EM Advances

Prevalence of methicillin-resistant *Staphylococcus aureus* in skin and soft tissue infections in patients presenting to Canadian emergency departments

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ABSTRACT

Background: Community-associated methicillin-resistant *Staphylococcus aureus* (MRSA) is an increasingly common cause of skin and soft tissue infection (SSTI) worldwide. The prevalence of MRSA in SSTIs across Canada has not been well described. Studies in the United States have shown significant geographic variability in the prevalence of MRSA. This study characterizes the geographic prevalence and microbiology of MRSA in patients presenting to Canadian emergency departments with SSTIs.

Methods: Using a prospective, observational design, we enrolled patients with acute purulent SSTIs presenting to 17 hospital emergency departments and 2 community health centres (spanning 6 Canadian provinces) between July 1, 2008, and April 30, 2009. Eligible patients were those whose wound cultures grew *S. aureus*. MRSA isolates were characterized by antimicrobial susceptibility testing and pulsed-field gel electrophoresis. All patients were subjected to a structured chart audit, and patients whose wound swabs grew MRSA were contacted by telephone to gather detailed information regarding risk factors for MRSA infection, history of illness, and outcomes.

Results: Of the 1,353 *S. aureus*–positive encounters recorded, 431 (32%) grew MRSA and 922 (68%) wounds grew methicillin-susceptible *S. aureus*. We observed significant variation in both the prevalence of MRSA (11–100%) and the proportion of community-associated strains of MRSA (0–100%) across our study sites, with a significantly higher prevalence of MRSA in western Canada.

Interpretation: MRSA continues to emerge across Canada, and the prevalence of MRSA in SSTIs across Canada is variable and higher than previously expected.

RÉSUMÉ

Contexte: La présence de *Staphylococcus aureus* résistant à la méthicilline (SARM) dans la collectivité est une cause de plus en plus fréquente d'infection de la peau et des tissus mous (IPTM), partout dans le monde. On ne connaît pas très bien la prévalence de SARM dans les IPTM au Canada. Des études menées aux États-Unis ont révélé une grande disparité géographique dans la prévalence de SARM. L'étude décrite ici vise à caractériser la prévalence géographique et les éléments microbiologiques de SARM chez des patients examinés dans des services d'urgence pour des IPTM au Canada.

Méthode: Des patients souffrant d'IPTM aiguës et purulentes, examinés dans 17 services d'urgence hospitaliers et 2 centres de santé communautaires (répartis dans 8 provinces), entre le 1er juillet 2008 et le 30 avril 2009, ont été retenus pour participer à une étude d'observation prospective. Pour être admissibles, les patients devaient avoir obtenu un résultat positif à l'égard de *S. aureus* dans les cultures de prélèvement de plaie. Les isolats de SARM ont été caractérisés à l'aide des épreuves de sensibilité antimicrobienne et de l'électrophorèse sur gel en champ pulsé. Tous les patients ont été soumis à un examen structuré de leur dossier, et nous avons joint par téléphone ceux chez qui les épreuves sur écouvillon s'étaient révélées positives à

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l'égard de SARM pour obtenir davantage de renseignements sur les facteurs de risque d'infection à SARM, l'histoire de la maladie, et l'évolution.
Résultats: Sur 1,353 cultures positives à l'égard de *S. aureus*, 431 (32%) ont produit la souche SARM et 922 (68%) une souche sensible à la méthicilline. Nous avons noté des écarts importants quant à la prévalence de SARM (11–100%) et à la proportion de souches de SARM présentes dans la collectivité (0–100%), entre les différents centres ayant participé à l'étude; une prévalence significativement plus élevée de SARM a été relevée dans l'Ouest canadien.
Interprétation: SARM continue de croître partout au Canada, et la prévalence des IPTM à SARM varie beaucoup au pays et elle est plus élevée que prévu.

Keywords: community-associated methicillin-resistant *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus*, skin infection, soft tissue infection, *Staphylococcus aureus*

Methicillin-resistant *Staphylococcus aureus* (MRSA) has emerged as a major hospital-related pathogen over the past several decades[1–5] and contributes to hospitalized patient morbidity and mortality.[6,7] In more recent years, it has emerged as a pathogen in community settings.[8] Epidemiologically, community-associated MRSA (CA-MRSA) infections may be defined as occurring in individuals in the community who have not had recent exposure to the health care system or in patients in health care facilities in whom infection was present or incubating at the time of admission.[8]

Microbiologically, CA-MRSA infections have been demonstrated to be caused predominantly by the Canadian MRSA-10/USA300 clone and to a lesser extent by the Canadian MRSA-7/USA400 clone. Some authors have, therefore, used the term CA-MRSA to connote specific MRSA strain types.[8] CA-MRSA strains typically carry the staphylococcal chromosomal cassette *mec* (SCC*mec*) type IV or V resistance determinant conferring methicillin resistance, the Panton-Valentine leukocidin (*PVL*) genetic determinant and are more susceptible to non-β-lactam antibiotics than hospital-associated strains.[9–11]

Risk factors for CA-MRSA, derived from early outbreak reports,[12–20] are notably different from risk factors for health care–associated MRSA (HA-MRSA).[5] Although early outbreak reports of CA-MRSA were generally confined to specific populations, CA-MRSA has now established itself in the United States and other jurisdictions[21] as the predominant pathogen causing purulent skin and soft tissue infections (SSTIs).[14,22,23] Additionally, in the United States, wide geographic variation in the prevalence of MRSA in SSTIs has been observed, with ranges reported between 15 and 74%.[22] Canada has largely lagged behind other parts of the world in CA-MRSA emergence, but reports of localized outbreaks and rising prevalence of MRSA in community settings across Canada are mounting.[24–26] These studies have also demonstrated wide geographic variation. The purpose of the present study was to determine the geographic prevalence, associated risk factors, microbiologic characteristics, and treatment outcomes of CA-MRSA in patients presenting to emergency departments (EDs) across Canada with purulent SSTIs.

METHODS

Study population

This study was conducted between July 1, 2008, and April 30, 2009 in the EDs of 17 hospitals and 2 community health care clinics in 6 Canadian provinces. These sites serve a cross section of patient populations, including the urban, rural, academic, and community sites serving both adult and pediatric populations, and are representative of the hospitals that most Canadians have access to. A map detailing the location of study sites is shown in Figure 1.

All patients presenting with SSTIs were informed that they may be contacted to participate in the study if eligible. Study information posters, brochures containing investigator contact information, and an option to decline participation were placed at each site.

