

Guidelines for the prevention and management of community-associated methicillin-resistant *Staphylococcus aureus*: A perspective for Canadian health care practitioners

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EXECUTIVE SUMMARY	6.1.1 When to suspect CA-MRSA	8.2 Laboratory support
1.0 PREAMBLE	6.1.2 When to obtain cultures	9.0 PREVENTION
2.0 METHODOLOGY	6.2 Treatment	9.1 Prevention of transmission of CA-MRSA
3.0 DEFINITIONS	6.2.1 Minor SSTIs (folliculitis, furuncles and small abscesses without cellulitis)	9.1.1 Role of the individual
3.1 General definitions	6.2.2 Empirical therapy of non-life-threatening infections other than minor skin infections, potentially due to CA-MRSA	9.1.2 Role of health care practitioners
3.2 Operational definition of CA-MRSA	6.2.3 Empirical therapy of life-threatening infections potentially due to CA-MRSA	9.1.3 Role of health authorities
3.3 Definition limitations	6.2.4 Confirmed non-life-threatening CA-MRSA infections other than minor skin infections	9.2 Prevention in specific settings
4.0 EPIDEMIOLOGY	6.2.5 Confirmed CA-MRSA life-threatening infections	9.2.1 Households with CA-MRSA infection
4.1 The rise of CA-MRSA	6.2.6 Adjunctive therapy	9.2.2 Daycare centres and schools
4.2 CA-MRSA in Canada	7.0 SCREENING AND DECOLONIZATION	9.2.3 Sports settings
4.3 Origin of CA-MRSA and its ability to disseminate	7.1 Screening for CA-MRSA	9.2.4 Pets and other animals
4.4 Populations at risk	7.2 Decolonization	9.2.5 Correctional facilities or shelters
4.5 Transmission	7.3 Guidelines for the use of decolonization regimens	9.2.6 Newborn care facilities
5.0 MICROBIOLOGY	8.0 POPULATION SURVEILLANCE	10.0 DIRECTIONS FOR FUTURE RESEARCH
5.1 <i>S aureus</i> and MRSA	8.1 Population surveillance program for CA-MRSA	10.1 Epidemiology
5.2 Virulence factors		10.2 Biology of CA-MRSA: Organism versus host
5.3 Nomenclature of strains		10.3 Clinical outcomes and management
5.4 Resistance to non-beta-lactam antibiotics		10.4 Infection prevention and control
5.4.1 Clindamycin		10.5 Knowledge translation
5.4.2 Erythromycin		11.0 CONCLUSION
5.4.3 Quinolones		APPENDIX
5.5 Differences between CA-MRSA and HA-MRSA		REFERENCES
6.0 MANAGEMENT		
6.1 Diagnostic evaluation		

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EXECUTIVE SUMMARY

Methicillin resistance among community isolates of *Staphylococcus aureus* has reached a staggering high of 75% in some communities in the United States (US) (1). These organisms, which are resistant to the entire class of beta-lactam antibiotics, have evaded an important component of the physician's armamentarium and may require clinicians to change their management of presumed staphylococcal infections. The recent emergence of community-associated (CA) methicillin-resistant *S aureus* (MRSA) strains as dominant clones signals their adaptation to survive and spread outside the hospital setting. Descriptions of severe disease and characterization of their virulence factors warn of their potential to inflict significant morbidity and mortality. Thus, we are faced with an emerging and formidable foe – a pathogen combining virulence, resistance and an ability to disseminate at large (2). At present, the prevalence of CA-MRSA in Canada is unknown but thought to be low based on the collective clinical experience of infectious disease experts across the country. If Canada is to delay or prevent the emergence of CA-MRSA in its communities, vigilance and determined control efforts are needed.

The purpose of the present document is to convey basic information regarding the epidemiology and microbiology of CA-MRSA, as well as to suggest recommendations related to the clinical management, prevention and control of CA-MRSA infections. It complements existing publications on hospital-associated (HA) MRSA and CA-MRSA, including a recent statement from the US Centers for Disease Control and Prevention (CDC) (3).

Sources of information and recommendations were derived from a comprehensive literature review, a Working Group meeting of Canadian and US experts, and extensive discussions within an expert panel writing group. When available, published and unpublished Canadian data are presented. The highlights of the present document include clinician-oriented treatment guidelines addressing the various presentations of presumed and confirmed CA-MRSA infection and their management. Guidelines for infection prevention and control in a variety of settings, such as homes, daycare centres and schools, sports settings, pet-owning households, prisons and homeless shelters, and neonatal care facilities, are included. The document does not address health care settings other than nurseries; existing guidelines for infection control in hospitals and clinics should be followed in these settings. Directions for future research are also suggested. The content of the present document will be modified and updated as microbiologists and public health specialists find evolving regional prevalence of CA-MRSA, and as new studies are published.

Front-line physicians need to be aware of the increasing prevalence and potential severity of CA-MRSA infections. They are advised to obtain specimens for culture from all serious skin and soft tissue infections (SSTIs), including abscesses and other infected sites. The management of presumed *S aureus* infection should include the use of surgical drainage when appropriate, and empirical antibiotic therapy should be adjusted when regional rates of clinical infections due to CA-MRSA increase. Judicious use of antibiotics is emphasized as a prevention strategy. Families, school and daycare centre personnel, and sports teams should be actively encouraged to practice meticulous handwashing, the most important measure to control or attenuate community transmission of CA-MRSA.

1.0 PREAMBLE

A dramatic increase in the rate of methicillin resistance among community isolates of *S aureus* has recently been observed in the US (4). CA-MRSA has emerged as the dominant pathogen in some communities in the US, with a prevalence as high as 75% of all *S aureus* isolates (1). These CA strains are genetically and clinically distinct from strains of HA-MRSA, which has been a familiar problem in health care institutions for several decades. Currently, the prevalence of CA-MRSA in Canada is unknown but thought to be low based on the collective clinical experience of infectious disease experts. However, as the prevalence of CA-MRSA increases, clinicians may need to change their approach to the management of presumed *S aureus* infections. Furthermore, if Canada is to limit the emergence of CA-MRSA in its communities, vigilance and determined control efforts are needed.

To date, there are no Canadian consensus guidelines for the management and prevention of CA-MRSA infections in children and adults. Recent reports (unpublished data, 5,6) of serious invasive disease and mortality due to CA-MRSA in Canada emphasize the need for such guidelines. Focus has centred for years on the challenge of controlling the spread of MRSA in hospitals and chronic care institutions. The present document addresses MRSA in the community and complements previously published guidelines (Appendix). The reader is specifically referred to other excellent existing documents on CA-MRSA, including a statement from the CDC (3), the BC Centre for Disease Control (7) and the Canadian Paediatric Society (8). The present CA-MRSA document is unique because it has a national focus; underwent a rigorous methodology, which included a Working Group meeting of national experts and an expert panel review process; consists of practical, clinician-oriented treatment guidelines addressing multiple possible presentations of CA-MRSA; and has a multidisciplinary focus on the prevention of transmission.

The goal of the present document is to provide information about the epidemiology and microbiology of CA-MRSA in Canada as well as recommendations on its treatment, prevention and control. The document is directed toward health care workers, including public health practitioners, laboratory personnel, clinicians, nurses, infection control practitioners, veterinary medicine personnel and other health care practitioners involved in outbreak management and direct patient care. While the guidelines provide suggestions for specific patient management, they are not meant to replace clinical judgment in the care of the individual patient. The scope of the present document includes the following:

- definitions and a general description of the epidemiology highlighting the Canadian experience, where available;
- microbiology of MRSA emphasizing differences between traditional HA strains and emerging CA strains;
- clinical management guidelines;
- recommendations for screening and decolonization;
- recommendations for the prevention and management of outbreaks and infections occurring in the community; and
- directions for future research, based on ideas generated at the Working Group meeting.

TABLE 1
Strength of recommendations and quality of evidence

Strength	Definition
A	Strong recommendation Should always be offered Experts agree
B	Moderate recommendation Should usually be offered Most experts agree
C	Optional recommendation May be offered Expert opinion varies
Grade	Definition
I	Evidence from at least one proper randomized, controlled trial
II	Evidence from at least one well-designed clinical trial without randomization from cohort or case-controlled analytical studies, or from dramatic results of uncontrolled experiments
III	Evidence from opinions of respected authorities based on clinical experience, descriptive studies or reports of expert committees

Data from reference 9

2.0 METHODOLOGY

The information and recommendations presented in the current document result from a comprehensive literature review, a Working Group meeting of Canadian and US experts, and discussions of an expert panel writing committee.

A review of the English-language medical literature from 1980 to March 2006 was conducted. Data sources included MEDLINE, EMBASE and the Cochrane Central Register of Controlled Trials. Published abstracts of papers presented at local and international infectious disease or microbiology conferences were cited when they were the only available information from ongoing trials or emerging reports.

An interdisciplinary Working Group meeting held on October 27 and 28, 2005, in Toronto, Ontario, assembled 70 Canadian experts in pediatric and adult infectious disease, infection control, microbiology and public health, as well as US experts in CA-MRSA from Texas and from the CDC. The meeting was supported by the Public Health Agency of Canada, the Canadian Committee on Antibiotic Resistance, and the Ontario Ministry of Health and Long-Term Care. A rich dialogue emerged around issues in CA-MRSA treatment, prevention and control, including important questions for future research.

