Health Canada and the Public Health Agency of Canada
Santé Canada et l'Agence de la santé publique du Canada

Evaluation of the Public Health Agency of Canada's Non-Enteric Zoonotic Infectious Disease Activities 2010-2011 to 2015-2016

Prepared by
Office of Audit and Evaluation
Health Canada and the Public Health Agency of Canada

March 2016

List of Acronyms

AB	Alberta
AMR	Anti-microbial Resistance
BC	British Columbia
CCDR	Canada Communicable Disease Report
CDC	Centre for Disease Control
CFEZID	Centre for Foodborne, Environmental and Zoonotic Infectious Diseases
CFIA	Canadian Food Inspection Agency
CSG	California serogroup viruses
CWHC	Canadian Wildlife Health Cooperative
DND	Department of National Defense
EBIC	Economic Burden of Illness in Canada
EID	Environmental Issues Division
EOC	Emergency Operations Centre
F/P/T	Federal/Provincial/Territorial
FTE	Full-time Equivalent
FY	Fiscal Year
GDP	Gross Domestic Product
GREZOSP	Research Group on Epidemiology of Zoonoses and Public Health
IHR	International Health Regulations
ISO	International Organization for Standardization
LFZ	Laboratory for Foodborne Zoonoses
MB	Manitoba
NB	New Brunswick
NGO	Non-Governmental Organizations
NML	National Microbiology Laboratory
NS	Nova Scotia
OECD	Organisation for Economic Co-operation and Development
OGD	Other Government Departments
ON	Ontario
PDI	Program Development and Integration Division
PHEIC	Public Health Emergency of International Concern
PHN	Public Health Network
P/T	Provincial/Territorial
QC	Quebec
RPP	Report on Plans and Priorities
SARS	Severe Acute Respiratory Syndrome
SK	Saskatchewan
TBS	Treasury Board of Canada Secretariat
U.S.	United States
USD	United States Dollar
WHO	World Health Organization
WNv	West Nile virus

Table of Contents

List of Tables

Executive Summary

This evaluation covered the Public Health Agency of Canada's Non-Enteric[i] Zoonotic Activities for the period from 2010-11 to 2015-16. The evaluation was undertaken in fulfillment of the requirements of the Treasury Board of Canada's *Policy on Evaluation* (2009).

Evaluation Purpose and Scope

The purpose of the evaluation was to assess the relevance and performance of the Public Health Agency of Canada's (Agency) Non-Enteric Zoonotic Infectious Disease Activities. The scope of the evaluation covered the period from April 2010 to December 2015 and included non-enteric zoonotic and vector-borne infectious disease activities. The evaluation did not cover foodborne enteric illness activities and waterborne infectious diseases; clean air; prion diseases; migration and travel health; the Canadian Public Health Service as well as Ebola and anti-microbial resistance as all have been or will be evaluated under separate covers.

Program Description

Zoonotic infectious diseases are transmitted between animals and humans and are caused by all types of pathogenic agents, including bacteria, parasites, fungi, and viruses. These types of diseases are of interest to the Agency because of their potential risk to human health and the possibility of sudden case surges and/or outbreaks. Non-enteric zoonotic activities undertaken by the Agency are conducted primarily by the Infectious Disease Prevention and Control Branch via the Centre for Foodborne, Environmental and Zoonotic Infectious Disease (CFEZID) and the National Microbiology Laboratory (NML). Activities include surveillance and monitoring, laboratory reference and diagnostic services, risk assessment development and risk modelling, policy analysis and development, research (laboratory, field, epidemiological), public awareness and education, as well as outbreak preparedness and response activities.

CONCLUSIONS - RELEVANCE

Continued Need

There is an increasing need for the Agency to address zoonotic diseases. Although there are a small number of human health cases in comparison to other diseases, the majority of emerging pathogens are zoonotic and there is the potential for a sudden impact on the Canadian population. Factors such as climate change and variability, and global trade and travel increase the likelihood of emerging diseases in Canada.

[i] An enteric illness affects the stomach or intestinal tract, often causing nausea, vomiting, abdominal cramps and diarrhoea. Non-enteric illness affects organs other than the digestive tract.

Alignment with Government Priorities

Zoonotic Disease activities have been identified as a priority of the Agency as reflected in a variety of planning and corporate documents (e.g., Lyme disease activities, Corporate Risk Profile).

Alignment with Federal Roles and Responsibilities

Program authorities clearly articulate both disease-based (i.e., West Nile virus, Rabies, Lyme disease, Avian Influenza) and functional (i.e., laboratory and surveillance) activities. Considering the multijurisdictional nature of preventing, detecting and responding to non-enteric zoonotic diseases, the Agency's collaborative approach to zoonotic activities is consistent with the objectives of 'One Health' approach, which recognizes the interface and importance of collaboration between groups that focus on human, animal and environmental health.

CONCLUSIONS – PERFORMANCE

Demonstration of Effectiveness

The Agency's activities appear to be effective in supporting public health actions, planning and decision making in the prevention and control of non-enteric zoonotic diseases. Many of the products and services developed by the Agency are considered useful and appropriate by stakeholders. Many of these activities are developed through and dependent on successful partnerships with provinces and territories, other government departments and non-governmental organizations:

- Provincial and Territorial governments reference the Agency's surveillance data on their websites and in their reports and materials – including risk assessments. This information appears to be timely, and is in line with what other countries are making publically available.
- Diagnostic services (of which the Agency does thousands a year) provide a direct impact on Canadians through diagnosis and scientific evidence for other products and activities, such as surveillance and monitoring, delivering on the International Health Regulations and travel health notices.
- The implementation of the Agency's Action Plan on Lyme Disease's education and awareness campaign has had extensive reach and key messages were used consistently. Online consultations with the public, including key stakeholders, as part of early work to inform the Federal Framework on Lyme Disease suggests that Canadians want to see enhanced diagnostic testing and reporting, better informed physicians and more collaboration with key stakeholders in endemic areas.
- The Agency has provided leadership on many fronts, including training and capacity building (e.g., research and diagnostic testing methodologies, emergency response training, bio-containment operations and maintenance) both nationally and internationally.

