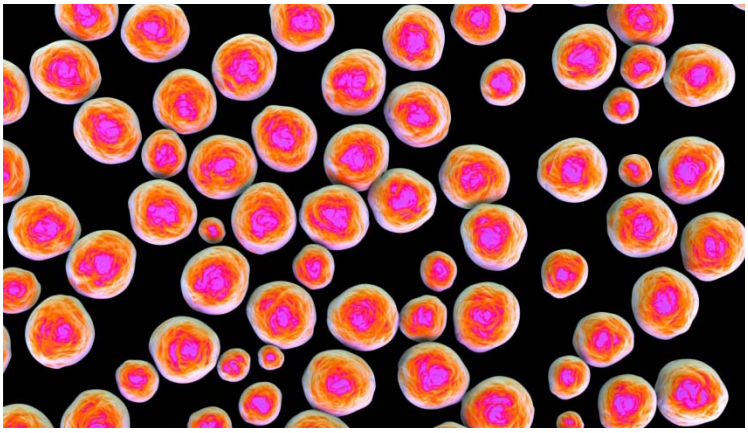
METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* IN CANADIAN ACUTE-CARE HOSPITALS

SURVEILLANCE REPORT JANUARY 1, 2008 TO DECEMBER 31, 2012



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To obtain additional information, please contact:

Centre for Communicable Diseases and Infection Control
Public Health Agency of Canada
Tunney's Pasture, AL 0602B
Ottawa, Ontario, K1A 0K9
Email: ccdic-clmti@phac-aspc.gc.ca

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INFORMATION TO THE READER OF METHICILLIN-RESISTANT STAPHYLOCOCCUS AUREUS IN CANADIAN ACUTE-CARE HOSPITALS

This report entitled Methicillin-resistant *Staphylococcus aureus* in Canadian acute-care hospitals: Surveillance Report January 1, 2008 to December 31, 2012 was produced by the Centre for Communicable Diseases and Infection Control of the Public Health Agency of Canada (Agency). The report provides a review of available methicillin-resistant *Staphylococcus aureus* (MRSA) surveillance data in Canada.

The Centre for Communicable Diseases and Infection Control (CCDIC) is responsible for the data collection, management, analysis and report production related to this MRSA surveillance report. CCDIC supports the use of these data to inform public health and policy action. In addition, CCDIC supports the Agency's ongoing commitment to improving data quality, defining and setting surveillance standards

The Public Health Agency of Canada collects national data on various healthcare-associated infections, including MRSA through the Canadian Nosocomial Infection Surveillance Program (CNISP), a collaborative effort of the Centre for Communicable Diseases and Infection Control, the National Microbiology Laboratory and sentinel hospitals across Canada who participate as members of the Canadian Hospital Epidemiology Committee (a subcommittee of the Association of Medical Microbiology and Infectious Disease Canada). As of December 2012, 54 largely university-affiliated tertiary care from 10 provinces participate in CNISP (Appendix 1). Of these, 9 hospitals are stand-alone pediatric hospitals, 14 hospitals provide services to adult & pediatric patients and the remaining 31 hospitals provide services to adult patients only. CNISP surveillance provides key information that informs the development of federal, provincial and territorial infection prevention and control programs and policies and provides rates and trends on healthcare-associated infections and antimicrobial resistant organisms.

The Agency surveillance reports are intended to provide up to date, timely CNISP rates to healthcare professionals and the provincial and territorial health authorities. When carried out in a uniform manner, surveillance provides a measure of the burden of illness, establishes benchmark rates for internal and external comparison and identifies potential risk factors. Surveillance for MRSA is considered an important measure of the quality of patient care.

These results replace any previously reported MRSA surveillance data and are subject to change as new data is made available by participating hospitals.

Highlights of the findings are outlined in the section entitled 'At a Glance' while the main findings of the surveillance data are outlined in the section entitled 'Results'. Data sources, references, national MRSA infection rates from 1995-2012 and MRSA colonization rates 2008-2012 are available in the Appendices.

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AT A GLANCE

The Public Health Agency of Canada (Agency) has collected data on hospitalized patients with methicillin-resistant *Staphylococcus aureus* (MRSA) infections and colonizations in Canadian acute-care hospitals through the Canadian Nosocomial Infection Surveillance Program (CNISP) since 1995. This report describes the epidemiology and microbiology of MRSA in Canada from 2008 to 2012. The following are highlights of this surveillance report.

- National MRSA infection rates have been decreasing since 2009 with the most dramatic reduction seen in healthcare-associated infection rates. Similar trends are also seen in other developed countries.

- A distinct difference in the trends between adult and pediatric MRSA infection rates was observed. Adult infection rates have steadily declined since 2008 while pediatric rates have increased significantly.

- Skin, soft tissue or burns were the most common source of MRSA clinical infections in each surveillance year. Central line associated BSI accounted for just over one-quarter of the total MRSA bloodstream infections from 2008-2012.

- The proportion of MRSA clinical and bloodstream infections identified as community-acquired MRSA (CA-MRSA) has steadily increased from 2008 to 2012 and represent just under one-third of cases classified.

- From 2008-2012, approximately 9% of patients with a clinical MRSA infection died and 25% of patients with a MRSA bloodstream infection died at 30 days after the date of positive culture.

- CMRSA-2, CMRSA-7 and CMRSA-10 were the three most predominant strain types identified in both clinical and blood isolates. CMRSA-2 (strain type most typically associated with hospital settings) represents the largest proportion identified followed by CMRSA-10 and CMRSA-7 (strain types most commonly associated with community settings). In both clinical and blood isolates the proportion of community-associated strain types has been steadily increasing since 2008 and currently represent approximately one-third of the strain types identified.

- Nationally, there has been no documented resistance to vancomycin, tigecycline, linezolid or daptomycin from among the isolates tested. The proportion of isolates tested exhibiting resistance to ciprofloxacin, erythromycin and clindamycin has remained relatively unchanged. Only a small proportion of isolates exhibit resistance to tetracycline and trimethoprim-sulfamethoxazole (TMP-SMX) across Canada.

BACKGROUND

Staphylococcus aureus (*S. aureus*) is a bacterial organism, which may asymptomatically colonize the skin and mucosal surfaces of healthy humans and can also cause infections such as wound, urine, skin and soft tissue infections, osteomyelitis, endocarditis, bacteremia, etc. *S. aureus* can be acquired in the community or in the hospital or other healthcare settings such as long-term care, dialysis and rehabilitation facilities.

Since the initial use of antibiotics in the 1940s, resistant strains of *S. aureus* have emerged, starting with penicillin-resistant, followed by methicillin-resistant and finally vancomycin-resistant strains[1]. *S. aureus* is particularly successful in the acquisition and expression of antibiotic resistance, explaining in part its high associated burden of disease worldwide.[2]

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a *S. aureus* that has become resistant to beta-lactam antibiotics (i.e., first-line antibiotics that include methicillin, oxacillin, penicillin, and amoxicillin).[3]

MRSA is classified as healthcare-associated MRSA (HA-MRSA) or community-acquired MRSA (CA-MRSA). Surveillance definitions of HA-MRSA are based on several factors, including length of stay in hospital prior to positive MRSA culture (greater than 48 hours), previous MRSA status, and the presence of traditional healthcare-associated risk factors. The most widely accepted definition for CA-MRSA is that developed by the Centers for Disease Control and Prevention (CDC) in 2000, which defines CA-MRSA infection as a case diagnosed within 48 hours of hospitalization or an outpatient that lacks traditional risk factors for MRSA infection such as: the receipt of hemodialysis, surgery, residence in a long-term care facility or hospitalization during the previous year, the presence of an indwelling catheter or a percutaneous device at the time culture samples were obtained, or previous isolation of MRSA.[4]

Laboratory characterization has revealed distinct differences in the microbiological characteristics of CA-MRSA and HA-MRSA. In addition to the surveillance definition, both HA- and CA-MRSA are differentiated based on the isolated strain types as described by McDougall et al 2003.[5] MRSA strains generally recognised as CA-MRSA include CMRSA-7 (also known as USA400, ST[a]1, CC[b]1) and CMRSA-10 (also known as USA300, ST8, CC8). The HA-MRSA strains are generally accepted as CMRSA-1 (USA600, ST45 or CC45), CMRSA-2 (USA100, USA800, ST5, or CC5), CMRSA-3/6 (ST241 or ST239), CMRSA-4 (USA200 or ST36), and CMRSA-5 (USA500, ST1, or CC1). CMRSA-7 (USA400) has been predominant in Canada and Alaska while in the contiguous United States, CMRSA-10 (USA 300, ST8) has almost entirely replaced the CMRSA-7 (US400 or ST1) strain type.[2] CA-MRSA strain types (CMRSA-7 (USA 400) and CMRSA-10 (USA300)) are increasingly being isolated in hospital cases of MRSA infection, contributing significantly to the continued increase of hospital-related cases. Typically HA-MRSA strains are persisting in hospital settings, while CA strains appear to be adding to the burden within healthcare settings.[2,6]

S. aureus infections are currently being reported as the leading cause of healthcare-associated infections worldwide and an increasing percentage of these infections are methicillin-resistant.[1,2,3,4] MRSA infections place a significant burden on healthcare systems, resource utilization and are associated with increased morbidity and mortality.[1]

[a] *Sequence Type*
[b] *Clonal Complex*

OBJECTIVES

The objectives of CNISP MRSA surveillance are to:

1. Describe the MRSA-associated burden of disease in Canadian acute-care hospitals participating in CNISP

2. Determine the annual incidence of MRSA in Canadian acute-care hospitals participating in CNISP

3. Determine MRSA bacteremia rates in Canadian hospitals participating in CNISP

4. Characterize all MRSA blood isolates, and a subset of clinical MRSA isolates (any isolate from any anatomical site other than blood) received from participating CNISP hospitals by antimicrobial resistance, molecular typing, and staphylococcal cassette chromosome *mec* (SCCmec) typing.

METHODS

SURVEILLANCE NETWORK

Prior to 1995, national data describing the incidence and epidemiology of MRSA in Canada were not available. In 1995, national surveillance for MRSA was initiated through the Public Health Agency of Canada (Agency) in collaboration with sentinel hospitals participating in the CNISP and has been ongoing.

The Agency collects data on hospitalized patients with methicillin-resistant *Staphylococcus aureus* (MRSA) in Canadian acute-care hospitals through the CNISP. Surveillance of MRSA at participating hospitals is considered to be within the mandate of hospital infection prevention and control programs and does not constitute human research. Therefore in participating hospitals this surveillance activity does not require Institutional Review Board (IRB) review.

A MRSA working group comprised of Canadian Hospital Epidemiology Committee (CHEC) members from participating hospitals, Agency epidemiologists and laboratory representatives are responsible for developing and regularly updating the surveillance protocol which includes standardized data collection forms and a data dictionary. In-service sessions are organised by the Agency for all hospitals participating in CNISP. The purpose of the in-service sessions are to provide training to Infection Control Practitioners (ICPs) on how to follow the surveillance protocol and complete the data collection forms, and to ensure consistency across the participating hospitals in the understanding of each question on the data collection forms. This ensures that the data are comparable between the participating hospitals and between the provinces and regions.

CASE DEFINITIONS[c]

MRSA case definition:

- Isolation of *Staphylococcus aureus* from any body site

AND

- Patient must be admitted to the hospital

AND

- Is a "newly identified MRSA case" at a participating CNISP hospital at the time of hospital admission or identified during hospitalization

A "newly identified MRSA case" includes:

- MRSA cases identified for the first time during this hospital admission
- Cases that have been previously identified at other non-CNISP hospitals
- Cases that have already been identified at the participating CNISP hospital but are new cases. This can only be identified if the previously identified case has another strain type. This means the person was exposed again to MRSA and acquired another strain of it from another source

A "newly identified MRSA case" DOES NOT include:

- MRSA cases previously identified at other participating CNISP hospitals
- Emergency, clinic, or other outpatient cases
- Cases re-admitted with MRSA (unless it is a different strain type)

The collected specimens are sent to the hospital's laboratory to determine if the inpatient is positive for MRSA.

Cases identified through CNISP MRSA surveillance are classified based on where MRSA was likely acquired either in the community or in the hospital.

Healthcare-associated (HA-MRSA) case definition:
Once the patient has been identified with MRSA, they will be classified as HA-MRSA based on an assessment by the practitioner using the following criteria:

- length of time in hospital prior to MRSA identification (> 48 hours)
- knowledge of previous MRSA status
- date of admission
- length of stay in hospital
- prior hospitalization or other healthcare facility history (previously admitted in past 12 months)
- where patient admitted from (e.g., long-term care)

Newborn HA-MRSA case definition:
A MRSA case in a newborn may be considered healthcare-associated if:

- the baby was hospitalized > 48 hours
- the mother was not known to be a case on admission and there is no epidemiological reason to suspect that the mother was colonized prior to admission, even if the newborn is < 48 hours of age,

In the case of a newborn transferred from another institution, MRSA may be classified as healthcare-associated if the organism was not known to be present and there is no epidemiological reason to suspect that acquisition occurred prior to transfer.

[c] *CNISP 2012 MRSA surveillance protocol definitions used. Definitions may undergo slight modifications from year to year.*

Community-acquired (CA-MRSA) case definition:
CA-MRSA cases are defined as meeting all of the following criteria:

- no previous known healthcare-associated MRSA
- MRSA identified ≤48 hours after hospital admission
- no hospitalization in the previous 12 months
- no surgery or dialysis in the previous 12 months
- no residence in a long-term care facility in the previous 12 months
- no indwelling catheter or medical device (e.g. foley catheter, IV line, tracheostomy, feeding tube)

DATA COLLECTION AND SUBMISSION

When a MRSA case is identified by the hospital's laboratory, a standardized patient questionnaire is completed through concurrent or retrospective chart review by an ICP. There are three distinct levels of surveillance conducted for MRSA, each associated to its own questionnaire. The three levels of surveillance are based on:
(i) screening specimens;
(ii) clinical isolates (from anatomical sites other than blood);
(iii) blood isolates.

Screening specimens are defined as MRSA isolated from nose, perineal, groin, axillary, or other screening sites and represent colonized cases. Colonizations are reported from each site as an aggregate number and the only additional information collected about these individuals is where MRSA was acquired (i.e. HA MRSA). Individuals from whom MRSA was recovered through either clinical investigation (clinical isolate, not including blood) or positive blood culture (blood isolate) are classified as either a clinical infection or bacteremia respectively. Separate questionnaires are required for each of these two types of infections. These questionnaires include patient demographics and clinical information, previous hospitalization within the past 12 months, site of positive culture, where MRSA was presumed to have been acquired (either in the community or in the hospital), and outcome within the first 30 days following positive identification of MRSA culture.

Data are submitted electronically through a web based information management system, the Canadian Network for Public Health Intelligence (CNPHI), by each participating hospital to the Agency for further statistical analysis and storage.

DENOMINATOR DATA

Participating hospitals provide the Agency with the number of patient-admissions and the number of patient-days for the corresponding surveillance year. These denominator data are used to calculate the annual incidence rates presented in this report.

LABORATORY ANALYSIS

Participating hospitals send one MRSA clinical isolate for each *clinically* infected case collected between January 1st and March 31st of each calendar year to the National Microbiology Laboratory (NML) for molecular testing. One blood isolate is sent by participating hospitals to the NML for molecular testing for bloodstream (bacteremia) cases that occur at any time during the surveillance year.

The NML submits the laboratory results to the Agency through the same web based information management system used by the hospitals for the submission of the patient questionnaire data. Both the laboratory results and data collected through the patient questionnaires are linked using a unique patient identifier.

DATA ANALYSIS

Data submitted to the Agency both by participating hospitals (patients' clinical and demographic data) and the NML (results of laboratory analysis) are extracted, validated and statistically analysed by Agency staff.
Annual incidence rates are calculated using patient admissions and patient days. For reporting purposes and to ensure confidentiality, provinces are grouped into three regions: Western (British Columbia, Alberta, Saskatchewan and Manitoba), Central (Ontario and Quebec), and Eastern (Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland and Labrador). The territories do not currently submit data to the Agency and Prince Edward Island began submitting data in 2011.

MRSA incidence rates with 95% confidence intervals (95% CI) are presented for 2008 to 2012. These rates are further stratified by region and facility type (adult or pediatric specific) if appropriate, facility type was determined based on the type of denominator (adult, pediatric or mixed adult/pediatric) that each specific site was able to provide. Rates in 2008 were compared to 2012 rates to identify any significant changes.