Recommendations were developed based on the literature review, the Working Group meeting and the opinions of the expert panel. Recommendations were graded on the basis of strength and quality of the supporting evidence (Table 1) (9). The consensus statements were proposed, debated, revised and agreed on by members of the expert panel through conference calls and face-to-face meetings. The document was rigorously reviewed and debated by the expert panel committee using electronic mail in an iterative process with multiple revision steps. Suggestions were then evaluated by the panel and incorporated into the final document.

The present document was approved for publication by the Guidelines Committee of the Association of Medical Microbiology and Infectious Disease Canada. These guidelines will be reviewed annually by the CA-MRSA expert panel and

will be considered current unless they are revised or withdrawn from distribution.

3.0 DEFINITIONS

3.1 General definitions

MRSA: MRSA demonstrates resistance to the semisynthetic penicillins (methicillin, oxacillin and cloxacillin). It is also resistant to cephalosporins, monobactams and carbapenems. Resistance to other antibiotic classes may occur, but it is strain dependent.

HA-MRSA: MRSA strains that circulate and are transmitted to individuals within health care facilities.

CA-MRSA: MRSA isolates obtained from individuals in the community who have not had recent exposure to the health care system, or from patients in health care facilities in whom the infection was present or incubating at the time of admission.

3.2 Operational definition of CA-MRSA

The case definition for CA-MRSA endorsed by the expert panel, consistent with that used by the US CDC, is MRSA infection in a person who has none of the following risk factors for HA-MRSA: isolation of MRSA more than 48 h after hospital admission; history of hospitalization, surgery, dialysis or residence in a long-term care facility within one year of the MRSA culture date; the presence of an indwelling catheter or a percutaneous device at the time of culture; or previous isolation of MRSA (10).

3.3 Definition limitations

Using a standard definition is important for consistently estimating the burden of CA-MRSA infection (11); however, operational definitions of CA-MRSA have varied among studies. MRSA detected within 24 h, 48 h or 72 h of admission has been variably considered to be of community origin (12). Isolates from patients with health care contact, such as recent hospitalization, hemodialysis or indwelling catheters, have been excluded in some studies but not in others (12).

It is not always possible to identify the source of MRSA with certainty, making the classification of 'CA' and 'HA' strains based on epidemiological criteria somewhat imprecise. Because genetic and molecular distinctions between CA and HA strains have been described, molecular markers can now be used to define isolates as CA-MRSA or HA-MRSA. The onset of MRSA disease in the community may be attributable to bacterial strains acquired by discharged inpatients or health care personnel and subsequently transmitted to close contacts in the community (13,14). In a meta-analysis, approximately one-half of community-based patients colonized with MRSA had a health care-associated risk factor, suggesting a hospital origin of the isolates (12). Conversely, the ability to track strains using molecular epidemiological markers has enabled investigators to describe the spread of CA-MRSA strains within the hospital (15-17). Because hospital strains have moved into the community and community strains have spread within hospitals, it has become increasingly difficult to distinguish CA-MRSA and HA-MRSA by epidemiological criteria (18). Figure 1 illustrates a classification scheme for MRSA based on molecular and epidemiological characteristics, and the challenge of accurately discriminating between 'community' and 'hospital' isolates.

4.0 EPIDEMIOLOGY

4.1 The rise of CA-MRSA

MRSA was first described in 1961 (19), shortly after the introduction of semisynthetic penicillins (methicillin, oxacillin and cloxacillin). MRSA has long been recognized as a nosocomial pathogen. In the US, up to 40% of hospital *S aureus* strains are methicillin-resistant, while in Canada, nosocomial MRSA rates have increased from 0.95% in 1995 to 10.4% in 2003 (20). A new phenomenon has been observed over the past 10 years: MRSA strains have emerged, increased in prevalence and become the dominant strains in some US communities. These clones are genetically distinct from HA-MRSA, are well adapted to spread within the community and have the potential to cause severe disease. The rise of MRSA, first in hospitals and now in the community, has been likened to the historically similar trend of resistance of *S aureus* to penicillin, which emerged first in hospitals in the 1940s and later in the community throughout the 1960s (21).

Cases of severe MRSA infection in patients without contact with health care institutions were reported in a remote Aboriginal population in Australia in 1993 (22). The pathogen gained North American attention when the CDC reported four pediatric deaths from CA-MRSA in 1999 (23). Since then, methicillin resistance among isolates of *S aureus* outside of health care institutions has reached epidemic proportions in some US communities (24-27). Over a 10-year period, the Driscoll Children's Hospital in Corpus Christi, Texas, documented an increase in the rate of methicillin resistance among community isolates from 2.9% in 1990 to 40.3% in 2001 (4). The Texas Children's Hospital in Houston now reports that over 75% of community isolates are methicillin resistant, so MRSA, rather than methicillin-sensitive *S aureus* (MSSA), is now the dominant community pathogen (1). Increasingly, CA-MRSA is being detected around the globe (28), with multiple reports from Europe (29-31), Southeast Asia (32-35) and Australia (36,37).

To date, a spectrum of clinical manifestations of CA-MRSA infection have been described. The most common manifestation of CA-MRSA infection is SSTI (38). However, there are accumulating reports of severe disease, including sepsis (39), necrotizing fasciitis (40), purpura fulminans (41), toxic shock syndrome (42,43), necrotizing pneumonia (44,45) and empyema (46,47), caused by CA-MRSA. These severe presentations may occur in otherwise healthy children and young adults.

4.2 CA-MRSA in Canada

The first reported cases of CA-MRSA in Canada occurred in an Aboriginal community in Alberta between 1986 and 1989 (48). A cluster of 15 cases of CA-MRSA infections, predominantly soft tissue in origin, with organisms that remained relatively susceptible to non-beta-lactam antibiotics was reported from a small, rural town in southern Manitoba from 1997 to 1998 (49). This strain is rapidly emerging in several neighbouring communities in northern Manitoba and Saskatchewan (50). In 1998, the first case of CA-MRSA disease and transmission in a child care centre was reported in Toronto, Ontario (51). In Ontario in 2004, 11% of 10,301 MRSA isolates were thought to be CA (52). However, it is possible that the overall prevalence of this emerging pathogen has been underestimated.

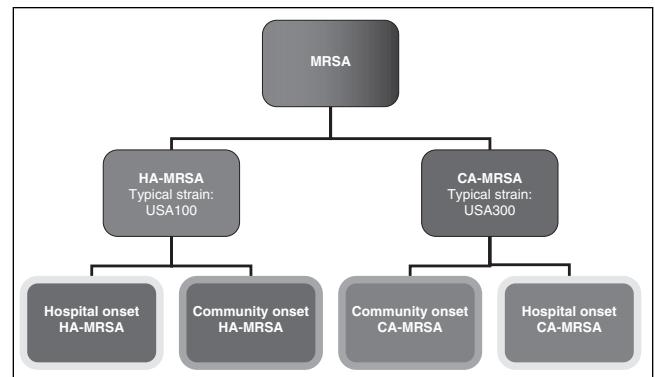


Figure 1) Classification scheme for methicillin-resistant *Staphylococcus aureus* (MRSA). Molecular techniques allow MRSA strains to be identified as community-associated (CA) MRSA (eg, the epidemic USA300 strain) or hospital-associated (HA) MRSA (eg, the USA100 strain [strain nomenclature described in section 5.3]). Epidemiological information can be used to further determine whether the infection arose in the community or in the hospital. Although, typically, HA-MRSA strains are isolated within health care facilities (ie, hospital-onset HA-MRSA), 'spillover' of these strains into the community (ie, community-onset HA-MRSA) has been observed (12). Conversely, CA-MRSA strains were first described in the population at large (ie, community-onset CA-MRSA) but have since been observed in health care settings (ie, hospital-onset CA-MRSA) (15-17)

This pathogen's potential to cause severe disease has been demonstrated in several Canadian reports. Severe soft tissue infections due to CA-MRSA have been reported in western Canada, including an outbreak in the Calgary Health Region in Alberta in 2004 involving illicit drug users and homeless people (53). The first case of fatal necrotizing pneumonia in a young, otherwise healthy adult was reported recently from the Calgary Health Region (5), and the first fatal pediatric case was described in Ontario (unpublished data). Several additional cases of severe necrotizing pneumonia without clinical or laboratory evidence of antecedent viral respiratory tract infection have been reported in southern Alberta (6).