Patient enrolment

Emergency physicians managed patients with purulent SSTIs according to their usual practice during the study period and were asked to swab the single largest area of infection in each patient presenting with a purulent SSTI. Patients whose wound swab grew *S. aureus* were eligible for inclusion.

Data collection

Trained study staff performed a structured standardized chart audit on all eligible patients (Appendix 2).

Figure 1. Map of methicillin-resistant *Staphylococcus aureus* study site locations.

They attempted to contact patients whose wound swabs grew MRSA to undertake a structured standardized telephone interview (Appendix 3). Both data collection tools were intended to collect basic demographic information and select information regarding previously identified MRSA risk factors.[12–20] Patients with laboratory-confirmed MRSA were contacted approximately 2 weeks following their ED visit. Trained interviewers made three attempts to reach each patient on different days and at different times, including evenings and weekends. Data were collected on demographics, clinical presentation, defined CA- and HA-MRSA risk factors, treatment, and outcomes. Patients were also asked about advice received regarding transmission prevention strategies. Interviewers were blinded to the patients' MRSA strain type.

This study was approved by the research ethics board at each participating site.

Laboratory methods

Participating laboratories identified *S. aureus* from wound specimens and determined methicillin susceptibility using standard methods. MRSA isolates were then forwarded to a central laboratory for batch reference susceptibility testing by broth microdilution.[27,28] Published interpretive criteria were used to determine the susceptibility of fusidic acid and mupirocin as Clinical Laboratory Standards Institute (CLSI) breakpoints have not been established.[29,30] Inducible clindamycin resistance was tested by double disk diffusion in accordance with the CLSI.[28]

Pulsed-field gel electrophoresis was performed using the Canadian standardized *S. aureus* protocol and classified by Canadian MRSA epidemic strain nomenclature, as previously described.[31] MRSA isolates were also tested at a reference laboratory for the presence of

PVL and SCC*mec* typing by previously defined methods.[32,33]

Statistical analysis

Data were managed using *EpiData* version 3.1 (The EpiData Association, Odense Denmark) and analyzed using *SAS* statistical software version 9.1 (SAS Institute Inc., Cary, NC). Descriptive statistics were used to describe patient characteristics and the prevalence of MRSA in the study population (by hospital site and by province), as well as the proportion of CA-MRSA strains as a percentage of all subtyped MRSA isolates. Demographics were compared between patients grouped by methicillin susceptibility (methicillin-susceptible *Staphylococcus aureus* [MSSA] compared to MRSA) and MRSA strain type (CA-MRSA compared to other MRSA strains) using the chi-square test, Fisher exact test, and Student *t*-test as appropriate. Risk factor frequencies were compared between patients grouped by MRSA strain type using the chi-square or Fisher exact test as appropriate. We defined a direct health care–related risk factor as any one of the following: health care worker/volunteer, hospitalized overnight or resident of a long-term care facility in the previous year, received dialysis in the previous year, had a urinary catheter or intravenous line in the previous year, or had surgery in the previous year. An indirect health care–related risk factor was defined as any one of the following: household/family member/close personal contact hospitalized overnight in previous year, had regular contact with anyone who is a health care worker/volunteer, lives/works in a nursing home, is/was receiving dialysis, or has/had a catheter/feeding tube/intravenous line.

Community risk factors included any of the following: lives/worked in a retirement home, home for the disabled, shelter, military barracks, correctional facility, or other group setting in the previous year; had regular contact with someone who lives/works in any of the above-listed group settings, or contact with someone who uses intravenous or inhaled drugs, or is HIV positive; is a member of the gay/lesbian/bisexual community; participation in group or contact sports; or has used illicit intravenous drugs in previous year. Confidence intervals and p values were derived based on a 5% significance level, and all tests were two-sided. Susceptibilities of MRSA isolates against various antibiotics were compared between patients grouped by MRSA strain type (CA-MRSA compared to other MRSA strains). CA-MRSA strains refer to CMRSA-7 and CMRSA-10 by pulsed field gel electrophoresis pattern.

RESULTS

A total of 1,353 *S. aureus*–positive encounters were included, comprising 922 (68%) MSSA and 431 (32%) MRSA purulent SSTIs. Figure 2 details patient enrolment and study design. There was a significant variation in the prevalence of MRSA across study sites (range 11–100%) as well as the proportion of CA-MRSA strain isolates (CMRSA-7/CMRSA-10) as a percentage of all subtyped MRSA isolates (range 0–100%; Table 1).

There was significant geographic variation in the prevalence of MRSA between regions (Table 2), with significantly higher ($p < 0.001$) rates in the western Canadian provinces of Alberta and British Columbia (combined prevalence = 49%, 95% CI 43–54), compared to other provinces (combined prevalence for Ontario, Nova Scotia, Manitoba, and Quebec = 26%, 95% CI 24–29).

CMRSA-10 was the most frequently encountered clone (Table 3), accounting for 304 of 422 (72%) typeable MRSA isolates. The prevalence of the CMRSA-7/CMRSA-10 clones was significantly ($p < 0.001$) higher in British Columbia, Alberta, Manitoba, and Quebec (combined prevalence = 90%, 95% CI 86–94) compared to Ontario and Nova Scotia (combined prevalence = 64%, 95% CI 57–70, data not shown). Manitoba had the highest percentage of CA-MRSA strains that were CMRSA-7 (40%) compared to other provinces combined (4%, $p < 0.001$, data not shown).

Comparison of the age and sex distributions of eligible patients with SSTIs caused by MSSA, MRSA, and CA-MRSA strains (Table 4) demonstrates that patients with CA-MRSA strains were more likely to be male and younger than other strains of MRSA. We analyzed known risk factors for MRSA colonization/infection among those patients who were reached for interview (Table 5). Having a direct health care–related risk factor ($p = 0.018$) or having known exposure to MRSA ($p = 0.022$) was significantly associated with non-CA-MRSA strains. Conversely, reporting a community risk factor was significantly associated ($p < 0.001$) with infections caused by