Demographic (age and sex), clinical (site of infection), molecular characterization (strain types) and antimicrobial resistance data are presented.

RESULTS

The following sections of this report outline CNISP MRSA surveillance data and provide a description of hospitalized patients who have been diagnosed with MRSA from 2008 to 2012. Surveillance for MRSA was initiated in 1995 and has been a core CNISP surveillance project ever since. A previous summary report of MRSA surveillance data from 1995 – 2009 was released in 2010 and is available for viewing or download on the Public Health Agency of Canada website at www.phac-aspc.gc.ca/nois-sinp/projects/res2009/index-eng.php

The focus of this surveillance report is on MRSA infections. There are five sections to this report. The first three sections report on all MRSA infections followed by more specific data relating to MRSA bloodstream infections and then MRSA infections that occurred in adult compared to pediatric hospitals. The last two sections provide information relating to the molecular characterization and antimicrobial resistance of MRSA isolates tested. A summary of MRSA infection rates from 1995-2012 can be found in Appendix 3 while information relating to MRSA colonization can be found in Appendix 4.

Any variation in MRSA surveillance data seen in this report when compared to previous reports or publications may be accounted for by the updating of information received by hospitals in the CNISP database.

SECTION 1 MRSA IN CANADA: NATIONAL MRSA SURVEILLANCE FROM JANUARY 1, 2008 TO DECEMBER 31, 2012

1.1 National and regional MRSA infections

Figure 1 shows national and regional trends in MRSA infection rates per 10,000 patient days from 2008 to 2012. Nationally and in the east, infection rates have decreased while centrally rates have remained relatively constant. Rates in the west have decreased since 2008 however have remained higher than the national average in each surveillance year (Table 1).

Figure 1: National and regional MRSA infection rates per 10,000 patient days

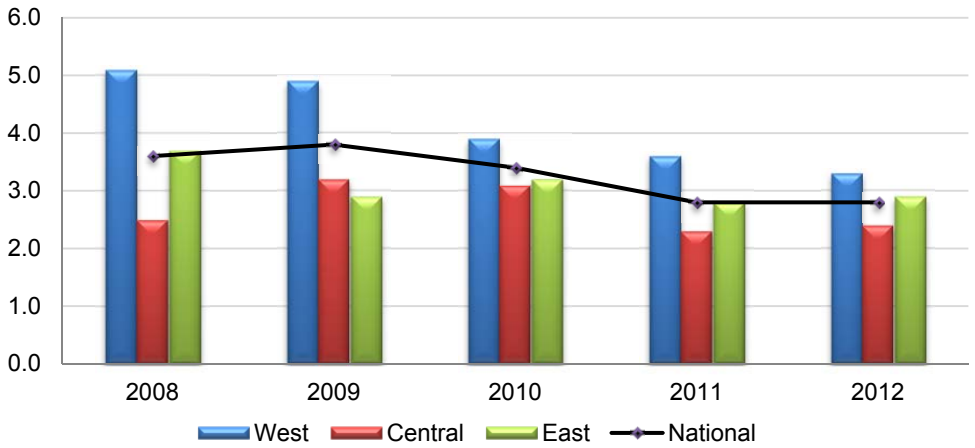


Table 1 provides the number of cases of MRSA infections, patient admissions, patient days, number of participating hospitals and incidence rates with 95% CI by year. The rates in 2008 and 2012 were compared.

Table 1 National and regional MRSA infection cases and incidence rates (95% CI) from 2008 to 2012

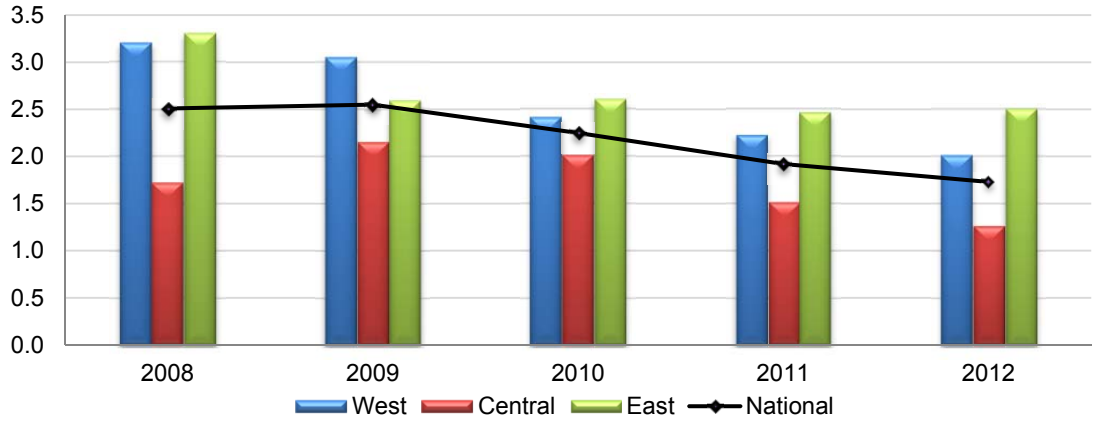
	2008	2009	2010	2011	2012	*p*[§]
National MRSA cases (eligible*)	1,982 (1,982)	2,033 (2,033)	1,991 (1,991)	1,865 (1,857)	1,787 (1,787)	
Patient admissions	678,610	701,477	820,634	834,365	824,812	
Rate per 1,000 pt adm	2.9 [2.8, 3.1]	2.9 [2.8, 3.0]	2.4 [2.3, 2.5]	2.2 [2.1, 2.3]	2.2 [2.1, 2.3]	<0.001
Patient days	5,441,458	5,374,036	5,859,813	6,551,954	6,383,538	
Rate per 10,000 pt days	3.6 [3.5, 3.8]	3.8 [3.6, 4.0]	3.4 [3.3, 3.6]	2.8 [2.7, 3.0]	2.8 [2.7, 2.9]	<0.001
No. of reporting hospitals[†]	46	50	52	52	51	
Western MRSA cases (eligible*)	1,064 (1,064)	962 (962)	898 (898)	891 (891)	844 (844)	
Patient admissions	265,774	283,737	340,073	338,779	348,658	
Rate per 1,000 pt adm	4.0 [3.8, 4.2]	3.4 [3.2, 3.6]	2.6 [2.5, 2.8]	2.6 [2.5, 2.8]	2.4 [2.3, 2.6]	<0.001
Patient days	2,084,979	1,983,469	2,318,603	2,500,602	2,560,811	
Rate per 10,000 pt days	5.1 [4.8, 5.4]	4.9 [4.5, 5.2]	3.9 [3.6, 4.1]	3.6 [3.3, 3.8]	3.3 [3.1, 3.5]	<0.001
No. of reporting hospitals	18	18	19	19	19	
Central MRSA cases (eligible*)	657 (657)	852 (852)	846 (846)	728 (720)	703 (703)	
Patient admissions	334,456	334,836	397,286	402,170	384,868	
Rate per 1,000 adm	2.0 [1.8, 2.1]	2.5 [2.4, 2.7]	2.1 [2.0, 2.3]	1.8 [1.7, 1.9]	1.8 [1.7, 2.0]	n/s
Patient days	2,640,941	2,635,922	2,778,135	3,180,282	2,986,017	
Rate per 10,000 days	2.5 [2.3, 2.7]	3.2 [3.0, 3.5]	3.1 [2.8, 3.3]	2.3 [2.1, 2.4]	2.4 [2.2, 2.5]	n/s
No. of reporting hospitals	22	26	27	26	25	
Eastern MRSA cases (eligible*)	261 (261)	219 (219)	247 (247)	246 (246)	240 (240)	
Patient admissions	78,380	82,904	83,275	93,416	91,286	
Rate per pt 1,000 adm	3.3 [2.9, 3.7]	2.6 [2.3, 3.0]	3.0 [2.7, 3.3]	2.6 [2.3, 3.0]	2.6 [2.3, 3.0]	0.008
Patient days	715,538	754,645	763,075	871,070	836,710	
Rate per 10,000 pt days	3.7 [3.5, 3.8]	2.9 [2.8, 3.0]	3.2 [3.1, 3.4]	2.8 [2.7, 2.9]	2.9 [2.8, 3.0]	0.007
No. of reporting hospitals	6	6	6	7	7	

**Rates are calculated using only eligible data = hospitals that supplied both numerator (cases) and denominator (patient admissions and days) data*
[†] Number of participating hospitals varies due to eligible data submitted
[§] Significance test (p) compares the 2008 MRSA infection rate to the 2012 rate

1.2 National and regional healthcare-associated and community-associated MRSA infections

MRSA is classified based on surveillance case definitions (see methods section p 8-9). Generally, HA-MRSA is identified as occurring in hospitals or other healthcare settings. CA-MRSA is identified as occurring outside of healthcare settings to people with no known healthcare exposures. Figure 2 shows national and regional trends of HA-MRSA* infections per 10,000 patient days. Rates have significantly decreased nationally and in all regions (Table 2).

Figure 2 National and regional HA-MRSA infections rates per 10,000 patient days



*HA-MRSA = *in hospital > 48 hours, infections acquired in another healthcare facility, a long-term healthcare facility or any other healthcare exposure.*

Table 2 provides the number of cases of HA-MRSA infections, patient admissions, patient days, number of participating hospitals and incidence rates with 95% CI by year. The rates in 2008 and 2012 were compared.

Table 2 National and regional HA-MRSA infection cases and incidence rates (95% CI) from 2008 to 2012

	2008	2009	2010	2011	2012	$p^{\S}$
National HA- MRSA cases (eligible*)	1,369 (1,369)	1,378 (1,378)	1,327 (1,327)	1,261 (1,261)	1,112 (1,112)	
Patient admissions	678,610	701,477	820,634	834,365	824,812	
Rate per 1,000 pt adm	2.0 [1.9, 2.1]	2.0 [1.9, 2.1]	1.6 [1.5, 1.7]	1.5 [1.4, 1.6]	1.4 [1.27, 1.4]	<0.001
Patient days	5,441,458	5,374,036	5,859,813	6,551,954	6,383,538	
Rate per 10,000 pt days	2.5 [2.4, 2.7]	2.6 [2.4, 2.7]	2.3 [2.1, 2.4]	1.9 [1.8, 2.0]	1.7 [1.6, 1.8]	<0.001
No. of reporting hospitals†	46	50	52	52	51	
Western HA- MRSA cases (eligible*)	672 (672)	607 (607)	562 (562)	558 (558)	517 (517)	
Patient admissions	265,774	283,737	340,073	338,779	348,658	
Rate per 1,000 pt adm	2.5 [2.3, 2.7]	2.1 [2.0, 2.3]	1.7 [1.5, 1.8]	1.6 [1.5, 1.8]	1.5 [1.4, 1.6]	<0.001
Patient days	2,084,979	1,983,469	2,318,603	2,500,602	2,560,811	
Rate per 10,000 pt days	3.2 [3.0, 3.5]	3.1 [2.8, 3.3]	2.4 [2.2, 2.6]	2.2 [2.0, 2.4]	2.0 [1.8, 2.2]	<0.001
No. of reporting hospitals	18	18	19	19	19	
Central HA-MRSA cases (eligible*)	460 (460)	575 (569)	563 (563)	486 (486)	382 (382)	
Patient admissions	334,456	334,836	397,286	402,170	384,868	
Rate per 1,000 pt adm	1.4 [1.3, 1.5]	1.7 [1.6, 1.9]	1.4 [1.3, 1.5]	1.2 [1.1, 1.3]	1.0 [0.9, 1.1]	<0.001
Patient days	2,640,941	2,635,922	2,778,135	3,180,282	2,986,017	
Rate per 10,000 pt days	1.7 [1.6, 1.9]	2.2 [2.0, 2.4]	2.0 [1.9, 2.2]	1.5 [1.4, 1.7]	1.3 [1.2, 1.4]	<0.001
No. of reporting hospitals	22	26	27	26	25	
Eastern HA-MRSA cases (eligible*)	237 (237)	196 (196)	202 (202)	217 (217)	213 (213)	
Patient admissions	78,380	82,904	83,275	93,416	91,286	
Rate per 1,000 pt adm	3.0 [2.7, 3.4]	2.4 [2.0, 2.7]	2.4 [2.1, 2.8]	2.3 [2.0, 2.6]	2.3 [2.0, 2.7]	0.006
Patient days	715,538	754,645	763,075	871,070	836,710	
Rate per 10,000 pt days	3.3 [2.9, 3.8]	2.6 [2.3, 3.0]	2.6 [2.3, 3.0]	2.5 [2.2, 2.8]	2.5 [2.2, 2.9]	<0.001
No. of reporting hospitals	6	6	6	7	7	

§ *Significance test (p) compares the 2008 HA-MRSA rate to the 2012 rate*
**Rates are calculated using only eligible data = hospitals that supplied both numerator (cases) and denominator (patient admissions and days) data*
† *Number of participating hospitals varies due to eligible data submitted*

Figure 3 illustrates national and regional trends in CA-MRSA infections per 10,000 patient days. Nationally, the rate has remained relatively constant over the surveillance period. In the West, rates significantly decreased from 2008-2012 while centrally rates have increased. Eastern region rates have remained relatively unchanged and have been consistently lower than the national average while rates in the west have been higher (Table 3).

Figure 3 National and regional CA-MRSA infection rates per 10,000 patient days

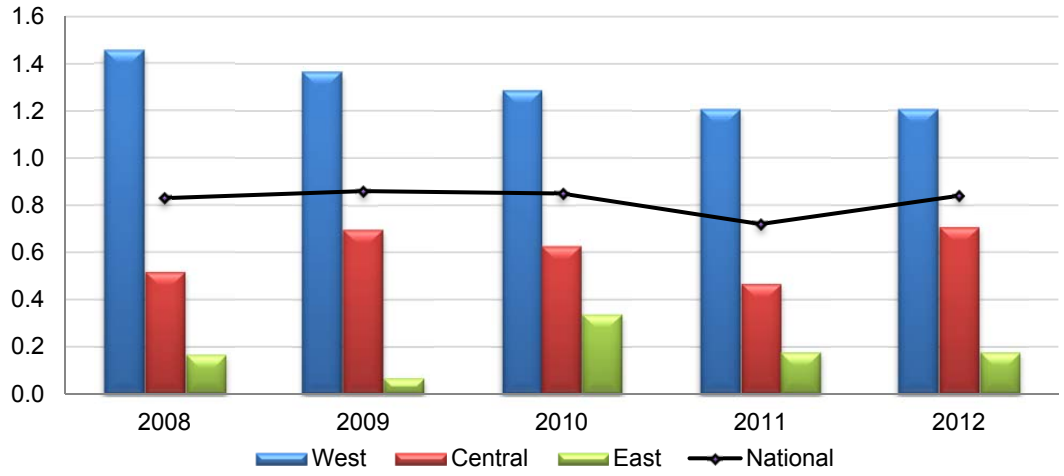


Table 3 provides the number of cases of CA-MRSA infections, patient admissions, patient days, number of participating hospitals and incidence rates with 95% CI by year. The rates in 2008 and 2012 were compared.