- Finally, evidence suggests that relationship building and informal arrangements over many years has led to the Agency's successful involvement in responding to non-enteric zoonotic events.

Yet non-enteric zoonotic disease activities are not organized in the Agency as a distinct program. In addition, current activities appear to be based primarily on pre-established and informal relationships between Agency experts and partners. While these relationships are appreciated and valued by stakeholders, there are concerns that a lack of formal ongoing collaborative activities may impact the ability to share information, exchange ideas and appropriately prevent, detect and respond to emerging and re-emerging non-enteric zoonotic diseases that fall outside of the Agency's priorities of West Nile virus and Lyme disease.

Demonstration of Economy and Efficiency

Efficiencies were demonstrated during the course of the evaluation, such as the natural reduction of the cost to the Agency when developing surveillance for emerging diseases like West Nile as knowledge and capacity is transferred to the provinces. The Agency is also meeting, in the vast majority of cases, turn-around times for diagnostic testing as outlined in the Guide to Services. In addition, it was evident that stakeholders perceived the Agency's activities to positively impact the overall prevention, detection and response to non-enteric zoonotic diseases.

During the conduct of the evaluation, the Agency was working on revising the program logic and performance measurement strategy for these activities. However, without these finalized products, it was difficult to determine proper performance measures, although the evaluation was able to provide evidence of the successes and challenges of the Agency's activities in this area.

RECOMMENDATIONS

Recommendation 1

In light of the increasing need for activities related to non-enteric zoonotic diseases, review the Agency's strategic approach in this area, including formalized structures to support the collaborative efforts consistent with a 'One Health' approach.

There is an increased need for the Agency to address zoonotic diseases as they constitute the largest number of emerging pathogens (approximately 75%, including enteric diseases) and have the potential to pose a sudden health risk to Canadians. Moreover, important considerations such as climate change and variability, global trade and travel, and AMR and the recent outbreak in the Americas of the Zika virus and the subsequent WHO declaration (PHEIC) simply reinforce and augment the need for the activities undertaken by the Agency to prevent, detect and respond to non-enteric zoonotic diseases. As noted previously, the Agency focussed on the prevention, detection of and response to West Nile virus and Lyme disease over the past few years. Stakeholders have noted the need for a wider non-enteric zoonotic set of activities which could address any emerging or re-emerging disease in Canada.

This evaluation found that the Agency recognizes both the multijurisdictional and multidisciplinary nature of zoonotic diseases, including environmental, animal and human health aspects. Furthermore, the Agency has identified zoonotic diseases as priorities to be addressed, for example the prominence of infectious disease risks (including zoonotic diseases) identified in the Corporate Risk Profile. However, the internal and relevant external stakeholder organisational management and governance structures to strongly support the collaborative approach to zoonotic activities needs to be created (or re-established) to permit effective working partnerships for surveillance and monitoring, reference services, education and awareness raising, outbreak management and research (laboratory, field, epidemiological).

Recommendation 2

Articulate and track the Agency's response to non-enteric zoonotic disease events in order to determine the effectiveness of activities, advance learning and provide necessary information for the prioritization and resourcing of activities during a response commensurate with risk.

From the limited and retrospective information available, including evidence from some key external interviews, the Agency appears to be effective in responding to zoonotic non-enteric events. However, the lack of performance measurement information, specifically documented tracking of outbreak response activities, made it difficult to capture the Agency's activities over the past five years. Articulating and tracking response activities would provide the evidence required to appropriately assess surge capacity needed for these types of events as well as activities which could be de-prioritized during a response situation.

Management Response and Action Plan

Evaluation of the Public Health Agency of Canada Non-Enteric Zoonotic Activities

Recommendations	Response	Action Plan	Deliverables	Expected Completion Date	Accountability	Resources
1. In light of the increasing need for activities related to non-enteric zoonotic diseases, review the Agency's strategic approach in this area, including formalized structures to support the collaborative efforts consistent with a "One Health" approach.	Agreed.	The Agency recognizes the need to engage in a more programmatic response to non-enteric zoonotic diseases and other emerging infectious diseases. Management of CFEZID and NML will develop a strategic approach to respond systematically to non-enteric zoonotic diseases.	**1(a)** Develop a strategic plan for the Agency's non-enteric zoonotic disease activities, with options for a comprehensive program on emerging infectious diseases.	March 31, 2018	ADM, Infectious Disease Prevention and Control Branch DG, Centre for Food-borne, Environmental and Zoonotic Infectious Diseases (OPI) DG, National Microbiology Laboratory (OSI)	To be completed using existing resources. Further resource requirements to be determined pending decisions on program options.
		Continue to maintain the health portfolio governance structure on non-enteric zoonotic diseases in support of the PHAC-CFIA MOU (i.e., PHAC-CFIA Steering Committee on Non-enteric Zoonotic Infectious Diseases). The Agency is currently analyzing the Action Plan on Lyme Disease for application to other emerging diseases as well as leading the implementation of the *Federal Framework on Lyme Disease Act.* The Agency will review the zoonotic outbreak response practices, and apply learnings from the Zika response to inform the work on the approach for the Agency's non-enteric zoonotic disease program. The Agency will continue to work with various human, animal, and environmental health partners to update various plans (e.g., Canadian Rabies Management Plan).	**1(b)** Explore options for communities of practice for non-enteric zoonotic diseases in support of PHN (F/P/T governance), building on the collaboration on WNv and Zika.	March 31, 2017		

Recommendations	Response	Action Plan	Deliverables	Expected Completion Date	Accountability	Resources
2. Articulate and track the Agency's response to non-enteric zoonotic disease events in order to determine the effectiveness of activities, advance learning and provide necessary information for the prioritization and resourcing of activities during a response commensurate with risk.	Agreed.	Apply learnings from foodborne outbreak management to develop and implement a zoonotic disease event tracking system.	**2(a)** Review and examine Agency non-enteric zoonotic response activities (including analysis of other outbreak management activities) to inform appropriate event tracking system for the Agency on zoonotic diseases.	September 2016	ADM, Infectious Disease Prevention and Control Branch DG, Centre for Food-borne, Environmental and Zoonotic Infectious Diseases	To be completed using shared resources (NML & CFEZID)
			2(b) Develop and implement a non-enteric zoonotic event tracking system (including identification of activities / resources needed to be reassigned to the event).	Q4 2017-18	DG, National Microbiology Laboratory	

1.0 Evaluation Purpose

The purpose of the evaluation was to assess the relevance and performance of the Agency's non-enteric[ii] zoonotic activities for the period from 2010-11 to 2015-16. The evaluation was also designed to assess the uses and impacts of the Agency's non-enteric zoonotic products and services.

