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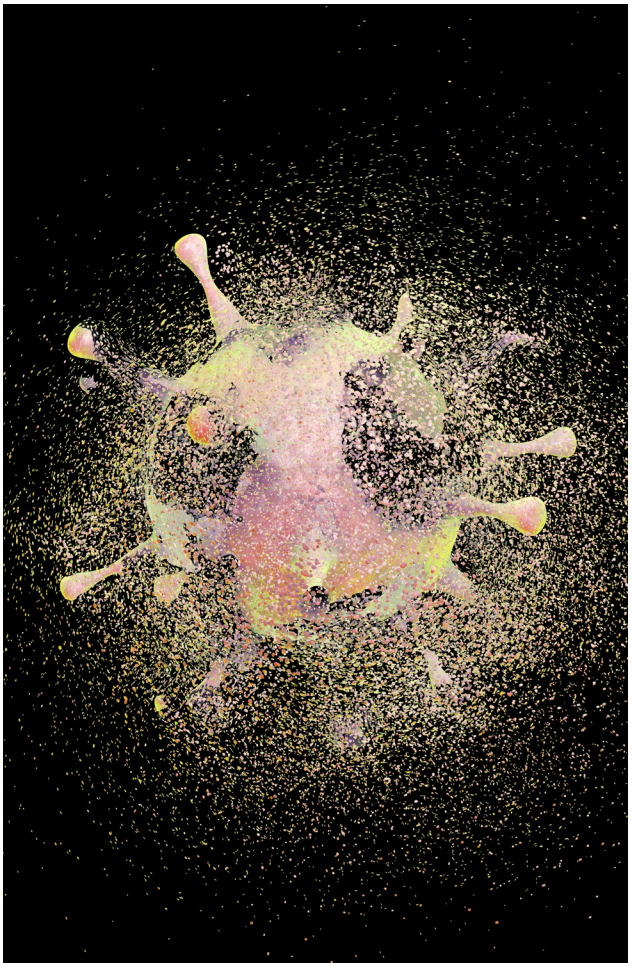
CCDR

CANADA COMMUNICABLE DISEASE REPORT

EMERGENCY RESPONSE



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Contact the Editorial Office

ccdr-rmtc@phac-aspc.gc.ca
613.301.9930

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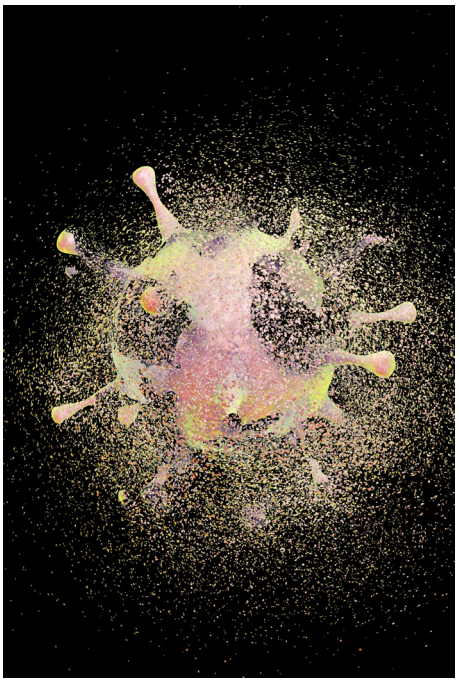

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COMMENTARY

Fifteen years post-SARS: Key milestones in Canada's public health emergency response

T Tam[1, †]*

Abstract

This year marks the 15th anniversary of Severe Acute Respiratory Syndrome (SARS) in Canada and the 100th anniversary of the 1918 Spanish influenza pandemic. These, and other recent public health events, provide an opportunity for us to review and reflect on the evolution of Canada's public health emergency response over the past 15 years—from SARS, to the 2009 H1N1 pandemic influenza, to Ebola virus and Zika virus disease. Key lessons have been learned and milestones achieved that have shaped and sharpened our response approach and structures. While SARS was a wake-up-call to strengthen infection prevention and control capacity in health care settings and led to the formation of the Public Health Agency of Canada, it also strengthened our Federal/Provincial/Territorial (FPT) senior-level governance and led to agreements for pan-Canadian mutual aid and infectious disease information sharing. As well, our collective public health laboratory capacity has been strengthened through ongoing response and sharing of advanced diagnostics and research. As we move forward, it will be important to explore the design of scalable or modular emergency response strategies and structures that are socio-culturally appropriate and employ evidence-based strategic risk communications that continue to be critical, especially given the volume and spread of misinformation. With the current global reality, we must recognize that public health threats that go unchecked anywhere in the world have the potential to very rapidly become a public health threat in Canada. We need to build, maintain and share our best public health practices globally, for we neglect these at our peril.

Affiliations

[1] Public Health Agency of Canada, Ottawa, ON

[†] Note: Dr. Tam is Canada's Chief Public Health Officer

***Correspondence:** drtheresa.tam@canada.ca

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Key words: Public health emergency response, SARS: severe acute respiratory syndrome, influenza, pandemic influenza, 1918 Spanish flu, Ebola, Zika

Introduction

In 2018, we mark both the 100th anniversary of the 1918 Spanish influenza pandemic and the 15th anniversary of Severe Acute Respiratory Syndrome (SARS) in Canada. Hence, this is a good opportunity to reflect on Canada's experience with public health emergency preparedness and response in recent decades.

Public health emergencies are complex, large-scale events that require comprehensive health system involvement as well as multi-sectoral and/or whole of society engagement in the response. Over and above the many individual patient treatment encounters at a variety of health care settings, a population-based approach is needed to manage the often extraordinary triage and treatment challenges as well as management of follow up, population spread and wider societal impacts. This approach has many components: governance; surveillance; diagnostics; risk identification and assessment; public health measures (hygiene, social distancing); specific interventions (vaccines and medication); infection prevention and control; clinical management; operations; and communications. Hence the need for multi-sectoral response to such emergencies, including involvement of social services and local community and non-governmental services.

This commentary sets out to summarize Canada's experiences and key milestones in advancing our national public health emergency response capacity over the last 15 years and identify current trends and challenges.

Canada's experience

SARS took the world by surprise in 2003 and, while comparatively small in terms of total number of cases, the outbreak nonetheless presented a formidable challenge to public health in Canada. There were 438 probable and suspect SARS cases reported, including 44 deaths, over a relatively short period of five months (1). Most of these cases were linked to nosocomial transmission events that themselves resulted in 100 cases with three deaths amongst health workers; thus, SARS was a wake-up-call to strengthen infection prevention and control in health care settings. Many thousands more experienced disruption to their lives as they were asked or were required, to self-quarantine to prevent further transmission of the disease.

Although the potential for pandemic spread of the SARS novel coronavirus, with much greater associated morbidity and mortality, ultimately went unrealized, the challenges in containing and responding to this novel infectious disease were many. These challenges and the attendant lessons learned were detailed in *Learning from SARS: Renewal of public health in Canada – Report of the National Advisory Committee on SARS and Public Health* (1). Key among them were the need for better coordination of response actions taken by the multiple levels of government and the need for increased or renewed recognition of the public health threat posed by emerging or re-emerging infectious disease. Although the emergence of SARS was not predicted, an influenza pandemic was and still is considered inevitable in the context of public health emergency preparedness. As such, in an effort to formally recognise and widely share Federal/Provincial/Territorial (FPT) coordinated planning, the *Canadian Pandemic Influenza Plan* (CPIP) was first published in 2004, incorporating lessons learned from SARS. With an updated and evergreen CPIP released in 2006, Canada was much better prepared to respond to the 2009 emergence, spread and ensuing global pandemic of novel H1N1 influenza virus that originated in Mexico (2). Canada benefited from significant capacity-building investments, such as assuring access to a domestic pandemic vaccine and stockpiles of antiviral drugs. As it turned out, the 2009 H1N1 pandemic was not as severe as some of its predecessors. Hence, during and post-H1N1, national governments and the World Health Organization (WHO) recognized that a more flexible and adaptable response to future pandemics was needed to reflect local and regional circumstances (2). The Ebola virus disease outbreak that began in West Africa in late 2013 was not only a severe disease with high morbidity and mortality, it was also an epidemic of fear. This outbreak demonstrated the fatal impact of poor communications and the importance of accounting for local cultural beliefs and local leadership in the response. It was also a poignant example of the need to strengthen public health emergency response capacity in every country and to better coordinate rapid global response capacity, including research, if we are to protect others as well as ourselves (3,4).

Yet another example of the variable and unexpected nature of emerging disease events was the Zika virus disease outbreak in the Americas. Zika was declared a Public Health Emergency of International Concern (PHEIC) by the WHO in February 2016. Notably, the declaration was *not* made on the basis of what was known about Zika virus infection up to that time (5). Rather the declaration was based on what was not known about clusters of microcephaly, Guillain-Barré syndrome (GBS) and other neurological defects associated in time and place with outbreaks of Zika infection reported from Brazil and retrospectively from French Polynesia (6). This precautionary and anticipatory approach was essential to galvanizing the international response to investigate and conduct surveillance and rapid research needed to inform an effective public health response.

Currently, Canada is in the midst of responding to the public health crisis posed by an epidemic of apparent opioid-related overdoses and deaths (7). To date, this crisis has resulted in close to 3,000 deaths of Canadians in 2016, a projected 4,000 or more deaths in 2017 and is continuing to unfold (8). Many of our emergency response strategies and structures, originally developed to address *infectious* disease emergencies, have been adapted to support this *non-infectious* public health crisis. The demands of the current opioid crisis have allowed us to reconsider what constitutes a public health emergency and how we can best address non-infectious public health challenges.

Key milestones

Since SARS, Canada has made important gains in terms of our capacity to respond effectively to the public health challenges of serious infectious disease outbreaks. Following the recommendations of the National Advisory Committee on SARS and Public Health, a number of foundational cornerstones for public health emergency response were put into place or enhanced. These included the creation of the Public Health Agency of Canada (PHAC) and the establishment of a FPT Public Health Network and Council (PHNC) as a forum for collaboration, coordination and governance. The PHNC, together with the Council of Chief Medical Officers of Health, can rapidly form a Special Advisory Committee (SAC) to coordinate and manage national public health emergencies or events. Such Special Advisory Committees were initiated during the 2009 influenza pandemic, during the Ebola outbreak in West Africa and, most recently, in 2016 to address the current epidemic of opioid-related deaths.

In 2009, recognising that FPT governments have varying degrees of public health capacity and that collaboration is beneficial when one jurisdiction may be overwhelmed by an emergency or public health crisis, Ministers of Health signed the Memorandum of Understanding On The Provision Of Mutual Aid In Relation To Health Resources During An Emergency Affecting the Health Of The Public (MOU on Mutual Aid). An Operational Framework for Mutual Aid Requests for Health Care Professionals (OFMAR) has since been developed to put into practice the key principles outlined in the MOU, with the PHAC acting as a coordination hub. One example of the utility of this mechanism was its use during the 2013 floods in Alberta when several jurisdictions contributed environmental health specialists and expertise to Alberta's post-flood recovery efforts. To enhance FPT's collaborative capacity, FPT governments are working together to establish Ebola Virus Disease (EVD) Collaborative Care Centres across the country to provide specialized care for high containment pathogens.