4.3 Origin of CA-MRSA and its ability to disseminate

Because CA-MRSA has emerged very recently, several questions regarding its origin and ability to spread in the community have been the focus of intensive investigation. Where did CA-MRSA come from? Among other hypotheses, horizontal gene transfer of the resistance determinants from coagulase-negative staphylococci to CA strains of MSSA has been postulated (54). Did antibiotic pressure contribute to the emergence of this pathogen? *S aureus* and coagulase-negative staphylococci may coexist on the skin of patients treated with beta-lactam antibiotics, providing an environment conducive to the selection of CA-MRSA strains after horizontal transfer of resistance genes (55). What properties of CA-MRSA have allowed it to propagate in the community and indeed arise as the dominant clone in some settings? CA-MRSA strains are genetically distinct and do not simply represent the 'spillover' of hospital strains into the community (55,56). CA-MRSA grows more rapidly in vitro than does HA-MRSA (57), likely because HA-MRSA strains carry many antibiotic resistance genes and have a high 'fitness cost' of resistance (58). The genome of the epidemic CA-MRSA USA300 strain (strain nomenclature

TABLE 2
Risk factors for community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) infections

Risk categories and factors	References
High-risk populations	
Young people	Age distribution for CA-MRSA younger than for hospital-associated MRSA (38) High rate of CA-MRSA in children younger than two years (61) CA-MRSA more common in Canadian children than adults (62)
Minority populations	
Native or Aboriginal, and African-American people	Higher risk in Aboriginal communities in midwestern United States (23,63,64) Higher risk in Alaskan natives (65) More common in African-Americans (61,66,67) Aboriginal communities in Canada (48,49,62,68,69)
Athletes – mainly those involved in contact sports	Outbreaks in football teams (70-74) Outbreak in wrestling team (75) Outbreaks in other competitive sports (71,76)
Intravenous drug users	San Francisco intravenous drug users (77) Western Canadian report of USA300 strain outbreak documents higher risk in intravenous drug users (78)
Men who have sex with men	CA-MRSA described in HIV-positive population of men who have sex with men (79,80)
Military personnel	3% of United States army soldiers colonized (81)
Inmates of correctional facilities	Reports of outbreaks in United States prisons (82-86) Two outbreaks (total of 10 inmates) in Hamilton, Ontario (87)
Previous positive MRSA cultures	
MRSA carriage	Colonized soldiers more likely to get CA-MRSA disease (81)
Past MRSA infection	Prior abscess a risk factor for CA-MRSA (88)
Medical history	
Chronic skin disorder	Dermatological condition most common underlying medical disorder for CA-MRSA infection (38) Classroom contact of an index CA-MRSA case had chronic dermatitis (51)
Recurrent or recent antibiotic use	Antibiotic use associated with CA-MRSA infection in rural Alaska (65)
Environmental risks	
Low socioeconomic status	Medically underserved populations at higher risk of CA-MRSA (88,89)
Overcrowding	Close contact implicated in jail outbreak (84), neonatal intensive care unit transmission (90)
Contact with colonized pet	Family dog a source of recurrent infection (91)
Veterinary work	Cases documented in veterinarians working with horses (92-94), small animal veterinarians (95,96) and pig farmers (97)

described in section 5.3) has recently been sequenced in its entirety and reveals a novel mobile genetic element – the arginine catabolic mobile element, also present in the ubiquitous skin commensal *Staphylococcus epidermidis* – that may enhance fitness and pathogenicity (59). Thus, CA-MRSA may be better suited to competition with other bacteria in the environment, whereas HA-MRSA dominates in hospital settings under intense antibiotic pressure. Interested readers are referred to several comprehensive reviews of these topics for more detailed explanations (54,55,60).

4.4 Populations at risk

CA transmission of MRSA has been documented in several identifiable populations (23,38,61-97). These groups, listed in Table 2, are considered to be at high risk for CA-MRSA.

4.5 Transmission

The spread of CA-MRSA, like *S aureus* in general, occurs through direct contact between an infected person and an uninfected person, or by indirect contact through touching contaminated objects or surfaces that are part of the infected person's environment. Zoonotic transmission (from animals to humans) has also been documented (91,93,95,96,98-103).

5.0 MICROBIOLOGY

5.1 *S aureus* and MRSA

S aureus is a Gram-positive coccus that tends to form clusters. Resistance to methicillin and the entire class of beta-lactam antibiotics in *S aureus* is determined by altered penicillin binding protein 2a. This enzyme is encoded by the gene *mecA*, which is located within a larger mobile genetic element called the staphylococcal chromosomal cassette *mec* (SCC*mec*). Currently, there are five types of SCC*mec* distinguished by their genetic sequence, labelled SCC*mec* I to SCC*mec* V. CA-MRSA strains usually contain SCC*mec* IV or V, whereas HA-MRSA strains usually contain SCC*mec* I, II or III (104).

5.2 Virulence factors

Factors produced by *S aureus* that may play a role in virulence are shown in Table 3. The role of each of these factors in clinical disease is not clear, although considerable attention has been focused on the Panton-Valentine leukocidin (PVL) (104). The PVL is an extracellular product of *S aureus* that is encoded by the genes *lukS*-PV and *lukF*-PV (104). This factor, by its cytolytic pore-forming activity, damages the cell membranes of neutrophils, monocytes and macrophages (Figure 2). Infection caused by PVL-positive strains tends to occur in

TABLE 3
Virulence factors of *Staphylococcus aureus*

Category	Toxin
Cytolytic toxins	Panton-Valentine leukocidin S and F
	Fibronectin-binding proteins A and B
	Leukocidin R
Superantigenic toxins	Enterotoxins (A to J)
	Epidermolytic toxins
	Toxic shock syndrome toxin-1
Enhanced growth and survival	Arginine catabolic mobile element

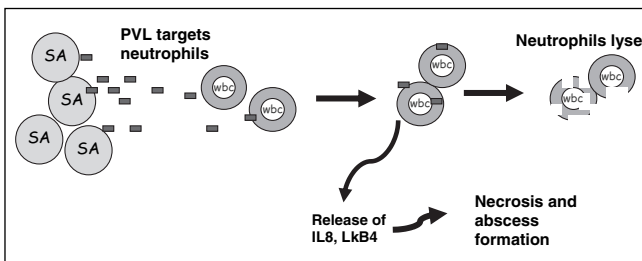


Figure 2) Mechanism of action of the Panton-Valentine leukocidin (PVL). PVL is a putative virulence factor associated with severe clinical disease. The toxin is released from *Staphylococcus aureus* (SA) and targets the cell membrane of neutrophils (wbc). This causes the release of cytokines, such as interleukin-8 (IL8) and leukotriene B4 (LkB4), which produce necrosis and abscess formation. The toxin also causes lysis of neutrophils such that infection with PVL-positive strains may be associated with neutropenia

children and young adults, and is associated with higher mortality (105,106). In patients with staphylococcal osteomyelitis, the presence of PVL-positive isolates is associated with a higher likelihood of complications (107,108).

5.3 Nomenclature of strains

Independent studies of the molecular epidemiology of MRSA have resulted in a confusing nomenclature of circulating strains (60). In Canada, based on *Sma*I macrorestriction patterns from pulsed-field gel electrophoresis, 10 major clusters have been labelled CMRSA-1 to CMRSA-10 (109). In the US, also using pulsed-field gel electrophoresis profiles, 11 major epidemic strains of MRSA, labelled USA100 to USA1100, have been described to date (110). The USA300 (equivalent to CMRSA-10) strain is the dominant circulating clone of CA-MRSA in North America (17,39,40,73,111,112). Another molecular method, multilocus sequence typing, has been used internationally to unambiguously categorize MRSA strains by using the sequence of internal fragments of seven chromosomal housekeeping genes (60). Table 4 shows the common circulating strains and the relationship among the different systems of nomenclature. Also provided are the associated SCCmec types and the presence or absence of PVL genes in the various strains.

5.4 Resistance to non-beta-lactam antibiotics

5.4.1 Clindamycin

While clindamycin resistance is common in HA-MRSA (observed in 79% of isolates) (38), CA-MRSA has a low

TABLE 4
Nomenclature of *Staphylococcus aureus* strains

US PFGE	CMRSA strain	MLST	SCCmec type	PVL presence
USA100	2	5	II	Negative
USA200	3,6	36	II	Negative
USA300	10	8	IVa	Positive
USA400	7	1	IVa	Positive
USA500	5,9	8	IV	Negative
USA600	1	45	II	Negative
USA700	–	72	IVa	Negative
USA800	2	5	IV	Negative
USA1000	–	59	IV	Positive
USA1100	–	30	IV	Positive

CMRSA Canadian methicillin-resistant *Staphylococcus aureus*; MLST Multilocus sequence typing; PFGE Pulsed-field gel electrophoresis; PVL Panton-Valentine leukocidin; SCCmec *Staphylococcal chromosomal cassette mec*; US United States

baseline resistance to clindamycin in some communities. Clindamycin resistance rates for CA-MRSA vary across the US, from 2% (Texas in 2001) to 17% (Minnesota in 2000) (61,113). In Canada, 49% of pediatric and 85% of adult MRSA isolates were resistant to clindamycin between 1995 and 2002 (62), but this reflects a preponderance of hospital strains within the Canadian Nosocomial Infection Surveillance Program.

Laboratory testing for clindamycin resistance should include the double disk diffusion test (D test) for inducible clindamycin resistance (114). A clindamycin disk is placed at a fixed distance from an erythromycin disk, and a D-shaped zone of inhibition around the clindamycin disk indicates that resistance has been induced by the diffusion of erythromycin (ie, MLS_B phenotype) (115). Clinical failures have been documented in CA-MRSA infection when clindamycin was used to treat strains with inducible clindamycin resistance (positive D test) (115,116). Therefore, laboratories should routinely test for inducible clindamycin resistance, and clindamycin should be avoided when inducible resistance is detected.

