

Molecular Epidemiology of Community- and Health Care-Associated Methicillin-Resistant *Staphylococcus aureus* in Manitoba, Canada

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Recently, acquisition of methicillin-resistant *Staphylococcus aureus* (MRSA) has been increasingly seen in community settings. Beginning in 1995, we have routinely conducted pulsed-field gel electrophoresis (PFGE) of MRSA isolates received at Cadham Provincial Laboratory (CPL) in Manitoba, Canada. Our diverse collection of isolates coupled with molecular subtype information allowed us to assess the extent to which MRSA isolates in general were associated with community acquisition and whether specific PFGE types were more likely to be found in community settings. Forty percent of the MRSA isolates in our analysis were designated community associated (CA), with two of the six most common PFGE types showing a greater likelihood to be CA-MRSA. Overall, CA-MRSA were more likely to show multiple sensitivity to antibiotics and to be associated with younger age groups. Mapping of specific CA-MRSA types over successive 5-year periods showed rapid temporal shifts in prevalence in different parts of the province.

The epidemiology of methicillin-resistant *Staphylococcus aureus* (MRSA) has changed with the apparent emergence of community-associated (CA) MRSA. For several decades following their first identification in 1961, MRSA were primarily associated with nosocomial infections. Risk factors for these health care-associated (HCA) MRSA included recent hospitalization or surgery, residence in a personal-care home, dialysis treatment, or the presence of an indwelling medical device. When CA-MRSA was first described, its occurrence and transmission was associated with specific populations with unique risk factors, e.g., injection drug users (19), aboriginal communities (7, 12), or specific circumstances (CA-MRSA transmission within a high school wrestling team) (11). As such, it was thought that the spread of CA-MRSA within the general population might continue to be a rare event.

In the late 1990s, several events suggested that CA-MRSA has become more widespread in the general population. The occurrence of four MRSA-associated deaths in North Dakota and Minnesota (both of these states border Manitoba, Canada) was notable for the unusual severity of the infections and as an indicator of spread of CA-MRSA in pediatric populations (9). Since then, other reports have also highlighted the spread of CA-MRSA in pediatric populations (5, 6, 8, 20) as well as in the general population (15, 16).

We have described a cluster of MRSA within several small rural communities in southern Manitoba (10). These individuals were all infected with MRSA showing the same pulsed-field gel electrophoresis (PFGE) pattern and did not exhibit

any of the known risk factors for HCA-MRSA, nor did they fit the profiles of any of the specific populations mentioned above. These data suggest that CA-MRSA may also be emerging in this province. CA-MRSA prevalence appears to vary widely in different regions, as other studies have found a low prevalence of CA-MRSA (18, 23). Additional efforts to define the prevalence of CA-MRSA in different regions is warranted to better understand the various epidemiologic patterns that are being identified.

At Cadham Provincial Laboratory (CPL), located in Winnipeg, Manitoba, Canada, we have routinely conducted PFGE surveillance of MRSA since 1995. It is becoming increasingly clear that CA-MRSA are genetically distinct from HCA-MRSA (1, 3, 25) and a retrospective review of our PFGE-based MRSA database could further clarify the prevalence of CA-MRSA in our area. Additionally, the catchment area of CPL covers a wide variety of community and institutional settings in different geographic areas of the province, providing an extensive cross-sectional sample of the MRSA found in Manitoba. In this paper, we analyze these data to investigate the molecular epidemiology of MRSA in Manitoba and conduct a more detailed analysis of the emergence and spread of the most common PFGE types in the province to determine whether specific MRSA PFGE types in Manitoba were more likely to be associated with community-acquisition.