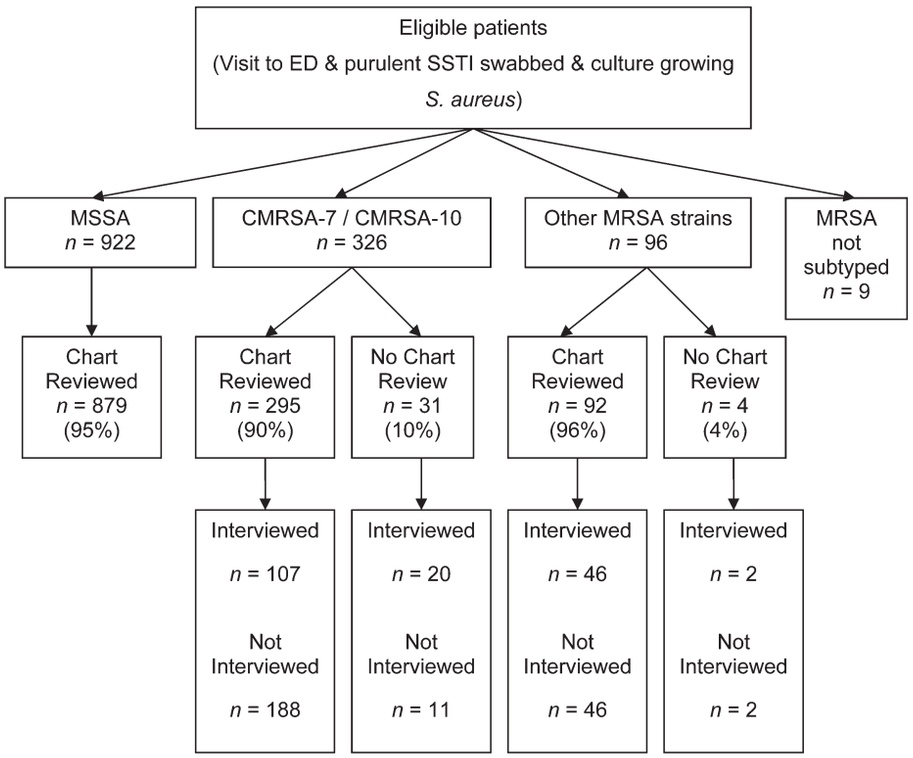

Figure 2. Flow diagram detailing patient enrolment. ED = emergency department; MRSA = methicillin-resistant *Staphylococcus aureus*; MSSA = methicillin-susceptible *Staphylococcus aureus*; SSTI = skin and soft tissue infection.

Table 1. Prevalence of MSSA, MRSA, and CMRSA-7/CMRSA-10 among staphylococcal purulent skin and soft tissue infections by study site

	MRSA		CMRSA-7/CMRSA-10		MSSA		
Study site number	*n*	*S. aureus* that were MRSA (%)	*n*	Subtyped MRSA* that were CMRSA-7/CMRSA-10 (%)	*n*	*S. aureus* that were MSSA (%)	Total swabs collected (*n*)
1	17	26	11	65	49	74	66
2	6	30	4	67	14	70	20
3	9	23	8	100*	30	77	39
4	19	19	17	94*	81	81	100
5	30	30	23	77	70	70	100
6	20	26	8	40	56	74	76
7	26	26	14	54	73	74	99
8	35	36	26	74	63	64	98
9	15	17	5	33	75	83	90
10	5	11	0	0	42	89	47
11	9	15	2	22	52	85	61
12	46	46	37	90*	55	54	101
13	29	25	25	89*	87	75	116
14	36	37	31	89*	61	63	97
15	6	100	6	100	0	0	6
16	5	71	3	60	2	29	7
17	46	46	43	93	55	54	101
18	29	91	24	83	3	9	32
19	43	44	39	91	54	56	97
Total	431	32	326	77*	922	68	1,353

MRSA = methicillin-resistant *Staphylococcus aureus*; MSSA = methicillin-susceptible *Staphylococcus aureus*.
*Nine MRSA isolates were not sent to the central reference laboratory in Toronto for subtyping. The percentages of MRSA that were CMRSA-7/CMRSA-10 for each study site are based on subtyped MRSA isolates.

Table 2. Prevalence of MRSA among staphylococcal purulent skin and soft tissue infections by Canadian province

Province	MRSA (*n*)	*S. aureus* that were MRSA (%)	Total *S. aureus* (*n*)	95% CI
Alberta	122	50	243	43.9–56.5
British Columbia	43	44	97	34.4–54.2
Ontario	186	28	672	24.3–31.1
Nova Scotia	23	27	86	17.4–36.1
Manitoba	29	25	116	17.1–32.9
Quebec	28	20	139	13.5–26.8
Total	431	32	1353	29.4–34.3

MRSA = methicillin-resistant *Staphylococcus aureus*.

CA-MRSA strains. We did not identify any specific clinical or epidemiologic risk factors associated with a particular MRSA phenotype at the time of ED presentation. Infections in patients with a history of skin break were significantly less likely ($p < 0.001$) to have been caused by CA-MRSA strains.

Only 2% of patients were treated with incision and drainage alone. Sixty percent of the MRSA patients in our study were treated with incision and drainage plus antibiotics, and 35% received antibiotics alone. Patients with CA-MRSA (65%) compared to other MRSA strains (44%) were significantly ($p < 0.001$) more likely to have been treated with the combination of antibiotics and incision and drainage compared to other MRSA strains. Despite having been treated with antibiotics that were not concordant with the responsible strain susceptibility profile, 94% (95% CI 89–98) and 88% (95% CI 78–97) of those with CA-MRSA and other MRSA strains, respectively, had resolved or improved their symptoms by the time they were contacted by telephone (data not shown). Only 32% of respondents recalled receiving advice regarding limiting the spread of bacterial pathogens associated with SSTIs.

Table 3. Prevalence of MRSA among staphylococcal purulent skin and soft tissue infections by MRSA strain type

PFGE strain	%	Patients (*n*)
CMRSA-10	72	304
CMRSA-2/USA100	10	40
CMRSA-7	5	22
USA1100	3	14
CMRSA-5	1	6
CMRSA-3/6	1	5
CMRSA-8	1	5
Other MRSA strains	6	26
Total	100	422

MRSA = methicillin-resistant *Staphylococcus aureus*; PFGE = pulsed field gel electrophoresis

Table 6 details the antibiotic susceptibilities for all MRSA isolates from our cohort, comparing CA-MRSA to all other MRSA types. With the notable exceptions of erythromycin and ciprofloxacin, CA-MRSA isolates were more susceptible to a greater number of antibiotics.