Table 3 National and regional CA-MRSA infection cases and incidence rates (95% CI) from 2008 to 2012

	2008	2009	2010	2011	2012	$p^{\S}$
National CA-MRSA cases (eligible*)	450 (450)	456 (456)	500 (500)	470 (468)	539 (539)	
Patient admissions	678,610	701,477	820,634	834,365	824,812	
Rate per 1,000 pt adm	0.7 [0.60, 0.73]	0.7 [0.59, 0.71]	0.6 [0.56, 0.66]	0.6 [0.51, 0.61]	0.7 [0.60, 0.71]	n/s
Patient days	5,441,458	5,374,036	5,859,813	6,551,954	6,383,538	
Rate per 10,000 pt days	0.8 [0.75, 0.91]	0.9 [0.77, 0.93]	0.9 [0.78, 0.93]	0.7 [0.65, 0.78]	0.8 [0.78, 0.92]	n/s
No. of reporting hospitals†	46	50	52	52	51	
Western CA-MRSA cases (eligible*)	303 (303)	270 (270)	299 (299)	303 (303)	309 (309)	
Patient admissions	265,774	283,737	340,073	338,779	348,658	
Rate per 1,000 pt adm	1.1 [1.0, 1.3]	1.0 [0.8, 1.1]	0.9 [0.8, 1.0]	0.9 [0.8, 1.0]	0.9 [0.8, 1.0]	0.002
Patient days	2,084,979	1,983,469	2,318,603	2,500,602	2,560,811	
Rate per 10,000 pt days	1.5 [1.3, 1.6]	1.4 [1.2, 1.5]	1.3 [1.1, 1.4]	1.2 [1.1, 1.4]	1.2 [1.1, 1.3]	0.02
No. of reporting hospitals	18	18	19	19	19	
Central CA-MRSA cases (eligible*)	135 (135)	180 (180)	175 (175)	152 (150)	216 (216)	
Patient admissions	334,456	334,836	397,286	402,170	384,868	
Rate per 1,000 pt adm	0.4 [0.3, 0.5]	0.5 [0.46, 0.62]	0.4 [0.38, 0.51]	0.4 [0.32, 0.44]	0.6 [0.49, 0.64]	0.002
Patient days	2,640,941	2,635,922	2,778,135	3,180,282	2,986,017	
Rate per 10,000 pt days	0.5 [0.4, 0.6]	0.7 [0.6, 0.8]	0.6 [0.5, 0.7]	0.5 [0.4, 0.6]	0.7 [0.6, 0.8]	0.001
No. of reporting hospitals	22	26	27	26	25	
Eastern CA-MRSA cases (eligible*)	12 (12)	6 (6)	26 (26)	15 (15)	14 (14)	
Patient admissions	78,380	82,904	83,275	93,416	91,286	
Rate per 1,000 pt adm	0.2 [0.1, 0.3]	0.1 [0.03, 0.20]	0.3 [0.2, 0.5]	0.2 [0.1, 0.3]	0.2 [0.1, 0.3]	n/s
Patient days	715,538	754,645	763,075	871,070	836,710	
Rate per 10,000 pt days	0.2 [0.1, 0.3]	0.1 [0.03, 0.17]	0.3 [0.2, 0.5]	0.2 [0.1, 0.3]	0.2 [0.1, 0.3]	n/s
No. of reporting hospitals	6	6	6	7	7	

§ Significance test (p) compares the 2008 to the 2012 CA-MRSA rate

**Rates are calculated using only eligible data = hospitals that supplied both numerator (cases) and denominator (patient admissions and days) data*

† Number of participating hospitals varies due to eligible data submitted

1.3 Demographics and outcome data for national MRSA clinical infections

Clinical infections represent those MRSA infections identified in anatomical sites other than in the blood. Clinical cases of MRSA include those identified in the skin, soft tissue, burn, surgical site, wound, sputum, respiratory tract, urine and sites other than those categorized in Table 6.

Table 4 shows the proportion of MRSA infections identified as clinical infections by year. Overall this proportion has remained relatively constant over the surveillance period.

Table 4 Proportion of MRSA clinical* and bloodstream infections (BSI) by year

MRSA infections	2008 N (%)	2009 N (%)	2010 N (%)	2011 N (%)	2012 N (%)
Clinical infections	1645 (83.0)	1646 (79.8)	1659 (83.3)	1493 (80.0)	1462 (81.8)
Bloodstream infections	337 (17.0)	387 (20.23)	332 (16.7)	372 (20.0)	325 (18.2)
Total	1982	2033	1991	1865	1787

**Clinical infections are those infections identified in anatomical sites other than in the blood*
Demographic and outcome data for MRSA bloodstream infections can be found in Section 2 of this report.

Table 5 reports the age and gender characteristics of patients with a MRSA clinical infection by year. The median age was similar across the 5-year surveillance period, while the proportion of males with a clinical MRSA infection was 10 to 20% higher in each surveillance year.

Table 5 Age* and gender of patients with a clinical MRSA infection by year

Age and Gender	2008 N=1645	2009 N=1646	2010 N=1659	2011 N=1493	2012 N=1462
Mean age* (Std dev)	56.4 (25.5)	58.2 (25.8)	56.0 (26.8)	56.0 (26.5)	54.0 (27.3)
Median age	62.0	63.8	62.0	61.0	60.0
Min - Max age	<1 day – 100 yrs	4 days – 110 yrs	2 days – 100 yrs	<1 day – 97 yrs	1 day – 100 yrs
Females (%)	693 (42.15)	718 (43.65)	692 (41.8)	663 (44.5)	590 (40.4)
Males (%)	951 (57.85)	927 (56.35)	962 (58.2)	828 (55.5)	872 (59.6)

Please note that only data for clinical MRSA infections are included (not bloodstream infections)
*Only cases for which age was provided were included in this table

Table 6 specifies the site of clinical MRSA infections by year. Infections identified as a skin, soft tissue or burn were the most common (36-40%) source of MRSA clinical infections.

Table 6 Site of clinical MRSA infection by year

Source	2008 (N=1645) n (%)	2009 (n=1646) n (%)	2010 (n=1659) n (%)	2011 (n=1493) n (%)	2012 (n=1462) n (%)
Skin/soft tissue/burn	638 (37.8)	605 (35.7)	645 (38.0)	650 (42.8)	605 (40.8)
Surgical site/wound	366 (21.7)	394 (23.2)	340 (20.0)	247 (16.3)	296 (19.9)
Sputum/lower respiratory	341 (20.2)	337 (19.9)	342 (20.2)	278 (18.3)	304 (20.5)
Urine	232 (13.7)	243 (14.3)	239 (14.1)	225 (14.8)	177 (11.9)
Other*	113 (6.7)	117 (6.9)	131 (7.7)	120 (7.9)	102 (6.9)
Total†	1690	1696	1697	1520	1484

**Other includes cultures from bone; brain, ascites; abdominal, pancreatic fluid, device tips; ear, eye, nasal, vaginal drainage/fluid; J, G, nephrostomy, Jackson-Pratt, PEG tubes*
†Total number of clinical infections per year may exceed the number of cases reported as a case can be associated with multiple sources of infection

Table 7 reports the classification of MRSA clinical infections (HA vs CA) by year. The majority (67-75%) were classified as HA in each surveillance year. However, the proportion of HA-MRSA has been steadily decreasing since 2008.

Table 7 Classification of MRSA clinical infections

Clinical infections	2008 N=1645 (%)	2009 N=1646 (%)	2010 N=1659 (%)	2011 N=1493 (%)	2012 N=1462 (%)
HA-MRSA[†]	1139 (74.9)	1106 (74.2)	1084 (71.4)	1011 (72.6)	919 (67.3)
CA-MRSA[§]	381 (25.1)	384 (25.8)	434 (28.6)	382 (27.4)	446 (32.7)
Total*	1520	1490	1518	1393	1365

[†]HA-MRSA = in hospital >48 hours, infections acquired in another healthcare facility, a long-term healthcare facility or any other healthcare exposure.
[§]CA-MRSA = in hospital <48 hours, no previous healthcare exposure or previously identified MRSA
**Totals may not add to reported number of clinical MRSA infections due to missing data*
MRSA is classified based on case definitions (see methods section p 8-9). HA-MRSA are identified as occurring in hospitals, other healthcare settings or exposures. CA-MRSA is identified as occurring outside of healthcare settings to people with no known healthcare exposures.
Clinical infections are those infections identified in anatomical sites other than in the blood

Table 8 reports patient outcome at 30 days after the clinical MRSA infection was identified. Data collection for outcome related to clinical MRSA infections was started January 1 2012. Death is reported as 'all-cause mortality' and is not necessarily attributable to the MRSA infection. Approximately 9% of patients with a clinical MRSA infection died although it is not known whether their death was directly related to their MRSA infection.

Table 8 Outcome 30 days after clinical MRSA infection for 2012

Outcome	2012 N=1462 n (%)
Patient died*	96 (8.6)
Patient alive (discharged, readmitted or still in hospital)	1022 (91.4)
Total[§]	1118

**Mortality data represent all-cause mortality, not MRSA attributable mortality*
[§]Total is less than number of cases due to missing data

Discussion

Overall, most national and regional MRSA infection rates have been slowly decreasing or have remained stable since 2009 (Table 9). Regional variation in rates is observed and the pattern is not consistent. Overall infection rates are highest in the west and lowest in central Canada while HA-MRSA rates are highest in the East and CA-MRSA infection rates are highest in the west.

Table 9 Trends in national and regional MRSA rates per 10,000 patient days by year

MRSA		National and regional rates per 10,000 patient days				
		2008	2009	2010	2011	2012
Infections	**National**	3.6	3.8	3.4	2.8	2.8
	West	5.1	4.9	3.9	3.6	3.3
	Central	2.5	3.2	3.1	2.3	2.4
	East	3.7	2.9	3.2	2.8	2.9
HA-MRSA infections	**National**	2.5	2.6	2.3	1.9	1.7
	West	3.2	3.1	2.4	2.2	2.0
	Central	1.7	2.2	2.0	1.5	1.3
	East	3.3	2.6	2.6	2.5	2.5
CA-MRSA infections	**National**	0.8	0.9	0.9	0.7	0.8
	West	1.5	1.4	1.3	1.2	1.2
	Central	0.5	0.7	0.6	0.5	0.7
	East	0.2	0.1	0.3	0.2	0.2

Compared to previously published CNISP data, MRSA infection rates have increased from 0.4 cases per 10,000 patient days in 1995[7] to a peak of 3.8 in 2009 and then have steadily decreased to 2.8 cases per 10,000 patient days in 2012.

Comparison of Canadian MRSA rates (combined clinical and bloodstream) with international rates is extremely difficult. Most countries do not report all MRSA cases but primarily focus on reporting cases of MRSA bloodstream infections. The USA (CDC) reports all cases of 'invasive MRSA' which is defined as 'MRSA found on a normally sterile site,[8] such as the blood, cerebrospinal fluid, pleural fluid, bone, respiratory, wounds etc. The US performs population-based surveillance for invasive MRSA infections and calculates and reports their rates using population estimates (e.g. rate per 100,000 population). Many Nordic countries such as Sweden, Finland, Norway, Iceland and Denmark also report their MRSA rates per 100,000 population. Canadian rates are calculated using hospital patient admissions and patient days.

Although comparison of MRSA rates from one country to another is difficult due to differing methodologies, the overall trend of declining MRSA rates seen in Canadian data has also been reported in the USA. Overall rates for invasive MRSA infections in the USA have declined in 2012 (23.99 per 100,000 population) compared to their 2009 incidence rate of 29.3 per 100,000 population.[8,9] This declining trend has not been observed in many Nordic countries (Sweden, Finland, Norway, Iceland, and Denmark) where rates of MRSA have been increasing. For example, in Denmark the number of cases of MRSA in 2012 has more than doubled since 2007.[10] Denmark's rate of MRSA in 2012 is 27.0 per 100,000 population compared to approximately 13.0 in 2007.
Regional variation in rates is also seen in countries and regions around the world. Regional variation in the proportion of *Staphylococcus aureus* reported as MRSA has also been observed in Europe. The percentage of isolates reported as MRSA ranged from 0.7% (Sweden) to 53.9% (Romania).[11]

A large US MRSA prevalence study in 2006 found significant inter-state variability in the rates of MRSA.[12] Regional variations in Canadian MRSA rates may be partially explained by the strain types that are predominant in the different regions of the country. Strains typically associated with community onset infections appear more predominantly in western Canada while strains associated with hospital acquired infections are more prominent in the eastern region of Canada (See Table 27, p. 35).

The proportion of all MRSA infections identified as clinical (cases identified at anatomical sites other than the blood) averaged 82% over the 5 year surveillance period with little variation by year. This is slightly lower than

previously published CNISP data which reported that 87% of all MRSA infections from 1995-2007 were identified as clinical infections.[7]

There were no significant differences in age between surveillance years and the median age ranged from 60 - 64 years which is slightly lower than the median age of 71 years reported for CNISP data from 1995-2007.[7] The youngest patients were less than one day and the oldest 110 years old. Older age is a known risk factor for acquisition of MRSA.[13,14]

The proportion of men with a clinical MRSA infection was 55-60% in each surveillance year. However, males represent only 42.3% of all inpatient hospitalizations in Canada in 2011-2012.[15] In 2012, males represented 60% of all clinical MRSA infections reported by CNISP hospitals. This proportion is relatively unchanged from previously published CNISP data where the proportion of males identified as infected or colonized with MRSA was 58% during the period from 1995-2007.[7] German, Asian and US national and state hospital data have also reported that significantly more men have MRSA infections.[13,14,16,17]

The most common source of MRSA clinical infections in each surveillance year were those identified from skin, soft tissue or burns and represented on average 40% of all clinical infections reported followed by respiratory (20%) and surgical sites or wounds (20%). This represents a slight increase from previously reported CNISP data where 36% of all infections from 1995-2007 were identified as skin and soft tissue followed by respiratory (23%) and surgical sites (20%).[7] These proportions are very similar to those reported in other countries. For example, in 2012 the CDC reported that skin and soft tissue MRSA infections represented approximately 34% of all invasive non-bloodstream infections.[8] A national study in 2010 of MRSA among inpatients in US healthcare facilities found the most common site of infection was skin and soft tissue.[18] A retrospective study conducted from 2007-2011 in a large acute care tertiary hospital in Singapore reported skin and soft tissue as the most common site (41%) of clinical MRSA infections.[17]

The proportion of clinical MRSA infections classified as CA-MRSA in Canadian acute-care hospitals has steadily increased from 25% in 2008 to 33% in 2012. Previously published CNISP data reported the proportion of all MRSA (infections & colonizations) identified as CA-MRSA as 17% in 1995 and 21% in 2007.[7] These increases are not surprising as they mirror those from other countries reporting similar increases in CA-MRSA.[10,18] In the US the proportion of invasive MRSA infections classified as CA was 17% in 2009 and 20% in 2012.[8,9]

Data relating to 30-day outcome of those patients with a clinical MRSA infection is only available for the 2012 surveillance year. Of the 1,118 patients where outcome was known, 9% (n=96) died although this proportion represents all-cause mortality and therefore it is not known whether death is directly attributable to the MRSA infection. Comparison of Canadian clinical MRSA mortality rates with international rates is difficult. Most countries do not report mortality data on all MRSA cases but primarily focus on reporting MRSA bacteremia mortality rates. However, of the limited data available, mortality rates in other countries appear higher than those seen in Canadian data. For example, 30-day mortality among clinically infected MRSA patients from a large acute-care tertiary hospital in Singapore was reported at 16.5% from a retrospective cohort study.[17]

In summary, MRSA infection rates are decreasing in Canada and in many countries around the world. The reduction in Canadian MRSA rates is most dramatically seen in MRSA infection rates and more specifically HA-MRSA infection rates. These decreases may in part be due to local and national hand hygiene campaigns introduced around 2007 following the WHO's Global Patient Safety Challenge – Clean Care is Safe Care (http://www.patientsafetyinstitute.ca/), antimicrobial stewardship programs and increased surveillance and screening activities.

SECTION 2 MRSA IN CANADA: NATIONAL AND REGIONAL MRSA BLOODSTREAM INFECTION (BSI) SURVEILLANCE (BACTEREMIAS) FROM JANUARY 1, 2008 TO DECEMBER 31, 2012

2.1 National and regional MRSA BSI from January 1, 2008 to December 31, 2012

Figure 4 illustrates national and regional MRSA BSI rates per 10,000 patient days. Nationally and in the west, the rate has significantly decreased since 2008. Centrally, the BSI rate peaked in 2009, and has since remained constant. The eastern BSI rate has remained unchanged over this 5-year surveillance period (Table 10).

Figure 4 National and regional MRSA BSI rates per 10,000 patient days

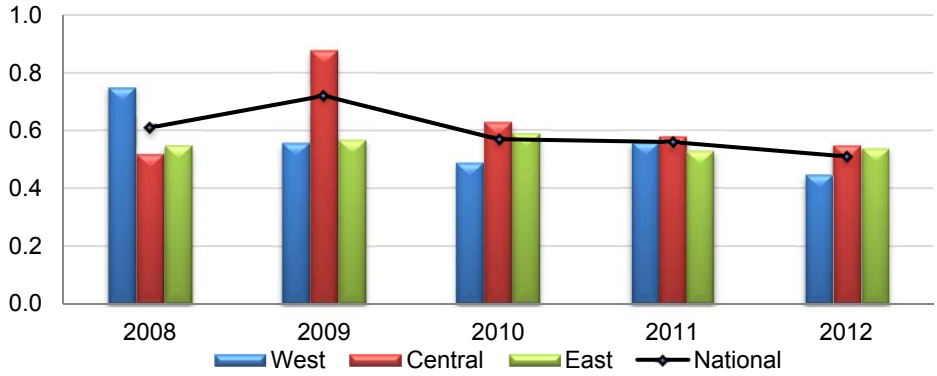


Table 10 provides the number of MRSA BSI cases, patient admissions, patient days, number of participating hospitals and incidence rates with 95% CI by year. The rate in 2008 was compared to the 2012 rate.