Surveillance and rapid information sharing are essential to an effective public health response. In 2016, FPT Ministers of Health signed the multi-lateral Information Sharing Agreement (MLISA), for the exchange of information for surveillance of infectious diseases and the management of pan-Canadian and multi-jurisdictional public health events and public health emergencies of international concern. While it can still be challenging to get consistent information in a federated system with varying capacity amongst jurisdictions, the MLISA represents a significant step towards formalizing the exchange of information during infectious disease emergencies.

Technological advances have meant that Canada's laboratory diagnostic capacity has evolved over the last 15 years. Genomics and other molecular techniques are now providing highly detailed evidence during public health investigations, including for outbreaks of foodborne diseases. The Canadian Public Health Laboratory Network (CPHLN) is a network of federal

and provincial public health laboratories that has become a well-established mechanism to effectively collaborate on laboratory capacity building and response to emerging threats such as Zika and Ebola viral diseases. The National Microbiology Laboratory (NML) has been able to rapidly develop diagnostic tests for emerging pathogens such as Zika virus, which may be required for a considerable period of time before all jurisdictions are able to access validated commercially available tests in order to perform their own testing.

Another important achievement is the successful foundational research performed at the PHAC's NML, which ultimately evolved into development and implementation of an effective Ebola vaccine and monoclonal antibody treatments (ZMapp) in collaboration with private industry, domestic research funders, international governments and researchers. This achievement serves as a reminder of the importance of research preparedness, including the establishment of research networks, such as the Canadian Immunization Research Network, that can be immediately activated during a response (9).

Current trends

As we move forward, it will be important to explore the design of more scalable or modular emergency response strategies and structures in order to affect more flexible responses to any public health threat; for example, the updated *Canadian Pandemic Influenza Preparedness: Planning Guidance for the Health Sector* (CPIP), released in 2015, includes four hypothetical planning scenarios to illustrate the importance of developing plans and response strategies that are both flexible and adaptable (2). The CPIP also provides triggers for action that are based on novel virus emergence and pandemic activity in Canada.

In October 2017, recognizing that it is not possible to have a disease-specific preparedness plan for every pathogen that may result in a public health event or emergency, the PHNC approved a *FPT Public Health Response Plan for Biological Events* (10). The response plan describes roles, responsibilities and authorities of FPT governments for public health and emergency management, a concept of operations outlining four scalable response levels and a governance structure that coordinates the response across jurisdictions. The plan also facilitates effective engagement amongst public health, health care delivery and health emergency management authorities.

Good strategic risk communications will continue to be a critical element as well as a perpetual challenge in an emergency response, especially given the large volume and ready availability of misinformation confronting the Canadian public. To counter epidemics of fear, public health institutions and leaders must continue to represent the most credible voice during times of uncertainty.

We need to have socio-culturally appropriate public health planning and interventions that are inclusive of First Nations, Inuit and Métis and other segments of our diverse Canadian population. As we remember the particularly devastating impact of the 1918 Spanish influenza on indigenous populations, the ongoing imperative to work with Indigenous organizations and communities to plan, prepare and respond to public health emergencies continues to resonate.

Conclusion

Although we can never be too prepared and ongoing work is still needed, much has improved in Canada's public health emergency preparedness and response capacity over the past 15 years. This began with the response to SARS, and has developed with each successive public health emergency since that time. Recent decades have been marked by an increase in the emergence and spread of infectious diseases worldwide that call for a strengthening of our global capacity to respond (11).

Given our current global reality, we must recognize that public health threats that go unchecked anywhere in the world have the potential to very rapidly become a Canadian public health threat. Support that we provide to other countries, to build capacity globally to detect, report, contain and treat public health threats also allows us to build essential international partnerships and response know-how while actively protecting our own best interests.

All that we have learned during SARS, and in the intervening 15 years, tells us that we must build, maintain and share our best public health practices, for we neglect these at our peril.

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An overview of the National Microbiology Laboratory emergency management program

D Marcino[1,2], K Gordon[1]*

Abstract

The National Microbiology Laboratory (NML) emergency management program was developed after the 2003 Severe Acute Respiratory Syndrome (SARS) outbreak to provide a framework for the responses to public health events. The program comprises three components (Site response, Continuity and Site support) that have adopted the Incident Command System (ICS) as their management structure and follows the four phases of emergency management. All program components have extensive competency-based training for staff and exercise plans. The emergency management program ensures quality and continuous improvement through its certification in International Organization for Standardization (ISO) 9001 and structured review processes. This means that the Operations Centre can be activated and working at optimum capacity with highly trained and experienced staff within an hour of receiving notice to begin a response. The NML can also send mobile laboratories to aid Canadian or international efforts to address outbreaks or bioterrorism events.

Affiliations

[1] National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg MB

[2] Canadian Public Health Laboratory Network

***Correspondence:** kristina.gordon@canada.ca

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Key words: Emergency management, emergency planning, laboratory preparedness, public health laboratory

Introduction

The National Microbiology Laboratory (NML) is a world-class infectious disease diagnostic and research organization and, in partnership with the National Centre for Foreign Animal Diseases, is home to Canada's only Containment Level 4 public health laboratory. With a mission to advance human health through laboratory leadership, scientific excellence and public health innovation (1), the NML has developed a reputation for its dedication in protecting the health of Canadians and making significant contributions to the global public health community during times of crisis.

The NML's history of contributing to global public health emergencies began in 2003 when an as-yet unknown pathogen was emerging globally and quickly revealing gaps in Canada's ability to respond to public health threats. As the disease spread around the world, NML laboratorians attempted to identify the pathogen that would become known as Severe Acute Respiratory Syndrome or SARS. While this laboratory work was being done, others at the NML worked diligently to develop a plan to respond to the outbreak. Boardrooms morphed into makeshift emergency operation centres, communications escalated and staff quickly came together to provide support and guidance to their public health partners.

In the 15 years since the SARS outbreak, the NML senior management have acted upon the lessons learned from this and many subsequent events by championing the development of a successful, comprehensive and evergreen emergency management program that is rooted in a culture of quality management. As outbreaks freely migrate across borders and continents, the public health community needs to optimize their understanding and knowledge of emergency management to be prepared.

The aim of this article is to provide a general overview of the emergency management program at the NML; how it integrates the four standard phases of emergency management and the incident command system management framework; and how it is maintained by a continuous cycle of improvement and strong management support.

Emergency management program components and teams

There are three components to the NML emergency management plan: Site response, Continuity and Site support. Responses can be launched internally at the NML or externally in the field and can be executed independently by NML or as part of a larger team with Canadian or international partners. How the NML coordinates with national and international efforts is beyond the scope of this article.

Site response

There are two types of internal site responses: Building Emergency Response Team (BERT) responses and Program area responses. A BERT response addresses incidents that affect the facility directly, such as a suspicious package, fire or medical

emergency. A Program area response addresses incidents that involve a pathogen; where NML's role within a coordinated FPT response can be done on site. Examples of program area responses include the Influenza and Respiratory Virus section's response to the 2009 H1N1 pandemic or the Viral Zoonosis section's response to the 2016 Zika epidemic.

External site responses engage the NML mobile laboratories and address incidents that involve a pathogen or biological agent in the field. The NML has two unique groups that provide field-based diagnostics: the Special Pathogens Diagnostic Response (SPDR) team spearhead responses to pathogen outbreaks (such as the 2014 Ebola virus disease outbreak); and the Microbiological Emergency Response Team (MERT) primarily lead responses to bioterrorism events. Both groups can also proactively deploy. The MERT could be deployed to a planned event such as was done for the 2010 Vancouver Olympics and will be done for the upcoming G7 Summit. Or SPDR could be deployed to assist an external partner prepare for, build capacity and assist in program development for outbreak responses, such as was done for the Nigeria Centre for Disease Control to combat Lassa fever earlier this year.

Continuity

The Continuity component of the Emergency Management Program (EMP) involves significant advanced planning functions to ensure that the NML continues its critical daily functions when responding to events or when access to the facility, equipment or personnel is lost. Business continuity planning activities include developing alternative facility arrangements and surge capacity staffing programs that cross-train laboratorians to backfill those who are responding to events. Activating these plans during an emergency enables the NML to provide the routine ongoing services to their clients.

Site support

The Site support component of the EMP is when the NML's Operations Centre is activated to provide coordination and support to a Site response, the Continuity component or both. The Operations Centre is a coordination hub that functions to ensure a comprehensive and collaborative response effort and to reduce pressures on the team that is responding. Site support personnel conduct a range of duties that could include ensuring logistical supplies are available, travel arrangements and documents are in place, and any Site personnel have had the appropriate vaccinations to participate in the response.

Phases of emergency management

All components of the NML emergency management program are built upon the four standard phases of emergency management: mitigation, preparedness, response and recovery. These phases need to be considered as a continuous cycle with each phase building upon the last and laying the groundwork for the next. This creates an environment where emergency management is accounted for in daily operations and in itself assists with mitigating the potential impact of future emergencies.

The Government of Canada defines the four phases of emergency management as follows:

- Mitigation: Actions taken to reduce the impact of disasters in order to protect lives, property and the environment, and to reduce economic disruption.
- Preparedness: Actions taken prior to a disaster/event to be ready to respond to it and manage its consequences.
- Response: Actions taken during or immediately before or after a disaster to manage its consequences and minimize suffering and loss.
- Recovery: Actions taken to repair or restore conditions to an acceptable level after a disaster (2).

In addition to the NML EMP components being developed upon these phases, all of NMLs response teams have adopted these phases as a part of their operational strategy. This has benefitted the NML in three ways. First, it has led to the development of rosters of highly trained and tested personnel who are ready to implement response plans. Second, it has provided justification for the response teams to develop an inventory of required equipment, maintenance plans and programs. And third, it has created a workforce culture that strives to implement lessons learned from each emergency response. Combined, these actions build NML's resilience for future events.