2.0 Description of Non-Enteric Zoonotic Activities

2.1 Program Context

Zoonotic infectious diseases are transmitted between animals and humans and are caused by all types of pathogenic agents, including bacteria, parasites, fungi, and viruses.[1] These types of diseases are of interest to the Agency because of their potential risk to human health and the possibility of sudden case surges and/or outbreaks.

The Agency seeks to reduce the risk of zoonotic diseases in Canada by collecting, analyzing, and sharing information, in addition to working with its international partners (e.g., World Health Organization, Pan-American Health Organization, European Centre for Disease Prevention and Control, U.S. Centres for Disease Control and Prevention).

Additionally, the Agency assesses the financial, social and economic cost of zoonotic infectious diseases to Canadians. The Agency's work assists governments at the federal, provincial/ territorial and local levels to develop policies and programs by providing evidence-based recommendations.

The following are examples of current priority non-enteric zoonotic and vector-borne diseases for the Agency (although other zoonotic diseases will be covered):

- Lyme disease – a bacterial illness transmitted to humans through the bite of infected blacklegged ticks.
- West Nile virus (WNv) – a virus spread by mosquitoes that have fed on the blood of infected birds. WNv can infect a variety of mammals, including horses, humans and domestic and wild birds (particularly crows, blue and grey jays, ravens and magpies).
- Avian influenza – a contagious viral infection that can affect several species of food producing birds as well as pet birds and wild birds.
- Chikungunya – a viral illness spread to humans through the bite of an infected mosquito.

ii An enteric illness affects the stomach or intestinal tract, often causing nausea, vomiting, abdominal cramps and diarrhoea. Non-enteric illness affects organs other than the digestive tract.

- Zika virus – a mosquito-transmitted pathogen causing an expanding outbreak in Central and South America, the Caribbean and Mexico, which may be responsible for microcephaly in babies and neurologic symptoms in adults. Because the Aedes-species mosquitoes that spread Zika virus (*Aedes aegypti & Aedes albopictus*) are found throughout much of the world, it is likely that the outbreak will spread to new countries. Currently no vaccine or treatment is available for Zika virus. Note that the evaluation did not focus on the Agency's activities in this area, due to the recency of this expanding outbreak.
- Rabies – a viral illness spread via the saliva of an infected animal. This usually occurs through biting another animal or a human. Transmission can also occur through saliva touching an open wound or touching mucous membranes. Any mammal can spread rabies; however, in Canada the animals that most often transmit rabies are bats, skunks and foxes.

2.2 Program Profile

Zoonotic activities undertaken by the Agency are conducted primarily by the Infectious Disease Prevention and Control Branch via the Centre for Foodborne, Environmental and Zoonotic Infectious Disease (CFEZID) and the National Microbiology Laboratory (NML).[iii]

CFEZID serves as the Agency's program and policy lead on zoonotic and emerging infectious diseases. Three divisions within CFEZID have responsibility for leading activities related to zoonotic infectious diseases, including the Zoonoses Division, Program Development and Integration Division, and the Environmental Issues Division. During the course of this evaluation, it was announced that these divisions/teams will be merged into one division under the leadership of a new Director.

The Zoonoses Division provides surveillance and monitoring leadership, technical expertise on zoonotic and vector-borne diseases. The division works with P/Ts, key partners and stakeholders across a range of sectors to coordinate national monitoring, surveillance, planning and response activities related to existing, emerging and re-emerging zoonotic diseases as well as rapid risk assessments, and epidemiological research. This work is undertaken with the Environmental Issues Division and Program Development and Integration Division as well as through collaboration, research and guidance from the Agency Laboratories. The division conducts risk analyses and modeling activities to assess the risk and consequences of infection by zoonotic pathogens. The division also responds to and provides content expertise to support outbreak investigations at international, national, provincial and territorial levels.

The Program Development and Integration Division (PDI) provides a policy lens on complex health issues through which CFEZID program and scientific program areas are further developed. It undertakes detailed analysis of technical advice from program areas and coordinates input, and provides non-technical subject matter expertise. It also provides policy capacity and strategic thinking and analysis in drafting strategies, plans, policies and

[iii] Note that not all of these areas of responsibility are in scope for this evaluation. Please see Section 3.1 – Evaluation Scope, Approach and Design for a description of what is included in this evaluation.

frameworks. Related to zoonotic infectious diseases, the PDI Division provides policy advice on complex health issues including Lyme disease and emerging and re-emerging vector-borne diseases. PDI Division developed and manages the Agency's Lyme Disease Action Plan and is the lead on implementing the legislative requirements for the *Federal Framework on Lyme Disease Act*.

The Environmental Issues Division (EID) in CFEZID is the Agency's lead on climate change adaptation and public health. This Division addresses climate change impacts on food-, water- and vector-borne infectious diseases, with consideration of the human, animal, and ecosystem interface. The EID leads the Agency's Preventative Public Health and Adapting to a Changing Climate program and provides oversight on several initiatives such as the development of the Climate Change Adaptation and Public Health toolkit (a web-based resource for public health professionals to enhance their ability to respond rapidly to vector-, food-, and water-borne disease events, and to reduce and mitiga the occurrence of infectious diseases). The EID also funds and/or develops models for disease surveillance, control and adaptive response for F/P/T public health decision- making and action on emerging vector-borne zoonoses in Canada.