DISCUSSION

This is the first cross-Canadian study to delineate the prevalence of MRSA infection in patients presenting with purulent SSTIs to Canadian EDs. The overall MRSA prevalence of 32% in this setting is higher than anticipated. The wide variation in the prevalence of MRSA across sites, however, demonstrates that CA-MRSA does not emerge in a uniform fashion. Our observation of 44% and 50% prevalence of MRSA in SSTIs in British Columbia and Alberta, respectively, confirms a significantly higher rate of infection in western Canada than in other regions. Although the reason for these significant geographic variations in the prevalence of MRSA remains unclear, similar results have been described in the United States.[22] In this study, the CMRSA-7/CMRSA-10 strains (equivalent to USA400/USA300) accounted for 77% of our MRSA isolates overall. Interestingly, the highest prevalence of CMRSA-7/CMRSA-10 strains was observed in the western regions of Canada, where MRSA was most prevalent overall, reinforcing previous observations and suggesting that CMRSA-7/CMRSA-10 may have increased fitness or virulence.[15,16]

Although our study reaffirms previous epidemiologic data regarding features more commonly associated with community acquisition of MRSA infection (patients are more likely to be male and younger and have typical community- as opposed to health

Table 4. Comparison of age and sex distributions among eligible patients with purulent skin and soft tissue infections caused by MSSA, MRSA, and the prototypical community-associated MRSA strains (CMRSA-7/CMRSA-10)

	Patients, *n* (%)			Patients, *n* (%)		
Demographics	MSSA (*n* = 879*)	MRSA (*n* = 409†)	*p* value‡	CMRSA-7/CMRSA-10 (*n* = 315)	Other MRSA strains (*n* = 94)	*p* value‡
Male	487 (55)	258 (63)	0.009	208 (66)	50 (53)	0.028
Age group, yr§			< 0.001			< 0.001
0–4	49 (6)	9 (2)		9 (3)	0 (0)	
5–19	86 (10)	39 (11)		31 (11)	8 (9)	
20–39	229 (27)	134 (36)		113 (41)	21 (23)	
40–59	267 (32)	133 (36)		113 (41)	20 (22)	
≥ 60	207 (25)	53 (14)		11 (4)	42 (46)	
Mean age, yr (SD)	44 (23.5)	41 (20.0)	0.052	36 (15.6)	55 (24.9)	< 0.001

MRSA = methicillin-resistant *Staphylococcus aureus*; MSSA = methicillin-susceptible *Staphylococcus aureus*.
*MSSA data based on isolates with corresponding chart reviews. Chart reviews were not performed for 43 MSSA patients.
†MRSA data based on subtyped isolates with corresponding chart reviews and/or interviews.
‡Fisher exact test for a difference among multiple proportions.
§Dates of birth not available for 41 MSSA and 41 MRSA patients.

care–related risk factors), as with previous studies,[34] we were not able to identify any particular clinical or epidemiologic feature or risk factor significantly associated with the methicillin-resistant phenotype at the initial ED visit. This reinforces the central role for ongoing MRSA surveillance prevalence data to inform local diagnostic and therapeutic algorithms, particularly in those settings where CA-MRSA strains have not become endemic. This study did not seek to delineate all bacterial causes of SSTI as previously published evidence spanning years both before and after MRSA emergence has demonstrated that *S. aureus* accounts for the majority of SSTIs.[22,34,35]

At present, there is no Canada-wide public health surveillance system for MRSA infections in community or ED settings, although data on inpatient/hospital-acquired MRSA in Canada have been available from several sources. The Canadian Nosocomial Infection Surveillance Program (CNISP), sponsored by Health Canada in collaboration with the Association of Medical Microbiology and Infectious Diseases (AMMI), provides invaluable insight into MRSA

Table 5. Comparison of risk factors among enrolled patients with purulent skin and soft tissue infections caused by MRSA and the prototypical community-associated MRSA strains (CMRSA-7/CMRSA-10), interviewed patients only

	Patients, *n* (%)		
Risk factor	CMRSA-7/CMRSA-10 (*n* = 127)	Other MRSA strains (*n* = 48)	*p* value*
Antibiotics in previous 3 mo	24 (19)	13 (27)	0.299
Known exposure to MRSA†	21 (17)	16 (33)	0.022
Direct health care–related risk factor‡	56 (44)	31 (65)	0.018
Indirect health care–related risk factor§	63 (50)	29 (60)	0.236
Community risk factor‖	77 (61)	14 (29)	< 0.001
Travel to United States in previous year	21 (17)	5 (10)	0.353
Chronic skin condition	28 (22)	12 (25)	0.690

MRSA = methicillin-resistant *Staphylococcus aureus*.
*Chi-square test or, where cell count < 5, Fisher exact 2 × 2 test for a difference in proportions.
†Known exposure to MRSA: patient or household/family member with a history of MRSA colonization or infection.
‡Direct health care–related risk factor included any one of the following: health care worker/volunteer; hospitalized overnight or resident of a long-term care facility in previous year; received dialysis in the previous year; had a urinary catheter or intravenous line in the previous year; had surgery in the previous year.
§Indirect health care–related risk factor included any one of the following: household or family member or close personal contact hospitalized overnight in previous year; had regular contact with anyone who is a health care worker/volunteer, lives or works in a nursing home, is/was receiving dialysis, or has/had a catheter, feeding tube, or intravenous line.
‖Community risk factor included any one of the following: lived or worked in a retirement home, home for the disabled, shelter, military barracks, correctional facility, or other group setting in the previous year; had regular contact with someone who lives/works in a home for the disabled, in shelter, is homeless, in military barracks, in correctional facility, uses intravenous or inhaled drugs, or is HIV positive; is a member of the gay/lesbian/bisexual community; participation in group or contact sports; or has used illicit intravenous drugs (including inhaling illicit drugs through the nose) in the previous year; (Other group settings reported by patients with MRSA included rehabilitation centre, recreational and educational facilities, centres for the disabled, and subsidized housing.)

Table 6. Comparison of susceptibilities of MRSA isolates: CMRSA-7/CMRSA-10 (prototypical community-associated MRSA strains) versus other MRSA strains

	Susceptible, *n* (%)	
Antibiotic	CMRSA-7/CMRSA-10 (*N* = 326)	Other MRSA strains (*N* = 96)
Vancomycin	326 (100)	96 (100)
Erythromycin	34 (10.4)	34 (35.4)
Clindamycin	269 (82.5)	34 (35.4)
Mechanism of resistance		
cMLS	53	38
iMLS	4	24
msrA	235	1
Erythromycin susceptible	34	33
Tetracycline	322 (98.8)	84 (87.5)
Mupirocin	303 (92.9)	83 (86.5)
HLR	23	4
LLR		9
Rifampin	324 (99.4)	95 (99.0)
Ciprofloxacin	61 (18.7)	36 (37.5)
Gentamicin	316 (96.9)	82 (85.4)
Trimethoprim/ sulfamethoxazole	326 (100)	87 (90.6)
Linezolid	326 (100)	96 (100)
Tigecycline*	326 (100)	96 (100)

cMLS = constitutive macrolide-lincosamide-streptogramin resistance; HLR = high level resistance; iMLS = induceable macrolide-lincosamide-streptogramin resistance; LLR = low level resistance; MRSA = methicillin-resistant *Staphylococcus aureus*; msrA = methionine sulfoxide reductase A gene.
*US Food and Drug Administration breakpoints were used to interpret tigecycline susceptibility.

infection/colonization, but these data are limited to admitted patients and nosocomial infections in participating Canadian hospitals.