Incident Command System

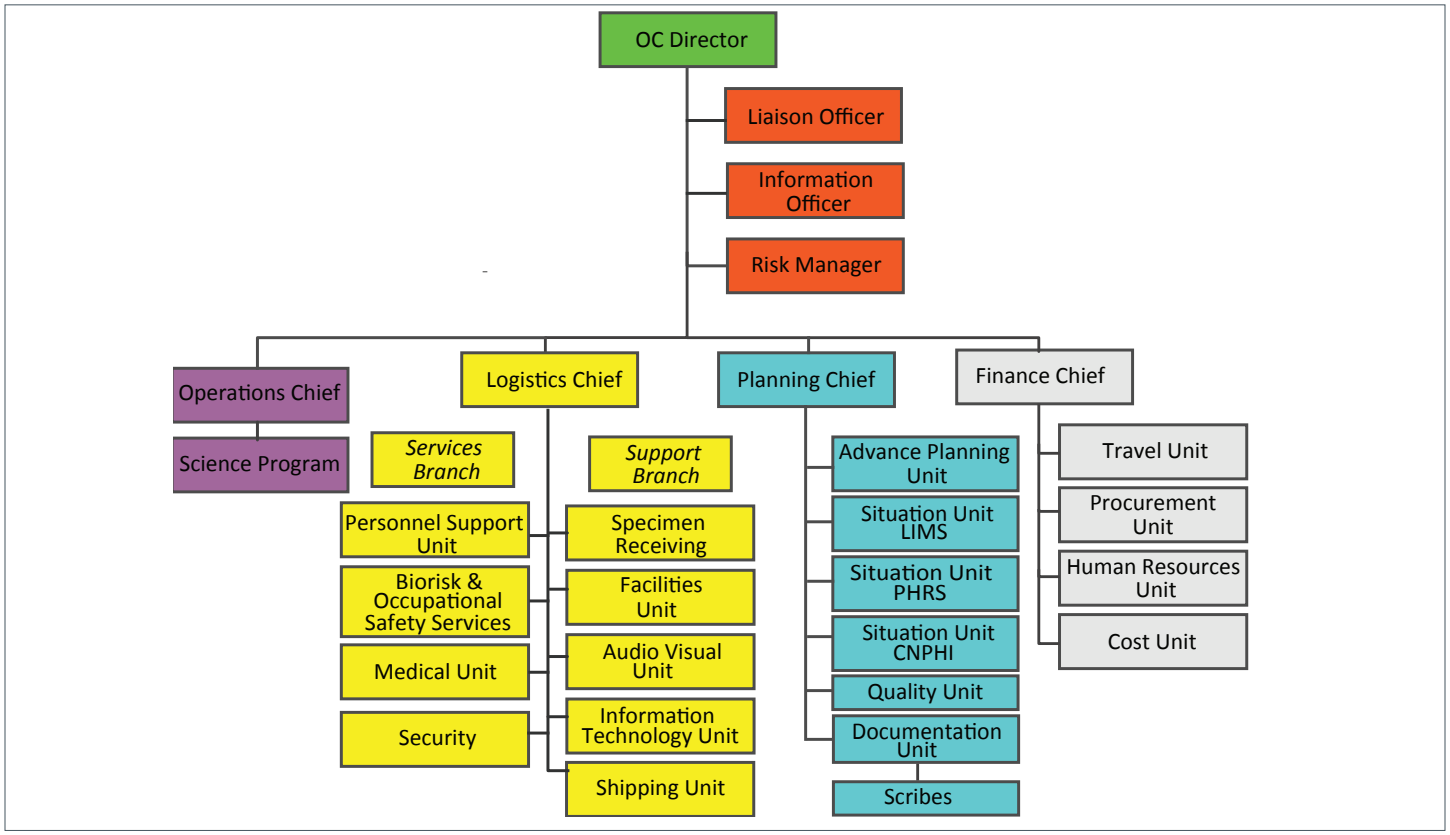
The Incident Command System (ICS) is a management framework that has been in use by first responders since the 1970's. The ICS is a well-tested universal system that facilitates the intra- and interjurisdictional management of events through the use of common roles and responsibilities; a scalable organizational structure; and standardized processes (3). All components of the NML's emergency management program have adopted ICS as their management tool. Utilizing a standardized and scalable management system allows NML responders to quickly adapt protocols to function proportionally to an event and to quickly integrate their operations when working with first responders, Canadian or international partners.

The organizational structure of the ICS at the operations centre is very robust (**Figure 1**). An important aspect of this structure is that it is able to adapt to each event. For example, during major events, like the 2009 H1N1 pandemic, the full complement of staff could be engaged for up to 24 hours a day, seven days a week. Conversely, for more localized events, such as recent SPDR deployments to Sierra Leone on the Ebola Bio-Banking project, the staffing of the operations centre was scaled down to include only essential positions such as the Operations Centre Director, Liaison Officer and Logistics Chief.

Additional aspects

In addition to the four phases of emergency management and ICS, dedicated emergency management staff, quality control, a well-developed training and exercise program, and strong, ongoing management support are vital to the success of the emergency management program.

Figure 1: National Microbiology Laboratory Operations Centre organizational structure



Abbreviations: CNPHI, Canadian Network for Public Health Intelligence; LIMS, Lab Information Management System; OC, Operations Centre; PHRS, Public Health Risk Science

Emergency management staff

The Operations Centre has four permanent full-time staff, including a Certified Emergency Manager, whose primary roles are to ensure that the NML is prepared to respond to any emergency event. The staff provide a range of services including conducting training and exercises, developing rosters for ICS, and ensuring computers, electronic equipment and other assets are available and functioning.

Training and exercise programs

All emergency management program components have extensive competency-based training and exercise plans. With the support and authority of NML senior management, 625 individuals have been provided with basic emergency management training since 2009 and over 60% have been identified or elected to continue their training, with some achieving certification in emergency management. All training and exercise/event participation is tracked within the NML's laboratory information management system. Having an extensive pool of trained individuals to draw upon means always having available highly trained and experienced specialists who are able to respond to all elements of the emergency management program during extended and even multiple, simultaneous events, which is vital to the program's capacity, capability and success.

Quality control and continuous improvement

The emergency management program operates within a culture of quality and continuous improvement. Since 2012, it has been certified by the International Organization for Standardization (ISO) 9001. The "ISO 9001" is the international standard that specifies requirements for a quality management system (4). The ISO 9001 certification is maintained by the NML's Quality Office. These ongoing requirements enable the emergency management program to function efficiently within defined objectives. This demonstrates to clients and stakeholders that their requirements are being met within the boundaries of federal and provincial legislations. The ISO 9001 certification requirements are woven throughout the fabric of the program and assist in facilitating consistency and client satisfaction.

A significant element of the continuous improvement strategy and ISO certification is ensuring that the NML implements lessons learned from all responses. To facilitate this, "hot-wash" discussions are conducted immediately following all responses. The goal of a hot-wash discussion is to bring together all the individuals who participated in a response to identify the strengths, weaknesses and challenges of the response so that opportunities for improvement can be identified and documented in an After Action Review. The After Action Reviews are integral to the program's continuous improvement strategy as they include prioritized recommendations for improvement. These recommendations are reviewed and approved by Senior Management and then are assigned either

to positions in the operations centre or to NML program areas. All recommendations are managed within the laboratory information management system to ensure accountability and completion, and incorporated into future responses.

Strong management support

The success of the emergency management program is deeply rooted in the long-term commitment of senior management. Their dedication has provided the opportunity to develop a program that addresses the gaps revealed by the SARS outbreak and garner strong buy-in from employees. This has resulted in an institutional philosophy that the NML is not just a public health laboratory but also a significant contributor to public health emergency response efforts in Canada and abroad.

Three of the most significant decisions made by senior management early in the development of the emergency management program were to construct a physical Operations Centre; hire experienced specialists to develop the program and operate the centre; and mandate introductory ICS and emergency Operation Centre training. A physical operations centre is important because it guarantees that the assets required to conduct a response are in place so that a response to an emergency can begin as efficiently as possible. Within an hour of receiving notice, the Operations Centre can be staffed with a full complement of trained individuals who function as a cohesive team.

The hiring of permanent, full-time specialists to develop the emergency management program and operate the Operations Centre has been beneficial for a number of reasons. Most importantly, they bring a comprehensive knowledge of the field of emergency management. Often, organizations attach the role of emergency manager to an existing, and unrelated, job description; the associated tasks are handled as time and knowledge permit and the emergency management program never gains the momentum or buy-in required to flourish. Having well-educated and dedicated staff, supported by organization authorities, is crucial to managing the four phases of emergency management. The Operations Centre staff lead organization-wide preparedness and mitigation phase activities, such as training programs, event exercises and the development of response plans. During the response phase, they make sure the Operations Centre is staffed and protocols and quality measures are adhered to. They also conduct recovery phase activities such as developing After Action Reviews and tracking and implementing lessons learned.

Having mandated introductory emergency management training for all employees has also proved to be invaluable for generating buy-in from staff. This training ensures that, at a minimum, all staff have a full understanding of NML's vital emergency functions. All training is conducted at the NML, which has reduced individual financial burden and time commitments.

Conclusion

Since the SARS outbreak, emergency management at the NML has evolved from an ad-hoc effort to an important function of daily operations and an institutional philosophy. Implementation of this program has allowed the NML to become a leader in the field and contribute to the development of similar programs within laboratories throughout Canada and worldwide. In turn, the NML has gained invaluable relationships that allow rapid connections and coordination during emergency events. Although developing an emergency management program may seem daunting, the benefits are immense and indispensable in ensuring the health of Canadians and the citizens of our global society.

Authors' statement

DM – Writing – original draft, review and editing
KG – Conceptualization, review and editing

Conflict of Interest

None.

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Canadian Pandemic Influenza Preparedness: Communications strategy

B Henry[1,2] on behalf of the Canadian Pandemic Influenza Preparedness (CPIP) Task Group*

Abstract

When faced with uncertainty and unpredictability, early and transparent communication during a pandemic is critical to build trust and to ensure the credibility of public health advice. The responsibility for communicating with Canadians during a pandemic is shared by federal, provincial, territorial and local governments. A common plan is needed to ensure consistent, coordinated and appropriate communication. Canada's diversity in terms of its size, geography, languages and culture also requires a multifaceted approach so that the right message is delivered at the right time to the right person in the right format.

The Communications and Stakeholder Liaison Annex is a recently updated communication strategy in the *Canadian Pandemic Influenza Preparedness: Planning Guidance for the Health Sector* (CPIP). The Annex emphasizes the importance of communicating with both the public and key stakeholders (e.g., health care providers, professional organizations and policymakers) before, during and after a pandemic. This strategy is grounded in several communications guiding principles: putting the health of Canadians first; providing timely and sound information; communicating in a coordinated fashion from across all levels of government; protecting confidentiality; and monitoring and adapting to the public's perception of risk. The Annex outlines a risk communications approach, proposes triggers for action based on pandemics of varying impact, and includes a Communication Protocol that will be used countrywide in the event of a pandemic.

Affiliations

[1] CPIP Task Group Chair

[2] Office of the Provincial Health Officer, Victoria, BC

***Correspondence:** phac.cpip.tg.secretariat-gt.pcp.aspc@canada.ca

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Key words: Influenza pandemic, communication strategy, risk perception, risk communication, emergency protocol

Introduction

During a pandemic, timely and transparent communication is critical in building public trust in the capacity of officials to manage the pandemic and to protect Canadians. At each stage of the pandemic, providing accurate, credible and timely information—through the right message, delivered at the right time by the right person to the right audience—can help protect the public's health, save lives and minimize social and economic disruption.