MATERIALS AND METHODS

Source of patient isolates. Cadham Provincial Laboratory (CPL) is the public health laboratory for the province of Manitoba. Facilities using CPL as their diagnostic and/or reference laboratory for MRSA include private clinics, nursing stations (stand-alone centers managed by on-site nurses), personal care homes (PCH), and several community hospitals. With the exception of two tertiary care hospitals in Winnipeg, which conduct their own diagnostic and molecular analyses, CPL requests that all MRSA isolated within the province be forwarded for routine PFGE analysis, and therefore, our culture collection represents both urban and rural settings as well as a variety of community and institutional facilities. Based on a comparison of our CPL database with annual statistics

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TABLE 1. MRSA isolate characteristics stratified by community versus health care association

Variable	CA-MRSA (<i>n</i> = 115)	HCA-MRSA (<i>n</i> = 175)	<i>P</i> ^a	OR ^b (95% CI)
Males, age in yr ^c				
<30	33	27	0.001	
30–69	15	30		
>69	10	38		
Females, age in yr ^c				
<30	21	21	0.15	
30–69	26	34		
>69	10	25		
Location				
Northern Manitoba	37	63	0.61	
Southern Manitoba	75	112		
Infection site ^d				
Skin	68	104	0.95	
Upper respiratory	37	56		
Eye	9	16		
Other ^e	12	22		
Antibiotic susceptibility ^f				
Trimethoprim-sulfamethoxazole	93 (90%)	129 (78%)	0.02	2.71 (1.2, 6.6)
Erythromycin	94 (40%)	129 (23%)	0.009	2.24 (1.2, 4.2)
Clindamycin	94 (89%)	128 (74%)	0.008	2.92 (1.3, 6.8)
Ciprofloxacin	86 (88%)	121 (79%)	0.002	3.35 (1.5, 7.8)
Gentamicin	91 (87%)	122 (75%)	0.042	2.24 (1.0, 5.0)

^a *P* values are based on chi² analysis of 2 × *n* tables for CA-MRSA vs. HCA-MRSA comparisons stratified by each of nine categorical variables (males, females, location, infection site, and the five antibiotics listed).

^b Odds ratios (OR) shown only for 2 × 2 tables with *P* < 0.05.

^c 44% of the individuals in the <30 age group were less than 4 years of age. The remainder were evenly distributed between the ages of 5 and 29 years.

^d Patients were not systematically sampled at all anatomic sites.

^e Urine, blood, sputum, rectal, stool, lung.

^f Percent susceptible with sample sizes shown in parentheses.

compiled by the Communicable Disease Control Unit of Manitoba Health (MRSA became reportable in Manitoba in 1999), we receive approximately 60 to 65% of all MRSA identified in the province.

Laboratory methods. CPL and other laboratories in Manitoba follow standard diagnostic methods for MRSA (14). Antimicrobial susceptibility in this paper was completed at CPL with the Vitek I (bioMérieux, St. Laurent, Canada) using standard guidelines and the manufacturer's instructions. Reference services for molecular characterization and comparison of MRSA types to global surveillance data was provided by the Nosocomial Infections and Antimicrobial Resistance section, Canadian Science Centre for Human and Animal Health, Winnipeg, Manitoba, Canada.

Pulsed-field gel electrophoresis (PFGE) used the standardized method developed by the Nosocomial Infections Section, National Microbiology Division, Health Canada (13). Electrophoresis of the SmaI-digested DNA was done with a CHEF-DRII system (Bio-Rad, Montreal, Canada) using 1.0% SeaKem Gold agarose (Mandel, Guelph, Canada) gels. From 1995 to 2002, scanning and analysis of PFGE gels was completed with the BioImage system (BioImage, Ann Arbor, MI). Subsequently, all PFGE gels were scanned using the Kodak EDAS system (Mandel, Guelph, Canada) and analyzed using Bionumerics version 3.0 (Applied Maths, Austin, TX). Isolates representing unique PFGE patterns originally identified with BioImage were rerun for inclusion in the Bionumerics database. Dendrograms reported in this paper were constructed using Bionumerics with the DICE coefficient and the unweighted pair group method of arithmetic averages (UPGMA) set with optimization and position tolerances of 1.0%.

Study design. The study was retrospective based on MRSA data originally collected from 30 August 1995 to 6 March 2000 (a geographic analysis presented in this paper used data from 1995 to 2004). Patient demographics (age, gender, and residence location) consisted of information supplied at time of specimen submission. To obtain information on each individual's contact with institutional health care (hospitalization and/or personal care home residence), demographic data were linked with each of the Manitoba Health Hospital Abstract Discharge and Personal Care Home Admission and Discharge databases (data linkage was approved by the Health Information Privacy Committee, Manitoba Health). Manitoba, and Canada in general, has a universal health care system which is able to readily track all patient institutional contacts, and therefore, our access to these databases provided an accurate and complete overview of all hospital or

personal care home contact of our MRSA cases. We defined patients with HCA-MRSA as those from whom MRSA was isolated >48 h after their admission to a hospital or PCH or those patients who had been hospitalized or had resided in a PCH in the 12 months prior to isolation of their MRSA. All other MRSA isolates were labeled CA-MRSA.