The NML is responsible for the identification, control and prevention of infectious diseases. The NML is Canada's main infectious disease public health laboratory with responsibility for reference microbiology and quality assurance, laboratory surveillance for infectious diseases, emergency outbreak preparedness and response, training, risk analysis and research and development. Recently, the NML merged with the former Laboratory for Foodborne Zoonoses (LFZ) which focuses on preventing infectious and chronic diseases by looking at public health risks that come from the interactions between animals, humans and the environment – also known as the 'One Health' approach. The lab works with provincial, federal and international public health partners to address priority public health risks in an integrated and proactive manner.

The NML specifically houses a Zoonotics and Special Pathogens division with the following sections:

- Field Studies, Zoonotic Diseases and Special Pathogens
- Rabies, Rickettsia and Related Zoonotic Diseases
- Special Pathogens
- Viral Zoonoses

Currently, zoonotic disease activities are not organized in the Agency as a distinct program but rather a set of activities under CFEZID and NML, who collaborate regularly, as needed.

2.3 Program Narrative

The evaluation used two draft logic models[iv] as the most recent articulation of CFEZID and NML's program theory. The long term expected outcome for CFEZID is "*Canadians and others living in Canada are protected from health risks associated with foodborne, environmental, and zoonotic infectious diseases and antimicrobial resistance (AMR),*" while the NML's expected outcome is that "*Canadians are protected from the health risks associated with infectious diseases*."

Specifically, the Agency conducts the following activities to support these outcomes:

CFEZID:

1) Active and Passive Surveillance and Epidemiological Research (Knowledge Creation)
   - Sample collection Diagnostic Support
   - Data collection and analysis
   - Epidemiological Research and Interpretation
2) Education and Knowledge Transfer
   - Providing Information and Advice
   - Raising Awareness and Knowledge
   - Capacity Building and Training
3) Governance to Enable Leadership
   - Development and Implementation of Infectious Disease Frameworks and Strategies
   - Networking / Liaison, collaboration, public health leadership (governance, frameworks, etc.)
4) Outbreak Investigation and Response
   - Outbreak Analysis
   - Outbreak Risk Assessment / Modelling

[iv] To obtain a copy of the Logic Models for the NML and for the CFEZID, please use the following e-mail "Evaluation Reports HC - Rapports Evaluation@hc-sc.gc.ca".

NML:

1) Microbiology Reference Services
   - Detecting and characterizing human infectious diseases
   - Analyzing, interpreting, synthesizing and reporting laboratory data
2) Applied and Discovery Research
   - Generating, documenting, developing and applying knowledge related to infectious diseases and their risk to the public through systematic investigations
3) Laboratory-based Surveillance
   - Monitoring and assessing infectious disease incidence and trends using data generated through laboratory detection and analysis
4) Emergency Preparedness and Outbreak Response
   - Planning, prepare for, and respond to infectious disease emergency, outbreak and pandemic events
5) Leadership, Training, Network and Capacity Building
   - Supporting/leading national and international laboratory networks
   - Providing training and educational opportunities
   - Developing and maintaining laboratory surge capacity

The connection between these activity areas and the expected outcomes is depicted in the logic models (to obtain a copy of the Logic Models for the NML and for the CFEZID, please use the following e-mail "Evaluation Reports HC - Rapports Evaluation@hc-sc.gc.ca". The evaluation assessed the degree to which the activities articulated in the logic models created tangible impacts over the evaluation timeframe.

2.4 Program Alignment and Resources

The activities reviewed for this evaluation can be found within the following areas of the Agency's Program Alignment Architecture (PAA):

- PAA 1.2.1.3 – Food-borne, Environmental and Zoonotic Infectious Diseases (CFEZID)
- PAA 1.1.3 – Public Health Laboratory Systems (National Microbiology Laboratory)

The financial data for the years 2010-2011 through 2014-2015 are presented below (Table 1) and include full-time equivalents (FTE's), as well as planned and actual spending. Overall, the Agency spent approximately $35.5 million for its non-enteric zoonotic activities over 5 years.

Table 1: Zoonotics FTE, Planned and Actual Spending (2010-2015), in $ millions

FY	CFEZID*			LNM						Totals		
				NML**			LFZ***					
	FTE	Planned	Actual	FTE	Planned	Actual	FTE	Planned	Actual	FTE	Planned	Actuals
2010-11	14.4	2.4	2.4	32.0	4.9	5.2	9.5	1.2	1.0	**55.9**	**8.5**	**8.6**
2011-12	13.5	1.9	1.9	24.0	3.5	3.7	9.5	1.1	1.0	**47.0**	**6.5**	**6.6**
2012-13	9.2	1.4	1.7	23.0	3.4	3.6	8.0	1.0	0.9	**40.2**	**5.8**	**6.2**
2013-14	10.9	1.4	1.7	28.0	3.9	3.9	8	1.1	1.0	**46.9**	**6.4**	**6.6**
2014-15	14.2	1.1	2.1	32.0	3.6	4.4	8	0.9	1.0	**54.2**	**5.6**	**7.5**

* These numbers include the following components: Program Development and Integration/Executive Director, Environmental Issues Division (Zoonoses Related), Zoonoses Division

** These numbers only include the Zoonotic Diseases and Special Pathogens Division; planned amounts are inclusive of in-year approved adjustments; capital funding and Ebola deployments not included

*** These numbers only include the zoonotic portion of LFZ's work (percent estimate applied to cost centres where a portion of work included zoonotics); capital funding not included

3.0 Evaluation Description

3.1 Evaluation Scope, Approach and Design

The scope of the evaluation covered the period from April 2010 to December 2015 and included non-enteric zoonotic infectious disease activities – vectorborne and non-vectorborne (CFEZID and NML); vectorborne surveillance and risk assessment (CFEZID and NML); and laboratory and diagnostic research (NML). The evaluation did not cover foodborne enteric illness activities and waterborne infectious diseases; clean air; prion diseases; migration and travel health; as well as Ebola and anti-microbial resistance as all have been or will be the subject of previous or future evaluations.