The "Communications and Stakeholder Liaison Annex" (1) is a recently updated communication strategy in the *Canadian Pandemic Influenza Preparedness: Planning Guidance for the Health Sector* (CPIP) (2). The primary focus of this Annex is federal, provincial and territorial (FPT) communication with the public, but it also recognizes the importance of communication with key stakeholders—health care providers, professional organizations and policymakers. The Annex has been updated based on experience gained during the 2009 H1N1 pandemic. That pandemic underscored the importance of clear, frequent and coordinated outreach to the public and key stakeholders and the need to plan for pandemics of varying impact.

This updated Annex uses a flexible and scalable approach to planning and includes best practices in risk communications. It integrates a broad range of communication methods such as social marketing, social media and stakeholder consultation. It outlines the roles and responsibilities of FPT governments in communications during a pandemic and the mechanisms through which key messages are coordinated, such as through established networks and nongovernmental organizations. The Annex is consistent with the concepts in the main body of the CPIP; it frames communications approaches using the guiding principles of ethics, collaboration, proportionality and evidence–informed decision-making.

Objectives

In a pandemic, risk communication objectives are to inform and to engage Canadians, and the organizations that represent them, about the risks posed by the pandemic so that people can take appropriate actions. This is done by conveying the relevant information in formats that are accessible and tailored to audience needs (e.g., in different languages, culturally sensitive)

and provided by and through multiple platforms (e.g. delivery by local leaders such as community elders or town mayors) and by coordinating communications through a clear focal point (e.g. from the Chief Medical Officer of Health). Established FPT networks are accessed to ensure consistency in messaging and share best practices and adjust approaches as necessary during the pandemic.

This article summarizes the recently updated Communication and Stakeholder Liaison Annex of the CPIP (1), and is part of a series outlining Canada's approach to influenza pandemic preparedness (3-6).

Canadian context

The Pan-Canadian Public Health Network (PHN) is the means by which a communications response is coordinated during a pandemic. The PHN is governed by a 17-member council of FPT government officials, including the Chief Public Health Officer and senior government officials from all provinces/territories who are responsible for public health. The PHN includes an intergovernmental communications group that provides risk communications and social marketing advice and support during a pandemic, facilitating cross-jurisdictional coordination and information-sharing among Canadian public health leaders.

Due to Canada's size and geographic population distribution, it is likely that a pandemic will affect different regions at different times and with varying severity, so messaging needs to explain the current situation in the global, national and regional context and address misinformation that may be circulating.

The Public Health Agency of Canada (PHAC) provides a focal point for national communications on public health issues. The PHAC collaborates with international organizations (e.g., the World Health Organization, the Global Health Security Action Group and the trilateral working group involved with the North American Plan for Animal and Pandemic Influenza [NAPAPI]), and coordinates with other federal departments to communicate health advice to Canadians, for example, on what precautions to take when travelling and how to prevent disease and injury.

The provinces/territories are the principal source of communications to the public and key stakeholders such as municipal and regional health authorities or provincial and territorial agencies or partners, within their jurisdictions. The PHAC and the provinces/territories coordinate their efforts and approaches through the PHN Communications Group.

In addition, the Annex identifies the importance of aligning communication strategies with trends in how Canadians access and use health information. Planners need to accommodate the fact that some Canadians have no or limited or unreliable Internet access. In addition, some populations may benefit from receiving information in different formats and languages, for example, those with hearing or visual impairments or low literacy, recent immigrants, or people experiencing homelessness. Several strategies can be used to reach Canadians: direct outreach to communities, traditional media (e.g., newspapers, telephone, radio and television), and new media trends and creative approaches (e.g., engaging outreach workers, social media) in addition to online media outlets.

Key elements of the communication approach

The Communications and Stakeholder Liaison Annex includes a joint FPT protocol for emerging public health events. This protocol identifies six guiding principles for pan-Canadian communications that can and should be applied during a pandemic context (see text box).

Guiding principles for communications during an influenza pandemic

1. Put the health of Canadians first. Ensure Canadians have the information they need to protect themselves and others.
2. Provide information that is informed by the latest available evidence. Information provided to the public must be as accurate as possible as it may be crucial to address misinformation and to enable people to protect themselves.
3. Provide information in a timely manner. Timely communication can prevent the spread of infections, thus reducing the severity and duration of outbreaks and saving lives.
4. Communicate in a coordinated fashion. It is important that all governments and partners who share responsibilities for public health align their efforts and ensure that the information they are providing to the public is consistent and appropriate.
5. Protect patient confidentiality. The patient's right to privacy should inform communications messaging. In turn, this messaging should comply with FPT protections, which balance public health interests with the rights of the individual patient.
6. Consider public perception of risk. Monitoring public perception, information needs and concerns is an important role in the pandemic response as public risk perception is the strongest indicator of willingness to change behaviour during a public health event.

Risk perception

The Annex highlights the importance of the public's risk perception, which is defined as "a subjective judgement that people make about the risks and benefits associated with an event or alternative courses of action" (1). Uncertainty during a pandemic can be accompanied by a high demand for information, increased feelings of fear and anxiety, rapid spread of misinformation, and speculation.

Risk communications theory suggests that an individual's initial perception of risk is formed early during a pandemic, based on the information available, and that it is filtered through personal beliefs, education and values (7). Moreover, once internalized, these perceptions are difficult to alter. Therefore, transparent, open and early communication with the public and stakeholders on what is known and what remains unknown (including actions being taken to gain further understanding) is critical. The annex emphasizes that public health authorities and trusted sources (e.g., nurses, doctors, pharmacists, community leaders, elders) not only influence early behaviours, but also establish the presence of a source of expert guidance and advice to help Canadians better understand the risks.

Social media plays an increasingly important role in how the public perceives risk. During a pandemic, many Canadians are likely to seek information on the outbreak through social media

channels (e.g., Facebook, Twitter). In this context, stakeholders can play an important role in influencing public perception of pandemic risk—either by correcting misinformation or by recirculating accurate and consistent messages. The recommended communication strategies take into account this new reality, both in terms of how information is disseminated and how social media is monitored. Strategies must be in place to counter the risks of misinformation ("fake news"). Social media, while not the creator of fake news, provide a widespread platform through which opinion or misinformation can be convincingly and quickly disseminated as fact. Credible information must be presented early and repeated often by trusted sources.

Scalability

In the 2009 pandemic, there was considerable variation in pandemic wave activity in terms of timing and intensity—around the world, across Canada and within the provinces and territories. This made it clear that a flexible and scalable planning approach was necessary. As outlined in the CPIP, the response to a pandemic needs to be appropriate to the local situation, with relevant actions applied at the provincial/territorial or regional/local level, as the situation requires.

The CPIP outlines four planning scenarios that describe pandemic impacts from low to high based on virus transmission and clinical severity. **Table 1** highlights these planning scenarios and their implications for risk communications.

Ongoing evaluation

There is a need for systematic evaluation of the overall communications response at three key stages of the pandemic:

- **Continuously:** To enable jurisdictions to adapt their plans to evolving circumstances and to share insights with their FPT counterparts to help to ensure a seamless and mutually reinforcing pan-Canadian communications response during the outbreak.
- **Between the first and second wave:** Recognizing that previous pandemics in North America have exhibited two waves, during the "pause," jurisdictions should reflect on their individual and collective response to the first wave of the outbreak and adjust their activities accordingly in advance of a potential second wave.
- **After the pandemic:** Evaluations will vary by jurisdiction, depending on the impact of the pandemic and the scope and scale of the communications response. Jurisdictions are encouraged to evaluate the effectiveness of their communications materials with their FPT counterparts.

To assist in these efforts, the Annex includes a list of performance indicators for both communication processes and outcomes that can be applied to evaluate the effectiveness of communications approaches and tools.

Integration of communication strategies with other CPIP components

Effective messaging and using a risk communications approach are inherent in every element of a pandemic response. Examples of how these principles are applicable to other CPIP components include communicating decisions on early allocation of vaccines, prioritization of vaccines in the event of short supply, or communicating about public health measures such as social distancing or self-isolation when ill.

Table 1: Implications and recommended adjustments to the communications response for pandemics of varying impact

Transmission	Clinical severity	
	LOW	HIGH
HIGH	**Scenario B (moderate impact):** An influenza virus with high transmissibility and low virulence • Anticipate that higher transmissibility will heighten public concern and increase demand for antivirals or pandemic vaccine • Develop communications to reinforce public health measures (vaccination, hand hygiene) and caring for the ill • Incorporate workplace wellness messages into internal communications (e.g., employee newsletters) • Implement marketing campaigns to encourage good health practices, stay-at-home when ill, etc. • Anticipate media and public questions and concerns on vaccine issues	**Scenario D (high impact):** An influenza virus with high transmissibility and high virulence • Anticipate that vaccine issues (e.g., availability, priority access, safety and effectiveness) will dominate public communications • Proactively monitor and explain any differences in public health measures or recommendations for the use of vaccines and antivirals (e.g., between different provinces/territories, between Canada and the United States) • Ensure consistent reporting of case counts, coordinated between jurisdictions
LOW	**Scenario A (low impact):** An influenza virus with low transmissibility and low virulence • Plan for public complacency (i.e., people may not consider themselves at risk) • Provide appropriate level of communications to avoid information saturation • Anticipate that public risk perception may focus on the appropriateness of the response efforts • Be prepared for rapid shifts in public perception of risk (e.g., following a fatality)	**Scenario C (moderate impact):** An influenza virus with low transmissibility and high virulence • Anticipate that high virulence (a virus causing severe clinical illness) will elevate public concern • Proactively address concerns through regular communications using multiple forms of media • Target communications to high-risk groups

Research needs

Research related to risk communication, stakeholder management, behavioural science, modelling and tracking can play a key role in pandemic preparedness and response. There is an ongoing need to consider new communications tools, techniques and methodologies. While much of this research can be carried out during the interpandemic period, some can only be conducted during a pandemic (e.g., comparing vaccine uptake rates based on jurisdictional communication strategies). Given the potentially long intervals between events, proactive strategies need to be in place to capitalize on and to leverage these infrequent but invaluable learning opportunities.

Discussion

A pandemic brings with it much uncertainty, which results in a high demand for information so people can make good decisions. Transparent, early and frequent communication with the public and stakeholders about what is known, and what remains unknown, is critical in reducing feelings of fear and anxiety while addressing misinformation and speculation—which remains a challenge given the rapid dissemination of information through electronic media.

Canada is diverse in terms of its size, geography, culture, languages and population needs. Specialized or tailored communications are required to be inclusive and account for traditional and alternative ways in which Canadians access information, while recognizing new technologies and trends in how Canadians are informed. These can be labour-intensive and challenging to prepare during a pandemic, so should be drafted ahead of time. A collaborative approach to developing, testing and evaluating messaging strategies would help inform the best approach during a pandemic.