Several individuals within our database had been screened multiple times for MRSA within the time frame of the study. If the PFGE patterns of their respective MRSA isolates were indistinguishable over time or showed less than a seven-band difference, they were entered into the database once, based on their earliest MRSA isolation date. Any individual who was infected at different points in time by different MRSA PFGE types (i.e., seven or more band differences) was entered in the database multiple times based on the assumption that the distinguishable MRSA PFGE types potentially represented different exposure and infection events (24). For individuals who had multiple cultures from different anatomic sites, a record was maintained of each main specimen type (skin, upper respiratory, eye, and "other" [urine, blood, sputum, stool]) but were not counted as multiple infection events. Specimens from upper respiratory sites (e.g., nares) likely represent colonization rather than an actual clinical infection, however, for simplicity the term infection is used for all MRSA isolations in this report (excluding individuals with nares isolates only [24 patients] from the analysis did not change the significance/nonsignificance of the statistical analyses shown in Tables 1 and 2).

Adjusted chi-square was performed for comparison of categorical data using EpiInfo version 6.04c (Centers for Disease Control and Prevention, Atlanta, Ga.).

RESULTS

Demographic overview of Manitoba. Manitoba is a Canadian province with a population of approximately 1.14 million. Approximately 660,000 individuals live in Winnipeg, the capital and only large urban center in the province. The majority of the provincial population outside Winnipeg lives in the southern part of the province. Provincially, approximately 10% of the population are registered treaty members. This figure un-

TABLE 2. MRSA isolate characteristics stratified by PFGE type

Variable	PFGE pattern						<i>P</i> ^a
	A (<i>n</i> = 26)	B (<i>n</i> = 13)	C (<i>n</i> = 38)	D (<i>n</i> = 35)	E (<i>n</i> = 14)	F (<i>n</i> = 15)	
MRSA type							
CA	6	4	22	12	9	5	0.026
HCA	20	9	16	23	5	10	
Age (yr)							
<30	4	2	19	12	8	5	0.017
>31	22	11	18	23	6	10	
Location							
Northern Manitoba	0	7	7	17	12	6	0.0001
Southern Manitoba	26	6	31	18	2	9	
Antibiotic susceptibility							
Trimethoprim-sulfamethoxazole	13 (100%)	12 (100%)	31 (97%)	22 (96%)	13 (94%)	7 (100%)	
Erythromycin	4 (31%)	0 (0%)	8 (25%)	5 (22%)	11 (69%)	2 (29%)	
Clindamycin	5 (38%)	12 (100%)	32 (100%)	22 (100%)	13 (81%)	5 (71%)	
Ciprofloxacin	3 (25%)	12 (100%)	30 (100%)	19 (100%)	11 (79%)	6 (86%)	
Gentamicin	13 (100%)	12 (100%)	29 (97%)	17 (74%)	13 (94%)	7 (100%)	

^a *P* values based on chi² analysis of 2 × 6 tables where the six clonal groups have been stratified by each of three categorical variables (MRSA type, age, and location).

derrepresents the number of aboriginal individuals in the provincial population, since not all eligible aboriginal persons register. The southern border of Manitoba is adjacent to the American states of North Dakota and Minnesota.

Patient sociodemographics. Between August 1995 and March 2000, MRSA from 324 individuals were isolated at CPL or received as reference isolates from other laboratories. Of these isolates, sufficient demographic data were available for accurate linkage to the Hospital Abstract Discharge and PCH databases. These 279 individuals formed the basis of our analysis. Since we had PFGE data for all of the MRSA that had been isolated over time from a given individual, we were able to examine PFGE types from each patient and consider individual infection events in our data summary.