The evaluation issues were aligned with the Treasury Board of Canada's *Policy on Evaluation* (2009) and considered the five core issues under the themes of relevance and performance, as shown in Appendix 1. Corresponding to each of the core issues, specific questions were developed based on program considerations and these guided the evaluation process.

As the Agency is currently reviewing its approach to performance measurement, the revised logic models for both CFEZID and NML were not finalized at the time of the evaluation. Consequently, the evaluation focused on the uses and impacts of the Agency's activities rather than assess the progress made towards the achievement of expected outcomes. This approach is in line with the pilot of a new methodology (Rapid Impact Evaluation) by the Treasury Board Secretariat in which the Agency agreed to participate. The Rapid Impact Evaluation methodology focuses on "the assessment of the incremental contribution of the direct effects to impacts" as well as the "assessment of the change in direct effects and impact attributable to the intervention," and is expected to be more timely than a typical evaluation.[2]

The Treasury Board's *Policy on Evaluation* (2009) also guided the identification of the evaluation design and data collection methods so that the evaluation would meet the objectives and requirements of the policy. A non-experimental design was used based on the Evaluation Framework document, which detailed the evaluation strategy for this program and provided consistency in the collection of data to support the evaluation.

Data for the evaluation was collected using various methods, which included a literature review, a document review, a stakeholder survey and key informant interviews. The stakeholder survey was sent to 145 external stakeholders and received a response rate of 30 percent. The primary purpose of the survey was to gather information on the uses and impacts of Agency products and services, collaboration with stakeholders, and challenges/areas for improvement. Key Informant interviews were conducted with 18 Agency staff and external experts to gather in-depth information, including individual perspectives, explanations, examples and factual information to address many of the evaluation questions related to relevance and performance.

More specific detail on the data collection and analysis methods are detailed in Appendix 2. In addition, data were analyzed by triangulating information gathered from the different methods listed above. The use of multiple lines of evidence and triangulation were intended to increase the reliability and credibility of the evaluation findings and conclusions.

3.2 Limitations and Mitigation Strategies

Table 2: Limitations and Mitigation Strategies

Limitation	Impact	Mitigation Strategy
Piloting a new methodology (Rapid Impact Evaluation)	This added a learning curve for the evaluators, and the differences between the approach and the realities of evaluation in a Canadian government context created the possibility of significantly increasing the timelines and cost set out for this evaluation.	The evaluation integrated as much from the methodology as was deemed appropriate for its timelines, the Agency and for evaluation in a Canadian government context.
Revised program logic not finalized	This made it difficult to determine proper performance measures.	The evaluation measured the uses and impacts of activities rather than assess the extent to which an outcome has been reached.
Lack of performance measurement data on response to zoonotic events	This made it difficult to assess the number of events that occurred, the impact of these events on staff and their ability to conduct routine work during a response.	The evaluation provides a recommendation to strengthen this area.

4.0 Findings

4.1 Relevance: Issue #1 – Continued Need for the Program

There is an increasing need for the Agency to address zoonotic diseases. Although there are a small number of human health cases in comparison to other diseases, the majority of emerging pathogens are zoonotic, and there is the potential for a sudden impact on the Canadian population. Factors such as climate change and variability and global trade and travel increase the likelihood of emerging diseases in Canada.

Considerations

The review of documents identified a number of important considerations which reinforce the need for the activities undertaken by the Agency.

First, sources note that of the globally known human pathogens, over 61% are zoonotic, and approximately 75% of all new pathogens (which would include both enteric and non-enteric diseases) in the past decade were zoonotic.[3,4,] While in Canada the number of human cases of non-enteric zoonotic diseases is relatively small, there remains the potential for a sudden surge in cases, whether from an existing or emerging disease. For example, there was a sudden and significant increase in the number of cases of West Nile virus from 154 in 2006 to 2,041 in 2007, which then dropped to 38 in 2009.[5] In addition, the spread and number of cases of Lyme disease in Canada is projected to increase significantly from 250 cases in 2010, with a range largely in southern Ontario, Quebec, and some of the Maritime provinces, to 18,000 cases in the 2050s, with a much wider geographical range.

The second of these considerations is climate variability, which is "the way climate fluctuates yearly above and below a long-term average value"[6] and longer term climate change. As areas become warmer, they are better able to support vectors such as mosquitos and ticks, increasing the risk that diseases such as WNv, Lyme disease, Chikungunya and dengue will become endemic in new regions.[7,8,9] In addition, as vectors are capable of carrying a variety of zoonotic diseases, many more diseases may become endemic in Canada. For example, the blacklegged tick is capable of carrying Lyme disease, but also pathogens such as *Anaplasma phagocytophilum*, *Babesia microti*, and the Powassan virus.[10] It has also been suggested that the increase in cases of Rabies in northern Canada is partly due to climate variability, as the habitat changes and animal behaviour changes, for example, seeking food in locations closer to humans.[11,12]

A third consideration is global travel, trade and commerce, all of which are methods for zoonotic diseases to spread into different regions, or to be transmitted to Canadians visiting other countries. Travel, including trade and tourism, to and from Canada has increased the risk of zoonotic diseases spreading into this country,[13,14,15] including by unintentionally introducing invasive alien species or importing animals into Canada which could potentially carry disease.[16,17] While some diseases are unable to become endemic in Canada because the climate

does not allow the vector to survive, travellers are at risk of contracting these illnesses while in endemic regions. Chikungunya is an example of this issue, where all cases of the disease are seen in Canada in travellers returning from endemic regions.[18] In another example, in the later stages of the evaluation, Zika virus was declared a 'Public Health Emergency of International Concern' by the World Health Organization on February 1, 2016 due to its "potential association between microcephaly and other neurological disorders."[19] For this reason, the use of preventive actions before and during anticipated travel to endemic areas is important, including vaccinations (e.g., Rabies) and the use of insect repellants and protective clothing (e.g., WNv, Chikungunya, Zika virus).[20,21,22,23]