The CPIP, with the *Communications and Stakeholder Liaison Annex* is intended to provide FPTs with planning guidance for addressing the communication challenges and planning advice during an influenza pandemic. The Annex is an evergreen document and, like the main body of the CPIP and the other technical annexes, will be reviewed and updated every five years.

Conclusion

The urgent and unpredictable nature of pandemics require a systematic approach to risk communications. In the early stages, evidence about the impact of a pandemic and the populations most at risk may be limited. The Communications and Stakeholder Liaison Annex has been designed to provide scalable communication strategies for varying pandemic wave activities in ways that will increase trust and self-empowerment among Canadians.

Authors' statement

Canadian Pandemic Influenza Preparedness Task Group (CPIPTG) Members: B Henry (Chair), C Alfieri, S Gantt, I Gemmill, T Hatchette, E Henry, B Schwartz

CPIP Secretariat: L Paddle, R Stirling, C Comeau

PHAC: P Salsbury, J Williams, S Smith, S Rempel

Conflict of interest

None.

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RAPID COMMUNICATION

Misidentification of Risk Group 3/Security Sensitive Biological Agents by MALDI-TOF MS in Canada: November 2015–October 2017

D Pomerleau-Normandin[1], M Heisz[1], M Su[1]*

Affiliation

[1] Centre for Biosecurity, Public Health Agency of Canada, Ottawa, ON

***Correspondence:** ming.su@canada.ca

Abstract

Background: Matrix-Assisted Laser Desorption/Ionization-Time of Flight Mass Spectrometry (MALDI-TOF MS) is a technology increasingly used in diagnostic identification of microorganisms. However, anecdotal evidence suggests that this technology is associated with misidentification of Risk Group 3 (RG3)/Security Sensitive Biological Agents (SSBA) resulting in exposure risks to laboratory personnel.

Objective: To investigate and characterize incidents related to the use of MALDI-TOF MS in Canada between November 6, 2015, and October 10, 2017.

Methods: Cases were identified from laboratory incident reports in the national Laboratory Incident Notification Canada (LINC) surveillance system. Eligible cases referred directly to MALDI-TOF MS or one of three RG3/SSBA organisms, *Brucella* species, *Francisella tularensis* and *Burkholderia pseudomallei*. A questionnaire was developed to identify potential risk factors leading to the exposure. Reporters from organizations with selected incidents were interviewed using the questionnaire. Data were entered into an Excel spreadsheet and standard descriptive statistical analysis performed to assess common characteristics and identify possible risk factors.

Results: There were eight eligible incidents and a total of 39 laboratory workers were exposed to RG3/SSBA organisms. In five (out of eight) of the incidents, the reporters indicated that their device was equipped with both clinical and research reference libraries. For six incidents where reporters knew the type of library used, only the clinical library was employed at the time of the incident even though both libraries were available in five of these incidents. In all eight cases, the exposure occurred during the sample preparation stage with analyses performed on an open bench and directly from the specimen. And in all eight cases, patient specimens were received without information regarding potential risk.

Conclusion: This first national study characterizing the nature and extent of laboratory incidents involving RG3/SSBA that are related to the use of MALDI-TOF MS identifies risk factors and provides baseline data that can inform mitigation strategies.

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Key words: MALDI-TOF MS, misdiagnosis, Risk Group 3 organisms, SSBAs

Introduction

The Matrix-Assisted Laser Desorption/Ionization-Time of Flight Mass Spectrometry (MALDI-TOF MS) technology has been described as "a revolution in clinical microbial identification" (1). Identification of microorganisms in cell cultures can take up to 18 hours to complete; with MALDI-TOF this takes approximately 15 minutes (2). This new technology is increasingly used for routine microbe identification in both clinical and reference laboratories due to its simplicity, rapidity and high throughput capacity (3). This technology enables early diagnosis; the cost of the analysis is also greatly reduced (2).

MALDI-TOF mass spectrometry generates a characteristic spectrum, called a peptide mass fingerprint, formed as a result of the presence of up to 2,000 proteins found in a unique pattern in each organism (3). The MALDI-TOF MS software subsequently compares this pattern of proteins to an internal reference library that contains the spectra of known organisms. Because each

bacterial species has a unique protein composition, the spectra enables accurate identification (4).

The main limitation of this technology is that the reference libraries must contain the spectrum of the organism in a sample to produce reliable identification (5). In the absence of the correct spectrum, the device will either not identify the organism or provide the identity of a similar organism. Close (but not exact) identifications can be a problem as closely related organisms can have different risk levels and therefore different safety protocols in the laboratory setting.

Organisms are classified in two ways: by risk group, based on an organism's pathogenicity, virulence, availability of treatment and the risk of spread to individuals or the public (**Table 1**); and as Security-Sensitive Biological Agents (SSBAs), a subset of human pathogens that pose a risk due to their potential for use as a biological weapon (6). Some, but not all Risk Group (RG)3, and most RG4 organisms are SSBAs.

Table 1: Definition of risk groups and examples of biological agents

Risk Group(RG) level	Definition (6)	Examples of biological agents
RG1	Low individual risk Low community risk	*Acholeplasma* spp. *Achromatium axoliferum* *Acidaminobacter* spp.
RG2	Moderate individual risk Low community risk	*Burkholderia multivorans* *Escherichia coli* *Salmonella enterica* spp.
RG3	High individual risk Low community risk	*Burkholderia pseudomallei* *Brucella* spp. *Francisella tularensis*
RG4	High individual risk High community risk	*Alkhumra virus* *Ebola virus* *Nipah virus*

Abbreviation: spp, species

If a specimen contains an RG3 organism but is misidentified as RG2, it may be handled on an open bench, rather than in a biosafety cabinet. Thus when misidentification occurs, laboratory technicians may not be appropriately protected and this can lead to exposure incidents.

A number of studies have reported that misidentification of organisms by MALDI-TOF MS appeared to have been caused by the incompleteness of the reference libraries used (2,7-26). Two types of reference libraries are currently in use in Canada: clinical libraries with spectra approved by Health Canada and research libraries, which contain a wider selection of spectra but are not cleared for clinical applications. Library extensions containing RG3 and SSBA spectra must be purchased separately. In certain cases, extensions are subject to extensive import regulations (10,27,28), making their acquisition laborious. Library extensions are therefore not necessarily equally accessible to all laboratories.

The Public Health Agency of Canada (PHAC) has the capacity to assess this risk of misidentification from MALDI-TOF MS at the national level through the Laboratory Incident Notification Canada (LINC) surveillance program. This was set up under the *Human Pathogens and Toxins Act*, which came into full force in 2015 and which made the reporting of laboratory incidents to PHAC mandatory. By doing so, PHAC is able to develop national statistics on biosafety and biosecurity issues and detect emerging trends in close to real time.

The LINC first identified issues related to MALDI-TOF MS when five exposure incidents involving the use of this technology were reported over a nine month period. All five incidents involved RG3/SSBA organisms: *Burkholderia pseudomallei*, *Francisella tularensis* or *Brucella* species. They are the causative agents of melioidosis, tularemia and brucellosis, respectively. They present an increased risk for laboratory technicians as they are easily transmitted through aerosols and because their slow growth on standard culture media often delays the suspicion of an RG3/SSBA (13,29-31). Detection of these five incidents triggered an investigation to assess the nature and extent of this problem at the national level.

The objective of this study was to describe the exposure incidents related to MALDI-TOF MS use in Canada between November 2015 and October 2017, and to identify risk factors associated with these exposures.

Methods

Eligible incidents

Incidents between November 6, 2015 (date of the first incident) and October 10, 2017 (last date of data gathering) were reviewed. Reports were selected for further assessment based on the following inclusion criteria:

- Incidents, both exposure and non-exposure, that referred directly to MALDI-TOF MS; and
- Incidents, both exposure and non-exposure, involving *Brucella* species, *F. tularensis* or *B. pseudomallei*, for which the reports did not have enough details to confidently rule out the use of MALDI-TOF MS leading up to the incident.

An exposure incident was defined as "contact with, or close proximity to, infectious material or toxins that may result in infection or intoxication, respectively" (6). Non-exposure incidents were occurrences of inadvertent possession of an organism not authorized under the licence (i.e. possession of an RG3 in a containment level 2) (6).

Based on these criteria, 17 reports from 15 reporters (organizations) were selected for assessment.

Investigation

Two LINC program agents interviewed the reporters between October and November 2017, using a list of questions provided to the interviewee ahead of time. The questionnaire collected data on the possession of the MALDI-TOF MS device and its library extension(s), on the method of analysis, including whether analysis was performed on an open bench, on specific standard

operating procedure (SOPs) for MALDI-TOF MS and triggers for enhanced SOPs and, in the opinion of the interviewee, whether the incident was caused, wholly or in part, as a result of misidentifying the organism. Data were also gathered on whether the medical staff, who requested the sample identification, provided information with the specimen (e.g., suspected diagnosis, patient medical and travel history) that may have alerted laboratory workers about the potential risk. An incident was confirmed as being part of the present study once the responsible reporter corroborated that the incident resulted from—or, at least, partly resulted from—misidentification or lack of identification from a MALDI-TOF MS device.

Analysis

Responses to the questionnaire were input into a spreadsheet designed for the purpose of this investigation. Excel 2010 was used for standard descriptive statistical analysis in order to assess and identify common characteristics.

Results

Of the 15 organizations contacted regarding 17 eligible incidents, 12 had a MALDI-TOF MS device. Among the remaining three organizations that did not have a device, two incidents still partly resulted from the use of MALDI-TOF MS. The reporters indicated that the specimens received for confirmation had previously been misidentified or not identified following MALDI-TOF MS analysis in a different laboratory.

The reporters at the 12 organizations that owned a MALDI-TOF MS device confirmed that, in six cases, the incidents were partly or wholly a result of relying on MALDI-TOF MS identification. With the addition of the two cases described above, in different laboratories, eight incidents related to misidentification or nonidentification by MALDI-TOF MS (**Figure 1**). These incidents represented over a third (n=8/17) of all incident reports LINC received between November 6, 2015, and October 10, 2017, that involved the three selected biological agents.