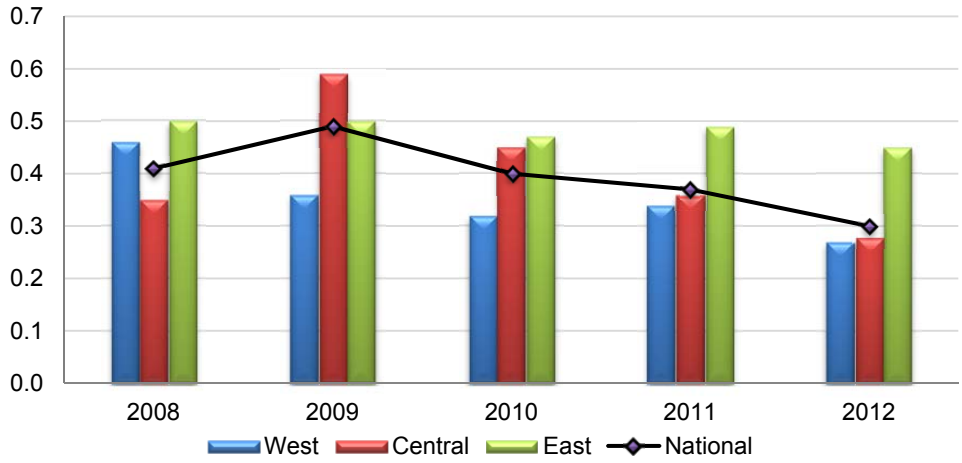
Table 10 National and regional MRSA BSI cases and incidence rates (95% CI) from 2008 to 2012

	2008	2009	2010	2011	2012	$p^{\S}$
National MRSA cases (eligible*)	337 (337)	387 (387)	332 (332)	372 (370)	325 (325)	
Patient admissions	678,610	701,477	820,634	834,365	824,812	
Rate per 1,000 pt adm	0.5 [0.4, 0.6]	0.6 [0.50, 0.61]	0.4 [0.36, 0.45]	0.4 [0.40, 0.49]	0.4 [0.35, 0.44]	0.003
Patient days	5,441,458	5,374,036	5,859,813	6,551,954	6,383,538	
Rate per 10,000 pt days	0.6 [0.56, 0.7]	0.7 [0.65, 0.79]	0.6 [0.51, 0.63]	0.6 [0.51, 0.63]	0.5 [0.45, 0.6]	0.01
No. of reporting hospitals†	46	50	52	52	51	
Western MRSA cases (eligible*)	159 (159)	112 (112)	113 (113)	139 (139)	116 (116)	
Patient admissions	265,774	283,737	340,073	338,779	348,658	
Rate per 1,000 pt adm	0.6 [0.5, 0.7]	0.4 [0.3, 0.5]	0.3 [0.27, 0.4]	0.4 [0.3, 0.5]	0.3 [0.27, 0.4]	<0.001
Patient days	2,084,979	1,983,469	2,318,603	2,500,602	2,560,811	
Rate per 10,000 pt days	0.8 [0.6, 0.88]	0.6 [0.5, 0.7]	0.5 [0.4, 0.6]	0.6 [0.5, 0.66]	0.5 [0.4, 0.54]	<0.001
No. of reporting hospitals	18	18	19	19	19	
Central MRSA cases (eligible*)	138 (138)	232 (232)	174 (174)	187 (185)	164 (164)	
Patient admissions	334,456	334,836	397,286	402,170	384,868	
Rate per 1,000 pt adm	0.4 [0.35, 0.5]	0.7 [0.6, 0.8]	0.4 [0.38, 0.5]	0.5 [0.4, 0.53]	0.4 [0.36 0.5]	n/s
Patient days	2,640,941	2,635,922	2,778,135	3,180,282	2,986,017	
Rate per 10,000 pt days	0.5 [0.4, 0.6]	0.9 [0.8, 1.0]	0.6 [0.5, 0.7]	0.6 [0.5, 0.7]	0.6 [0.5, 0.64]	n/s
No. of reporting hospitals	22	26	27	26	25	
Eastern MRSA cases (eligible*)	40 (40)	43 (43)	45 (45)	46 (46)	45 (45)	
Patient admissions	78,380	82,904	83,275	93,416	91,286	
Rate per 1,000 pt adm	0.5 [0.4, 0.7]	0.5 [0.4, 0.7]	0.5 [0.4, 0.7]	0.5 [0.4, 0.7]	0.5 [0.4, 0.7]	n/s
Patient days	715,538	754,645	763,075	871,070	836,710	
Rate per 10,000 pt days	0.6 [0.4, 0.7]	0.6 [0.4, 0.8]	0.6 [0.4, 0.8]	0.5 [0.4, 0.7]	0.5 [0.4, 0.7]	n/s
No. of reporting hospitals	6	6	6	7	7	

§*Significance test (p compares the 2008 MRSA BSI rate to the 2012 rate*
**Rates are calculated using only eligible data = hospitals that supplied both numerator (cases) and denominator (patient admissions and days) data*
†*Number of participating hospitals varies due to eligible data submitted*

Figure 5 illustrates national and regional HA-MRSA BSI rates per 10,000 patient days. Nationally and in the west HA-MRSA rates have significantly decreased. Centrally and in the east, there were no significant differences in HA-MRSA BSI rates per 10,000 patient days in 2012 compared to 2008 (Table 11).

Figure 5 National and regional HA-MRSA BSI rates per 10,000 patient days



MRSA is classified based on case definitions (see methods section p 8-9). HA-MRSA are identified as occurring in hospitals, other healthcare settings or exposures. CA-MRSA is identified as occurring outside of healthcare settings to people with no known healthcare exposures.

Table 11 provides the number of HA-MRSA BSI cases, patient admissions, patient days, number of participating hospitals and incidence rates with 95% CI by year. The rate in 2008 was compared to the 2012 rate.

Table 11 National and regional HA-MRSA BSI cases and incidence rates (95% CI) from 2008 to 2012

	2008	2009	2010	2011	2012	$p^{\S}$
National HA- MRSA cases (eligible*)	230 (230)	272 (272)	243 (243)	250 (250)	193 (193)	
Patient admissions	678,610	701,477	820,634	834,365	824,812	
Rate per 1,000 pt adm	0.3 [0.29, 0.39]	0.4 [0.34, 0.44]	0.3 [0.26, 0.34]	0.3 [0.26, 0.34]	0.2 [0.20, 0.27]	<0.001
Patient days	5,441,458	5,374,036	5,859,813	6,551,954	6,383,538	
Rate per 10,000 pt days	0.4 [0.37, 0.48]	0.5 [0.4, 0.6]	0.4 [0.37, 0.47]	0.4 [0.34, 0.43]	0.3 [0.26, 0.35]	<0.001
No. of reporting hospitals[†]	46	50	52	52	51	
Western HA- MRSA cases (eligible*)	98 (98)	73 (73)	77 (77)	85 (85)	68 (68)	
Patient admissions	265,774	283,737	340,073	338,779	348,658	
Rate per 1,000 pt adm	0.4 [0.37, 0.45]	0.3 [0.20, 0.32]	0.2 [0.18, 0.28]	0.3 [0.20, 0.31]	0.2 [0.15, 0.25]	<0.001
Patient days	2,084,979	1,983,469	2,318,603	2,500,602	2,560,811	
Rate per 10,000 pt days	0.5 [0.4, 0.6]	0.4 [0.3, 0.5]	0.3 [0.26, 0.41]	0.3 [0.27, 0.42]	0.3 [0.21, 0.34]	<0.001
No. of reporting hospitals	18	18	19	19	19	
Central HA- MRSA cases (eligible*)	95 (95)	161 (161)	126 (126)	121 (121)	86 (86)	
Patient admissions	334,456	334,836	397,286	402,170	384,868	
Rate per 1,000 pt adm	0.3 [0.23, 0.35]	0.5 [0.4, 0.6]	0.3 [0.27, 0.38]	0.3 [0.25, 0.36]	0.2 [0.18, 0.28]	n/s
Patient days	2,640,941	2,635,922	2,778,135	3,180,282	2,986,017	
Rate per 10,000 pt days	0.4 [0.29, 0.44]	0.6 [0.5, 0.7]	0.5 [0.38, 0.54]	0.4 [0.32, 0.45]	0.3 [0.2, 0.4]	n/s
No. of reporting hospitals	22	26	27	26	25	
Eastern HA- MRSA cases (eligible*)	37 (37)	38 (38)	40 (40)	44 (44)	39 (39)	
Patient admissions	78,380	82,904	83,275	93,416	91,286	
Rate per 1,000 pt adm	0.5 [0.3, 0.6]	0.5 [0.3, 0.6]	0.5 [0.3, 0.6]	0.5 [0.3, 0.6]	0.4 [0.3, 0.6]	n/s
Patient days	715,538	754,645	763,075	871,070	836,710	
Rate per 10,000 pt days	0.5 [0.4, 0.7]	0.5 [0.4, 0.7]	0.5 [0.4, 0.7]	0.5 [0.4, 0.7]	0.5 [0.3 ,0.6]	n/s
No. of reporting hospitals	6	6	6	7	7	

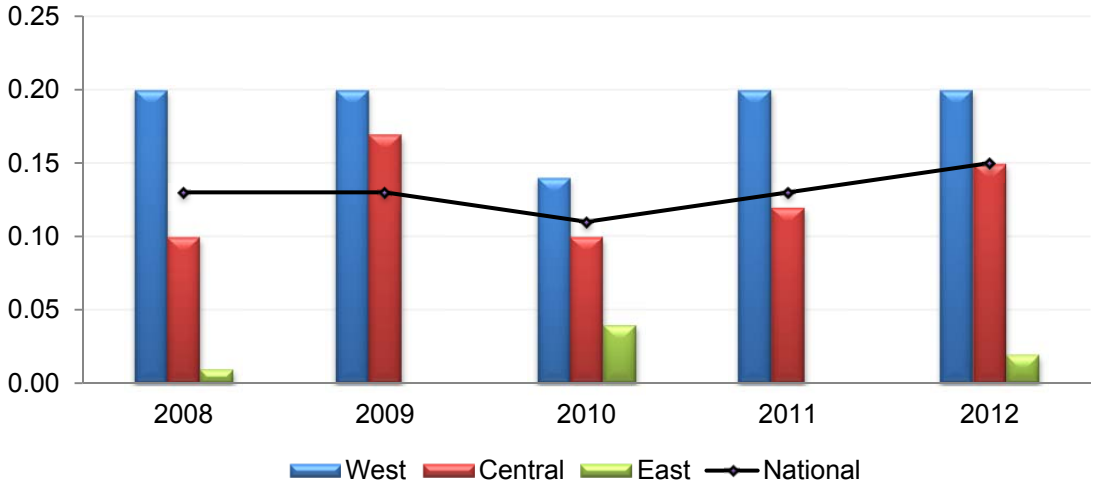
[§] Significance test (p) compares the 2008 HA-MRSA BSI rate to the 2012 rate

**Rates are calculated using only eligible data = hospitals that supplied both numerator (cases) and denominator (patient admissions and days) data*

[†] Number of participating hospitals varies due to eligible data submitted

Figure 6 illustrates national and regional incidence rates of CA-MRSA BSI per 10,000 patient days. Overall, the CA-MRSA BSI rate has remained relatively stable from year to year. CA-MRSA BSI rates remain lowest in the east and highest in the west. There was a slight increase in central MRSA BSI rates in 2012 compared to 2008 (Table 12).

Figure 6 National and regional CA-MRSA BSI rates per 10,000 patient days



MRSA is classified based on case definitions (see methods section p 8-9). HA-MRSA are identified as occurring in hospitals, other healthcare settings or exposures. CA-MRSA is identified as occurring outside of healthcare settings to people with no known healthcare exposures.

Table 12 provides the total number of CA-MRSA BSI cases, patient admissions, patient days, number of participating hospitals and incidence rates with 95% CI by year. The 2008 rate was compared to the 2012 rate.

Table 12 National and regional CA-MRSA BSI cases and incidence rates (95% CI) from 2008 to 2012

	2008	2009	2010	2011	2012	*p*[§]
National CA-MRSA cases (eligible*)	69 (69)	72 (72)	66 (66)	88 (87)	93 (93)	
Patient admissions	678,610	701,477	820,634	834,365	824,812	
Rate per 1,000 pt adm	0.1 [0.79, 0.13]	0.1 [0.08, 0.13]	0.08 [0.06, 0.10]	0.1 [0.09, 0.13]	0.1 [0.09, 0.14]	n/s
Patient days	5,441,458	5,374,036	5,859,813	6,551,954	6,383,538	
Rate per 10,000 pt days	0.13 [0.10, 0.16]	0.13 [0.11, 0.17]	0.11 [0.09, 0.14]	0.13 [0.11, 0.16]	0.15 [0.12, 0.18]	n/s
No. of reporting hospitals[†]	46	50	52	52	51	
Western CA-MRSA cases (eligible*)	44 (44)	31 (31)	34 (34)	51 (51)	46 (46)	
Patient admissions	265,774	283,737	340,073	338,779	348,658	
Rate per 1,000 pt adm	0.2 [0.12, 0.22]	0.1 [0.08, 0.15]	0.1 [0.07, 0.14]	0.15 [0.11, 0.20]	0.1 [0.09, 0.17]	n/s
Patient days	2,084,979	1,983,469	2,318,603	2,500,602	2,560,811	
Rate per 10,000 pt days	0.2 [0.15, 0.28]	0.2 [0.11, 0.22]	0.15 [0.10, 0.20]	0.2 [0.15, 0.27]	0.2 [0.13, 0.24]	n/s
No. of reporting hospitals	18	18	19	19	19	
Central CA-MRSA cases (eligible*)	24 (24)	41 (41)	29 (29)	37 (36)	45 (45)	
Patient admissions	334,456	334,836	397,286	402,170	384,868	
Rate per 1,000 pt adm	0.07 [0.05, 0.11]	0.1 [0.09, 0.16]	0.07 [0.05, 0.10]	0.1 [0.07, 0.12]	0.1 [0.09, 0.16]	0.05
Patient days	2,640,941	2,635,922	2,778,135	3,180,282	2,986,017	
Rate per 10,000 pt days	0.1 [0.06, 0.13]	0.2 [0.13, 0.21]	0.1 [0.07, 0.14]	0.1 [0.08, 0.16]	0.2 [0.11, 0.20]	0.04
No. of reporting hospitals	22	26	27	26	25	
Eastern CA-MRSA cases (eligible*)	1 (1)	0	3 (3)	0	2 (2)	
Patient admissions	78,380	82,904	83,275	93,416	91,286	
Rate per 1,000 pt adm	0.01 [0.001, 0.07]	0.00	0.04 [0.01, 0.11]	0.00	0.02 [0.002, 0.08]	n/s
Patient days	715,538	754,645	763,075	871,070	836,710	
Rate per 10,000 pt days	0.01 [0.002, 0.08]	0.00	0.04 [0.01, 0.11]	0.00	0.02 [0.003, 0.09]	n/s
No. of reporting hospitals	6	6	6	7	7	

[§] *Significance test (p) compares the 2008 HA-MRSA BSI rate to the 2012 rate*

**Rates are calculated using only eligible data = hospitals that supplied both numerator (cases) and denominator (patient admissions and days) data*

[†] *Number of participating hospitals varies due to eligible data submitted*

2.2 Demographics and outcome data for national MRSA bloodstream infections (BSI)

MRSA BSIs (or MRSA bacteremia) are a subset of MRSA infections and include only cases that had a MRSA infection in the blood. Since 2008 MRSA BSIs have represented approximately 17 – 20% of all MRSA infections identified (Table 4).

Table 13 reports the age and gender characteristics for patients with a MRSA BSI by year. Overall the median age was similar across the 5-year surveillance period. The proportion of males with a MRSA BSI was approximately 20 – 30% higher in each surveillance year.