Antimicrobial resistance (AMR) is the fourth important consideration identified. As outlined by the World Health Organization (WHO), a significant danger associated with AMR is that antimicrobial treatments can become ineffective as microorganisms become able to withstand the attack by antimicrobial drugs (i.e., antibiotics). Patients can then be infectious for a longer period of time and increase the risk of spreading the disease, and strains of the diseases can evolve, causing additional treatment problems.[24,25] Furthermore, a 'One Health' approach to AMR is appropriate [26,27,28] given that bacteria carrying AMR genes and antibiotic residues can be spread in the environment, including in wild and domesticated animals, which can become reservoirs of resistance and a source of reintroduction of resistant bacteria into the food-animal and human reservoirs."[29]

Non-enteric zoonotic infectious diseases in Canada

The following table (Table 3) outlines a number of the most commonly known or tested non-enteric zoonotic diseases in Canada. It is important to note that the NML conducts diagnostic tests for a wide range of zoonotic and vector-borne diseases, including ones endemic in Canada and ones that may be contracted in other regions, such as Q Fever, Dengue and Yellow Fever. A number of the non-enteric zoonotic diseases monitored and tested for by the Agency are rarely seen in humans, but the risk of outbreaks or a change in their endemic region means that continued surveillance is critical.

Table 3: Selected Zoonotic Diseases and Trends[v]

Disease	Common Signs and Symptoms	Number of cases in Canada in 2014	Trend	Vulnerable / susceptible population	Highest Burden
Lyme disease	Fatigue, fever, headache, skin rash then neurological cardiac and arthritis manifestations, can lead to long-term health problems. [30]	522[31]	Increase in incidence since 2009.	People who work or participate in outdoor activities in areas where the tick is prevalent.[32]	Southern areas of BC, MB, QC, ON, and parts of NB and NS[33]
West Nile virus	In mild case, fever, headache, body aches, mild rash, swollen lymph glands, but potentially fatal encephalitis occurs in approximately 10% of cases. Some people will	21 per 100,000[35]	Weather-driven interannual variations in incidence. The highest rate was 7.3 per 100,000 in 2007, and the lowest was	People working or participating in outdoor activities where the mosquito is prevalent; pre-existing health conditions, and over the age of 50.[36]	QC, ON, MB, SK, AB, BC[37]

[v] Additional details about the zoonotic diseases in this table are found in Appendix 3.

Disease	Common Signs and Symptoms	Number of cases in Canada in 2014	Trend	Vulnerable / susceptible population	Highest Burden
	develop more serious and long-term symptoms.[34]		0.01 in 2010.		
Chikungunya virus	Fever, arthritis-like joint pain, rash. Symptoms can appear similar to Dengue fever.[38]	429[39]	A significant increase in confirmed cases in Canada from 15 in 2013 to 429 in 2014, only among people travelling outside Canada.	Travellers to Caribbean countries and Asia-Pacific region where continuing outbreaks are increasing.[40]	Not endemic in Canada. [41]
Hantavirus	Tiredness, dizziness, fever, chills, muscle aches, nausea and vomiting, stomach pain, coughing and death from respiratory failure in a high proportion of cases. Can lead to long-term health problems in those that recover.[42,43]	10[44]	Substantial increase in past two years (2013 & 2014)[45]	People involved in outdoor activities, rural and forest-related activities, outdoor military training.[46]	AB, BC, SK, MB[47]
Rabies	Once symptoms have begun the disease is almost always fatal in humans. [48]	0 cases in humans	Only 3 cases of Rabies in humans from 2005-2013.[49] There were 92 confirmed animal cases in 2014.[50]	Veterinarians, animal control and wildlife workers, hunters and trappers in Canada, and travellers to endemic areas overseas.[51]	Animal cases confirmed in all P/T since 2009 except Yukon.[52,53,54,55]
California serogroup viruses (CSG) (e.g., Jamestown Canyon virus, snowshoe hare virus)	Headache, fever, dizziness, vomiting, stiff neck, lethargy. Most infections result in mild illness, however, cases of meningitis and encephalitis have been documented. [56,57,58]	15 cases (including one neurological case)	Case numbers remain fairly consistent from year to year.	Although CSG cases involve all age groups, snowshoe hare virus has been more commonly associated with cases of neuroinvasive disease in children,[59] while Jamestown Canyon virus appears to primarily cause disease in adults.[60]	Virus activity demonstrated in all provinces and territories.[61]
Brucellosis	Fever, headache, weakness, sweating, chills, weight loss, joint pain, and fatigue.[62, 63]	19 in 2013[64]	Number and rate remained fairly steady from 2005-2013.	Farmers, hunters, animal handlers, veterinarians, laboratory workers and people travelling to endemic regions overseas.[65]	Wildlife reservoirs in Wood Buffalo National Park and in Arctic, sub-arctic regions[66]
Avian Influenza in wild birds (H5N1 & H7N9)[67,68]	Symptoms in birds include fewer eggs, soft-shelled or shell-less eggs, diarrhea, high and sudden high mortality rate, quietness.[69] Severe influenza and death in humans for some virus types.	16 H5N1 outbreaks in poultry between Jan 1 2008 and April 22, 2015.[70]	Monitoring of live and dead wild birds continues. (CWHC)	Poultry workers are at higher risk.[71] Some Aboriginal Canadians may be at higher risk because of subsistence harvesting of wild birds.[72]	Recent outbreaks in poultry in BC, ON, including H5N1 strain[73]

4.2 Relevance: Issue #2 – Alignment with Federal Roles and Responsibilities

Program authorities clearly articulate both disease-based (i.e., West Nile virus, Rabies, Lyme disease, Avian Influenza) and functional (i.e., Labs and surveillance) activities. The Agency's collaborative approach to zoonotic activities is consistent with the 'One Health' approach.

The Agency's non-enteric zoonotic disease activities are aligned with federal roles and responsibilities, as laid out in Program Authorities, and are also aligned with the 'One Health' approach.