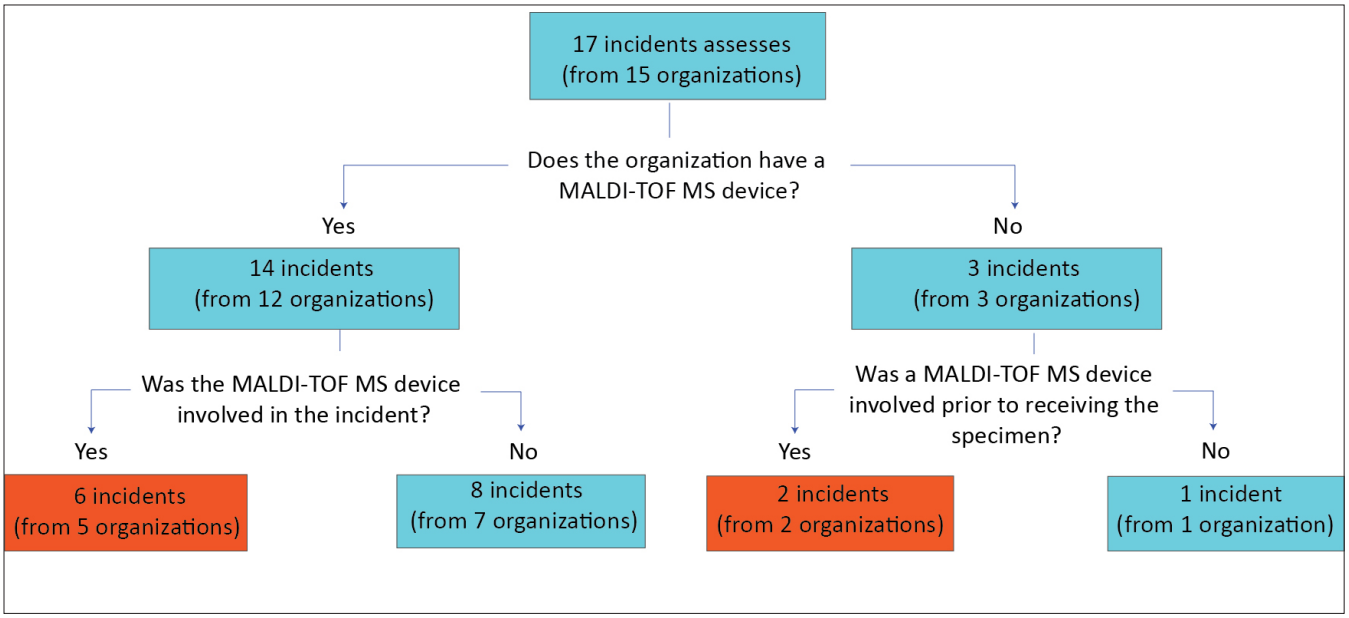
Based on the information provided in the eight incident reports, of which two were non-exposure incidents, 39 laboratory technicians were exposed. *Burkholderia pseudomallei* was the biological agent involved in three of the incidents, *Brucella* species in another three, and *F. tularensis* in two (**Table 2**).

Table 2: Biological agent involved and number of individuals exposed per incident

Incident number	Biological agent involved	Number of exposed individuals
1	*Burkholderia pseudomallei*	1
2	*B. pseudomallei*	1
3	*Francisella tularensis*	13
4	*F. tularensis*	4
5	*Brucella abortus*	15
6	*B. pseudomallei*	5
7	*Brucella melitensis*	n/a
8	*Brucella spp*	n/a

In five of the eight incidents the reporters indicated that their organization's MALDI-TOF MS device was equipped with both clinical and research reference libraries. In one incident, the device was only equipped with the clinical reference library, and in two incidents, the reporter did not know what type of reference library was used. However, in the five incidents where both clinical and reference libraries were available, all the analyses were performed using only the clinical reference library.

Figure 1: Case selection and eligible incidents



Abbreviation: MALDI-TOF MS; Matrix-Assisted Laser Desorption/Ionization-Time of Flight Mass Spectrometry

All eight incidents related to the use of MALDI-TOF MS occurred during the sample preparation stage, and all analyses were performed on an open bench, directly from the specimen. Furthermore, in every incident where the organization possessed a MALDI-TOF MS device (n=6), the reporter developed enhanced SOPs designed specifically for the use of this technology following the incident. The triggers for these enhanced SOPs included a slow growth coupled with small gram-negative coccobacilli (n=2), no identification results (n=2), the geographic region from which the patient specimen originated (n=1) and the specimen type (n=1).

Finally, in all eight incidents related to the use of MALDI-TOF MS, specimens were received without clinical or travel history information (i.e. to trigger suspicion of RG3/SSBA agent).

Discussion

This is the first national study assessing laboratory incidents related to misidentification or lack of identification of RG3/SSBAs by MALDI-TOF MS devices. We found that 39 individuals were exposed to RG3/SSBA organisms in six exposure incidents involving MALDI-TOF MS. These organisms are consistent with other incidents reported in the literature (3,10-12,15,19,22).

One risk factor associated with an exposure incident was reliance on the clinical reference library software. According to the reporters, although both clinical and research reference libraries were available in most cases, only the clinical libraries were in use when the incidents occurred as the two libraries cannot be used simultaneously and switching libraries requires a series of lengthy steps that are impractical under current workloads. Therefore, while complementary reference libraries such as research-use only or security-relevant libraries can help mitigate the risk of misidentification by relying on a wider selection of spectra, their utility remains limited as both types of library cannot be actively combined. These results are consistent with other reports in the literature that suggest MALDI-TOF MS clinical libraries do not reliably identify certain RG3/SSBAs pathogens (9,11,12,20,22).

A second risk factor associated with exposure incidents was an open-bench approach for sample preparation. All incidents occurred while preparing the sample and all analyses were performed directly from specimens on an open bench. This, however, does not actually reflect manufacturers' recommendations, which suggest that analysis be performed from extraction (32) that effectively deactivates pathogens in most cases and thereby reduces exposure risks.

A third risk factor associated with an exposure incident was the lack of alerting information on the laboratory requisition. A challenge with identifying these three diseases is that they usually present with nonspecific symptoms that can easily be mistaken for more common illnesses (8,25-27). As such, clinicians may not suspect an RG3/SSBA diagnosis and may not provide alerting information on the requisition forms (i.e. suspected diagnosis, patient travel history) that would cause the initiation of adequate safety measures for the manipulation of the patient specimens in laboratories (30,33).

Our study identified two incidents from samples received following misidentification from a MALDI-TOF MS device in a different laboratory. This revealed that exposures due to a single specimen may occur in multiple laboratories.

Strengths and limitations

The main strength of this study is that it is based on mandatory, standardized and detailed reporting of laboratory incidents. Furthermore, it provides the baseline to assess the evolution of the problem over time.

There are also a few limitations to consider. The incident sample identified is likely incomplete for two reasons. First, the eligibility criteria may have missed some incidents. There is currently no efficient way to identify with certainty all incidents related to the use of MALDI-TOF MS among all laboratory incidents reported to LINC. Second, this investigation only captured incidents involving the three selected organisms. Indeed, MALDI-TOF MS devices have also been reported to misidentify or be unable to identify certain RG2 organisms as well (34). Finally, the small number of exposure incidents over almost a two-year time period is inherently unstable. Additional studies showing trends over time will further inform the extent of this problem.

Conclusion

This national surveillance study of laboratory incidents related to the misidentification of RG3/SSBAs by MALDI-TOF MS identified three risk factors: the reliance on clinical reference libraries; the use of an open-bench approach for sample preparation; and the lack of alerting information on the laboratory requisitions. This information can be used to raise awareness regarding the limitations of the MALDI-TOF MS technology and stimulate work on mitigation measures to help prevent similar incidents. It also provides the baseline for surveillance over time. The Centre for Biosecurity is continuing the investigation and working with stakeholders to address the issue and improve biosafety measures.

Authors' statement

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MS – Investigation, Writing – Review & Editing, Supervision
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Conflict of interest

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Raccoon rabies outbreak in Hamilton, Ontario: A progress report

D Lobo[1]*, C DeBenedet[2], C Fehlner-Gardiner[3], SA Nadin-Davis[3], MEC Anderson[4], T Buchanan[5], K Middel[5], C Filejski[6], J Hopkins[7,8]*

Abstract

Background: Raccoon rabies is caused by a variant of the rabies virus found in raccoons but transmissible to other mammalian species, including humans. The disease of rabies caused by raccoon variant rabies virus is indistinguishable from rabies caused by other rabies virus variants.

Objective: This paper describes the raccoon rabies outbreak in Ontario (identified in December 2015) and the control measures undertaken to curb the spread of the epizootic using the One Health approach.

Investigation and Results: Representatives from local, provincial and federal agencies collectively activated a raccoon rabies response that involved policy updates, enhanced surveillance, a public education campaign and mass vaccination of wildlife and domestic animals. Between December 2015 and June 2017, 338 animals tested positive for raccoon rabies in Ontario. While the majority of the cases were raccoons, there was significant spillover into striped skunks, as well as other species including two cats, a fox and a llama. Viral genome sequencing determined that this epizootic was likely caused by long-distance translocation from the United States.

Conclusion: This outbreak of raccoon rabies is by far the largest to have occurred in Canada and the first raccoon rabies outbreak documented in a densely populated urban area. This is also the first time this rabies virus variant has been identified in a domestic animal in Canada. A collaborative approach involving numerous stakeholders in the public and private sectors has been instrumental in addressing this epizootic. Though case incidence appears to be declining, several years will likely be required to reach elimination. Continued collaboration between these agencies is necessary to achieve this goal.

Affiliations

[1] Public Health and Preventive Medicine Residency Program, McMaster University, Hamilton, ON

[2] Hamilton Public Health Services, Hamilton, ON

[3] Canadian Food Inspection Agency, Ottawa, ON

[4] Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, ON

[5] Ministry of Natural Resources and Forestry, Peterborough, ON

[6] Ministry of Health and Long-Term Care, Toronto, ON

[7] Region of Peel, Mississauga, ON

[8] Department of Health Research Methods, Epidemiology, and Impact, McMaster University, Hamilton, ON

***Correspondence:** deepika.lobo@medportal.ca; jessica.hopkins@peelregion.ca

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Key words: Raccoon rabies, rabies outbreak, One Health approach, genome sequencing

Introduction

On December 4, 2015, the public health department in Hamilton, Ontario was notified that a locally trapped raccoon had tested positive for the raccoon variant of the rabies virus. The raccoon had been tested because it had been in a fight with two unvaccinated domestic dogs. This was the first case of raccoon rabies in the province since 2005 and the first case of raccoon rabies ever recorded in southwestern Ontario. In the following 19 months, raccoons with rabies were identified in areas surrounding Hamilton including Niagara Region, Brant County, Halton Region and Haldimand–Norfolk.

Rabies virus is a Lyssavirus in the family Rhabdoviridae. It has a high affinity for neural tissue and causes death through encephalomyelitis (1). Viral variants are viral populations that are maintained in specific host reservoirs in a geographic area and are distinct from other viral populations that may be located in the same area or that have diverged from a common viral ancestor (2). The disease caused by the raccoon variant rabies virus is indistinguishable from rabies caused by other variants. In the interest of brevity, for this report "raccoon rabies" is used to mean rabies caused by the raccoon variant rabies virus, whether the disease is present in raccoons or another species.

This article provides an update on the raccoon rabies epizootic in Ontario, particularly in and around Hamilton, Ontario, where the outbreak was first identified in December 2015. It describes the control measures undertaken to curb the spread of the epizootic and the collaborative One Health approach used by the many agencies involved in the response.