5.4.2 Erythromycin

Both HA-MRSA and CA-MRSA are frequently resistant to erythromycin. For example, resistance was detected in vitro in 91% and 56% of HA-MRSA and CA-MRSA isolates, respectively, in Minnesota in 2000 (61). A large, laboratory-based survey indicated that 93% of Canadian MRSA isolates demonstrated resistance to erythromycin (117).

5.4.3 Quinolones

Emergence of resistance during therapy leading to treatment failure may occur when quinolones are used for the treatment of *S aureus* infections, including CA-MRSA (118).

5.5 Differences between CA-MRSA and HA-MRSA

In summary, CA-MRSA strains are genetically and phenotypically distinct from HA-MRSA strains, as highlighted in Table 5.

6.0 MANAGEMENT

6.1 Diagnostic evaluation

At the initial clinical presentation, CA-MRSA may not be easily distinguished from HA-MRSA, MSSA or streptococci

TABLE 5
Contrasting community-associated methicillin-resistant
***Staphylococcus aureus* (CA-MRSA) and hospital-**
associated (HA) MRSA

	CA-MRSA	HA-MRSA
Typical demographic characteristics	Younger Minority population	Older Nursing home resident
Common SCCmec type	IV	II
PVL virulence factor	Common	Unusual
Predominant strains	USA300 (CMRSA-10) USA400 (CMRSA-7)	USA100 (CMRSA-1) USA200 (CMRSA-3,6)
Multidrug resistance (other than beta-lactam)	Rare	Common

CMRSA Canadian MRSA; PVL Panton-Valentine leukocidin; SCCmec Staphylococcal chromosomal cassette mec; USA United States

as the agent of infection. Epidemiological risk factors (Table 2) should heighten suspicion of CA-MRSA. Furthermore, microbiological diagnosis can be helpful in guiding management and may prove helpful in monitoring local rates of CA-MRSA as this pathogen emerges in the community. The following principles of management are intended to assist the clinician faced with a possible or proven case of CA-MRSA infection and address clinical presentations that are potentially consistent with *S aureus* infection.

6.1.1 When to suspect CA-MRSA

Recommendations

- In areas where approximately 10% to 15% of community isolates of *S aureus* are methicillin resistant, CA-MRSA should be suspected in any patient who presents with an SSTI. (BIII)
- Suspect CA-MRSA in severe infections compatible with *S aureus* (eg, sepsis [39], necrotizing fasciitis [40], necrotizing pneumonia [44,45] and empyema [46,47]). (AIII)
- Suspect CA-MRSA when risk factors for CA-MRSA are present (Table 2). (AIII)
- Suspect CA-MRSA when there is a poor response to beta-lactam therapy in individuals with presumed staphylococcal infection. (AIII)

6.1.2 When to obtain cultures

Recommendations

- Cultures should be obtained from SSTIs, as well as other sites where *S aureus* infection is suspected, that have not responded to initial therapy. (AIII)
- Culture recurrent furuncles or abscesses (two or more in six months). (AIII)
- Obtain cultures in any severe presentation of the disease (should include blood cultures). (AIII)
- Obtain cultures when an outbreak is suspected in consultation with public health. (AIII)
- Consider an attempt to obtain material for culture from areas of cellulitis by aspiration of the area, with or

without preceding saline injection, particularly for patients who are going to be admitted for inpatient therapy or whose cellulitis progresses on treatment. (BIII)

- Specimens for culture of SSTIs should not be routinely obtained for all individuals presenting with minor skin infections and without previous CA-MRSA infection. (AIII)

6.2 Treatment

Studies have demonstrated that antibiotics may not be necessary in patients with minor SSTIs due to CA-MRSA (119). When systemic antimicrobial therapy is indicated for an infection consistent with *S aureus*, clinicians should bear in mind the possibility of methicillin resistance. The prevalence of CA-MRSA in the community is an important factor in guiding empirical antibiotic choice, but is unknown in most areas in Canada. The rate of methicillin resistance among community strains of *S aureus* is assumed to be low at the present time because of the relatively few cases of antibiotic failures reported to date, but may rise in the near future, as has occurred in many US cities. The threshold of resistance that should prompt a change in empirical therapy is thought to be approximately 10% to 15% (113). However, even in communities in which the rate is lower than 10% to 15%, clinicians may wish to include antimicrobial coverage for CA-MRSA in cases in which the infection is severe or life-threatening. In the absence of data to suggest a high prevalence of methicillin resistance in Canada, no change in empirical therapy of presumed *S aureus* infections is advocated at the present time. As resistance rates become better defined, recommendations for empirical therapy may change.

Table 6 summarizes the treatment principles and antimicrobial options for various presentations of CA-MRSA infection. Further details of the antimicrobial agents useful in the treatment of CA-MRSA are presented in Table 7. The following recommendations are categorized according to empirical therapy for suspected CA-MRSA infection versus therapy for confirmed infection, and according to severity and location of infection.

6.2.1 Minor SSTIs (folliculitis, furuncles and small abscesses without cellulitis)

Recommendations

- One or more of the following measures may be used:
 1. local therapy using hot soaks and elevation; (AIII)
 2. incision and drainage without antimicrobial therapy (119); (AII)
 3. topical mupirocin or bacitracin; (AIII) and/or
 4. topical antiseptics. (BIII)
- For young infants and for the immunocompromised host, antimicrobial therapy is recommended in addition to local measures, incision and drainage. (BIII)
- In follow-up, routine screening for colonization of the nares or other body sites is not recommended. (AIII)

TABLE 6
Guidelines for the management of infections due to community-associated methicillin-resistant *Staphylococcus aureus* (MRSA)

Clinical disease	Key features	Management principles	Antimicrobial choices*
Skin and soft tissue infection (SSTI)			
Mild	Localized disease	Culture selectively†	Generally not indicated
	Infected scratches	No antibiotic therapy recommended except for young or immunocompromised host	Topical antiseptic or antibacterial (eg, bacitracin) therapy may be considered.
	Insect bites	Cover draining lesions	Systemic antimicrobial therapy may be considered in the young infant or immunocompromised host.
	Furuncles	Emphasize personal hygiene	
	Small abscesses	Close follow-up	
Moderate	Absence of systemic illness	Return if worsening	
	Cellulitis	Culture (blood if febrile, site if purulent)	ET includes clindamycin 150 mg to 450 mg every 6 h po and ped dose of 30 mg/kg/day ÷ every 6 h to 8 h po, or TMP-SMX one double-strength tablet or two regular-strength tablets every 12 h po and ped dose of 8 mg/kg/day to 12 mg/kg/day (based on TMP component) ÷ every 12 h po/IV plus coverage for group A streptococcus, or doxycycline‡ 100 mg every 12 h po. If parenteral therapy is necessary, see choices for severe SSTI.
	Moderate abscesses	Drainage of abscess or needle aspiration	
	Minimal or no associated systemic features	Oral therapy in older child or adult	
		Consider parenteral therapy for young or immunocompromised host	
Severe		Appropriate infection control measures	
		Imaging for extent and complications (case by case)	
		Close follow-up	Treat proven MRSA as above, based on sensitivity testing.
		Return if worsening	If parenteral therapy is necessary, see choices for severe SSTI.
		Culture (blood if febrile, site if purulent)	ET includes vancomycin 1 g every 12 h IV and ped dose of 40 mg/kg/day to 60 mg/kg/day ÷ every 6 h IV. Some experts recommend adding cloxacillin or a first-generation cephalosporin while awaiting culture and sensitivity results (superior for MSSA). Clindamycin may be added in cases of toxin-mediated syndrome.
	Large or multiple abscesses		
	Associated systemic features	Hospitalize	Treatment for proven MRSA includes vancomycin 1 g every 12 h IV and ped dose of 40 mg/kg/day to 60 mg/kg/day ÷ every 6 h IV. Alternatives include clindamycin 600 mg to 900 mg every 8 h IV/IM (if sensitive) and ped dose of 30 mg/kg/day to 40 mg/kg/day ÷ every 6 h to 8 h IV or TMP-SMX* 8 mg/kg/day to 10 mg/kg/day (based on TMP component) ÷ every 12 h IV (if sensitive) and ped dose of 8 mg/kg/day to 12 mg/kg/day (based on TMP component) ÷ every 6 h IV. Clindamycin is bacteriostatic and should not be used alone if a bactericidal drug is required.
		Parenteral therapy	
		Appropriate infection control measures	
		Infectious disease consultation	
		Imaging for extent and complications	
Musculoskeletal infection (MSI)			
Osteomyelitis	Preceding trauma	Cultures (blood, bone and tissue)	ET includes vancomycin 1 g every 12 h IV and ped dose of 40 mg/kg/day to 60 mg/kg/day ÷ every 6 h IV, or clindamycin 600 mg to 900 mg every 8 h IV/IM/po and ped dose of 30 mg/kg/day to 40 mg/kg/day ÷ every 6 h to 8 h IV or po, or TMP-SMX 8 mg/kg/day to 10 mg/kg/day (based on TMP component) ÷ every 12 h IV and ped dose of 8 mg/kg/day to 12 mg/kg/day (based on TMP component) ÷ every 6 h IV.
	Tendency for multifocal lesions	Involve surgical team (early debridement and drainage)	Treat proven MRSA as above, based on sensitivity testing.
	Disease in adjacent muscle not uncommon	Infectious disease consultation	Addition of rifampin may be considered for osteomyelitis.
	Progression to chronic osteomyelitis possible	Parenteral therapy	Treat similar to osteomyelitis.
	May be complicated by DVT	Consider combination therapy for severe cases or if slow to respond	
Pyomyositis		Infection control measures	
		Look for other infected sites (imaging)	
	May be extensive	Cultures (blood, tissue)	
	Tendency for multifocal involvement	Surgical drainage	
		Infectious disease consultation	
Necrotizing fasciitis		Parenteral therapy	
		Infection control measures	
	Clinically indistinguishable from GAS disease	Imaging	
	Toxic	Cultures (blood and tissue)	ET includes vancomycin 1 g every 12 h IV and ped dose of 40 mg/kg/day to 60 mg/kg/day ÷ every 6 h IV. Some experts recommend adding cloxacillin or a first-generation cephalosporin while awaiting culture and sensitivity results (superior for MSSA). Clindamycin may be added in case of toxin-mediated syndrome.
	High complication rate	Surgical debridement	Adjuncts such as IVIG should be considered on a case-by-case basis in conjunction with ID specialist.
	Infectious disease consultation		
	Parenteral therapy		
	Infection control measures		
	Imaging		
			Treat proven MRSA as above, based on sensitivity testing.