Table 13 Age and gender of patients with a MRSA BSI by year

	2008 N=337 n (%)	2009 N=387 n (%)	2010 N=332 n (%)	2011 N=372 n (%)	2012 N=325 n (%)
Mean age* (Std dev)	59.9 (22.6)	60.6 (21.2)	60.6 (20.8)	60.3 (23.5)	57.1 (23.2)
Median age	65	63	63	63	61
Min - Max age	<1 day – 99 yrs	1 day - 99 yrs	<1 day - 97 yrs	2 days – 100 yrs	6 days – 101 yrs
Females (%)	140 (41.5)	156 (40.3)	117 (35.2)	132 (35.5)	111 (34.2)
Males (%)	197 (58.5)	231 (59.7)	215 (64.8)	240 (64.5)	214 (65.9)

Please note that only data for MRSA BSI are included (not clinical infections)
**Only cases for which age was provided were included in this table*

The source of MRSA BSIs has been commonly associated with several different sites. Table 14 shows the most frequently reported sources of MRSA BSI acquisition over the surveillance period. Central line associated BSI accounted for approximately 27% of the total bacteremias from 2008-2012 followed by skin, soft tissue or burn infections (21%).

Table 14 Source of infection by year

	2008 (n=337) N (%)	2009 (n=387) N (%)	2010 (n=332) N (%)	2011 (n=372) N (%)	2012 (n=325) N (%)
Bone/Joint	19 (6.9)	12 (4.0)	15 (5.3)	13 (4.3)	10 (4.0)
Central line associated	63 (23.0)	71 (23.4)	83 (29.2)	83 (27.2)	78 (31.6)
Endocarditis	13 (4.7)	9 (3.0)	14 (4.9)	14 (4.6)	11 (4.5)
Pleural/Pulmonary	43 (15.7)	48 (15.8)	52 (18.3)	58 (19.0)	40 (16.2)
Skin/soft tissue/burn	70 (25.5)	74 (24.4)	55 (19.4)	51 (16.7)	53 (21.5)
Surgical site/wound	35 (12.8)	39 (12.9)	33 (11.6)	30 (9.8)	26 (10.5)
Urinary	25 (9.1)	43 (14.2)	25 (8.8)	48 (15.7)	23 (9.3)
Other[†]	6 (2.2)	7 (2.3)	7 (2.5)	8 (2.6)	6 (2.4)
Total*	274	303	284	305	247

[†]Other includes cholecystitis; bowel; biliary tract infection; abdominal sepsis; parotitis; subhepatic fluid; renal, pancreatic, epidural, paraspinal, perinephric, spinal, liver abscesses
** Total is less than number of cases due to missing data*

Table 15 reports the classification of MRSA BSIs (HA vs CA) by year. Of the MRSA BSIs able to be classified as HA or CA, the majority were classified as HA. However, the proportion of HA-MRSA has been steadily decreasing since 2008.

Table 15 Classification of MRSA BSIs

MRSA BSI infections	2008 N=337 n (%)	2009 N=387 n (%)	2010 N=332 n (%)	2011 N=372 n (%)	2012 N=325 n (%)
HA-MRSA[†]	230 (76.9)	272 (79.1)	243 (78.6)	250 (74.0)	193 (67.5)
CA-MRSA[§]	69 (23.1)	72 (20.9)	66 (21.4)	88 (26.0)	93 (32.5)
Total*	299	344	309	338	286

[†] HA-MRSA = in hospital >48 hours, prior healthcare exposure
[§] CA-MRSA = in hospital <48 hours, no previous healthcare exposure or previously identified MRSA
** Total is less than number of cases due to missing data*
Note: MRSA is classified based on case definitions (see methods section p 8-9). HA-MRSA are identified as occurring in hospitals, other healthcare settings or exposures. CA-MRSA is identified as occurring outside of healthcare settings to people with no known healthcare exposures.

Table 16 describes the proportion of MRSA BSI cases that were admitted to the ICU within 30 days of their first positive MRSA blood culture. Approximately 20 - 30% of patients with a MRSA BSI were admitted to ICU annually.

Table 16 Intensive care unit (ICU) admission by year

Admitted to ICU	2008 N=337 n (%)	2009 N=387 n (%)	2010 N=332 n (%)	2011 N=372 n (%)	2012 N=325 n (%)
Yes	90 (26.9)	105 (28.6)	96 (30.1)	103 (29.1)	74 (23.9)
No	245 (73.1)	262 (71.4)	223 (69.9)	251 (70.9)	236 (76.1)
Total*	335	367	319	354	310

** Total is less than number of cases due to missing data*

Table 17 reports patient outcome at 30 days after the MRSA BSI was identified. Death is reported as 'all-cause mortality' and is not necessarily related specifically to the MRSA BSI. Annually, approximately 25% of patients with a MRSA BSI died.

Table 17 Outcome at 30 days following positive MRSA blood culture by year

Outcome	2008 N=337 n (%)	2009 N=387 n (%)	2010 N=332 n (%)	2011 N=372 n (%)	2012 N=325 n (%)
Patient died*	74 (22.0)	94 (24.4)	74 (22.4)	102 (27.8)	71 (22.0)
Patient alive (discharged or remains in hospital)	263 (78.0)	291 (75.6)	256 (77.6)	265 (72.2)	252 (78.0)
Total[§]	337	385	330	367	323

**Mortality data represent all-cause mortality, not MRSA attributable mortality.*
[§] May not add to total number of BSI cases per year due to missing data

Discussion

Overall national and some regional MRSA BSI rates have significantly decreased since 2008 while other region's MRSA BSI rates have remained relatively unchanged. Regional variation is minimal compared to the more pronounced variability seen in overall (clinical & bloodstream combined) MRSA infection rates.

The proportion of all MRSA infections identified as bloodstream infections (bacteremias) averaged 18% over the 5 year surveillance period with little variation by year. This is slightly greater than previously published CNISP data which reported that 13% of all MRSA infections from 1995-2007 were identified as bloodstream infections.[7]

Compared to early CNISP MRSA BSI data[d], MRSA BSI infection rates have increased from 0.03 cases per 10,000 patient days in 1995 to a peak of 0.7 in 2009 and then decreased to 0.5 cases per 10,000 patient days in 2012. MRSA BSI rates have been relatively stable since 2008.

Although many countries report national MRSA BSI rates, the case definition and denominator data (population estimates versus patient admissions or patient days) differ, making it difficult to compare rates internationally. However, of the countries where data is somewhat comparable most have shown a decreasing trend as also seen in Canada. Australian MRSA BSI rates have declined from 1.1 per 10,000 days of patient care to 0.9.[19] Hospital-onset MRSA BSI rates from acute-care tertiary hospitals in California, USA reported a rate of 0.5 per 10,000 patient days in 2012,[20] higher than the rate (0.3 per 10,000 patient days) reported by similar hospitals participating in the CNISP MRSA surveillance.

MRSA rates in England have also shown significant declines. In England, the rate of MRSA BSI per 10,000 bed-days decreased from 0.43 in 2008/09 to 0.12 in 2012/13.[21] For England it has been suggested that their national MRSA strategy was rigidly directed at MRSA BSI.[22] The English National Health System operates under a 'zero tolerance policy for MRSA bacteremias'.[21] English hospitals are measured against this strategy and data is published. As a result hospitals may have been under more pressure to comply with the national MRSA strategy.[22]

The US reports all 'invasive MRSA' cases per 100,000 population of which BSIs in 2012 represented just over half (54%) of their invasive MRSA cases.[8] The rates of invasive MRSA in the US have also declined from their baseline rate of 34.0 per 100,000 population in 2007 to 24.0 in 2012, although since 2010 the decrease has been much slower.[8,23]

Variation in MRSA BSI rates has been reported in other regions. For example, in England 2012-2013 region-specific rates vary from 0.8 – 3.4 per 100,000 population.[21] In 2012, MRSA BSI rates in acute-care tertiary hospitals in the state of California varied from 0.0 to 2.0 per 10,000 patient days.[20]

There were no significant differences in age between surveillance years and the median age ranged from 61 - 65 years which is slightly higher than the median age reported for clinical infections (60 – 64 years) and lower than the median age of 71 years reported for all CNISP data from 1995-2007.[7] The youngest patients were less than one day and the oldest 101 years old. Older age is a known risk factor for acquisition of MRSA.[13,14]

The proportion of men with a clinical MRSA infection was 59-66% over the surveillance period. The proportion of males with MRSA BSI is slightly higher than that reported for clinical infections (55-60%). However, males represented only 42.3% of all inpatient hospitalizations in Canada in 2011-2012.[15] In 2012, males represented 66% of all MRSA BSI infections reported by CNISP hospitals. English, Irish and US data have also reported that more men have MRSA infections.[21,24,25]

The most common source of MRSA BSI in each surveillance year were central-lines and represented on average 27% of all BSIs reported followed by skin, soft tissue or burns (22%) and pleural or pulmonary (17%). These sources of acquisition for MRSA BSI are the most commonly reported in other countries.[12,26,27] For example, in national English data, central and peripheral lines and skin/soft tissue represented 30-40% of the source of all MRSA BSIs from 2007 – 2014.[21]

[d] *MRSA BSI infection rates from 1995-2007 may be underestimated as formal surveillance of MRSA BSI was not initiated till 2008. All colonizations or clinical infections that may have resulted in an MRSA BSI may not have been captured as there was no explicit definition or methods to identify these till the 2008 surveillance year*.

The majority of MRSA BSIs (average 70%) since 2010 have been identified as HA-MRSA. However, the proportion classified as CA-MRSA in Canadian acute-care hospitals has steadily increased from 22% in 2010 to 33% in 2012. These increases mirror those from other countries reporting similar increases in CA-MRSA BSI.[24,28,29] In the US the proportion of invasive MRSA infections classified as CA was 17% in 2009 and 20% in 2012.[8,9]

Just under one-third of all MRSA BSI cases were admitted annually to an intensive care unit (ICU). This is not surprising given the high morbidity and mortality associated with MRSA BSI. From 2008 to 2012 approximately 25% of patients with MRSA BSI died compared to 9% of those with a clinical MRSA infection. Although this percentage represents all-cause mortality and therefore it is not known whether death is directly attributable to the MRSA BSI, increased morbidity and mortality associated with MRSA BSI has been well established.[19,30,31] Canadian MRSA BSI mortality rates are very similar to those reported in Germany (30%), Ireland (28%), and Italy (38%)[31] and in the US (12%).[8] The US reports mortality for invasive MRSA of which BSI represent approximately 54% of their invasive MRSA infections.[8]

SECTION 3 MRSA IN CANADA: NATIONAL AND REGIONAL MRSA SURVEILLANCE BY FACILITY TYPE (ADULT AND PEDIATRIC HOSPITALS) FROM JANUARY 1, 2008 TO DECEMBER 31, 2012

Table 18 illustrates the proportion of adult (≥18 years) and pediatric (<18 years) cases with MRSA infection identified from 2008 to 2012. Adult patients represent the majority (86-90%) of MRSA infections in every surveillance year.

Table 18 Proportion of adult and pediatric cases with an MRSA infection (clinical and bloodstream)

Adult vs pediatric	2008 N=1520	2009 N=1489	2010 N=1517	2011 N=1393	2012 N=1364	2008-2012
Adults	1787 (90.2)	1844 (91.5)	1761 (88.5)	1653 (88.9)	1529 (86.1)	8574 (89.1)
Pediatric	194 (9.8)	172 (8.5)	228 (11.5)	207 (11.1)	246 (13.9)	1047 (10.9)
Total	1981	2016	1989	1860	1775	9621

3.1 National MRSA infections in adult and pediatric hospitals from January 1, 2008 to December 31, 2012

Hospitals participating in CNISP surveillance that identify as admitting only adult patients (generally ≥18 years of age) were used to calculate MRSA rates for adult inpatients and hospitals that identify as admitting only pediatric patients (generally < 18 years) were used to calculate rates for pediatric inpatients. Due to the small number of hospitals available to calculate rates by region only national rates and number of cases are presented.

Figure 7 illustrates the national incidence rates of MRSA infections (clinical and bloodstream combined) in adult and pediatric hospitals from 2008-2012. Nationally, MRSA infection rates in adult hospitals have decreased while pediatric rates have increased (Table 19).

Figure 7 National MRSA infection rates in adult and pediatric hospitals per 10,000 patient days

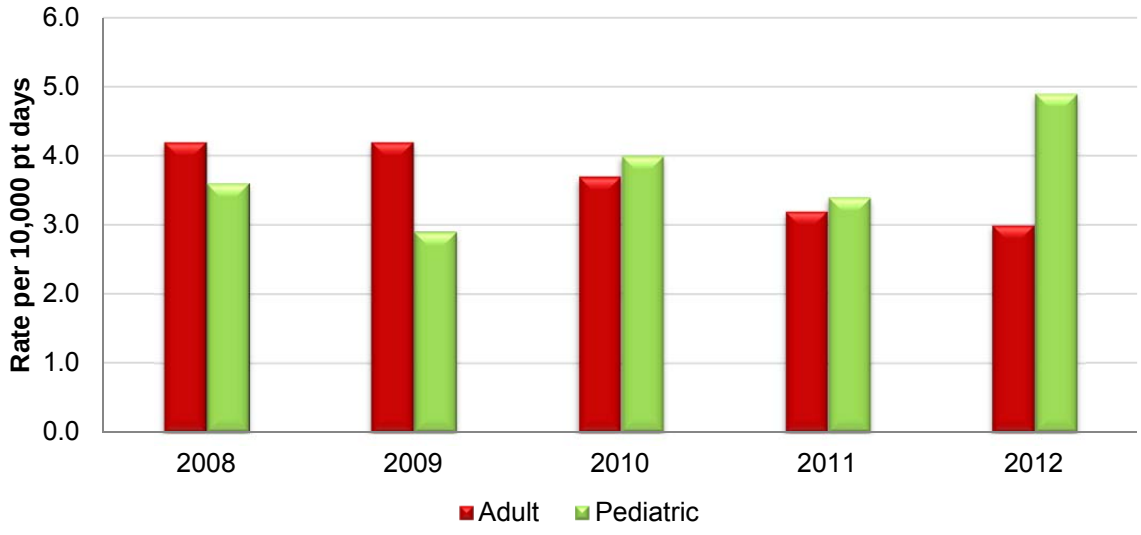


Table 19 provides the total number of MRSA infections, patient admissions, patient days, number of participating hospitals and incidence rates with 95% CI by year. The rate in 2008 was compared to the 2012 rate.

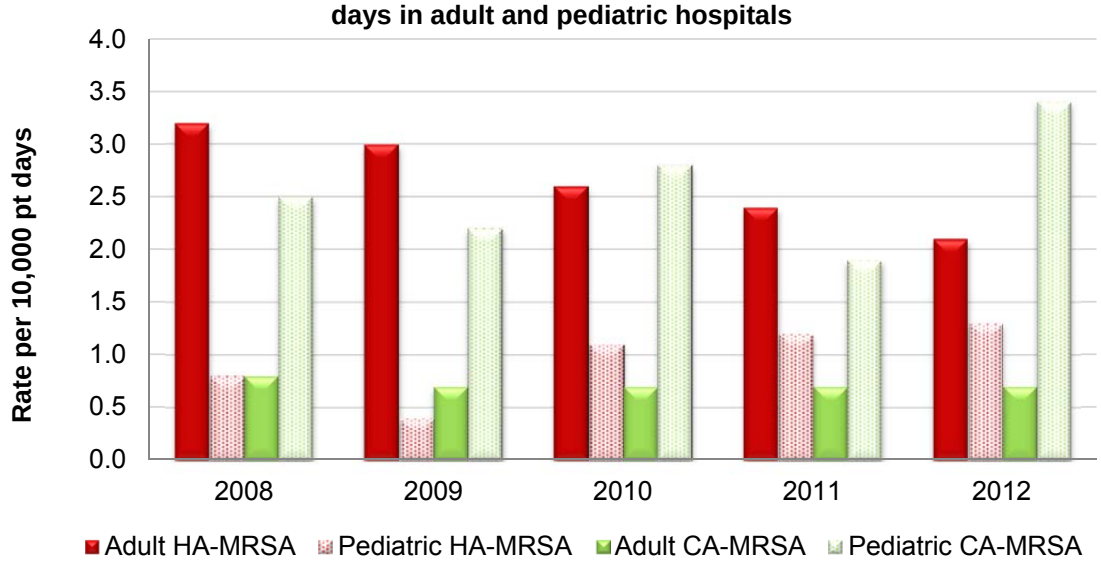
Table 19 National MRSA infections and incidence rates (95% CI) in adult and pediatric hospitals from 2008 to 2012

	2008	2009	2010	2011	2012	$p^{\S}$
National Adult MRSA infections (eligible*)	1,413 (1,413)	1,510 (1,510)	1,477 (1,477)	1,367 (1,367)	1,221 (1,221)	
Patient admissions	379,582	428,484	513,292	503,866	480,845	
Rate per 1,000 adm	3.7 [3.5, 3.9]	3.5 [3.4, 3.7]	2.9 [2.7, 3.0]	2.7 [2.6, 2.9]	2.5 [2.4, 2.7]	<0.001
Patient days	3,340,702	3,602,965	4,045,037	4,217,331	4,027,171	
Rate per 10,000 days	4.2 [4.0, 4.5]	4.2 [4.0, 4.4]	3.7 [3.5, 3.8]	3.2 [3.1, 3.4]	3.0 [2.9, 3.2]	<0.001
No. of reporting hospitals†	23	28	29	28	26	
National Pediatric MRSA infections (eligible*)	122 (122)	99 (99)	135 (135)	125 (125)	173 (173)	
Patient admissions	52,833	52,204	53,412	55,958	59,984	
Rate per 1,000 adm	2.3 [1.9, 2.8]	1.9 [1.6, 2.3]	2.5 [2.1, 3.0]	2.2 [1.9, 2.7]	2.9 [2.5, 3.5]	n/s
Patient days	338,950	339,526	339,731	366,524	352,686	
Rate per 10,000 days	3.6 [3.0, 4.3]	2.9 [2.4, 3.5]	4.0 [3.3, 4.7]	3.4 [2.9, 4.1]	4.9 [4.2, 5.7]	0.009
No. of reporting hospitals†	8	8	8	8	8	

§ Significance test (p) compares the 2008 adult MRSA infection and colonization rate to the 2012 rate
**Rates are calculated using only eligible data = hospitals that supplied both numerator (cases) and denominator (patient admissions and days) data*
† Number of participating hospitals varies due to eligible data submitted

Figure 8 illustrates the trends in HA and CA-MRSA infection incidence rates per 10,000 patient days in adult and pediatric hospitals. National adult HA-MRSA rates have significantly decreased over the surveillance period while CA-MRSA rates have remained stable (Table12). There is an increasing national trend in both HA and CA-MRSA infections among patients in pediatric hospitals with CA-MRSA infections exhibiting the most marked increase. Both HA and CA-MRSA infection rates have increased significantly among patients in pediatric hospitals in 2012 compared to 2008 (Table 20).