Previously published Canadian data on CA-MRSA infections have largely been limited to local outbreaks[12,24,36,37] and/or local laboratory surveillance data.[25,38–40] Our network previously described a multicentre pilot surveillance study at seven Greater Toronto Area hospitals in 2007[25] and noted a MRSA prevalence of 19% in 299 patients presenting to the ED with purulent SSTI in 2007. Of these 58 MRSA isolates, 29 (50%) were caused by the CMRSA-10 clone and none were caused by the CMRSA-7 clone. Two recent studies conducted in western Canada suggest higher rates of MRSA in SSTIs than in central Ontario. In two single-centre studies, Stenstrom and colleagues and Weibe found MRSA prevalence rates of 55% and 74%, respectively, in SSTIs undergoing surgical drainage in their EDs.[24,26]

Currently available evidence suggests that there is no consensus regarding which patients with SSTIs require antimicrobial therapy. Many studies have demonstrated no difference in treatment outcomes irrespective of whether or not patients were treated with antibiotics active against the cultured organism,[22,35,41–43] a finding that appears valid for patients with both MSSA and MRSA infections. The optimal treatment of MRSA remains to be determined. In our study, approximately half (65% of CMRSA-7/CMRSA-10, 44% of other MRSAs) were treated with incision and drainage plus antibiotics. A significant proportion of those undergoing incision and drainage received two or more different classes of antibiotics. A large proportion of MRSA-infected individuals in our study (40%) were treated with antibiotics alone. Despite the antibiotic having no activity against the causative pathogen in most cases, overall outcomes 2 weeks later were very good (94% for CMRSA-7/CMRSA-10, 88% for other MRSA), in keeping with previous studies.

The inability to determine which infections are most likely to be caused by MRSA at the time of presentation and the fact that most infections appear to improve if incised and drained regardless of which antibiotic patients are placed on suggest that significant additional study is required to determine the optimal management of SSTIs in general and MRSA infections specifically.

STUDY LIMITATIONS

Our study was conducted at Canadian hospitals with infrastructure able to support the study; therefore, our results may not be generalizable to smaller rural hospitals. However, our study was based on recruitment of patients, identified by the provision of routine emergency care, by emergency physicians who were encouraged to swab all purulent SSTIs. Our study methodology did not allow us to identify consecutive patients or ensure that every patient with a purulent wound was swabbed and as such may be subjected to some selection bias. A chart audit conducted at one participating hospital determined that 90% of patients with SSTIs were swabbed appropriately, but we did not systematically audit all hospital ED visits for SSTIs during the study period. Our data collection was limited to clinical information available on the chart and provided telephone interviews in the subset of patients consenting, which

may have introduced some bias. We did not attempt to determine the cause of all SSTIs swabbed in the study as previous reports have already demonstrated that approximately 70% of SSTIs are caused by *S. aureus* species.

SUMMARY AND CONCLUSIONS

This study is the first to document the prevalence of MRSA in purulent SSTIs presenting to EDs across Canada. An overall MRSA prevalence rate of 32% in patients presenting with SSTIs will likely be surprising to ED and family physicians across the country. Our findings highlight the need for ongoing surveillance of community-based MRSA infection rates and to address the many questions surrounding the identification of the most appropriate treatment of MRSA SSTIs.

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APPENDIX 1: COMPLETE LIST OF CONTRIBUTING MEMBERS OF THE EMERGENT WORKING GROUP

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APPENDIX 2: CHART REVIEW DOCUMENTATION FORM, CANADIAN EMERGENCY DEPARTMENT STUDY FOR COMMUNITY-ASSOCIATED METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* (CA-MRSA)

Site number: _____ Study ID _____
Date of chart review: _____ Reviewer name: _____

Note to reviewer: Once chart review is complete, compare data to that collected by patient interview. The question numbers on this form correspond to those in the interview tool. Please double check charts if there are any discrepancies and indicate discrepancies on this form with a large asterisk (*).

A. Demographics I - For all patients with MSSA and MRSA

Address: ☐1 Private residence →A.2) First three digits of postal code? ___ ___ ___
☐2 Nursing home
☐3 Retirement home
☐4 Home for the disabled
☐5 Homeless shelter
☐6 Military barracks or camp
☐7 Correctional facility
☐8 Other group setting → Specify: _____
☐9 No fixed address

☐ Not documented

A.3) Date of birth: _____ (dd/mm/yyyy)

A.4) Sex:☐$_1$ Male☐$_2$ Female

B. Clinical information: For all patients with MSSA and MRSA

Date of visit to emergency department: _____ (dd/mm/yyyy)

Purulent infection: ☐$_0$ No ☐$_1$ Yes ☐ Not documented

B.4) Site of infection: ☐ Head/neck ☐ Torso ☐ Arm ☐ Groin/perineum/buttocks
☐ Leg ☐ Hand ☐ Foot ☐ Not documented

B.3a) Skin break/injury: ☐$_0$ No ☐$_1$ Yes ☐ Not documented

B.3b) Type of skin break/injury:

☐$_1$ Accidental cut, scrape or other abrasion
☐$_2$ Chronic wound (e.g., decubitus ulcer, diabetic foot ulcer, pressure sore)
☐$_3$ Possible insect or spider bite
☐$_4$ Animal or human bite
☐$_5$ Burn
☐$_6$ Tattoo
☐$_7$ Needlestick
☐$_8$ Surgical wound →Specify procedure: _____
Date of procedure: _____(dd/mm/yyyy)
☐$_9$ Pimple
☐$_{10}$ Other → specify: _____
☐ Not documented

C.20a) Antibiotic use in 3 months before infection: ☐$_0$ No ☐$_1$ Yes ☐ Not documented