Continued on next page

TABLE 6 – CONTINUED

Guidelines for the management of infections due to community-associated methicillin-resistant *Staphylococcus aureus* (MRSA)

Clinical disease	Key features	Management principles	Antimicrobial choices*
Respiratory tract infection (RTI)			
Necrotizing pneumonia	Influenza-like prodrome, hemoptysis, fever, shock, leukopenia, pneumatoceles, abscesses, consolidation Respiratory failure High mortality	Cultures (blood, pleural fluid and sputum) ID consultation Intensive care unit care Infection control measures Combination parenteral therapy Chest drainage if empyema	ET includes vancomycin 1 g every 12 h IV and ped dose of 40 mg/kg/day to 60 mg/kg/day + every 6 h IV. Treat proven MRSA as above, based on sensitivity testing. Consider linezolid (superior for hospital-associated MRSA pneumonia [123,124]), as guided by ID opinion.
Other			
Sepsis syndrome	Shock Multiorgan failure May have purpura fulminans Associated SSTI, MSI, RTI May be complicated by Waterhouse-Friedrichsen syndrome High mortality	Blood cultures Culture any pus or fluid collection Look for primary or secondary focus ID consultation Intensive care unit care Imaging: look for occult abscesses, bone infection or endocarditis Involve surgery and other specialists as needed Infection control measures Parenteral, multidrug therapy Prolonged therapy for endovascular infections	ET includes vancomycin 1 g every 12 h IV and ped dose of 40 mg/kg/day to 60 mg/kg/day + every 6 h IV. Some experts recommend adding cloxacillin or a first-generation cephalosporin while awaiting culture and sensitivity results (superior for MSSA). Clindamycin may be added in case of toxin-mediated syndrome. Adjuncts such as IVIG should be considered on a case-by-case basis in conjunction with ID specialist Proven MRSA treatment includes vancomycin 1 g every 12 h IV and ped dose of 40 mg/kg/day to 60 mg/kg/day + every 6 h IV. Alternatives include clindamycin 600 mg to 900 mg every 8 h IV/IM (if sensitive) and a ped dose of 30 mg/kg/day to 40 mg/kg/day + every 6 h to 8 h IV or TMP-SMX 8 mg/kg/day to 10 mg/kg/day (based on TMP component) + every 12 h IV (if sensitive) and ped dose of 8 mg/kg/day to 12 mg/kg/day (based on TMP component) + every 6h IV. Clindamycin is bacteriostatic and should not be used alone if a bactericidal drug is required.
Septic thrombophlebitis, DVT	Complicates musculoskeletal infection	Management as for sepsis syndrome, plus Doppler ultrasound, often found on magnetic resonance imaging Anticoagulation, under direction of hematology (159)	Treat as above For endovascular infections, combination antimicrobial therapy is recommended (ie, vancomycin plus either gentamicin or rifampin) Prolonged therapy is required for endovascular infection, and expert advice from an ID specialist should be considered.
Endocarditis	Suspect if persistent bacteremia Pre-existing valvular heart disease may not be present	Management as for sepsis syndrome, plus Echocardiogram Cardiology consultation ID consultation Parenteral therapy Monitor for complications (embolic phenomena and hemodynamic instability)	

*Choice of antimicrobial therapy depends on local susceptibility patterns; ¹Patients with risk factors, as a part of an outbreak investigation, and patients with slowly responding or recurrent lesions; ²Not recommended for pediatric patients younger than eight years or during pregnancy. (AIII) Further information on antibiotic dosages and adverse effects can be found in Table 7. DVT Deep vein thrombosis; ET Empirical therapy; GAS Group A streptococcal; ID Infectious disease; IM Intramuscularly; IV Intravenously; IVIG Intravenous immunoglobulin; MSSA Methicillin-sensitive *Staphylococcus aureus*; ped Pediatric; po Orally; TMP-SMX Trimethoprim-sulfamethoxazole

6.2.2 Empirical therapy of non-life-threatening infections other than minor skin infections, potentially due to CA-MRSA Recommendations

- Antibiotic choice should be based on the severity of illness at presentation, clinical judgment and regional susceptibilities of strains. Antibiotic chosen should include an agent effective against group A streptococcus. (AIII)
- At present, cloxacillin or cefazolin remain appropriate empirical antibiotic choices for moderate infections (serious enough to require systemic antibiotics but not considered life threatening), consistent with *S aureus*. (AIII)

6.2.3 Empirical therapy of life-threatening infections potentially due to CA-MRSA Recommendations

- Include MRSA coverage, regardless of prevalence rates of CA-MRSA in the community. (AIII)

- Include an effective anti-MSSA agent until susceptibility results become available (cloxacillin is superior to vancomycin against MSSA) (120,121). (BIII)

6.2.4 Confirmed non-life-threatening CA-MRSA infections other than minor skin infections Recommendations

- For patients older than eight years, first-line oral agents include clindamycin, trimethoprim-sulfamethoxazole (TMP-SMX) or doxycycline. Fusidic acid in combination with another agent may also be considered. (AIII)
- Treatment should be guided by the susceptibility pattern. Clindamycin should only be considered an appropriate choice if susceptibility is confirmed using the D test. (AIII)

TABLE 7
Recommended antibiotics and doses

Drug	Dose (adult)	Dose (pediatric)*	Adverse reaction	Notes
Oral options for mild to moderate SSTI with no systemic features				
Clindamycin	150 mg to 450 mg every 6 h po	30 mg/kg/day + every 6 h to 8 h po	Pseudomembranous colitis	Resistance may occur Check susceptibility with D test
TMP-SMX	1 DS or 2 RS tabs (160 mg TMP/800 mg SMX) every 12 h po	8 mg/kg/day to 12 mg/kg/day (based on TMP component) + every 12 h po	Allergy (skin rash) Bone marrow suppression	Not recommended for group A streptococcus
Doxycycline	100 mg every 12 h po	2 mg/kg/day to 4 mg/kg/day + every 12 h to maximum 100 mg every 12 h po Not for children younger than eight years	Photosensitivity Erosive esophagitis Teeth staining	Not for children younger than eight years Not for use in pregnancy
Linezolid	400 mg every 12 h po	20 mg/kg/day + every 12 h po (160)	Dose-dependent bone marrow suppression Peripheral neuropathy Optic neuritis (rare)	Selected cases only Expensive ID consultation recommended
Parenteral therapy for systemic and severe infections				
Vancomycin	1 g every 12 h IV	40 mg/kg/day to 60 mg/kg/day + every 6 h to a maximum 4 g/day IV	Renal toxicity	Lower efficacy in pneumonia Monitor levels
Clindamycin	600 mg to 900 mg every 8 h IV/IM	30 mg/kg/day to 40 mg/kg/day + every 6 h to 8 h IV	Pseudomembranous colitis	Resistance may occur Check susceptibility with D test Bacteriostatic
TMP-SMX	8 mg/kg/day to 10 mg/kg/day + every 12 h IV	8 mg/kg/day to 12 mg/kg/day (based on TMP component) + every 12 h IV	Allergy (skin rash) Bone marrow suppression	Not recommended for group A streptococcus
Linezolid	600 mg every 12 h IV/po	Children younger than 12 years: 30 mg/kg/day + every 8 h IV (160) Children older than 12 years: 20 mg/kg/day + every 12 h IV	Dose-dependent bone marrow suppression Peripheral neuropathy Optic neuritis (rare)	Selected cases only Expensive ID consultation recommended Bacteriostatic
Adjunctive therapy				
Rifampin	600 mg po qd	10 mg/kg/day to 20 mg/kg/day + every 12 h to 24 h po/IV	Hepatotoxicity Rash Discoloured urine Stains soft contact lenses	Consider in high bacterial burden Never use alone Potential for drug interactions
Fusidic acid	500 mg tid po/IV	No data for children	Skin rash Jaundice	No cerebrospinal fluid penetration Not excreted in urine Never use alone (161) Bacteriostatic