MRSA was isolated at multiple points in time for 61 individuals. The MRSA isolates from 48 of these cases were either indistinguishable or showed less than a seven-band difference over time, with the time between cultures ranging from 4 to 1,368 days (mean, 181 days; median, 72 days). For the remaining 13 individuals, their MRSA isolates were considered to be sufficiently different to potentially represent different infection events, rather than long term persistence. Twelve of these 13 cases were included in the database twice to reflect each unique PFGE type, while one person was included three times to reflect the three unique PFGE patterns identified for their MRSA isolates. In total, the database therefore represented 293 infection events in 279 individuals. Some data points were missing from the data set, so stratified data discussed below may not tally to 293.

Infections occurred in all age groups, with 103 (36%), 104 (36%), and 83 (29%) infection events occurring in individuals <30, 30 to 69, and >69 years of age, respectively. Within the <30 group, 44% of infections occurred in individuals <4 years of age, and the remainder were evenly distributed between the ages of 5 and 29 years. One hundred and thirty-seven infections occurred in females (47%), while 153 occurred in males (53%). Infections were unevenly distributed within the different age groups, with the majority of infections in the <30 and >69 age groups occurring in males (60 [59%] infections and 48 [58%] infections, respectively), while 60 (57%) infections in

the 30- to 69-year age group occurred in females (*P* = 0.028 for a chi² analysis stratified by gender and the three age groups indicated above).

Microbiologic characteristics. Based on data obtained from specimen requisitions, skin was the most common site of MRSA isolation (172 [53%] requisitions indicated skin or wound infections), followed by specimens from upper respiratory sites (93 [29%] requisitions indicated nares, throat, or ear). Eye specimens totaled 25 (8%), while 34 (10%) isolates were cultured from blood, urine, sputum, or stool specimens.

Data had routinely been collected for five antibiotics: trimethoprim-sulfamethoxazole; clindamycin, ciprofloxacin, gentamicin, and erythromycin (sample sizes for the various antibiotics ranged from 207 to 223). Isolates were typically susceptible to these antibiotics with the exception of erythromycin. Overall, susceptibilities for these antibiotics were 83%, 81%, 77%, 80%, and 30%, respectively. Of 200 isolates for which data were available on antibiotic susceptibility to all five antibiotics, 55 (28%) were sensitive to all five antibiotics, while 19 (10%) were resistant to all five antibiotics.

Health care- versus community-associated MRSA. Linkage with hospital or PCH admission/discharge databases allowed 290 of the 293 infection events to be designated as HCA or CA, as per the definition outlined in the Materials and Methods section. One hundred and fifteen infections were designated CA-MRSA (40%), while 175 were designated HCA-MRSA (60%). Table 1 compares the characteristics of CA- versus HCA-MRSA stratified by age, gender, antibiotic susceptibility, geography, and anatomic site. CA- versus HCA-MRSA were unevenly distributed across different age groups. Age and gender trends were clearest for males, who showed a significant correlation between CA-MRSA and younger age (*P* = 0.001), while females showed a similar but nonsignificant trend with age (*P* = 0.15). CA-MRSA were more likely to be susceptible to all antibiotics examined, with odds ratios ranging from 2.2 to 3.4. No significant differences were noted for geographic distribution or anatomic site of isolation.

Temporal trends in persistence of PFGE genotypes. As part of our analysis of the molecular epidemiology of MRSA in Manitoba, we examined the temporal persistence of the PFGE

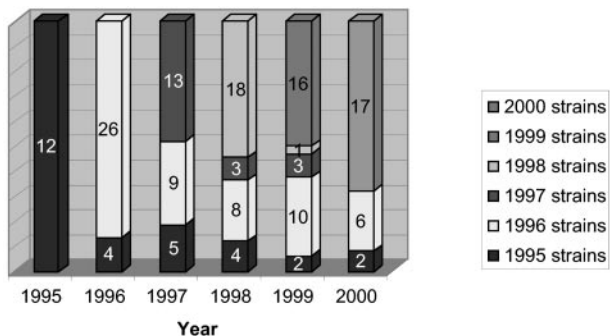


FIG. 1. Temporal trends of MRSA SmaI PFGE patterns. The histogram shows the number of new PFGE patterns identified each year of the study and the number of patterns from that year which were seen in subsequent years (e.g., 13 new PFGE patterns were identified in 1997 with three of these patterns seen again in 1998 and 1999).