Policy Authorities

The Agency has cabinet authorities for specific zoonotic activities which clearly articulate a mandate for the Agency in addressing specific zoonotic *diseases*, namely WNv, Lyme disease, and Rabies. In addition, these authorities allow for activities in the area of 'emerging diseases' or those that are not known or endemic in Canada. Activities addressing Chikungunya, for example, would be covered by these authorities.

Cabinet authorities also clearly articulate zoonotic disease *functions* which are appropriate for the Agency to undertake. In particular, surveillance, risk assessment, policy development, educational activities, research and outbreak response are all stipulated in various cabinet authorities. Some of these functions fall outside a traditional human health mandate for the Agency, such as the testing of vectors (ticks such as Lyme disease) by the NML. This may not be understood as a traditional public health activity (i.e., testing of non-human samples), but is an internationally-recognised method of surveillance for vector-borne diseases of public health significance, and no other departments have responsibility for this type of testing when the disease has no consequences for livestock production/trade (in the case of the Canadian Food Inspection Agency) or environmental impacts (in the case of Environment and Climate Change Canada).

Additionally, the Agency has binding obligations under the *International Health Regulations* (IHR).[74] Although no specific reference is made in the IHR to non-enteric zoonotic diseases, it applies to these diseases and requires the Agency to perform many zoonotic disease-related activities, including the development and maintenance of surveillance systems, the assessment and notification of events, the sharing of information, producing reports, and responding to public health risks and emergencies. The activities undertaken by the Agency suggest that it is meeting its obligations under the IHR.

Furthermore, Cabinet Authorities authorize the Agency to establish networks and partnerships with other agencies (i.e., Other Governmental Departments (OGDs), Provincial and Territorial (P/T) governments, the Canadian Wildlife Health Cooperative (CWHC) and other NGOs, academia, and international organizations) in order to focus on zoonotic disease activities such as surveillance and promoting public education and awareness. The Agency works with many other

agencies such as the Canadian Food Inspection Agency (CFIA), provincial laboratories, and Canadian Blood Services and Héma-Québec. In addition, the Agency has a number of agreements with other countries, including the United States and Mexico, and with international organizations, including the WHO, the U.S. Centre for Disease Control (CDC) and the European Centre for Disease Prevention and Control.

'One Health'

These authorities fall in line with the 'One Health' approach, which is a multi-disciplinary and multi-sectoral concept acknowledging interconnectability of the human, animal, and environmental health areas, and so require a collaborative approach from agencies specializing in each health area. The concept is that collaboration will "advance health care by accelerating biomedical research discoveries, enhancing public health efficacy, expanding the scientific knowledge base, and improving medical education and clinical care for the purpose of protecting and saving lives in our present and future generations."[75] While the concept of the interconnectedness of human, animal and environmental health is not new, the 'One Health' approach was spurred by outbreaks of various zoonotic diseases, such as SARS, WNv, and Avian influenza.[76] It is important to note that the Agency has had a collaborative 'One Health' approach to zoonotic diseases long before the term was coined.

The 'One Health' approach is applicable to three key objectives in public health: prevention; detection; and response.[77,78] These three objectives are often closely linked and dependent on each other, but are also dependent on the multi-disciplinary approach of 'One Health,' with an emphasis on collaboration between organizations in the animal, human, and public health fields and amongst countries.[79,80,81,82,83] The application of the 'One Health' approach, involving collaboration between groups that focus on human, animal, and environmental health, is consistent with the Agency's activities of prevention, surveillance, and preparedness and response.

The 'One Health' objective of prevention emphasizes the need for joint educational efforts within and between the different branches of health care to ensure consistent messaging regarding zoonotic diseases.[84] In keeping with this objective, the Agency creates and distributes health promotional materials about zoonotic diseases, such as Lyme and WNv, to inform Canadians of the ways to help reduce the risk of exposure to the diseases.[85,86,87] The Agency has also worked with other organizations (i.e., P/T, NGO) to develop educational materials to best reach the target groups.

The 'One Health' approach further recognizes the importance of using the information identified through the detection of emerging and re-emerging zoonotic diseases to develop and implement adequate and appropriate responses.[88] The Agency is able to conduct investigations into disease outbreaks or events, including non-enteric zoonotic diseases, helping the Agency learn more about the diseases, in addition to providing additional information and recommendations to partners. The Agency's rapid response teams can also be deployed to help Provincial/Territorial (P/T) and local health authorities, particularly in treating and limiting the spread of the disease.[89]

4.3 Relevance: Issue #3 – Alignment with Government Priorities

Zoonotic Disease activities have been identified as a priority of the Agency as reflected in a variety of planning and corporate documents (e.g., Lyme disease activities, Corporate Risk Profile).

Zoonotic infectious disease activities are aligned with the Government of Canada's priorities of "protecting the health and safety of Canadians and their families."[90] The emphasis on the health of Canadians was stated as recently as Spring 2015 in the former government's *2015 Budget Plan*.[91] As part of this commitment, the Government of Canada has, since 2006, invested nearly $5 million for Lyme disease research.[92]

Further to this commitment, Parliament enacted the *Federal Lyme Disease Framework Act* in 2014. [93] The *Act* articulated that Canadians would benefit from the establishment of guidelines and enhanced sharing of best practices regarding the prevention, identification, treatment and management of Lyme disease, a coordinated national effort to track the spread of the disease through an enhanced surveillance system, and increased public education and awareness to better prevent and detect instances of Lyme disease in Canada. The Minister of Health was required to convene a conference with the provincial and territorial ministers and stakeholders, including representatives of the medical community and patients' groups, for the purpose of developing a comprehensive federal framework on Lyme disease.

The Government of Canada, in its statement on World Health Day in 2014, stated its commitment to protect Canadians from vector-borne diseases such as Lyme disease and West Nile virus. This included collaboration between the federal, provincial, and territorial health authorities and partners to improve "surveillance, prevention and control, and research and diagnosis."[94] On January 26, 2015, the then Minister of Health spoke about the first case of H7N9 in Canada, and said that the Government of Canada "is committed to disease surveillance and is working closely with its public health partners across the country and world."[95]

Zoonotic diseases are one of the Agency's priorities, and as such the zoonotic disease activities align with the Agency's four key priorities listed in its Strategic Plan (*2013-2018 Strategic Horizons*).[96] The Strategic Plan emphasized the need for prevention and surveillance of infectious diseases, responding to new and emerging health issues, and continuing collaboration with the Agency's many partners.