*Doses in the neonate may be different. DS Double strength; D test Double disk diffusion test; ID Infectious disease; IM Intramuscularly; IV Intravenously; po Orally; qd Once daily; RS Regular strength; SSTI Skin and soft tissue infection; tid Three times daily; TMP-SMX Trimethoprim-sulfamethoxazole

- For children younger than eight years, first-line oral agents include clindamycin and TMP-SMX. Doxycycline is contraindicated in children younger than eight years, as are all tetracyclines, and there are limited data regarding the use of fusidic acid in children (122). (AIII)
- Do not use doxycycline in pregnancy. (AIII)
- Patients should be followed, and the antimicrobial therapy should be reconsidered if there is evidence of treatment failure. (CIII)
- In follow-up, routine screening for colonization of the nares or other body sites is not recommended. (AIII)

6.2.5 Confirmed CA-MRSA life-threatening infections Recommendations

- Treatment options include parenteral vancomycin, clindamycin (provided susceptibility confirmed with D test) and TMP-SMX. (AIII)
- Some experts recommend against the use of bacteriostatic agents such as clindamycin alone for the treatment of life-threatening infections. (CIII) Fusidic acid and rifampin should not be used alone because of rapid emergence of resistance. (AIII)
- Newer drug therapies, such as linezolid, tigecycline or quinupristin-dalfopristin, should be guided by an infectious disease specialist. In particular, drugs such as

quinupristin-dalfopristin and daptomycin should be used with caution in pediatric populations in which there are limited data for their use. (CIII)

- Linezolid is preferred over vancomycin for the treatment of MRSA pneumonia because of its superiority in clinical trials for adults with HA-MRSA pneumonia (123), possibly explained by better penetration into the lung parenchyma (124). (BII)
- In follow-up, routine screening for colonization of the nares or other body sites is not recommended. (AIII)

6.2.6 Adjunctive therapy Recommendations

- Combination of first-line drugs with rifampin or gentamicin to enhance killing in serious invasive disease should be decided on a case-by-case basis in discussion with an infectious disease specialist (125). (BIII)
- Other adjunctive therapy, such as intravenous immunoglobulin, may play a role in neutralizing toxin-mediated effects and may be considered for selected patients with severe disease as guided by an infectious disease or critical care specialist (126). (CIII)

7.0 SCREENING AND DECOLONIZATION

7.1 Screening for CA-MRSA

S aureus may asymptotically colonize body surfaces, particularly the nares. Rates of colonization in a recent US population-based survey (127) were 31.6% for *S aureus* and 0.84% for MRSA. These asymptomatic carriers may act as a reservoir for infection; therefore, identifying *S aureus* carriers and eradicating the carriage state may theoretically prevent recurrent *S aureus* infections or person-to-person spread. However, at present, there is insufficient evidence to support the use of eradication regimens; thus, there is no clear role for screening (128).

Recommendations

- In the nonoutbreak setting, routinely screening individuals infected with CA-MRSA or their contacts for colonization of nares or other sites is not recommended. (AIII)
- In selected circumstances, following consultation with public health or an infectious disease consultant, nasal and/or additional site screening may be considered. These selected circumstances include the following:
 1. Individuals with recurrent *S aureus* skin infections (two or more in six months), in whom eradication therapy is being considered; (BIII)
 2. In a family setting, where recurrent skin infections continue despite repeated review and reinforcement of hygiene measures, and there is not known to be a high prevalence of CA-MRSA in the community; (BIII) and
 3. To investigate an outbreak in a closed population with continuing new infections despite repeated

reinforcement of hygiene practices. (BIII) When a colonization survey is performed as part of an outbreak investigation, assessing carriage sites other than the nares may be considered, in consultation with public health officials and/or other experts (51). (BIII)

7.2 Decolonization

Decolonization refers to the process of eradicating or reducing carriage of a particular organism from the skin, nose or other mucosal surfaces. In the case of staphylococcal carriage, decolonization has been attempted using topical or systemic (usually oral) therapy. The available systemic options include rifampin plus another antistaphylococcal antibiotic, such as TMP-SMX, clindamycin, fusidic acid, doxycycline or minocycline. Eradication from the skin can be attempted using topical agents, such as chlorhexidine or triclosan, whereas nasal decolonization usually requires intranasal mupirocin. Eradication from sites other than the nose usually requires systemic and topical therapy in addition to intranasal therapy. However, decolonization regimens have met with limited success. A systematic review (128) of the literature published in 2003 concluded that there is insufficient evidence to support the use of topical or systemic antimicrobial therapy for eradicating nasal or extranasal MRSA. Experience in hospitals indicates that recolonization is frequent (129,130). In the community setting, decolonization has been attempted with mixed success. Decolonization was successful in eradicating CA-MRSA carriage in a daycare facility (51); however, recurrent infection occurred despite decolonization attempts in two CA-MRSA outbreaks involving football teams (73,74).

One disadvantage of attempted decolonization is the development of resistance to the agents used. Mupirocin resistance has been documented in several studies (131-134), usually associated with prolonged use or repeated courses of mupirocin. In Canada, Mulvey et al (109) have reported mupirocin resistance rates of up to 50% in community isolates on the prairies. Limiting its use to a maximum course of five to 10 days and ensuring a minimum time period of one month between recurrent use are strategies that have been found to be effective in preventing the emergence of mupirocin resistance (133,134).

Recommendations

- Decolonization is not recommended for usual management of individual CA-MRSA infections, endemic infection or outbreaks (128,131,135-138). (AI)
- Decolonization should be considered only in exceptional circumstances, which may include the following:
 1. recurrent CA-MRSA skin infections (two or more in six months) with no evidence of repeated re-exposures when hygiene measures have been reinforced and after discussion with an infectious disease expert; and (BIII)
 2. as a public health strategy for ongoing transmission despite repeated review and reinforcement of appropriate hygiene interventions in outbreaks in selected closed settings. (BIII)

7.3 Guidelines for the use of decolonization regimens

In exceptional situations in which decolonization regimens are used, several options are available: intranasal mupirocin ointment, topical antiseptics applied to the skin and systemic antibiotics active against the colonizing strain, particularly those that achieve high levels in body secretions, such as rifampin and clindamycin. Some experts favour a combined approach (including intranasal mupirocin, topical antiseptics and two systemic agents) for maximum possible effect in the rare circumstances when decolonization is indicated. Other experts offer only intranasal mupirocin to patients with isolated nasal carriage of *S aureus* (139).

Recommendations

- Decolonization regimens should be administered only to individual patients or well-defined closed cohorts, and only over a limited time interval to minimize the potential for resistance to develop. (BIII)
- Selection of a decolonization regimen should take into consideration the sensitivities of the organism isolated as well as the sites colonized, and infectious disease consultation should be sought. (BIII)
- The recommended regimen for nasal decolonization for mupirocin-susceptible isolates is mupirocin ointment to the nares twice daily for five to 10 days (133,134,140). (BII)
- When mupirocin is used to eradicate carriage, isolate susceptibility to mupirocin should be tested. (BIII)
- No recommendations can be made at this time for the use of other topical intranasal agents for decolonization. (CIII)
- There is insufficient evidence to make a recommendation for or against the use of topical antiseptics for cleaning or cutaneous decolonization. (CIII)
- A combined strategy of intranasal mupirocin, topical antiseptics and systemic antibiotics (active against the colonizing strain and achieving high levels in body secretions [eg, rifampin or clindamycin]) may be considered (140). (BIII)

8.0 POPULATION SURVEILLANCE

8.1 Population surveillance program for CA-MRSA

The Working Group meeting identified several possible purposes of a population surveillance program: to document the emergence of resistance to methicillin among community isolates of *S aureus* to inform empirical therapy; to describe the occurrence and impact of severe *S aureus* disease in a community, irrespective of resistance pattern; and to facilitate timely identification of potential outbreaks.

Recommendations

- Surveillance for methicillin resistance among CA strains of *S aureus* should be considered. (CIII)
- Population-based surveillance for severe CA *S aureus* infections (including severe SSTIs, osteomyelitis, pyomyositis, necrotizing fasciitis, sepsis and endocarditis

[Table 6]), irrespective of susceptibility, should be considered. (CIII)

- Intermittent or targeted surveillance of all purulent skin lesions in patients presenting to primary care may be considered to support timely identification of outbreaks, and to recognize emergence and spread of new strains in the community. (CIII)
- Populations recognized to be at increased risk (eg, sports teams and Aboriginal communities) should be included in the development of a surveillance program. (BIII)

8.2 Laboratory support

Monitoring CA-MRSA in the community requires collaboration among the clinician managing individual patients, the microbiology laboratory and public health departments.