types identified in Manitoba from 1995 to 2000 (Fig. 1). Ninety-five PFGE types were identified for the 55-month study period, with an average of 20 new PFGE types identified per year (for this analysis, all PFGE patterns with unique PFGE banding patterns were considered unique genotypes, regardless of the number of band differences between the patterns). The number of new patterns ranged from 12 in 1995 (only 4 months of PFGE surveillance conducted in this year) to 26 in 1996. The majority of these PFGE types were seen one or two times in their first year of observation and typically were not seen for the remainder of the study period. The small number of PFGE types that did persist over time was reflected in the observation that six PFGE types accounted for 51% of the MRSA infections occurring over the 5-year study period.

Epidemiology of individual PFGE genotypes. The six most common PFGE types were selected for further analysis. A dendrogram of these PFGE types is shown in Fig. 2. The microbiologic and epidemiologic characteristics of the isolates exhibiting these PFGE patterns are summarized in Table 2. There was a significant difference in the distribution of PFGE types between CA and HCA ($P = 0.026$), with two types (C and E) skewed towards community acquisition. Consistent with this observation was the significant difference in age distribution between the PFGE types ($P = 0.017$), again with types C and E showing a trend to younger age groups. Unlike the overall CA- versus HCA-MRSA comparison, the two CA-MRSA PFGE types were not clearly different from the other types in their antibiotic susceptibility patterns. The only exception was type E, which showed a trend to erythromycin sus-

ceptibility. PFGE type A showed a trend towards resistance to clindamycin and ciprofloxacin.

To place our results in the context of global surveillance data, representative isolates of types C and E were characterized at the molecular level by the Nosocomial Infections and Antimicrobial Resistance section, Canadian Science Centre for Human and Animal Health. PFGE analysis showed that type C was indistinguishable from the USA400 MRSA strain. It was designated MLST type 1, Canadian SmaI pattern 0142 (CMRSA 7 group), and was positive for the Panton-Valentine leukocidin gene. Type E was designated MLST type 508 (a new type for the global MLST database), Canadian SmaI pattern 0008 (CMRSA I group), and was negative for the Panton-Valentine leukocidin gene. A more comprehensive analysis of the molecular characteristics of MRSA in Manitoba is currently under way.

The six PFGE types showed a significant difference in their geographic distribution across the province ($P < 0.0001$). Type C was more common in southern Manitoba, while the other apparent CA-MRSA, type E, was most common in northern Manitoba. Type A was present only in southern Manitoba, while the remaining types (B, D, and F) were dispersed throughout the province.

Given our focus on CA-MRSA, we extended our geographic analysis of PFGE types C and E. Geographic data were available on the distribution of these two types up to March 2004. The temporal trends in their distribution were mapped for two time periods: 1995 to 2000 (corresponding to the time frame of the retrospective analysis, above) and for the 4 years following this period (Fig. 3). Type C was first identified in the northeastern part of the province, after which it was associated with a community outbreak in southern Manitoba as described by Kurbis and Wylie (10) (Fig. 3A). In the last 4 years it has largely disappeared from this area while rapidly emerging in several northern Manitoba communities and neighboring communities in northern Saskatchewan (Fig. 3B). In contrast, following its emergence in generally the same northeastern part of the province as type C, type E has diminished rapidly in numbers and was seen only infrequently in Manitoba from 2001 to 2004 (Fig. 3).

DISCUSSION

This retrospective study was aimed at characterizing the molecular epidemiology of CA- and HCA-MRSA in Manitoba and identifying whether specific PFGE types were associated with community acquisition. A notable strength of our analysis

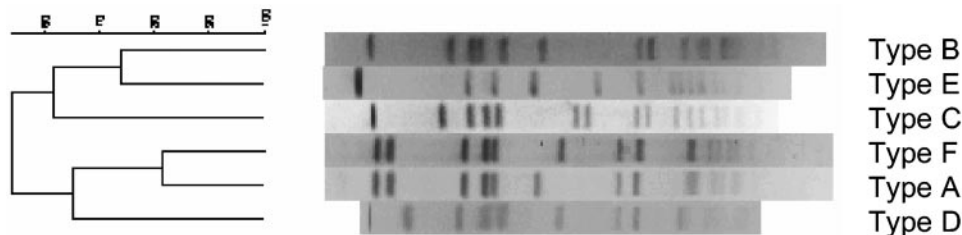


FIG. 2. Dendrogram showing the six most common types of SmaI PFGE patterns seen over the duration of the study. Together, these six types accounted for 51% of infections. The dendrogram was constructed using Bionumerics with optimization and position tolerance set at 1.0%.