C.20b)Antibiotics: _____

B. Clinical information: MRSA-positive patients only

Date infection first noted: _____ (dd/mm/yyyy)

B.2) No. days between onset & ED visit: _____ *(no. of days)*

B.5a) Pain due to infection: ☐$_0$ No ☐$_1$ Yes ☐ Not documented

B.6) Fever due to infection: ☐$_0$ No ☐$_1$ Yes ☐ Not documented

B.7a) Physician visit before ED visit? ☐$_0$ No ☐$_1$ Yes ☐ Not documented

B.8a) Patient ever admitted for this infection: ☐$_0$ No ☐$_1$ Yes ☐ Not documented

B.8b) Admit date: _____ (dd/mm/yyyy)

B.8c) Discharge date: _____ (dd/mm/yyyy)

B.9b) Incised and drained infection in ED: ☐$_0$ No ☐$_1$ Yes ☐ Not documented

B.10a) Antibiotics for this infection: ☐$_0$ No ☐$_1$ Yes ☐ Not documented

Complete table for all documented antibiotics for treatment of this infection. Include those prescribed at previous physician visits if it is clear that they were prescribed to treat the skin infection.

Antibiotic name	Oral	IV	Start date (dd/mm/yyyy)	Stop date (dd/mm/yyyy)
	☐	☐		
	☐	☐		
	☐	☐		

B.13a) Medical complications as a result of skin infection: ☐$_0$ No ☐$_1$ Yes ☐ Not documented

B.13b) Specify complications: ☐$_1$ Bacteremia ☐$_2$ Other: _____

C. Potential risk factors

C.1a) Previously MRSA positive: ☐$_0$ No ☐$_1$ Yes ☐ Not documented

C.1b) Similar skin infection in past: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.2a) MRSA-positive family/household/close contact: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.2b) Relationship to MRSA positive contact: ☐$_1$ Spouse/partner ☐$_2$ Parent
☐$_3$ Child ☐$_4$ Sibling
☐$_5$ Other → specify: _____
C.4a) Health care worker or volunteer: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.5a) Admitted to hospital in past year? ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.5c) When last discharged: _____ (dd/mm/yyyy)
Attends daycare: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.11) Participates in group or contact sports: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
Specify: _____
C.12a) Traveled outside Canada in the past year: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
Specify: ☐$_1$ USA ☐$_2$ Other: _____
C.13a) Chronic skin condition: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
Specify: _____
C.13b) HIV: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.14) Dialysis in the last year: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.15) Urinary catheter in last year: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.16) Intravenous line in last year: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.17a) Illicit drug use in last year: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.18) Gay/lesbian/bisexual: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
C.19a) Surgery in past year: ☐$_0$ No ☐$_1$ Yes ☐ Not documented
b) Specify procedure: _____

APPENDIX 3: TELEPHONE INTERVIEW TOOL, CANADIAN EMERGENCY DEPARTMENT STUDY FOR COMMUNITY-ASSOCIATED METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* (CA-MRSA)

Site number _____ Study ID: _____
Date of interview: _____ Interviewer name: _____

SECTION I: INTRODUCTION

I.1) Hello, I'm calling on behalf of <*hospital name*>, may I please speak to <*patient name*>?
Yes – speaking/I'll go get them *(go to I.2a)*
No Is there a better time to reach him/her? *(record)*

I.2a) Hi. My name is <*interviewer name*> and I'm calling on behalf of <*hospital name*>.

We are contacting patients who came to the hospital's emergency department with skin infections. A group of doctors and nurses at this hospital and hospitals across Canada are conducting a study to better understand how to prevent and treat these infections. Did you receive a pamphlet from the nurse about this study while you were in the emergency department?
Yes
No

I.2b) May I tell you more about the study now?
Yes
No – later Is there a better time to call? *(record)*
No – never Okay, thank you for your time. Goodbye.

I.2c) Like other types of infections, skin infections are now sometimes caused by bacteria that are resistant to the antibiotics that are usually used to treat them. One such bacterium is called methicillin-resistant *Staphylococcus aureus*. MRSA is a bacterium that can live in the nose, on the skin, or other parts of the body without causing any harm, but sometimes these bacteria can cause skin infections.

I am calling you today because the sample taken at the hospital from your wound grew these bacteria (MRSA). In this study, we are trying to help doctors in emergency departments know which patients are likely to have infections due to the resistant bacteria and find out which treatments work best so that we can learn how to prevent and treat these infections in the future. Participating in this study will involve spending about 20 minutes on the telephone with me answering some questions about yourself and your infection.

Your participation is voluntary. Your answers are confidential and will only be seen by the study personnel. I ask the same questions of everyone that I interview. You can refuse to answer any question at any time. The information that you provide will be used for this study only. No names or personal identifiers will be attached to the information collected. Your answers will not affect any health services available to you.

Do you have any questions or concerns about the survey?

Yes *(answer questions)*

No

I.3) Are you willing to complete the survey with me now?

Yes *Begin interview*

No – later Is there a better time to call? *(record)*

No – never/refused Okay, thank you for your time. Goodbye.

Telephone Call Log

Attempt	Weekday Date & Time	Weekend Date & Time	Outcome: C = completed, I = invalid number, R = refused, D = deceased, Other—please specify	Callback Date & Time
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

SECTION II: INTERVIEW

Please answer the questions as best you can. If a question does not make sense to you, please feel free to stop and ask me questions at any time.

A. Demographics I

I'd like to begin by asking you some questions about yourself and your infection.

A.2) Please tell me, what are the first three digits of your postal code? ___ ___ ___ *(record 3 digits only)*

A.3) What is your date of birth? _____ (dd/mm/yyyy)

A.4) And you are *(read options)*: ☐$_1$ Male ☐$_2$ Female

A.5) What is your occupation *(do not read options)*?

☐$_1$ Daycare attendee

☐$_2$ Student

☐$_3$ Unemployed

☐$_4$ Volunteer _____

☐$_5$ Employed _____

A.6a) *If proxy respondent…* What is your relationship to <*patient name*>?