Recommendations

- Clinicians and public health personnel in a given region should develop, together with microbiological laboratories, a method for rapid dissemination and timely feedback of susceptibility profiles for CA-MRSA in the region. (AIII)
- Clinical microbiology laboratories should follow the current guidelines laid out by the Clinical and Laboratory Standards Institute (USA) when testing erythromycin-resistant strains of CA-MRSA for inducible clindamycin resistance (ie, D testing). (AIII)
- Antimicrobials that are tested and reported back to practitioners should reflect the usual standard of care for CA-MRSA (eg, fluoroquinolone susceptibilities should not be provided). (AIII)

9.0 PREVENTION

9.1 Prevention of transmission of CA-MRSA

The goal of community control of CA-MRSA is to prevent spread of the bacteria from an infected or colonized individual to other persons in the family and the community. This requires individuals to take a proactive role to limit transmission. As a general rule, the prevention of CA-MRSA and infections with other common skin pathogens requires consistent application and reinforcement of good hygienic practices with emphasis on handwashing, not sharing potentially contaminated personal articles, and covering of draining skin lesions to prevent direct or indirect contact with infected secretions of another person. These measures are not specific to CA-MRSA, and apply to draining lesions, wounds or potentially infected sites caused by any microorganism.

9.1.1 Role of the individual

Recommendations

- Individuals should follow basic practices for good hygiene at all times and in all settings. These include, but are not limited to the following:
 1. regular hand hygiene to limit personal contamination and transmission; and (AIII)
 2. regular bathing with soap and water. (AIII)

- If skin lesions are present:
 1. cover lesions with appropriate dressings to contain drainage or exudate, and ensure that appropriate medical care has been received; (AIII)
 2. do not share creams, lotions, soaps, cosmetics and other personal products that are in contact with the skin; (AIII)
 3. do not share unwashed towels; (AIII)
 4. do not share personal items that come in contact with the skin lesions – such as razors, toothbrushes, towels, nail files, combs and brushes – without cleaning; (AIII)
 5. discard contaminated waste, including used dressings, in a safe and timely manner to avoid exposure to other individuals; (AIII) and
 6. wash hands with soap and water after touching any skin lesions and potentially infected materials, such as soiled dressings. (AIII)

9.1.2 Role of health care practitioners

Recommendations

- Practitioners should use antibiotics judiciously (141). (AIII)
 1. Treatment of viral infections with antimicrobials should be avoided; and
 2. Patients should be encouraged to complete all courses of antibiotics as prescribed.
- Public health officials should be notified if spread occurs beyond a family unit to a localized community group, such as a school or sports team (ie, if an outbreak of the disease is suspected). (AIII)
- Educate patients about appropriate hygiene practices, as outlined in section 9.1.1. (AIII)

9.1.3 Role of health authorities

Recommendations

- Communication strategies that inform the general public, as well as high-risk groups, about CA-MRSA and practices to limit infection need to be developed, implemented and evaluated. (AIII)
- Strategies for ensuring early diagnosis and appropriate treatment of skin infections should target physicians, and should include education about risk factors, clinical features and expected treatment response time. (AIII)
- Regional and local programs to review antibiotic use and resistance should be developed. (BIII)
- Education programs should be developed to educate the public on the proper use of antibiotics in the community. (AIII)

9.2 Prevention in specific settings

9.2.1 Households with CA-MRSA infection

In addition to the general measures outlined in section 9.1, specific measures can be recommended within households in which one or more members have a CA-MRSA infection.

Recommendations

- The household environment should be regularly cleaned with a standard household detergent. (AIII)
- Clothes and linens from individuals who are MRSA-positive or have other skin lesions can be included in the regular household laundry. Usual laundry washing and drying destroys most potentially pathogenic bacteria. (AIII)
- Cutlery and dishes may be washed in the usual manner with other household utensils using soap and hot water, or a dishwasher. (AIII)
- Individuals who are MRSA-positive, or their family members, should be advised to notify at the time of contact with the health care system that they are either MRSA-positive or living in a household with someone who is MRSA-positive. (BIII)

9.2.2 Daycare centres and schools

Isolation of children with CA-MRSA in childcare settings or schools is not a practical solution and impacts negatively on the child's well-being. The emphasis must be placed on the consistent application of hygienic measures within the daycare or school setting to reduce the risk of transmission. In addition to the general measures outlined in section 9.1, specific measures are recommended to prevent transmission in schools and daycare centres.

Recommendations

- Educate providers, teachers, children and families on general hygiene practices (eg, hand hygiene, respiratory etiquette and staying home if ill). (AIII)
- Ensure availability of products to allow hand hygiene to be performed. This includes access to liquid soap in pump dispensers, running water and paper towels to dry hands. Alcohol-based, waterless hand sanitizers can be used as an alternative as long as hands are not visibly soiled. (AIII)
- Structure activities to include opportunities for hand hygiene to be practised (before eating, after outdoor play and after using the washroom). (BIII)
- In situations in which open lesions cannot be kept covered, consider temporary exclusion from the daycare or school setting until the wound has healed or drainage can be contained. (BIII)
- Ensure that frequently touched surfaces (eg, counters, desks and toys) are cleaned at least daily with a disinfectant solution. (AIII)
- Items soiled with body fluids should be cleaned and disinfected as soon as possible and before use by another child. (AIII)

9.2.3 Sports settings

CA-MRSA transmission has been documented in several reports among athletes and contact sports participants (70-74). In addition to the general measures outlined in section 9.1, the following recommendations address infection prevention and control in this high-risk group.

Recommendations

At all times:

- Use alcohol-based hand antiseptic rinse or gel when handwashing facilities are not available. (AIII)
- Individuals participating in sports should shower with soap and water after every practice or tournament. (AIII)
- Do not share hygiene items, such as bar soap or towels (73). (AIII)
- Ensure regular cleaning of communal bathing facilities and frequently touched surfaces. (AIII)
- Personal items, such as towels and supporters, should be laundered or cleaned after each use. (AIII)
- Clean or launder shared athletic equipment, such as pads or helmets, at least once a week, but ideally after each use. Establish a routine cleaning schedule for nonpersonal devices, such as sensor wires used in fencing. (AIII)

Individuals with skin lesions:

- Provide both verbal and written instructions describing management of skin lesions infected with CA-MRSA or other potential pathogens to coaches and/or participants. (BIII)
- Individuals who have open lesions that cannot be kept covered should not participate in contact sports until the wound has healed or drainage can be contained. (AIII)
- Individuals who have open skin lesions should be excluded from common whirlpools or saunas. (AIII)
- Persons with skin lesions should not share athletic equipment that is in contact with the skin. (AIII)

9.2.4 Pets and other animals

Recurrent MRSA infections in household contacts of colonized companion animals (pets) have been described (91,96,102,103). Given the evidence of transmission of MRSA between humans and animals, there is concern that pets may serve as a reservoir for MRSA in the community (96). In addition to the general measures outlined in section 9.1, the following recommendations are made for owners of pets infected or colonized with MRSA.

Recommendations

- Pet ownership and contact information may identify risk and should be queried as part of the standard history for any patient. Known MRSA status of pets or owners, when available, should be documented. (AIII)
- Pet screening should only be considered when recurrent infections are occurring within an isolated group exposed to the pet and despite repeated reinforcement of hygiene practices. Consultation with a veterinarian, as well as a public health or infectious disease expert, is recommended. (BIII)
- Treatment of colonized pets is not indicated because there is little evidence that antimicrobial-based

eradication therapy is effective in colonized pets, and colonization tends to be short term. (BIII)

- In exceptional circumstances, when a colonized pet is implicated as a source of infection and the infection is serious and recurrent, temporary removal of the pet from the household may be considered. While there is the potential for pets to be involved in dissemination of MRSA in the community, the beneficial effects of pet contact should be considered in any discussion about removal of the pet from the household. (BIII)
- There should be increased awareness in the veterinary community about MRSA infection and colonization in pets, interspecies transmission of MRSA, appropriate testing, management of infected and colonized pets, and relevant infection control measures. (BIII)

9.2.5 Correctional facilities or shelters

Outbreaks of CA-MRSA have been documented in incarcerated populations in the US, Australia and Canada (82-84,86,87,142). In addition to the general measures outlined in section 9.1, the following recommendations address this high-risk group.

Recommendations

- Educate correctional facility staff and inmates on transmission, prevention, treatment and containment of MRSA infections. (BIII)
- Restrict inmates who have uncovered draining skin lesions, as well as inmates with skin lesions and poor hygiene, to prevent exposure of other inmates. (BIII)
- Consider housing assignments based on the potential harm to individuals who could acquire infection. (BIII)

9.2.6 Newborn care facilities

Routine practices can be expected to limit the transmission of CA-MRSA within newborn care facilities and must be followed at all times (143).

Recommendations: Routine care

- Wash hands before and after contact with the newborn. (AIII)
- Use gloves until the newborn has been cleaned or bathed for the first time. (AIII)
- Clean and disinfect all used equipment before it is used with another infant (eg, thermometers, weigh scales, glucose meters and stethoscopes). (AIII)
- Staff should wear a gown when holding the infant against the body. (AIII)

There are several reports of outbreaks of CA-MRSA strains within the nursery setting (144-148). In the outbreak setting, strategies to interrupt transmission may be directed toward infants, health care workers or the nursery environment because all three elements play a role in the chain of transmission (Table 8).