Background

Raccoon rabies originally emerged in the state of Florida in the 1940s, spreading to the Mid-Atlantic states in the 1970s. It has since spread throughout the eastern seaboard of the United States (US), reaching the Canada–US border in the mid-1990s (3,4). It was first detected in Ontario in 1999 (5) and was localized to two rural areas in eastern Ontario with 132 laboratory-confirmed cases detected over six years. It was successfully eliminated in 2005 with Ontario being declared free of raccoon rabies in September 2007 (6). Incursions of raccoon rabies from neighbouring US states into New Brunswick (2000–2002; 64 cases) and Quebec (2006–2009; 104 cases) were similarly eliminated (6).

The responsibility for rabies control in Canada is shared across multiple jurisdictions and reflects the One Health approach, a concept that recognizes the relationships between public health, animal health and the environment. The One Health approach applies a coordinated, collaborative, multidisciplinary and cross-sectoral effort to address potential or existing risks that originate at the animal–human–ecosystems interface (7). At the federal level, the Canadian Food Inspection Agency (CFIA) provides rabies laboratory testing services for animal and human samples. In Ontario, the Ministry of Health and Long-Term Care (MOHLTC) provides guidance and support for the local management of suspected rabies exposure, local rabies contingency plans and legislation around rabies immunization. Local public health units are responsible for all activities dealing with prevention of rabies cases in humans, including postexposure case management of people potentially exposed to rabies virus, provision of rabies postexposure prophylaxis (rPEP) vaccine to primary care providers, and raising public awareness. The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) assists veterinarians as needed with risk assessments, sample submission and postexposure management of companion animals and livestock (collectively, domestic animals) potentially exposed to rabies by wildlife or other domestic animals. The Ministry of Natural Resources and Forestry (MNRF) is responsible for rabies control activities in wildlife, which include enhanced surveillance in wildlife populations at risk, testing of samples and mass vaccination programs.

Investigation and Results

Coordinating a One Health approach

Following confirmation of the first case of raccoon rabies in Hamilton in December 2015, Hamilton Public Health Services activated a raccoon rabies response based on the MOHLTC raccoon rabies contingency plan, and revised its rabies risk assessment tool to reflect the change in local epidemiology (i.e. a local rabid raccoon). This was followed by updating case management algorithms for potential human exposures and alerting local health care providers to incorporate local epidemiology into postexposure management.

In 2013, Hamilton Public Health Services was one of six health units in Ontario that helped form a community One Health committee. Members of the committee met with local veterinary professionals, animal control services and representatives from other agencies to discuss diseases prevalent in both humans and animals, and share information about various environmental risk factors. As a result, Hamilton Public Health Services had well-established relationships in place before the identification of this epizootic, which helped in the rapid implementation of the raccoon rabies response.

Rabies does not have a direct environmental impact as it is a mammalian virus and very fragile outside of the body. However, it can have a significant impact on wildlife populations (especially the reservoir species – bats, raccoons, skunks, foxes – in which specific rabies virus variants circulate) and therefore the ecosystems in which they live. In this sense, the contributions of public health, OMAFRA and MNRF round out the One Health players in terms of human, animal and environmental health.

Another unique feature of this response was that there was no single "lead" organization; the response was shared with each organization leading the part that was within their mandate. Close collaboration and active communication were essential to coordinate activities and work towards one common overall goal of eliminating raccoon rabies in Ontario.

Animal health response

Case definition

A confirmed case of raccoon rabies was defined as an animal testing positive for rabies using the fluorescent antibody test together with virus typing methods utilizing either monoclonal antibody panels or sequencing to identify the raccoon variant. These procedures were carried out by the Centre of Expertise for Rabies at the CFIA. Geographical attribution of positive animals was based on local public health unit boundaries.

Case detection/Surveillance

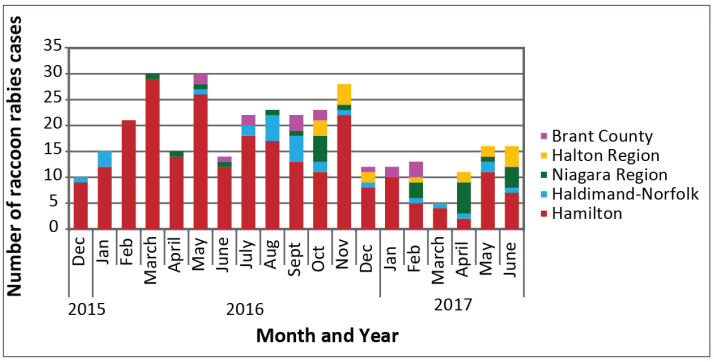
Cases were identified through different processes, depending on whether people or domestic animals had been potentially exposed to the suspect animal or the suspect animal was identified through other surveillance activities. The decision to test a suspect animal that had potentially exposed humans to rabies was made by the local public health unit. The decision to test a suspect animal that had potentially exposed domestic animals alone to rabies was made by OMAFRA, typically in collaboration with the exposed animal's veterinarian. In both cases, samples were shipped directly to CFIA for testing.

In December 2015, MNRF implemented enhanced rabies surveillance in an area extending 50 kilometers beyond where all diagnosed cases were found, with weekly testing of sick or found-dead animals with no known human or domestic animal contact, using a direct rapid immunohistochemical test (dRIT) (8). Confirmatory testing on all dRIT-positive and inconclusive samples was performed by CFIA. This enhanced surveillance was used to understand the scope (species and geographic) of spread and number of animals impacted.

Between December 2015 and June 2017, 338 animals tested positive for raccoon rabies in Ontario. Of these, 251 (74%) were from the area around Hamilton. Five or more animals tested

positive for raccoon rabies every month between December 2015 and June 2017, with an average of 18 animals per month (range 5–30). In contrast, in 2014 only 18 rabies cases were detected in the entire province, all in bats (9). An epizootic curve for the outbreak is shown in **Figure 1**.

Figure 1: Epizootic curve showing ongoing raccoon rabies outbreak in Ontario, December 2015 to June 2017



While the rabies outbreak was mostly confined to raccoons, the reservoir species for this virus variant, there was significant cross-species transmission of the raccoon virus ("spillover") into striped skunks, as well as some spillover into other species, including two cats, a red fox and a llama (**Table 1**).

Table 1: Animal species tested positive for raccoon rabies in Ontario, December 2015 to June 2017

Year	Animal	Hamilton Region	Haldimand-Norfolk County	Niagara Region	Halton Region	Brant County	TOTAL
2015 (December)	Raccoon	9	1	0	0	0	10
2016	Raccoon	126	17	10	7	11	171
	Skunk	76	1	2	2	0	81
	Cat	0	1	0	0	0	1
	Fox	1	0	0	0	0	1
	Llama	0	1	0	0	0	1
2017 (January to June)	Raccoon	24	5	12	4	5	50
	Skunk	14	1	2	5	0	22
	Cat	1	0	0	0	0	1
TOTAL		251	27	26	18	16	338

Between December 2015 and June 2017, MNRF tested 6,685 animals (wildlife species with no known human or domestic animal exposure) using dRIT. Of these, 326 (4.89%) were identified by dRIT and confirmed by fluorescent antibody testing and subsequent variant typing as positive for raccoon rabies (**Table 2**). An additional 12 cases were identified during this time from samples submitted by MOHLTC or OMAFRA.

Source identification

The source of this outbreak was explored by comparing the whole-genome sequence of two virus isolates from Hamilton with a large database of raccoon variant rabies virus genomes

Table 2: Number of animals tested for rabies using dRIT in Ontario, December 2015 to June 2017

Year	Month	Number of animals tested	Number of animals confirmed positive	Proportion of animals tested positive (%)
2015	Dec	147	12	8.2
2016	Jan	369	19	5.2
	Feb	588	26	4.4
	March	781	19	2.4
	April	627	23	3.7
	May	453	24	5.3
	June	338	16	4.7
	July	274	18	6.6
	Aug	304	23	7.6
	Sept	228	27	11.8
	Oct	247	22	8.9
	Nov	255	19	7.5
	Dec	123	11	8.9
2017	Jan	121	12	9.9
	Feb	277	13	4.7
	March	310	3	1.0
	April	377	12	3.2
	May	445	16	3.6
	June	421	11	2.6
Total	---	6,685	326	4.9

Abbreviation: dRIT, direct rapid immunohistochemical test

from across the eastern US. The viruses circulating just across the border in New York state, where raccoon rabies has been endemic since the late 1990s, were phylogenetically very distinct from those responsible for the Hamilton outbreak, supporting the conclusion that this epizootic represents a long-distance translocation into the area (10).

Vaccination

Animal vaccination was one of the main strategies in minimizing the spread of raccoon rabies, particularly through oral vaccination of raccoons and skunks. Between December 2015 and June 2017, MNRF distributed over 1.7 million baits containing ONRAB® (live adenovirus vector AdRG 1.3) oral rabies vaccine during campaigns in December 2015, spring 2016 and fall 2016. The baits were distributed by hand in urban areas, by helicopter in large urban green spaces and by fixed-wing aircraft in surrounding rural areas across the enhanced surveillance area.

In addition, Hamilton Public Health Services in conjunction with local veterinarians held two rabies vaccination clinics for domestic cats and dogs in September 2016 and April 2017. These clinics were organized to provide rabies vaccination at a lower cost, enabling lower income families to vaccinate their pets. Thirteen veterinarians participated, vaccinating a total of 472 pets (321 dogs and 151 cats). Of these, 169 (36%) pets had had no previous vaccination history. Hamilton Public Health Services continues to work with Community Veterinary Outreach,

which provides pet care for people facing financial pressures, to offer rabies vaccination at a lower cost so pets and people are protected from rabies.

Public health response

Education and awareness

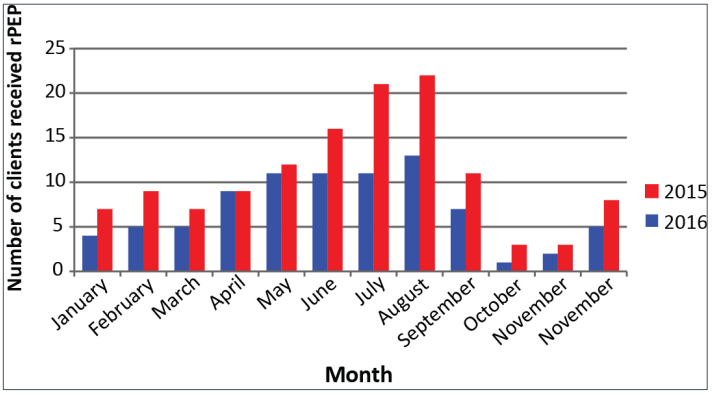
The Hamilton Public Health Services developed the "Rabies is Real" public awareness campaign, requesting people to stay away from wild animals; report dead or strangely behaving animals to local animal services; contact public health if they are bitten or scratched by an animal; and to get their pets vaccinated. Campaign materials included billboard posters, colouring booklets for children, social media messaging, newspaper articles, television interviews, a rabies awareness video, and in-person information sessions for high-risk groups (e.g., animal welfare groups). Billboard viewership estimates were provided by the billboard owners and social media views were calculated by the communication team.