Figure 8 National HA and CA-MRSA infection rates per 10,000 patient days in adult and pediatric hospitals



MRSA is classified based on case definitions (see methods section p 8-8). HA-MRSA are identified as occurring in hospitals, other healthcare settings or exposures. CA-MRSA is identified as occurring outside of healthcare settings to people with no known healthcare exposures.

Table 20 provides the total number of HA and CA-MRSA infections, patient admissions, patient days, number of participating hospitals and incidence rates with 95% CI for adult and pediatric hospitals by year. The rate in 2008 was compared to the 2012 rate.

Table 20 National HA and CA-MRSA infection cases and incidence rates (95% CI) in adult and pediatric hospitals from 2008 to 2012

	2008	2009	2010	2011	2012	*p§*
National Adult HA-MRSA cases (eligible*)	1,064 (1,064)	1,097 (1,097)	1,070 (1,070)	1001 (1001)	847 (847)	
Patient admissions	379,582	428,484	513,292	503,866	480,845	
Rate per 1,000 adm	2.8 [2.6, 3.0]	2.6 [2.4, 2.7]	2.1 [2.0, 2.2]	2.0 [1.9, 2.1]	1.8 [1.6, 1.9]	<0.001
Patient days	3,340,702	3,602,965	4,045,037	4,217,331	4,027,171	
Rate per 10,000 days	3.2 [3.0, 3.4]	3.0 [2.9, 3.2]	2.6 [2.5, 2.8]	2.4 [2.2, 2.5]	2.1 [2.0, 2.3]	<0.001
No. of reporting hospitals†	23	28	29	28	26	
National Pediatric HA-MRSA cases (eligible*)	26 (26)	12 (12)	36 (36)	45 (45)	47 (47)	
Patient admissions	52,833	52,204	53,412	55,958	59,984	
Rate per 1,000 adm	0.5 [0.3, 0.7]	0.2 [0.1, 0.4]	0.7 [0.5, 0.9]	0.8 [0.6, 1.1]	0.8 [0.6, 1.0]	0.05
Patient days	338,950	339,526	339,731	366,524	352,686	
Rate per 10,000 days	0.8 [0.5, 1.1]	0.4 [0.9, 0.6]	1.1 [0.7, 1.5]	1.2 [0.9, 1.6]	1.3 [1.0, 1.7]	0.02
No. of reporting hospitals†	8	8	8	8	8	
National Adult CA-MRSA cases (eligible*)	253 (253)	266 (261)	281 (281)	283 (283)	293 (293)	
Patient admissions	379,582	428,484	513,292	503,866	480,845	
Rate per 1,000 adm	0.7 [0.6, 0.8]	0.6 [0.5, 0.7]	0.5 [0.48, 0.6]	0.6 [0.5, 0.63]	0.6 [0.5, 0.7]	n/s
Patient days	3,340,702	3,602,965	4,045,037	4,217,331	4,027,171	
Rate per 10,000 days	0.8[0.7, 0.9]	0.7 [0.65, 0.8]	0.7 [0.6, 0.8]	0.7 [0.6, 0.8]	0.7 [0.6, 0.8]	n/s
No. of reporting hospitals†	23	28	29	28	26	
National Pediatric CA-MRSA cases (eligible*)	83 (83)	76 (76)	94 (94)	70 (70)	120 (120)	
Patient admissions	52,833	52,204	53,412	55,958	59,984	
Rate per 1,000 adm	1.6 [1.3, 1.9]	1.5 [1.2, 1.8]	1.8 [1.4, 2.1]	1.3 [1.0, 1.6]	2.0 [1.7, 2.4]	n/s
Patient days	338,950	339,526	339,731	366,524	352,686	
Rate per 10,000 days	2.5 [2.0, 3.0]	2.2 [1.8, 2.8]	2.8 [2.2, 3.4]	1.9 [1.5, 2.4]	3.4 [2.8, 4.0]	0.02
No. of reporting hospitals†	8	8	8	8	8	

§ *Significance test (p) compares the 2008 adult HA-MRSA & CA-MRSA rate to the 2012 rate*

**Rates are calculated using only eligible data = hospitals that supplied both numerator (cases) and denominator (patient admissions and days) data*

† *Number of participating hospitals varies due to eligible data submitted*

MRSA is classified based on case definitions (see methods section p 8-9). HA-MRSA are identified as occurring in hospitals, other healthcare settings or exposures. CA-MRSA is identified as occurring outside of healthcare settings to people with no known healthcare exposures.

Discussion

The majority (89%) of MRSA infections during the 2008-2012 surveillance periods have been identified among adult inpatients. As a result, the decreasing trend in national MRSA infection rates is primarily driven by the adult inpatient population. These surveillance results have shown a distinct difference in the trends between adult and pediatric MRSA infection. Adult MRSA infection rates have significantly decreased or been stable since 2008 while pediatric infection rates have all significantly increased. In addition, pediatric CA-MRSA infection rates are more than triple the CA-MRSA rate for adults (Table 21).

Table 21 Trends in adult and pediatric MRSA infections

MRSA		National adult and pediatric rates per 10,000 patient days				
		2008	2009	2010	2011	2012
Infections	**Adult**	4.2	4.2	3.7	3.2	3.0
	Pediatric	3.6	2.9	4.0	3.4	4.9
HA-MRSA infections	**Adult**	3.2	3.0	2.6	2.4	2.1
	Pediatric	0.8	0.4	1.1	1.2	1.3
CA-MRSA infections	**Adult**	0.8	0.7	0.7	0.7	0.7
	Pediatric	2.5	2.2	2.8	1.9	3.4

Previously published CNISP pediatric MRSA data from 1995 to 2007 indicated substantial increases in pediatric MRSA rates.[32] More specifically CA-MRSA rates increased from 0.08 (1995) to 3.9 (2007) per 10,000 patient days. Current surveillance data indicate the rate continues to increase and in 2012 is 4.9 per 10,000 patient days. To our knowledge there are no other national surveillance systems and very little literature that exists which report comparisons of adult and pediatric MRSA infection rates. However, similar increases among pediatric patients were reported in the US where national pediatric MRSA rates rose from 6.7 (2002) to 21.2 (2007) per 1,000 patient admissions.[33] Although population-based, a more recent study in the US which evaluated trends in invasive MRSA among children from 2005 to 2010 found the incidence of CA-MRSA has increased and there were no significant reductions in HA-MRSA infections among children.[34]

In summary, rates of pediatric MRSA in Canada and other countries continue to increase in contrast to reports of declining incidence of MRSA among adult patients and adult and pediatric patients combined.

SECTION 4 MRSA IN CANADA: NATIONAL AND REGIONAL MOLECULAR CHARACTERIZATION OF MRSA ISOLATES FROM JANUARY 1, 2008 TO DECEMBER 31, 2012

The following section presents the molecular characterization (epidemic strain types) of a subset of MRSA infections submitted to the National Microbiology Laboratory (NML). As per the CNISP MRSA surveillance protocol, specimens related to clinical MRSA infections were submitted for cases whose infection occurred between January 1st and March 31st of any calendar year.

For MRSA bacteremia cases, blood specimens are submitted all year round to the NML. Table 22 indicates the number of clinical and blood isolates eligible for testing at the NML by year, as well the number of MRSA isolates that were submitted. Over the 5 year surveillance period, 79% of all eligible clinical isolates and 76% of all eligible blood isolates were submitted to the NML.

Table 22 Clinical and blood MRSA isolates submitted to the NML by year

	2008 N (%)	2009 N (%)	2010 N (%)	2011 N (%)	2012 N (%)	Total N (%)
Eligible clinical isolates	422	407	421	377	344	1971
Clinical isolates submitted	310 (73.5)	324 (79.6)	354 (84.1)	286 (75.9)	281 (81.7)	1555 (78.9)
Eligible blood isolates	334	387	332	372	325	1750
Blood isolates submitted	237 (71.0)	278 (71.8)	280 (84.3)	287 (77.2)	245 (75.4)	1327 (75.8)

Note: All eligible isolates that were submitted to the NML were analyzed. Clinical isolates were considered eligible for laboratory analysis if the case occurred between January 1st and March 31st of any calendar year while blood isolates are eligible for laboratory analysis all year.
Clinical infections are those infections identified in anatomical sites other than in the blood

Table 23 describes MRSA epidemic strain types identified from clinical isolates submitted annually for cases with a clinical MRSA infection. Three strain types, CMRSA-2, CMRSA-10, and CMRSA-7 together accounted for almost 90% of all strain types identified over the 5 year surveillance period. CMRSA-2 (corresponds to USA100/800) is most commonly attributed as a healthcare-associated genotype while CMRSA-7 (corresponds to USA400) and CMRSA-10 (corresponds to USA300) are attributed to community associated genotypes.

4.1 Epidemic strain types of MRSA clinical* infections

Table 23 National MRSA epidemic strain types for clinical infections by year

	2008 N (%)	2009 N (%)	2010 N (%)	2011 N (%)	2012 N (%)	Total N (%)
CMRSA-1	1 (0.3)	3 (0.9)	3 (0.8)	7 (2.4)	5 (1.8)	**19 (1.2)**
CMRSA-2	172 (55.5)	171 (52.8)	190 (53.7)	158 (55.2)	143 (50.9)	**834 (53.6)**
CMRSA-3/6	17 (5.5)	17 (5.2)	6 (1.7)	3 (1.0)	2 (0.7)	**45 (2.9)**
CMRSA-4	8 (2.6)	2 (0.6)	0 (0.0)	1 (0.3)	2 (0.7)	**13 (0.8)**
CMRSA-5	1 (0.3)	1 (0.3)	4 (1.1)	3 (1.0)	6 (2.1)	**15 (1.0)**
CMRSA-7	18 (5.8)	13 (4.0)	22 (6.2)	24 (8.4)	21 (7.5)	**98 (6.3)**
CMRSA-8	3 (1.0)	8 (2.5)	8 (2.3)	4 (1.4)	2 (0.7)	**25 (1.6)**
CMRSA-9	0 (0.0)	2 (0.6)	1 (0.3)	2 (0.7)	0 (0.0)	**5 (0.3)**
CMRSA-10	77 (24.8)	98 (30.2)	107 (30.2)	75 (26.2)	86 (30.6)	**443 (28.5)**
ST-88	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.4)	**1 (0.1)**
ST-97	0 (0.0)	0 (0.0)	2 (0.6)	2 (0.7)	1 (0.4)	**5 (0.3)**
ST-398	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	**1 (0.1)**
USA-700	2 (0.6)	1 (0.3)	0 (0.0)	0 (0.0)	1 (0.4)	**4 (0.3)**
USA-1000, China/Taiwan	5 (1.6)	2 (0.6)	4 (1.1)	2 (0.7)	2 (0.7)	**15 (1.0)**
USA-1100, SWP/Oceania	1 (0.3)	2 (0.6)	1 (0.3)	2 (0.7)	7 (2.5)	**13 (0.8)**
Strain type unassigned	0 (0.0)	4 (1.2)	6 (1.7)	3 (1.0)	2 (0.7)	**15 (1.0)**
Not Typed	4 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	**4 (0.3)**
Total	**310**	**324**	**354**	**286**	**281**	**1555**

**Clinical infections are those infections identified in anatomical sites other than in the blood*

Figure 9 illustrates the trends in proportions of the 3 most common MRSA strain types identified in clinical MRSA infections over the five year surveillance period. Nationally CMRSA-2, a strain typically associated with healthcare settings, remains the most predominant strain type identified. Annually, CMRSA-2 accounted for 51% to 56% of the strains submitted followed by CMRSA-10 (25 – 30%) and CMRSA-7 (4 - 8%) typically community-associated strain types.

Figure 9 National distribution of MRSA strain types for clinical infections

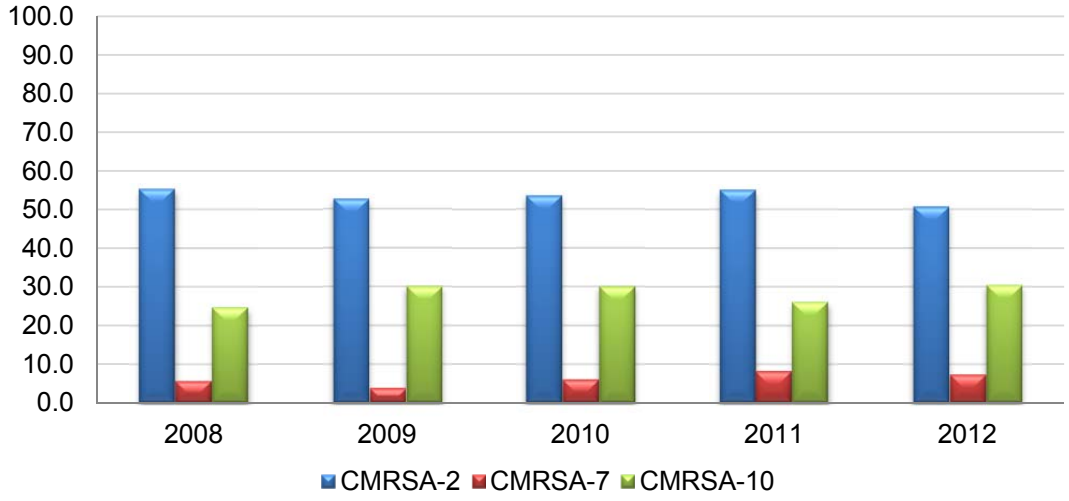


Table 24 presents the 3 most common MRSA strain types for clinical infections by region and year. In the West, CMRSA-2 (HA strain type) remained predominant until 2009. Starting in 2010, the proportion of CMRSA-7 and CMRSA-10 (CA strain types) started to increase and in 2012 have replaced CMRSA-2 as the predominant strain types identified. Centrally CMRSA-2 remains predominant over all 5 years, however, the proportion of CA strain types (CMRSA-7 and 10) are increasing. In the east CMRSA-2 (HA strain type) continues to account for greater than three-quarters of strain types identified. The east has shown a slight increase in CMRSA-10 from 2008-2012 however, no CMRSA-7 strain types have been identified in the eastern region to date.