☐$_1$ Mother

☐$_2$ Father
☐$_3$ Guardian
☐$_4$ Spouse
☐$_5$ Daughter/Son
☐$_6$ Other specify: _____

A.6b) *Interviewer record reason proxy required:*
☐$_1$ Patient deceased
☐$_2$ Patient requested proxy due to language barrier
☐$_3$ Other → specify: _____

B. Clinical Information

I have from the laboratory records that you came to the emergency department on _____.
<*specimen collection date, state day of week*>

B.1a) Does this sound right to you? *Prompt:* It may help you remember if you refer to your agenda or calendar. Feel free to take a moment to find that now.
☐$_0$ No
☐$_1$ Yes *(go to B.2)*

B.1b) Okay, can you tell me when you visited the emergency department? _____ (dd/mm/yyyy)

B.2) How long did you have the infection before you visited our emergency department? _____ *(no. of days)*

B.3a) Did you have a skin break or injury that you think might have started this infection (e.g., a cut, burn, bite, tattoo or needlestick injury)?
☐$_0$ No *(go to B.4)*
☐$_1$ Yes
☐$_2$ Don't know/refused *(go to B.4)*

B.3b) What type of skin break or injury *(do not read list; check one)*?
☐$_1$ Accidental cut, scrape, or other abrasion
☐$_2$ Chronic wound (e.g., decubitus ulcer, diabetic foot ulcer, pressure sore)
☐$_3$ Possible insect or spider bite
☐$_4$ Animal or human bite
☐$_5$ Burn
☐$_6$ Tattoo
☐$_7$ Needlestick
☐$_8$ Surgical wound → Specify procedure: _____
Date of procedure: _____(dd/mm/yyyy)
☐$_9$ Pimple
☐$_{10}$ Other → specify: _____

B.4) Where was the skin infection located on your body? *(do not read list, check all that apply)*
☐ Head/neck ☐ Torso ☐ Groin/perineum/buttocks
☐ Arm ☐ Leg ☐ Hand
☐ Foot

Prompt: Were any other areas of your body affected?

B.5a) Was the infection painful? ☐$_0$ No *(go to B.6)*
☐$_1$ Yes
☐$_2$ Don't know/refused *(go to B.6)*

B.5b) How painful was the infection? Would you say the pain was *(read options)*:
☐$_1$ Mild
☐$_2$ Moderate
☐$_3$ Severe

Note: Indicate most severe pain that the patient reports experiencing.

B.6) Did you have a fever at any time because of this infection?

☐$_0$ No
☐$_1$ Yes
☐$_2$ Don't know/refused

B.7a) Did you see a doctor about the infection before you came to our emergency department?

☐$_0$ No
☐$_1$ Yes
☐$_2$ Don't know/refused

B.7b) Have you seen a doctor for your infection since you left our emergency department?

☐$_0$ No
☐$_1$ Yes *(include doctors seen if patient was subsequently admitted)*
☐$_2$ Don't know/refused

B.8a) Were you ever admitted to a hospital overnight as a result of this infection? By admitted, I mean did you move from the emergency department to stay overnight on another unit in the hospital?

☐$_0$ No *(go to B.9a)*
☐$_1$ Yes
☐$_2$ Don't know/refused *(go to B.9a)*

B.8b) When were you admitted to hospital? _____
(dd/mm/yyyy)
☐ Still in hospital

B.8c) When were you discharged from hospital?_____
(dd/mm/yyyy)

B.9a) Did a doctor or nurse ever remove any tissue from or drain fluid from the skin infection? This does not include the swabs that the doctor or nurse took to test what type of infection you had.

☐$_0$ No *(go to B.10a)*
☐$_1$ Yes
☐$_2$ Don't know/refused *(go to B.10a)*

B.9b) When was tissue or fluid removed from the skin infection? Was it on your visit to our emergency department or at some other time?

☐$_1$ Emergency visit
☐$_2$ Other time → when_____ (dd/mm/yyyy)

B.10a) Did you ever receive antibiotics for this infection?

☐$_0$ No *(go to B.11)*
☐$_1$ Yes
☐$_2$ Don't know/refused *(go to B.11)*

Complete table below based on the following questions.

B.10b) Do you remember the name of the antibiotics you took for the skin infection?
Prompt: If you have a pill bottle at home, please feel free to take a moment to go get it.

B.10c) Were they given to you orally or intravenously?

B.10d) When did you start taking antibiotics for this infection?

B.10e) When did you finish taking antibiotics for this infection?

Antibiotic name	Oral	IV	Start date (dd/mm/yyyy)	Stop date (dd/mm/yyyy)	Still taking antibiotic
	☐	☐			☐
	☐	☐			☐
	☐	☐			☐

B.10f) Did you have any trouble taking the antibiotics? ☐$_0$ No *(go to B.11)*
☐$_1$ Yes
☐$_2$ Don't know/refused *(go to B.11)*

B.10g) Can you tell me about these difficulties *(do not read options; check all that apply)*:
☐$_1$ Forget
☐$_2$ Other specify: _____

B.11) How is your infection now? Do you feel it is *(read options)*:
☐$_1$ Resolved
☐$_2$ Improved
☐$_3$ Unchanged
☐$_4$ Worse
☐$_5$ Other → specify: _____

B.12a) Did a doctor or nurse in our emergency department give you advice about preventing the spread of skin infections to other people?
☐$_0$ No *(go to B.13a)*
☐$_1$ Yes
☐$_2$ Don't know/refused *(go to B.13a)*

B.12b) Can you remember what advice they gave you *(do not read options; check all that apply)*:
☐ Practice frequent hand hygiene
☐ Encourage contacts to practice frequent hand hygiene
☐ Cover wound
☐ Don't share personal items (towels, razors, sports equipment)
☐ Wash sports equipment after use
☐ Frequent laundering of clothes, linens
☐ Environmental cleaning
☐ Other → specify: _____

B.13a) Did you have any medical complications or other health problems as a result of this infection?
☐$_0$ No *(go to C.1a)*
☐$_1$ Yes
☐$_2$ Don't know/refused *(go to C.1a)*

B.13b) Can you tell me about these complications? _____

C. Potential Risk Factors

C.1a) Prior to your visit to our emergency department, has anyone ever told you that you were colonized or infected with methicillin-resistant *Staphylococcus aureus* or MRSA for short?
☐$_0$ No
☐$_1$ Yes
☐$_2$ Don't know/refused

C.1b) Have you ever had a similar type of skin infection in the past?
☐$_0$ No
☐$_1$ Yes
☐$_2$ Don't know/refused

C.2a) Do you have a household or family member or close personal contact who has been told that they were colonized or infected with methicillin-resistant *Staphylococcus aureus* or MRSA for short?
☐$_0$ No *(go to C.3a)*
☐$_1$ Yes
☐$_2$ Don't know/refused *(go to C.3a)*

C.2b) What is your relationship to this person *(do not read list; check one)*?
☐$_1$ Spouse/partner
☐$_2$ Parent