The "Rabies is Real" campaign was launched in September 2016. Seventeen billboards at multiple locations across Hamilton were estimated to have been viewed over 8 million times during a 12-week period. Campaign banners at 46 different transit shelters were estimated to have had over 13 million views over an 8-week period. The City of Hamilton rabies webpage had 7,393 unique visitors between October 2016 and May 2017, with users spending an average of 3.6 minutes on the webpage and 83% leaving without going elsewhere on the website.

Rabies Postexposure Prophylaxis (rPEP)

Hamilton Public Health Services sent out medical advisories informing primary care providers about the raccoon rabies epidemic and the criteria for rPEP and created an educational video on rPEP administration. Compared to 2015, there was a 52% increase in the number of people who received rPEP in and around Hamilton in 2016 (**Figure 2**).

Figure 2: Number of clients received rPEP in Hamilton Region in 2015 and 2016



Abbreviation: rPEP, rabies postexposure prophylaxis

The One Health approach to the raccoon rabies outbreak in Ontario is summarized in **Table 3**.

Table 3: Summary of the One Health approach to the raccoon rabies outbreak, Ontario 2015–2017

Level	Government body or group	Human health	Animal health (pets and livestock)	Environment (wild animals)
Federal	CFIA	Rabies laboratory testing and virus typing		
Provincial	MOHLTC	Overall guidance for local public health units: Rabies case management protocol Rabies immunization guidelines (pre and postexposure)	NA	NA
	OMAFRA	NA	Assistance to veterinarians regarding risk assessment, sample submission, postexposure management	NA
	MNRF	NA	NA	Enhanced rabies surveillance including dRIT testing Distribution of 1.7 million rabies oral vaccine baits
Local	Public health units	Notification to primary care providers and revised rabies risk assessment tool Postexposure case management including provision of rPEP as needed Launched a public awareness campaign	Notification to veterinary professionals and animal services personnel Co-organized rabies vaccine clinics with veterinary physicians	NA
	Primary care providers and veterinarians	Clinical management of potentially exposed cases and administration of rPEP	Clinical management of potentially exposed cases and administration of rabies vaccine	NA
	Animal control services	NA	Retrieval and preservation of dead animals for further testing or disposition	

Abbreviations: CFIA: Canadian Food Inspection Agency; dRIT, direct rapid immunohistochemical test; MOHLTC, Ministry of Health and Long-Term Care; MNRF, Ministry of Natural Resources and Forestry; NA, not applicable; OMAFRA, Ontario Ministry of Agriculture Food and Rural Affairs; rPEP, rabies postexposure prophylaxis

Discussion

At the time of this publication, Hamilton Region and surrounding area continue to experience an epizootic of raccoon rabies. The outbreak of raccoon rabies in southwestern Ontario is by far the

largest to have occurred in Canada. It also differs from previous outbreaks in Ontario, Quebec and New Brunswick in that it is centred in a densely populated urban area. This poses many challenges with respect to control. For example, distribution of baits by low-flying fixed-wing aircraft, as is standard for oral vaccination campaigns in rural areas, is not possible in urban areas. This outbreak required a combination of oral rabies vaccine delivery approaches, such as distribution of baits by hand in the urban centres and by helicopter in large urban green spaces. Bait distribution in the urban core required coordinated messaging from Hamilton Public Health Services, MNRF and OMAFRA to advise the public who came across or into contact with these baits.

A further complication of this urban rabies outbreak lies in the large populations of potential spillover hosts, such as dogs and cats, further raising concern for an increased risk of transmission to humans. Indeed, although the majority of cases have been in wildlife, this is the first time that the raccoon rabies virus variant was identified in domestic animal species in Canada. In the US, the domestic animal species most commonly reported with rabies is the cat, with the majority from areas endemic for raccoon rabies (11). As the outbreak progresses, there is a risk that more cases of raccoon rabies in domestic animal species could occur. As such, key public health messages include encouraging vaccination of all dogs and cats and avoidance of contact with stray animals that are unlikely to be vaccinated. This is challenging given many people choose not to vaccinate their pets despite the legal requirement in Ontario.

Surveillance for rabies in Canada is based on a passive model whereby only suspect animals that have potentially exposed people or domestic animals are tested for rabies. Since the detection of the outbreak in December 2015, the vast majority of cases (>96%) were detected through the enhanced rabies surveillance program implemented by MNRF. Such surveillance helps delineate the extent of the outbreak, which informs management decisions regarding oral vaccination zones as well as public health risk determinations. These data also speak to the utility of going beyond a passive surveillance model to include the testing of animals found dead or exhibiting clinical signs consistent with rabies, regardless of the history of exposure to humans or domestic animals. Such actions may contribute to earlier detection of new rabies incursions. However, the cost of such a program particularly in the absence of evidence of a disease incursion is a critical consideration. It is important to find a balance between the risk of an incursion going undetected for a period of time and the cost of enhanced surveillance programs.

Introduction of raccoon rabies into Canada in the past has typically resulted from cross-border spread and thus the viral variants on either side of the US–Canada border were very similar. However, genetic analysis of the virus circulating in Hamilton demonstrated that a simple cross-border spread was not the source of this outbreak. It appears that the disease was introduced after a long-distance translocation of a diseased raccoon either by water (shipping) or by land (transport trucking), which has been previously described (12). Thus, even jurisdictions deemed at low risk of a rabies incursion should have contingency plans in place for such an event. The prior existence of contingency plans at MOHLTC (human health response) and MNRF (wildlife rabies control) as well as the existence of the community One Health committee in Hamilton, were key to the speed with which response measures involving diverse programmatic activities were put in place.

Previous raccoon rabies epizootics were eliminated from the provinces of Ontario, Quebec and New Brunswick in six, four and three years, respectively. Given the size of the current epizootic, and the unique challenges of dealing with an urban outbreak, it is not surprising that the outbreak has extended beyond 19 months. However, the decrease in the monthly number of cases and in the percentage of animals testing positive suggests that the epizootic may be decreasing in intensity. The collaborative approach between the various interdisciplinary agencies at the federal (CFIA), provincial (MOHLTC, OMAFRA and MNRF) and local levels (public health units, local animal control and private veterinary professionals) has been instrumental in addressing this raccoon rabies epizootic. Continued collaboration is necessary to again eliminate raccoon rabies from Ontario.

Authors' statement

DL – Conceptualization, Formal analysis, Writing-Original draft, Writing-Review and editing, Visualization
CDB – Writing-Review and editing, Investigation
CFG – Writing-Review and editing, Investigation
SAND – Writing-Review and editing, Investigation
MECA – Writing-Review and editing
TB – Writing-Review and editing, Formal analysis, Investigation
KM – Writing-Review and editing, Investigation
CF – Writing-Review and editing
JH – Conceptualization, Writing-Review and editing, Investigation, Supervision

Conflict of Interest

None.

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CATMAT: Use of booster doses of yellow fever vaccine

Source: Committee to Advise on Tropical Medicine and Travel (CATMAT). **Statement on the Use of Booster Doses of Yellow Fever Vaccine**. January 18, 2018. https://www.canada.ca/en/public-health/services/publications/diseases-conditions/use-booster-doses-yellow-fever-vaccine.html

The Committee to Advise on Tropical Medicine and Travel (CATMAT) recently released their Statement on the Use of Booster Doses of Yellow Fever Vaccine. Yellow fever is caused by a mosquito-borne flavivirus and is vaccine-preventable. The World Health Organization recently determined that booster doses were not required as a single dose of the vaccine confers lifelong immunity. The International Health Regulations (IHR) were amended, rendering proof of yellow fever vaccination valid for life. To evaluate the need for a booster dose of yellow fever vaccine, CATMAT reviewed the evidence used to inform the IHR amendment. The CATMAT statement contains a summary and assessment of the evidence and concludes that use of a booster dose of the vaccine was not recommended for travellers to endemic regions, except for certain groups at increased risk.

Use of a one-time booster dose is recommended for travellers who may have received a primary dose of yellow fever vaccine during a period of reduced immunocompetence. This includes those who were pregnant, taking immunosuppressive medication, received a previous dose that may have been inadequate for long-term protection and individuals diagnosed with an illness associated with an immunocompromised state. Individuals who underwent a hematopoietic stem cell transplant after having received yellow fever vaccine are also included in this category.

A booster dose of yellow fever vaccine every 10 years is recommended for HIV-positive individuals prior to travel to endemic regions. Individuals who travel frequently to areas with higher risk of yellow fever, particularly to areas experiencing a major outbreak of yellow fever, may consider obtaining a one-time booster dose if 10 years have elapsed since the primary dose. Those working with the yellow fever virus in a laboratory setting are also candidates for 10-year boosters.

The Statement on the Use of Booster Doses of Yellow Fever Vaccine contains detailed recommendations for the use of booster dose of the yellow fever vaccine for special groups at increased risk.

Update on CATMAT's evidence-based recommendations

Source: Committee to Advise on Tropical Medicine and Travel (CATMAT). **Evidence based process for developing travel medicine related guidelines and recommendations.** Ottawa (ON): Public Health Agency of Canada; 2017 Dec [cited 2018 Mar]. https://www.canada.ca/en/public-health/services/publications/diseases-conditions/evidence-based-process-developing-travel-tropical-medicine-guidelines-recommendations.html

The Committee to Advise on Tropical Medicine and Travel (CATMAT) has been developing guidelines for travel health and tropical diseases for more than 20 years. Over this time, evidence-based medicine methods have evolved dramatically.

The CATMAT has updated its guideline development process and will use the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) method for certain recommendations. For other recommendations, a less rigorous search and synthesis of the literature will be used. The choice of recommendations to which GRADE will be applied will depend on a number of factors including: the anticipated burden of the disease, the seriousness of the outcomes to be prevented, the potential benefits and harms of the intervention, the quality of the evidence, and the resources available to the committee.

These updated evidence-based methods will provide a transparent process for developing travel and tropical medicine–related recommendations and are designed to help with the interpretation and implementation of statement recommendations.

VACCINES WORK

DISEASE	CASES THEN*	CASES NOW**	DECREASE
WHOOPING COUGH	17,777	2,332	87%
MEASLES	53,584	292	99%
MUMPS	36,101	103	99%
RUBELLA	14,974	1	99%
DIPHTHERIA	8,142	1	99%
POLIO	2,545	0	100%






Pub.: 140510

* Average number of cases reported annually in Canada during the five years before routine vaccine use, or the closest possible five years where stable reporting was occurring.

** Average number of cases reported annually in Canada from 2011 to 2015.

Some numbers are subject to change as reports are updated. For details about the data sources and methods, visit Canada.ca/vaccines

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