Table 24 Regional MRSA strain types for clinical infections by year

		2008 N (%)	2009 N (%)	2010 N (%)	2011 N (%)	2012 N (%)	2008-2012 N (%)
West	**CMRSA-2**	80 (44.7)	75 (39.3)	64 (37.0)	49 (36.6)	59 (39.3)	**327 (39.5)**
	CMRSA-7	17 (9.5)	12 (6.3)	19 (11.0)	23 (17.2)	12 (8.0)	**83 (10.0)**
	CMRSA-10	59 (33.0)	73 (38.2)	72 (41.6)	45 (33.6)	59 (39.3)	**308 (37.2)**
	Other*	23 (12.8)	31 (16.2)	18 (10.4)	17 (12.7)	20 (13.3)	**109 (13.2)**
	Total	**179**	**191**	**173**	**134**	**150**	**827**
Central	**CMRSA-2**	53 (66.3)	63 (66.3)	82 (62.1)	77 (69.4)	51 (56.0)	**326 (64.0)**
	CMRSA-7	1 (1.3)	1 (1.1)	3 (2.3)	0 (0.00)	9 (9.9)	**14 (2.8)**
	CMRSA-10	15 (18.8)	23 (24.2)	31 (23.5)	25 (22.5)	23 (25.3)	**117 (23.0)**
	Other*	11 (13.8)	8 (8.4)	16 (12.1)	9 (8.1)	8 (8.8)	**52 (10.2)**
	Total	**80**	**95**	**132**	**111**	**91**	**509**
East	**CMRSA-2**	39 (76.5)	33 (86.8)	44 (89.8)	32 (78.0)	33 (82.5)	**181 (82.6)**
	CMRSA-7	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.4)	0 (0.00)	**1 (0.5)**
	CMRSA-10	3 (5.9)	2 (5.3)	4 (8.2)	5 (12.2)	4 (10.0)	**18 (8.2)**
	Other*	9 (17.7)	3 (7.9)	1 (2.0)	3 (7.3)	3 (7.5)	**19 (8.7)**
	Total	**51**	**38**	**49**	**41**	**40**	**219**

**Other includes all strain types that are not CMRSA-2/7/10, including not typed and unassigned strain types.*
Please note that percentages represent the proportion the strain type accounts for in the region specified

4.2 Epidemic strain types of MRSA bloodstream infections

Table 25 describes the MRSA strain types identified in blood isolates submitted each year for cases identified as MRSA bloodstream infections (MRSA BSI). CMRSA-2, 7, and 10 combined accounted for approximately 90% of all strain types identified from 2008 – 2012.

Table 25 National strain types for MRSA BSI by year

	2008 N (%)	2009 N (%)	2010 N (%)	2011 N (%)	2012 N (%)	Total N (%)
CMRSA-1	3 (1.3)	2 (0.7)	6 (2.1)	2 (0.4)	4 (1.6)	**17 (1.3)**
CMRSA-2	126 (53.2)	163 (58.6)	165 (58.9)	157 (54.7)	123 (50.2)	**734 (55.3)**
CMRSA-3/6	13 (5.5)	7 (2.5)	6 (2.1)	5 (1.7)	1 (0.4)	**32 (2.4)**
CMRSA-4	2 (0.8)	1 (0.4)	3 (1.1)	1 (0.4)	0 (0.0)	**7 (0.5)**
CMRSA-5	0 (0.0)	1 (0.4)	2 (0.7)	2 (0.7)	0 (0.0)	**5 (0.4)**
CMRSA-7	15 (6.3)	6 (2.2)	7 (2.5)	16 (5.6)	7 (2.9)	**51 (3.8)**
CMRSA-8	5 (2.1)	11 (4.0)	7 (2.5)	8 (2.79)	8 (3.3)	**39 (2.9)**
CMRSA-10	62 (26.2)	79 (28.4)	72 (25.7)	84 (29.3)	89 (36.3)	**386 (29.1)**
European	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	0 (0.0)	**1 (0.1)**
ST-88	0 (0.0)	0 (0.0)	2 (0.7)	0 (0.00)	0 (0.0)	**2 (0.2)**
ST-97	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.3)	1 (0.4)	**3 (0.2)**
USA-700	2 (0.8)	0 (0.0)	1 (0.4)	1 (0.3)	1 (0.4)	**5 (0.4)**
USA-1000, China/Taiwan	5 (2.1)	0 (0.0)	2 (0.7)	1 (0.3)	6 (2.4)	**14 (1.1)**
USA-1100, SWP/Oceania	0 (0.0)	4 (1.4)	2 (0.7)	4 (1.3)	3 (1.2)	**13 (1.0)**
Unassigned	0 (0.0)	4 (1.4)	4 (1.4)	5 (1.7)	2 (0.8)	**15 (1.1)**
Not Typed	3 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	**3 (0.2)**
Total	**237**	**278**	**280**	**287**	**245**	**1327**

Figure 10 illustrates trends in the 3 most common strain types identified in MRSA BSI over the five year surveillance period. Overall CMRSA-2 (HA) remained the most predominant strain type identified in each surveillance year (50-59%). However, the proportion of CMRSA-10 (CA) increased in 2012 (36%) compared to 2008 (26%) while the proportion of CMRSA-2 has slightly decreased (53% in 2008 to 50% in 2012).

Figure 10 National distribution of strain types for MRSA BSI

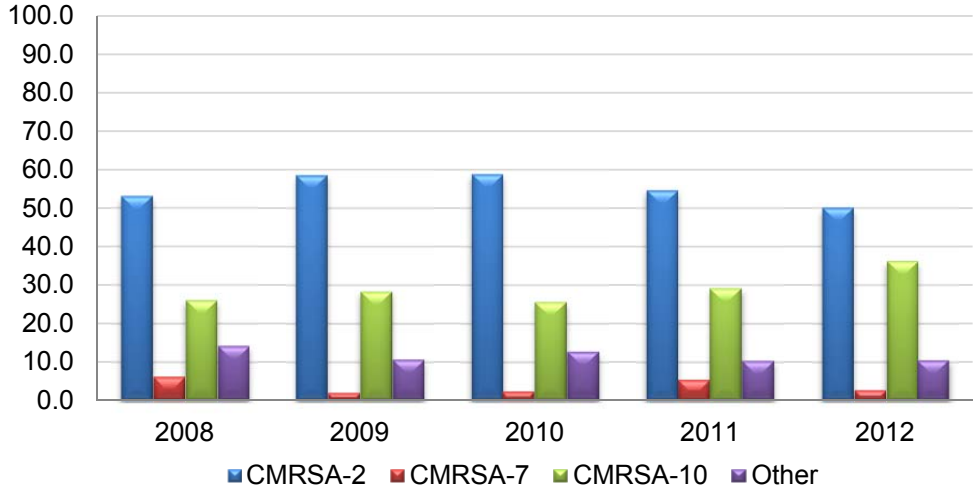


Table 26 presents strain types for MRSA BSI by region and year. In the west, CMRSA-10 (typically associated with community-associated infections) represented the largest proportion of the region's blood isolates in each year (38-51%) followed by CMRSA-2 (31-42%) typically associated with hospital settings. CMRSA-2 represented the majority of blood isolates characterized in the central (54-72%) and eastern (78-88%) regions although the proportion of CMRSA-10 is steadily increasing in both of these regions.

Table 26 Regional strain types for MRSA BSI by year

		2008 N (%)	2009 N (%)	2010 N (%)	2011 N (%)	2012 N (%)	Overall N (%)
West	**CMRSA-2**	34 (31.2)	30 (30.9)	43 (42.2)	40 (31.3)	32 (33.7)	**179 (33.7)**
	CMRSA-7	14 (12.8)	5 (5.2)	7 (6.9)	13 (10.2)	5 (5.3)	**44 (8.3)**
	CMRSA-10	42 (38.5)	47 (48.5)	39 (38.2)	54 (42.2)	48 (50.5)	**230 (43.3)**
	Other*	19 (17.4)	15 (15.5)	13 (12.7)	21 (16.4)	10 (10.5)	**78 (14.7)**
	Total	**109**	**97**	**102**	**128**	**95**	**531**
Central	**CMRSA-2**	59 (64.8)	103 (72.0)	88 (63.3)	82 (68.9)	60 (54.5)	**392 (65.1)**
	CMRSA-7	1 (1.1)	1 (0.7)	0 (0.0)	2 (1.7)	2 (1.8)	**6 (1.0)**
	CMRSA-10	18 (19.8)	29 (20.3)	31 (22.3)	28 (23.5)	35 (31.8)	**141 (23.4)**
	Other*	13 (14.3)	10 (7.0)	20 (14.4)	7 (5.9)	13 (11.8)	**63 (10.5)**
	Total	**91**	**143**	**139**	**119**	**110**	**602**
East	**CMRSA-2**	33 (88.2)	30 (78.9)	34 (87.2)	35 (87.5)	31 (77.5)	**163 (84.0)**
	CMRSA-7	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.5)	0 (0.0)	**1 (0.5)**
	CMRSA-10	2 (5.4)	3 (7.9)	2 (5.1)	2 (5.0)	6 (15.0)	**15 (7.7)**
	Other*	2 (5.4)	5 (13.2)	3 (7.7)	2 (5.0)	3 (7.5)	**15 (7.7)**
	Total	**37**	**38**	**39**	**40**	**40**	**194**

**Other includes all strain types that are not CMRSA-2/7/10, including not typed and unassigned strain types.*
Please note that percentages represent the proportion the strain type accounts for in the region specified

Discussion

Overall, CMRSA-2, CMRSA-7 and CMRSA-10 accounted for the majority (90%) of strain types identified in both clinical and blood isolates submitted to the NML for molecular characterization.

CMRSA-2, the strain type most typically associated with hospital settings, remains the most predominant strain type identified nationally in both clinical and blood isolates followed by CMRSA-10 and CMRSA-7, the two strain types most commonly associated with community settings. In both clinical and blood isolates the proportion of CMRSA 10 has been steadily increasing since 2008 while this increase is not as pronounced for CMRSA-7 strain types.

Regional variations exist for both clinical and blood isolates. In the west the proportion of community associated strain types (CMRSA-7 and 10) have replaced the typically hospital associated strain type (CMRSA-2) and now are the predominant strain types identified. The central region is also experiencing increases in community associated strain types (CMRSA-10) while in the eastern region of Canada the hospital strain type (CMRSA-2) continues to represent the largest proportion identified although CMRSA 10 is slowly increasing.

Compared to previously published CNISP data, the proportion of community-associated strains identified from both clinical and blood isolates submitted has more than tripled. From 1995-2007 the proportion of all isolates (clinical and blood) that were identified as community-associated strain types (CMRSA-7 and 10) was 11%, from 2008 to 2012 this proportion increased to 34%. This trend has been observed in the USA as well. As early as 2003, a US hospital based study found that the proportion of their healthcare-associated MRSA infections identified as community associated strain types increased from 17% in 1999 to 56% in 2003.[35] Another US hospital based study showed an increase from 4% (2001) to 42% (2005) of their MRSA skin and soft tissue infections that were identified as a community associated strain.[36] European studies have suggested that although community acquired strains have been reported in a number of European countries including Austria, Denmark, Germany, Italy and the UK the evidence indicates they are less prevalent than that seen in the USA or Canada.[37]

SECTION 5 MRSA IN CANADA: NATIONAL AND REGIONAL ANTIMICROBIAL RESISTANCE DATA FROM JANUARY 1, 2008 TO DECEMBER 31, 2012

National and regional antimicrobial resistance associated with MRSA isolates (clinical and blood) collected from 2008 to 2012. Table 28 presents the number of isolates tested nationally and regionally by year along with the proportion of isolates resistant to antibiotics commonly used in the treatment of MRSA infection.

Nationally, there has been no documented resistance to vancomycin, tigecycline, linezolid or daptomycin from 2008 to 2012 among the isolates tested. The proportion of isolates tested exhibiting resistance to ciprofloxacin, erythromycin and clindamycin nationally has remained relatively unchanged over this surveillance period. There has been a slight decrease in the proportion of isolates tested exhibiting resistance to tetracycline and TMP-SMX.*

Regionally, a greater proportion of isolates tested from eastern Canada have shown resistance to ciprofloxacin, erythromycin and clindamycin each year compared to the rest of Canada. Although only a small proportion of isolates tested exhibit resistance to tetracycline and TMP-SMX across Canada, the smallest proportion of isolates exhibiting resistance is seen in eastern Canada.

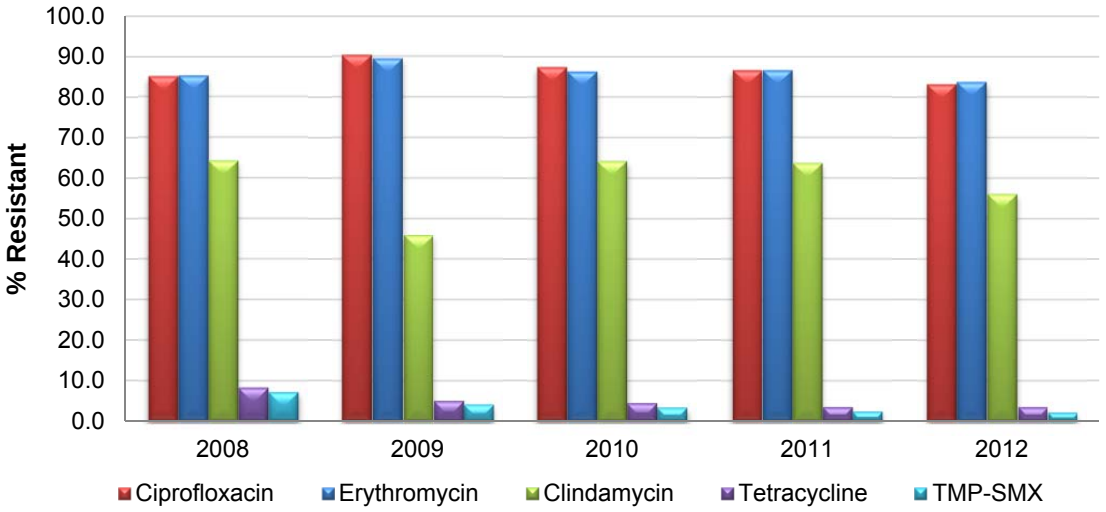
Table 27 Antimicrobial resistance of MRSA isolates (clinical and blood) 2008 to 2012

	Number of MRSA isolates tested nationally and regionally by year and number and percent resistant to specified antimicrobials					
	2008 National=610 West=323 Central=180 East=107 n (%)	**2009 National=553 West=254 Central=223 East=76 n (%)**	**2010 National=638 West=277 Central=274 East=87 n (%)**	**2011 National=537 West=231 Central=226 East=80 n (%)**	**2012 National=510 West=236 Central=196 East=78 n (%)**	**2008-2012 National=2848 West=1321 Central=1099 East=428 n (%)**
Ciprofloxacin National	520 (85.2)	501 (90.6)	559 (87.6)	466 (86.8)	425 (83.3)	2471 (86.8)
West	269 (83.3)	226 (89.0)	240 (86.6)	183 (79.2)	190 (80.5)	1108 (83.9)
Central	146 (81.1)	202 (90.6)	234 (85.4)	206 (91.2)	158(80.6)	946 (86.1)
East	105 (98.1)	73 (96.1)	85 (97.7)	77 (96.3)	77 (98.7)	417 (97.4)
Erythromycin National	521 (85.4)	496 (89.7)	552 (86.5)	466 (86.8)	428 (83.9)	2463 (86.5)
West	264 (81.7)	224 (88.2)	228 (82.3)	183 (79.2)	191 (80.9)	1090 (82.5)
Central	153 (85.0)	201 (90.1)	240 (87.6)	207 (91.6)	163 (83.2)	963 (87.6)
East	104 (97.2)	71 (93.4)	84 (96.6)	76 (95.0)	74 (94.9)	409 (95.6)
Clindamycin National	393 (64.4)	255 (46.1)	411 (64.4)	343 (63.9)	287 (56.3)	1689 (59.3)
West	176 (54.5)	121 (47.6)	154 (55.6)	111 (48.1)	109 (46.20)	671 (50.8)
Central	121 (67.2	106 (47.5)	179 (65.3)	160 (70.8)	117 (59.7)	683 (62.1)
East	96 (89.7)	28 (36.8)	78 (89.7)	72 (90.0)	61 (78.2)	335 (78.3)
Tetracycline National	52 (8.5)	29 (5.2)	30 (4.7)	20 (3.7)	19 (3.7)	150 (5.3)
West	42 (13.0)	25 (9.8)	16 (5.8)	8 (3.5)	8 (3.4)	99 (7.5)
Central	9 (5.0)	4 (1.8)	14 (5.1)	7 (3.1)	10 (5.1)	44 (4.0)
East	1 (0.9)	0	0	5 (6.3)	1 (1.3)	7 (1.6)
TMP-SMX* National	45 (7.4)	24 (4.3)	23 (3.6)	14 (2.6)	12 (2.4)	118 (4.1)
West	40 (12.4)	22 (8.7)	16 (5.8)	8 (3.5)	5 (2.1)	91 (6.9)
Central	5 (2.8)	2 (0.9)	7 (2.6)	5 (2.2)	6 (3.1)	25 (2.3)
East	0	0	0	1 (1.3)	1 (1.3)	2 (0.5)
Vancomycin	0	0	0	0	0	0
Tigecycline	0	0	0	0	0	0
Linezolid	0	0	0	0	0	0
Daptomycin	0	0	0	0	0	0

**Trimethoprim-Sulfamethoxazole*

Figure 11 illustrates the national trend of antimicrobial resistance among MRSA isolates from 2008 – 2012. Nationally, the proportion of isolates tested exhibiting resistance to ciprofloxacin, erythromycin, clindamycin, has remained relatively unchanged from 2008 to 2012. There has been a slight decrease in the proportion of isolates tested exhibiting resistance to tetracycline and TMP-SMX*.

