, the study was not designed to identify causality of associated factors or to account for severity of illness.

While not primarily designed as a survey of use of antimicrobial therapy in hospitalised patients, the results did provide an interesting snapshot of such use in adult patients in Canadian hospitals. The prevalence of patients receiving antimicrobials in our survey was very high; 36% overall and nearly half of all patients on antimicrobials received more than one systemic agent. There was significant variation in overall use as well as the distribution of

Table III Comparison of patients with and without healthcare-associated infection (HAI), $N = 5750$

Patient characteristics	Patients with HAI, $N = 601$ No. (%)	Patients without HAI, $N = 5149$ No. (%)	OR (95% CI)	*P*-value[a]
Age (years), mean ± SD	65 ± 17	65 ± 17		
Median (range)	69 (19–94)	69 (19–99)		0.40
Male gender	315 (52)	2623 (51)		0.54
Extended hospital stay over 7 days prior to onset	484 (81)	2888 (51)	3.2 (2.6–4.0)	<0.0001
Medical service				
Surgery	233 (39)	1879 (36)	1.1 (0.9–1.3)	0.27
Medicine	182 (31)	2437 (47)	0.5 (0.4–0.6)	<0.0001
Critical care	123 (20)	339 (7)	3.6 (2.9–4.5)	<0.0001
Oncology–haematology	26 (4)	224 (5)	1.0 (0.7–1.5)	0.98
Gynaecology–oncology	9 (2)	109 (2)	0.7 (0.4–1.4)	0.32
Trauma and burn	16 (3)	81 (2)	1.7 (1.0–2.9)	0.05
Transplant	12 (2)	70 (1)	1.5 (0.8–2.7)	0.21
Patients taking antimicrobials	550 (92)	1536 (30)	25.4 (18.9–34.0)	<0.0001
Patients on isolation precautions	113 (19)	277 (5)	4.1 (3.2–5.2)	<0.0001
Patients with indwelling devices				
Indwelling urinary catheter	262 (44)	991 (19)	3.2 (2.7–3.9)	<0.0001
Central venous catheter	214 (36)	682 (13)	3.6 (3.0–4.4)	<0.0001
ETT, with mechanical ventilation	94 (16)	130 (3)	7.2 (5.4–9.5)	<0.0001
ETT, without mechanical ventilation	33 (6)	67 (1)	4.4 (2.9–6.7)	<0.0001

ETT, endotracheal tube; OR, odds ratio; CI, confidence interval.
[a] Wald or Pearson's Chi-squared test where appropriate.

use of specific agents; for example carbapenem and antifungal use was heavily skewed towards critical care, haematology–oncology and transplant units, reflecting the different spectrum of HAI pathogens on these units. Aminoglycoside use in hospitalised Canadian adults was infrequent (<2% prevalence), reflecting the availability of reliably effective less toxic alternatives. Vancomycin is also relatively infrequently used currently (3.9% overall but as high as 10.8% on haematology–oncology units); however, if meticillin-resistant *Staphylococcus aureus* (MRSA) increases in frequency this is likely to change significantly in Canadian hospitals over the next decade.

There are limitations to our study, primarily inherent to large multicentre point prevalence surveys. First, although experienced and trained infection control professionals conducted data collection using standardised definitions, this remained unmonitored and there may be inconsistencies between hospitals in identifying HAIs. However, the accuracy of the method chosen for this survey can be supported by the fact that the sites of HAI and the organisms responsible for the infection have been previously reported and the prevalence rates of HAI were within the range expected for our adult patient population.[2–5,9,10,12–18] Second, patients who were previously hospitalised and readmitted may not have been identified with an HAI, therefore underestimating its true prevalence. Third, seasonal variations may have influenced the results of this survey, particularly for CDAD as this has been shown, in

Table IV Patient characteristics independently associated with a healthcare-associated infection: stepwise logistic regression model[a]

Characteristic	OR	95% CI	*P*-value
Extended hospital stay over 7 days prior to enrolment	3.2	2.6–4.0	<0.0001
Central venous catheter	1.9	1.6–2.4	<0.0001
ETT with or without mechanical ventilation	2.6	1.9–3.6	<0.0001
Indwelling urinary catheter	2.1	1.7–2.5	<0.0001

ETT, endotracheal tube; OR, odds ratio; CI, confidence interval.
[a] Adjusted for being in a medical unit or critical care unit.

previous studies, to increase over the winter months.[24] Fourth, the populations examined in this survey were in major teaching hospitals and so likely not entirely representative of all hospitalised adult patients in Canada. Severity of illness between hospitals was not evaluated and therefore our finding cannot be generalized to the general patient population in Canada.

Lastly, prevalent infections likely differ somewhat in type from incident infections. Gastmeier *et al*. have demonstrated that prevalence studies have higher rates of infection when compared to incidence rate studies.[25] However, incidence surveys are time-consuming and costly and require significant resources which hospitals can no longer afford. Prevalence surveys of HAI are valuable and low cost alternatives to incidence surveys. As the first national survey of the prevalence of HAI in adult patients in Canada, this survey provides data that can be used as baseline for future HAI prevalence studies, in Canada and elsewhere. Repeat national prevalence studies have been performed in other countries, notably in Europe.[2,4,12,14,15] Repeated prevalence surveys are a practical and efficient method for measuring trends over time. They can be used to provide data on infected and non-infected patients and can be used to access the impact of infection prevention and control programmes on HAI either hospital-wide or unit specific. National surveys also provide opportunities for inter-hospital collaboration that may lead to more standardised use of surveillance methodology, including application of definitions and case-finding methods.

Despite these limitations, the data presented in this study are an important contribution to understanding the impact of HAIs in adults admitted to Canadian hospitals. The results are sufficiently robust to be used as baseline indicators for future comparisons.

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