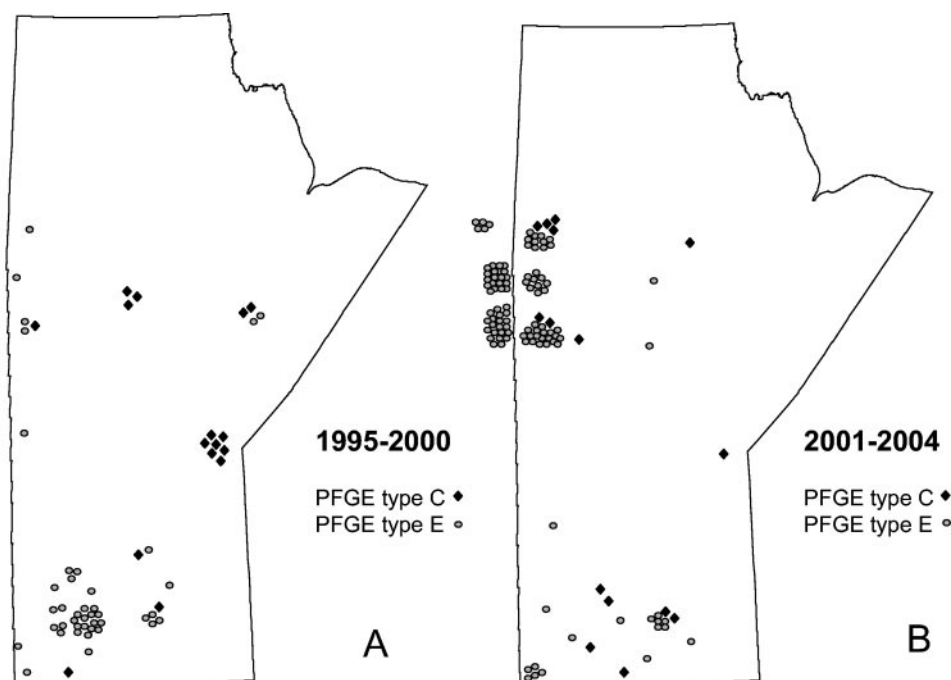


FIG. 3. Geographic distribution of PFGE types C and E from 1995 to 2000 (A) and 2001 to 2004 (B). Each dot represents an individual infected with either PFGE type C or type E. Closely clustered dots represent individuals residing in the same community.

was the size of the data set. The catchment area of CPL covers a wide variety of community and institutional settings in different geographic areas of the province, providing an extensive cross-sectional sample of the MRSA present in the provincial population. The routine PFGE data available from all of these isolates, coupled with the comprehensive health care databases available in the province, provided an opportunity for a comprehensive survey of the types of MRSA typically found in this area.

Several of our results are similar to published results from other regions (16, 17). We found CA-MRSA are more likely to be associated with younger age groups, be susceptible to multiple antibiotics, and show PFGE patterns distinct from HCA types. The percentage of MRSA in Manitoba considered to be CA-MRSA was higher (40%) than that found in Minnesota (12%) (16), a state which has also done extensive work on MRSA and is geographically adjacent to Manitoba. In general, given the proximity of Minnesota and Manitoba in the Midwest region of North America, common sociodemographic and socioeconomic factors and/or microbiologic characteristics of the endemic CA-MRSA may be driving high transmission rates in both locales. The higher prevalence of CA-MRSA in Manitoba may be due to the different study designs; however, Manitoba has documented large clusters of PFGE type C MRSA in both nonaboriginal populations (10) and several aboriginal populations in northern Manitoba (and in neighboring communities in northern Saskatchewan) (Fig. 3B). This strain may be more widespread in Manitoba and contribute to a higher CA-MRSA prevalence in Manitoba.