When increased transmission of CA-MRSA is documented within the nursery, intensified infection control measures are necessary.

TABLE 8
Risk factors for neonatal infections and outbreaks

Risk category	Factors
Staff	Lack of compliance with routine practices, including hand hygiene Inadequate staff education Staff carriage of the outbreak strain Poor staff to patient ratios (90) Intensity of colonization (eg, chronic skin conditions and concurrent upper respiratory tract infections)
Neonate	Prematurity Prolonged neonatal intensive care unit stay Use of invasive medical devices Exposure intensity (eg, to carriers with chronic skin conditions or concurrent upper respiratory tract infections)
Environment	Poor cleaning of equipment and environment Patients residing in common areas (eg, large nurseries) Overcrowding and inadequate spacing of patients (90); nonadherence to facility guidelines Common newborn bath areas Lack of isolation areas during an outbreak

Recommendations: Outbreak setting

Measures directed at health care workers:

- Enhance hand hygiene. Consider the use of antiseptic handwashing agents, such as chlorhexidine gluconate or triclosan, before each contact with the newborn (143,149). (BIII)
- Reinforce infection prevention and control practices. (BIII)
 1. Provide staff education sessions; and
 2. Perform practice audits to document compliance.
- Staff screening may be considered in selected situations (eg, if cohorting and barriers are in place and the outbreak continues, or if a staff member is epidemiologically linked to cases). (AIII)
 1. Screen nares, examine hands for lesions, inquire about skin conditions on other areas of body (scalp and feet) and inquire about upper respiratory symptoms.
 2. For staff epidemiologically linked to cases, perform thorough full-body skin examinations and culture any lesions.
 3. Staff screening should be performed through the occupational health department, ensuring staff confidentiality, and education and counselling for staff should be provided.
 4. Decolonization may be attempted for the identified staff carriers with topical and/or systemic therapy (149,150).
 5. Exclusion of carriers from the area must be carefully considered, which depends on factors such as compliance with decolonization therapy,

compliance with hand hygiene and routine practices or additional precautions, severity of illness in cases, exposure intensity (eg, chronic skin conditions, concurrent upper respiratory tract infection or allergic rhinitis) and evidence of ongoing transmission.

- Cohort personnel who care for colonized and infected newborns. (BIII)
- Increase the nurse to patient ratio. (AIII)

Measures directed at neonates:

- There is insufficient evidence to make a recommendation for or against measures to decrease the burden of organisms through cord care, topical antiseptic baths or intranasal mupirocin (149-157). (CIII)
- Consider screening all patients for the epidemic strain. (AIII)
 1. Examine carefully for skin lesions and eye discharge and culture any lesions or pustules.
 2. Culture nares, perineum, umbilicus, device exit sites and open skin lesions.
 3. Continue weekly screening of entire cohort until the outbreak is over.

At the time of discharge:

- Communicate with family physicians and pediatricians receiving newborns from the facility, bringing to their attention the risk of colonization or infection with CA-MRSA in discharged neonates. (AIII)
- There is insufficient evidence to make a recommendation for or against routine screening at the time of discharge and periodically thereafter. Although colonization may not be detectable without repeated sampling, the value of screening at or after discharge is questionable if no intervention is planned for colonized infants, and this may increase parental anxiety (158). (CIII)
- Advise parents of discharged infants to watch carefully for skin lesions and to report immediately whether these occur, at which time the lesions should be cultured. If a baby sees a physician for an infection or is to be readmitted to the hospital, parents should inform the physician of possible MRSA exposure. (AIII)

Measures directed at the nursery environment:

- Institute contact precautions and cohorting for colonized and infected infants; avoid cohorting infants with CA-MRSA together with those with HA-MRSA. (BIII)
- Reduce overcrowding, strongly encourage rooming-in and correct spacing deficiencies (90). (AIII)
- Consider ward closure, balancing the risks and benefits of closure versus infection risk. (BIII)

Additional measures:

- Assign a dedicated additional infection control professional to the nursery during the outbreak. (BIII)
- Perform epidemiological typing of the strains. (BIII)
- Consider recall of discharged infants for screening. (BIII)
- Notify public health. (AIII)
- Consider a case-control study. (BIII)

10.0 DIRECTIONS FOR FUTURE RESEARCH

The Working Group meeting identified numerous areas in need of further research, classified here by category.

10.1 Epidemiology

- Establish the current incidence and prevalence of CA-MRSA disease in Canadian communities.
- Determine modifiable risk factors for CA-MRSA infection; in particular, better define any link with antibiotic use.
- Determine the impact of animals, especially household pets, on CA-MRSA infection.
- Determine the role that colonized persons play in the spread of CA-MRSA in the community.

10.2 Biology of CA-MRSA: Organism versus host

- Better define the virulence factors of CA-MRSA, including the role of virulence factors such as PVL and the use of immunotherapy to neutralize these virulence factors.
- Pursue vaccine development.
- Investigate host or pathogen factors that may be implicated in the particular virulence and rapid dissemination of CA-MRSA.
- Study the effect of the pneumococcal vaccine, now in widespread use, on colonization with CA-MRSA, particularly in children.
- Study the effect of influenza and influenza vaccination on CA-MRSA colonization and disease.

10.3 Clinical outcomes and management

- Within the pediatric population, define the safety and efficacy of newer agents, such as daptomycin.
- Investigate the use of options other than antibiotic therapy, including anticytokines, immunomodulators or intravenous immunoglobulin.
- Study the effect of combination therapy (eg, addition of fusidic acid or rifampin to standard antibiotic regimens).
- Define the role of novel testing modalities (eg, polymerase chain reaction for rapid diagnosis).
- Define best practices in wound management that may have implications for minimizing antibiotic use.

10.4 Infection prevention and control

- Investigate primary prevention initiatives.
- Determine the effect of infection prevention and control practices in the community on rates of CA-MRSA and clinical outcomes.
- Define appropriate infection control practices for the purulent wound, particularly the challenges of wound management outside the hospital.
- Develop strategies for managing household clusters.
- Determine the psychosocial impact on individuals 'labelled' as MRSA-positive.
- Develop strategies for infection control in the physician's office.

10.5 Knowledge translation

- Determine which public health communication strategies should be used.
- Investigate factors that will result in 'cultural' change (eg, improving hygienic practices at a population level).
- Discover how target groups (eg, the community and sports teams) can be involved in the development of guidelines and best practices.

11.0 CONCLUSION

The epidemiology of MRSA is changing, as evidenced by the dramatic increase and stable high prevalence of CA-MRSA in several US communities. While the problem does not yet appear to be widespread in Canada, several early reports indicate that CA-MRSA is emerging as an important pathogen in Canada as well. Physicians and other health care providers should be aware of the increasing prevalence and potential severity of CA-MRSA infection because beta-lactam antibiotics, currently used for the treatment of presumed staphylococcal infections in the community, are ineffective. The management of presumed *S aureus* infection should include surgical drainage when appropriate, culture of significant draining lesions and abscess collections, and empirical antibiotic therapy, taking into account both the severity of the infection and the regional prevalence of CA-MRSA. Families, school and daycare centre personnel, and sports teams should be actively encouraged to practice meticulous handwashing, the most important measure to control or attenuate the community transmission of CA-MRSA.

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APPENDIX
Useful resources for specific questions related to the management of health care facilities and health care workers

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ERRATUM

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In Table 4, USA200 should correlate with CMRSA strain '4', not '3,6'. In Table 5, 'USA100 (CMRSA-1)' and 'USA200 (CMRSA-3,6)' are incorrect and should read 'USA100 (CMRSA-2)' and 'USA200 (CMRSA-4)', respectively. The authors regret these errors. The corrected tables are as follows:

TABLE 4
Nomenclature of *Staphylococcus aureus* strains

US PFGE	CMRSA strain	MLST	SCCmec type	PVL presence
USA100	2	5	II	Negative
USA200	4	36	II	Negative
USA300	10	8	IVa	Positive
USA400	7	1	IVa	Positive
USA500	5,9	8	IV	Negative
USA600	1	45	II	Negative
USA700	–	72	IVa	Negative
USA800	2	5	IV	Negative
USA1000	–	59	IV	Positive
USA1100	–	30	IV	Positive

CMRSA Canadian methicillin-resistant *Staphylococcus aureus*; MLST Multilocus sequence typing; PFGE Pulsed-field gel electrophoresis; PVL Panton-Valentine leukocidin; SCCmec *Staphylococcal chromosomal cassette mec*; US United States

TABLE 5
Contrasting community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) and hospital-associated (HA) MRSA

	CA-MRSA	HA-MRSA
Typical demographic characteristics	Younger Minority population	Older Nursing home resident
Common SCCmec type	IV	II
PVL virulence factor	Common	Unusual
Predominant strains	USA300 (CMRSA-10) USA400 (CMRSA-7)	USA100 (CMRSA-2) USA200 (CMRSA-4)
Multidrug resistance (other than beta-lactam)	Rare	Common

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USA500	5,9	8	IV	Negative
USA600	1	45	II	Negative
USA700	–	72	IVa	Negative
USA800	2	5	IV	Negative
USA1000	–	59	IV	Positive
USA1100	–	30	IV	Positive

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