☐3 Child
☐4 Sibling
☐5 Other → specify: _____

C.2c) Do you assist this person with daily life activities such as eating, dressing bathing, walking, or getting up and down?
☐0 No
☐1 Yes *(go to C.3a)*
☐2 Don't know/refused

C.2d) Does this person provide you with assistance in daily life activities?
☐0 No
☐1 Yes
☐2 Don't know/refused

C.3a) Do you know anyone else who has had a recent skin infection like yours?
☐0 No *(go to C.4a)*
☐1 Yes
☐2 Don't know/refused *(go to C.4a)*

C.3b) What is your relationship to this person *(do not read list; check one)*?
☐1 Family or household member
☐2 Partner/intimate contact
☐3 Other → specify: _____

C.4a) Do you work or volunteer at a health care facility?
☐0 No *(go to C.5a)*
☐1 Yes
☐2 Don't know/refused *(go to C.5a)*

C.4b) Do you have contact with patients?
☐0 No
☐1 Yes
☐2 Don't know/refused

C.5a) Have you been admitted to a hospital overnight any time in the past year?
☐0 No *(go to C.6)*
☐1 Yes
☐2 Don't know/refused *(go to C.6)*

C.5b) How many days did you stay at the hospital? (*if > 1 admission* → How many days in total have you spent at the hospital for all hospital visits in the last year combined?)
_____ *(no. of days)*

C.5c) When was your most recent discharge from the hospital prior to this infection?
_____ (dd/mm/yyyy)

C.5d) Were you in isolation at any time when you were in the hospital? Isolation is when nurses and visitors wear gloves and gowns when they visit you to prevent them from getting infected or spreading bacteria to other patients.
☐0 No
☐1 Yes
☐2 Don't know/refused

C.6) In the past year, have you lived or worked in any of the following institutional or group settings?

	No	Yes	Don't know/refused
a. Nursing home or long-term care facility	☐0	☐1	☐2
b. Retirement home	☐0	☐1	☐2
c. Home for the disabled	☐0	☐1	☐2
d. Shelter (e.g., Salvation Army)	☐0	☐1	☐2

e. Military barracks or camp ☐0 ☐1 ☐2
f. Correctional facility ☐0 ☐1 ☐2
g. Other group setting ☐0 ☐1 ☐2
Specify: _____

C.7) Do you have a household or family member or close personal contact who has stayed overnight in a hospital in the last year?

☐0 No
☐1 Yes
☐2 Don't know/refused

C.10) In the last year, have you had regular contact with anyone who:

	No	Yes	DK/ref.	Do they live1 or work2 there?
a. works or volunteers at a hospital	☐0	☐1	☐2	
b. lives or works in a nursing home	☐0	☐1	☐2	*if yes*→☐1 ☐2
c. lives or works in a home for the disabled	☐0	☐1	☐2	*if yes*→☐1 ☐2
d. lives or works in a shelter or is homeless	☐0	☐1	☐2	*if yes*→☐1 ☐2
e. lives or works in military barracks or camp	☐0	☐1	☐2	*if yes*→☐1 ☐2
f. lives in a correctional facility	☐0	☐1	☐2	*if yes*→☐1 ☐2
g. is or was receiving dialysis	☐0	☐1	☐2	
h. has or had a catheter, feeding tube, IV line	☐0	☐1	☐2	
g. uses illicit intravenous or inhaled drugs	☐0	☐1	☐2	
i. is HIV positive	☐0	☐1	☐2	

C.11) Do you participate in any regular group or contact sports such as football, wrestling, soccer, volleyball, aerobics?

☐0 No *(go to C.12)*
☐1 Yes →specify: _____

C.12a) Have you traveled outside of Canada in the past year?

☐0 No
☐1 Yes → Which country(ies)? ☐1 United States
☐2 Other: _____
☐2 Don't know/refused

C.13) Please tell me if you have any of the following medical conditions.

	No	Yes	Don't know/refused
a. Chronic skin condition Specify: _____	☐0	☐1	☐2
b. HIV	☐0	☐1	☐2
C.14) Have you received dialysis in the last year?	☐0	☐1	☐2
C.15) Did you have a urinary catheter in the last year?	☐0	☐1	☐2
C.16) Did you have an intravenous line in the last year? (i.e., PICC or Hickman line)	☐0	☐1	☐2
C.17a) Have you used illicit intravenous drugs in the last year?	☐0	☐1	☐2
C.17b) Have you inhaled illicit drugs through your nose in the last year?	☐0	☐1	☐2
C.18) Do you consider yourself to be a member of the gay/lesbian/bisexual community?	☐0	☐1	☐2
C.19a) Have you had surgery in the past year?	☐0	☐1	☐2

C.19b) What type of procedure was it? _____

C.20a) Other than the antibiotics you received for this infection, have you taken any other antibiotics in the past 3 months?

☐0 No *(go to D.1)*
☐1 Yes

☐$_2$ Don't know/refused *(go to D.1)*

C.20b) Can you tell me the name of the antibiotics? _____

C.20c) Can you tell me, why the antibiotics were prescribed? _____

D.Demographics II

This is the last section. The questions are similar to those in the census.

D.1) Including you, how many people live in your household? _____ *(no. of people)*

D.2) How many bathrooms does your home have? ☐$_0$ ☐$_1$ ☐$_2$ ☐$_3$ ☐$_4$ ☐$_{5+}$

D.3a) In what country were you born?

☐$_1$ Canada

☐$_2$ Other → specify:_____

D.3b) What year did you come to Canada? _____

D.4) Can you tell me, to which ethnic or cultural groups do your ancestors belong (eg. Chinese, British, Aboriginal, French, Scottish)?

_____ _____ _____

D.4) What was your total household income in 2007? Was it *(read list)*:

☐$_1$ < $30,000

☐$_2$ $30,000 to $50,000

☐$_3$ $50,000 to $70,000

☐$_4$ > $70,000

☐$_5$ Don't know/refused

D.5) What is the highest level of education you have completed?

☐$_1$ Less than high school

☐$_2$ Graduated from high school

☐$_3$ Some post-high school education

☐$_4$ College/university diploma/degree

☐$_5$ Refused

E. Conclusion

Thank you very much for your time. This completes the interview. If you have any questions or concerns, please do not hesitate to contact <*lead study site investigator at tel. no.*>. There is also an information pamphlet that I can mail to you if you like <*record mailing or e-mail address and send pamphlet*>.

Thanks again for your time. Goodbye.