In Manitoba, the identification of two main types of CA-MRSA, based on PFGE data, is consistent with the Minnesota data in which two PFGE CA-types were also identified, with

one numerically dominant over the other (16). The most common CA-MRSA (USA400) in Minnesota was indistinguishable by PFGE from type C in Manitoba (this MRSA type has been associated with pediatric deaths in the North Dakota/Minnesota area) (9) and a community-based cluster of cases in the southwest portion of Manitoba (10). These and some other HCA PFGE-types of MRSA in Manitoba showed strong associations with certain geographic regions of the province. This characteristic likely represents the effects of snapshots in time, as the distribution of types C and E in Fig. 3 shows the rapidity with which geographic trends can change over time. The rapid emergence and subsequent disappearance of individual MRSA strains is similar to the epidemiology of MRSA in Portugal, where epidemic MRSA have serially emerged and disappeared (2). In the case of PFGE type C in Manitoba, its disappearance from southern Manitoba does not appear to be associated with replacement by another CA-MRSA type.

Unlike other studies, we did not find a difference in the anatomic site from which CA- versus HCA-MRSA were isolated. However, this difference could represent the lack of systematic sampling of these sites from our patients. Unlike the distribution of individual PFGE types, we also found no difference between the overall geographic distribution of CA- and HCA-MRSA between northern and southern Manitoba. Many aboriginal communities are present in northern Manitoba, and the known association between CA-MRSA and aboriginal communities (4, 7, 12) suggested that Manitoba CA-MRSA cases would be more common in the north. The lack of an association may be a reflection of the general CA-MRSA epidemiology in Manitoba during the study period. Within this time frame, PFGE type C MRSA spread rapidly in a largely nonaboriginal community in southern Manitoba. Given the

subsequent rapid spread of this strain in northern Manitoba (Fig. 3B), it should be noted that geography as a variable would be particularly subject to temporal trends and could yield different results dependant on when a study is conducted.

We conducted a temporal analysis of the persistence of different PFGE patterns over time as part of our characterization of PFGE MRSA types in Manitoba. New patterns are frequently identified, but generally represent sporadic isolates that are rarely seen more than once or twice. Whether these are unsuccessful strains which originate from locally endemic strains or represent new types which enter the province but do not become established is not known at this time. The persistent strains represent both CA and HCA types which, either through their own inherent characteristics or through chance introductions into environments conducive to their spread, are able to propagate successfully within a given area. The persistence of several PFGE types first seen in 1996 represents the emergence of Canadian epidemic MRSA strain 2 in Manitoba, one of the most widespread epidemic MRSA strains in Canada (21) and one which seems to have generated several successful, genetically similar PFGE types in Manitoba.

Like other retrospective studies, a limitation of this study was the inability to fully characterize the risk factors associated with each patient, potentially resulting in some incorrect CA or HCA designations. Although we had accurate data available on institutional contact, we did not have any information on dialysis treatment or the presence of indwelling medical devices, and therefore some CA-designated MRSA may have actually been HCA types. Conversely, some HCA-MRSA may actually have been true CA-MRSA, acquired while the person was in the community and only having coincidental contact with an institution. Okuma et al. (17) noted occasional carriage of CA-MRSA in Australian hospitals, so a patient's epidemiologic data may not match the normal niche of a given MRSA strain type.

This study suggests that at least two types of CA-MRSA have emerged and spread to several areas in Manitoba. Stevens (22) has noted that the small size of the *mecA* gene cassette commonly found in CA-MRSA could contribute to a high mobility of the cassette to many strains of methicillin-sensitive *Staphylococcus aureus*. Okuma et al. (17) noted that CA-MRSA grows faster than HCA-MRSA, possibly in response to the different selective pressures of community versus institutional environments. Together, these microbiologic factors could contribute to the rapid emergence and transmission of new CA-MRSA types. Given the likelihood of incorrect empirical treatment of CA-MRSA as noted previously (9, 16), heightened surveillance, targeted towards the differentiation of CA- and HCA-MRSA, is warranted to monitor the relative prevalence of these organisms in different areas.

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