Figure 11 National antimicrobial resistance for MRSA isolates tested



TMP-SMX = Trimethoprim-Sulfamethoxazole

Discussion

MRSA remains the most commonly identified antimicrobial resistant organism in healthcare facilities in many parts of the world.[38] Successful pharmacological treatment of MRSA infections depends largely on making appropriate clinical decisions relating to antimicrobial therapy and the antimicrobial susceptibility of the organisms. The emergence of MRSA in the 1980's resulted in the increased use of antimicrobials other than beta-lactam antibiotics which include the penicillins (methicillin, dicloxacillin, oxacillin, etc.) and the cephalosporins (cefoxitin, cefuroxime, etc.). Depending on the source and severity of infection, currently the most commonly used antimicrobials in the treatment of MRSA are vancomycin, daptomycin, linezolid, TMP-SMX, tetracycline and clindamycin. With the increased use of these antibiotics selective pressure raises the concern of increased MRSA isolate resistance to the current antimicrobials used to treat MRSA infections.

Antimicrobial susceptibility patterns can vary widely by geographical region. In Canada resistance to ciprofloxacin, erythromycin and clindamycin remains slightly higher in the east and resistance to tetracycline and TMP-SMX remains lower in the east compared to the rest of Canada.

There is limited international data available to compare Canadian MRSA resistance to specific antimicrobials. Of the data available MRSA resistance patterns exhibit global variability. Table 28 illustrates international antimicrobial resistance compared to Canada.

Table 28 International comparison of antimicrobial resistance of MRSA isolates

Antibiotic	Countries						
	Canada 2012 N=510 n (%)	USA (Iowa) 2012[39] N=1,071 n (%)	USA (Mich) 2010[40] N=718 N (%)	Australia 2009[41] N=916 n (%)	Denmark 2012[10] N=1556 N (%)	EARS-NET 2012[11] N=20,000 n (%)	India 2011[42] N=58 N (%)
Ciprofloxacin	425 (83.3)	N/A	N/A	652 (71.2)	N/A	N/A	N/A
Erythromycin	428 (83.9)	945 (88.2)	N/A	649 (70.9)	591 (38)	N/A	39 (67.2)
Clindamycin	287 (56.3)	306 (28.6)	N/A	321 (35.0)	576 (37)	N/A (81.0)	41 (70.7)
Tetracycline	19 (3.7)	56 (5.2)	N/A	413 (45.1)	0	N/A	N/A
TMP-SMX*	12 (2.4)	27 (2.5)	N/A	381 (41.6)	0	N/A	N/A
Vancomycin	0	0	5 (0.7)	0	N/A	N/A	2 (3.4)
Tigecycline	0	N/A	0	N/A	N/A	N/A	N/A
Linezolid	0	0	0	0	0	N/A (0.2)[e]	N/A
Daptomycin	0	0	5 (0.7)	N/A	N/A	N/A	N/A

**TMP-SMX = Trimethoprim-Sulfamethoxazole*
N/A = Data not available
EARS-NET represents 29 countries reporting Staphylococcus aureus (SA) isolate resistance to ECDC. For Ciprofloxacin resistance, of the SA isolates tested a proportion were MRSA and the proportion reported by the ECDC represents those MRSA isolates resistant to at least one fluoroquinolone of which ciprofloxacin is one. Linezolid resistance reported is for all SA isolates tested.

In relation to Canada, Australian MRSA isolates exhibit less resistance to ciprofloxacin, erythromycin and clindamycin and increased resistance to tetracycline and TMP-SMX. MRSA isolates from Denmark exhibit less resistance to all comparable isolates.[10] Similar antimicrobial resistance patterns are seen among Canadian and US MRSA isolates. Internationally there has been little or no reported resistance to vancomycin, a last line antimicrobial used for treating MRSA.

LIMITATIONS

Several limitations should be considered when interpreting the data presented in this report. First, surveillance data understates the magnitude of MRSA and subsequently does not represent the total number of inpatients infected with MRSA in Canada. Surveillance data can only tell us about inpatients who have been tested and diagnosed with MRSA and not those who remain untested and undiagnosed.

These data only include hospitalized patients from participating CNISP hospitals, therefore cases identified in outpatient settings such as emergency departments and clinics are not captured by this surveillance system. Furthermore, only cases who are hospitalized at participating hospitals are included.

Participating hospitals are not necessarily representative of all Canadian hospitals. Hospitals which submit MRSA data to the Agency are large, tertiary acute care centres located in major cities. MRSA data from small hospitals and those in rural and northern areas are underreported.

Antibiotic prescribing practices and implementation of infection prevention and control measures may vary between hospitals, but because the Agency does not collect data regarding these factors, it was not possible to correlate them with the occurrence of MRSA.

Healthcare-associated infection surveillance methodologies are not standardized across countries. For this reason, caution must be used when comparing rates between countries without knowing the details of their surveillance strategies.

International comparisons of rates, strain types and antimicrobial resistance data may be affected by differing surveillance and laboratory methodologies.

Misclassification bias may have occurred when categorizing healthcare and community associated infections given the difficulty in sometimes applying the case definitions to the complexities of patient admissions.

APPENDIX 1. DATA SOURCES

The following are members of the Canadian Nosocomial Infection Surveillance Program:

Natalie Bridger, Eastern Health-HSC, St. John's, NFLD;
Elizabeth Bryce, Vancouver Coastal Health Authority, Vancouver, BC;
John Conly, Foothills Medical Centre, Calgary, AB;
Janice de Heer, Interior Health Authority, Kelowna, BC;
John Embil, Health Sciences Centre, Winnipeg, MB;
Joanne Embree, Health Sciences Centre, Winnipeg, MB;
Gerald Evans, Kingston General Hospital, Kingston, ON;
Sarah Forgie, Stollery Children's Hospital, Edmonton, AB;
Charles Frenette, McGill University Health Centre, Montreal, QC;
Gregory German, Queen Elizabeth Hospital, Charlottetown, PEI;
Deanna Hembroff, University Hospital of Northern BC, Prince George, BC;
Elizabeth Henderson, Alberta Health Services, Calgary, AB;
Michael John, London Health Sciences Centre, London, ON.;
Lynn Johnston, Queen Elizabeth II Health Sciences Centre, Halifax, NS;
Kevin Katz, North York General Hospital, Toronto, ON;
Pamela Kibsey, Royal Jubilee Hospital, Victoria, BC;
Magdalena Kuhn, South East Regional Health Authority, Moncton, NB;
Joanne Langley, IWK.Health Centre, Halifax, NS;
Bonita Lee, Stollery Children's Hospital, Edmonton, AB;
Camille Lemieux, University Health Network, Toronto, ON;
Victor Leung, Providence Health Care, Vancouver, BC;
Yves Longtin, SMBD-Jewish General Hospital, Montreal, QC;
Mark Loeb, Hamilton Health Sciences Corporation, Hamilton, ON;
Allison McGeer, Mount Sinai Hospital, Toronto, ON;
Dominik Mertz, Hamilton Health Sciences Corporation, Hamilton, ON;
Jessica Minion, Regina Qu'Appelle Health Region, Regina, SK;
Dorothy Moore, Montreal Children's Hospital, McGill University Health Centre, Montreal, QC;
Suzanne Pelletier, Health Sciences North, Sudbury, ON;
Caroline Quach, Montreal Children's Hospital, McGill University Health Centre, Montreal, QC;
Susan Richardson, Hospital for Sick Children, Toronto, ON;
Virginia Roth, The Ottawa Hospital, Ottawa, ON;
Andrew Simor, Sunnybrook Health Sciences Centre, Toronto, ON;
Stephanie Smith, University of Alberta Hospital, Edmonton, AB;
Paula Stagg, Western Memorial Hospital, Corner Brook, NL;
Kathryn Suh, The Ottawa Hospital, Ottawa, ON;
Geoffrey Taylor, University of Alberta Hospital, Edmonton, AB;
Nisha Thampi, Children's Hospital of Eastern Ontario, Ottawa, ON;
Eva Thomas, Children's and Women's Health Center, Vancouver, BC;
Nathalie Turgeon, CHUQ-Hôtel-Dieu, Québec, QC;
Mary Vearncombe, Sunnybrook Health Sciences Centre, Toronto, ON;
Joseph Vayalumkal, Alberta Children's Hospital, Calgary, AB;
Karl Weiss, Maisonneuve-Rosemont Hospital, Montreal, QC;
Alice Wong, Royal University Hospital, Saskatoon, SK.

APPENDIX 2. REFERENCES

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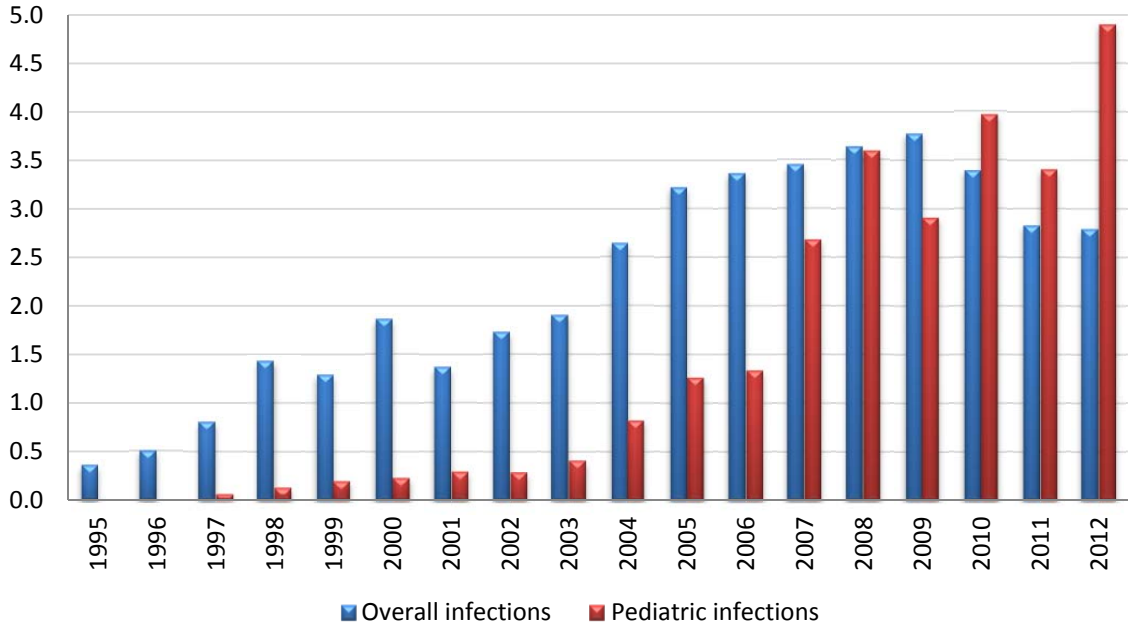
APPENDIX 3

The graph below illustrates the trends in national MRSA infection (clinical and blood) rates. Overall infections include both adult and pediatric cases. Pediatric infections reflect the rates in the 8 pediatric hospitals that participate in CNISP MRSA surveillance.

Although overall infection rates have been slowly declining since 2009 this most likely reflects the effect of the greater proportion of adult cases in the CNISP. When pediatric infection rates are disaggregated from the overall rates a steady increase in the rates of pediatric MRSA infection is observed.

National incidence rate of MRSA infections per 10,000 patient days



APPENDIX 4

The following table provides the number of cases of MRSA colonizations, patient admissions, patient days, number of participating hospitals and incidence rates with 95% CI by year. The rates in 2008 and 2012 were compared

National and regional MRSA colonization cases and incidence rates (95% CI) from 2008 to 2012

	2008	2009	2010	2011	2012	$p^{\S}$
National MRSA cases (eligible*)	4,364 (4,364)	4,531 (4,519)	5,368 (5,368)	5,827 (5,813)	5,463 (5,418)	
Patient admissions	678,610	689,690	820,634	810,324	815,685	
Rate per 1,000 pt adm	6.4 [6.2, 6.6]	6.6 [6.4, 6.7]	6.5 [6.37, 6.72]	7.2 [6.9, 7.4]	6.6 [6.5, 6.8]	n/s
Patient days	5,441,458	5,303,013	5,859,813	6,352,235	6,302,784	
Rate per 10,000 pt days	8.0 [7.8, 8.3]	8.5 [8.3, 8.8]	9.2 [8.9, 9.4]	9.2 [8.9, 9.4]	8.6 [8.4, 8.8]	<0.001
No. of reporting hospitals†	46	48	52	50	50	
Western MRSA cases (eligible*)	979 (979)	1,118 (1,118)	1,222 (1,2220	1,634 (1,634)	1,582 (1,582)	
Patient admissions	265,774	283,737	340,073	338,779	348,658	
Rate per 1,000 pt adm	3.7 [3.45, 3.91]	3.9 [3.7, 4.2]	3.6 [3.4, 3.8]	4.8 [4.6, 5.0]	4.5 [4.3, 4.8]	<0.001
Patient days	2,084,979	1,983,469	2,318,603	2,500,602	2,560,811	
Rate per 10,000 pt days	4.7 [4.40, 4.99]	5.6 [5.3, 6.0]	5.3 [5.0, 5.6]	6.5 [6.2, 6.9]	6.2 [5.9, 6.5]	<0.001
No. of reporting hospitals	18	18	19	19	19	
Central MRSA cases (eligible*)	2,933 (2,933)	3,100 (3,090)	3,765 (3,765)	3,754 (3,740)	3,516 (3,516)	
Patient admissions	334,456	334,582	397,286	378,129	384,868	
Rate per 1,000 pt adm	8.8 [8.5, 9.1]	9.2 [8.9, 9.6]	9.5 [9.2, 9.8]	9.9 [9.6, 10.2]	9.1 [8.8, 9.4]	n/s
Patient days	2,640,941	2,622,979	2,778,135	2,980,563	2,986,017	
Rate per 10,000 pt days	11.1 [10.7, 11.5]	11.8 [11.4, 12.2]	13.6 [13.1, 14.0]	12.6 [12.2, 13.0]	11.8 [11.4, 12.2]	0.02
No. of reporting hospitals	22	25	27	24	25	
Eastern MRSA cases (eligible*)	452 (452)	313 (311)	381 (381)	439 (439)	365 (320)	
Patient admissions	78,380	71,371	83,275	93,416	82,159	
Rate per 1,000 pt adm	5.8 [5.2, 6.3]	4.4 [3.9, 4.8]	4.6 [4.1, 5.0]	4.7 [4.3, 5.1]	3.9 [3.5, 4.3]	<0.001
Patient days	715,538	696,565	763,075	871,070	755,956	
Rate per 10,000 pt days	6.3 [6.1, 6.5]	4.5 [4.1, 4.6]	5.0 [4.8, 5.2]	5.0 [4.9, 5.2]	4.2 [4.1, 4.4]	<0.001
No. of reporting hospitals	6	5	6	7	6	

§ Significance test (p) compares the 2008 adult HA-MRSA & CA-MRSA rate to the 2012 rate

**Rates are calculated using only eligible data = hospitals that supplied both numerator (cases) and denominator (patient admissions and days) data*

† Number of participating hospitals varies due to eligible data submitted

Colonization rates have increased nationally and in the central and west regions while in the east there has been a significant decrease since 2008.