As discussed previously, cases of non-enteric zoonotic diseases remain relatively low in Canada, but are expected to increase, both because the range of the vectors will spread, and because it is projected that additional zoonotic diseases will become endemic in the country. According to the Corporate Risk Profile (2013-15),[97] three of its five corporate ris ks are specific to infectious disease, which can include zoonotic diseases:

1. Emerging and Re-Emerging Infectious Respiratory Diseases – Pandemic (including, but not limited to influenza): There is a risk that the Agency will not be able to effectively monitor, detect and coordinate a response to infectious respiratory disease outbreaks, and effective medical countermeasures will not be available, leading to significant morbidity and mortality, adversely affecting the public's trust in the Agency.

2. Infectious Disease – Antimicrobial Resistance (AMR): There is a risk that the absence of a comprehensive national action plan may exacerbate the growing impact of antimicrobial resistance on the health and well-being of Canadians, leading to a loss of public confidence in the Agency.

3. Infectious Disease – Emerging and Re-Emerging Vector-Borne Zoonotic Infectious Diseases (Lyme disease): There is a risk that the total burden of vector-borne disease will increase without a national approach to monitor and assess these diseases and to enable the implementation of prevention and control measures, adversely affecting the public's trust in the Agency.

As part of the response to the risks of zoonotic diseases, the Agency has stated in its 2015-16 Report on Plans and Priorities that it will continue to "work with stakeholders to monitor the emergence and impact of vector-borne pathogens in Canada through laboratory-based testing and surveillance."[98]

The Agency's zoonotic disease activities are critical in mitigating the risk of these diseases to Canadians, and remain a priority for the Agency and the Government of Canada.

4.4 Performance: Issue #4 – Demonstration of Effectiveness

4.4.1 Surveillance (CFEZID and NML)

Partnerships are critical in surveillance activities. Information produced is being used for preparedness and response activities as well as the development of policies and guidelines to help protect Canadians against emerging diseases such as West Nile.

The World Health Organization states that with regard to infectious diseases, "effective public health surveillance is critical for the early detection and prevention of epidemics."[99] And since Canada is a signatory to the World Health Organization's International Health Regulations (2005), it must have sensitive and flexible surveillance systems that allow for "the rapid detection of public health risks, as well as the prompt risk assessment, notification, and response to these risks."[100]

Effective surveillance systems require that various organizations work in partnership to gather the necessary data to monitor and detect vectors and the pathogens they may carry. The Agency's partners play a significant role in detecting, monitoring, researching and/or managing zoonotic diseases from either a human or animal/wildlife health perspective, and range from

other federal government departments, provincial governments, provincial laboratories, non-governmental organizations, universities, and international organizations. Together, they work to better understand the incidence and trends of zoonotic diseases in Canada and globally, which informs public health interventions and the measures that are put in place, including prevention activities.

For example, the West Nile virus surveillance system is a collaborative effort between the Agency, provincial and territorial Ministries of Health, the Canadian Food Inspection Agency, Health Canada's First Nations and Inuit Health Branch, the Canadian Wildlife Health Cooperative (CWHC), Canadian Blood Services, and Hema-Quebec. With the exception of the CWHC, these partners collect data for their own purposes and share the results with the Agency in order to contribute to an integrated national picture of West Nile virus in Canada that can detect potential outbreaks and inform required activities.[101] The CWHC is contracted by the Agency to conduct surveillance on wildlife; this partnership has since been modelled by other countries such as Australia and parts of Europe.

The uses of the Agency's surveillance are many. From an Agency perspective, surveillance data is used to inform a number of other zoonotic activities, such as reference/diagnostic services (and vice-versa), risk assessments and modelling, policy and program development and outbreak preparedness and response. It was noted by key informants that these other activities cannot be effectively undertaken without surveillance. The Agency further uses its surveillance data to produce travel advisories, public health notices, awareness and education activities for the public, develop tools and guidelines for health professionals and stakeholders, inform research, and report on domestic (Departmental Performance Reports – in conjunction with P/T partners) and international (World Health Organization) commitments.

As for P/T partners, the evaluation found that all jurisdictions reference the Agency's surveillance data on their websites and in their reports and materials. This includes preparedness and prevention plans and risk management guidelines for both Canadians and public health professionals. The strong working relationships that have been formed between the Agency and the P/Ts and other organizations have translated into actionable intelligence being shared multi-laterally.

For surveillance data to be used effectively, it is important that it be timely. The Agency's public reporting of West Nile is consistent with other countries such as the United States, the United Kingdom and organizations such as the European Centre for Disease Prevention and Control, who all report cases within the month. However, the information on other non-enteric zoonotic diseases provided by the Agency is not as timely and can be out of date for internal use or use by stakeholders. For example, the Agency's case numbers on Lyme disease are reported annually to the public, whereas the U.S. reports their Lyme disease case numbers on a weekly basis. Key informants and a few survey respondents noted in their commentary that the Agency's surveillance data could be more timely and easier to find on the website. While it is likely unnecessary for the Agency to report as frequently on Lyme disease numbers as the U.S., these comments reflect a need from stakeholders for more up-to-date public reporting.

West Nile virus and Lyme disease are currently the only non-enteric zoonotic diseases that have formal surveillance systems in place within the Agency, although internal key informants noted the possibility that other mosquito-borne diseases such as Chikungunya may be rolled up into the West Nile virus system. Some key informants and survey respondents expressed an appetite for better collaboration around decisions for what is considered a nationally notifiable disease, as these decisions have a direct impact on other agencies.

It is worth noting that a number of Agency and non-Agency resource issues (both human and financial) were presented by stakeholders around surveillance activities for zoonotic diseases. Specifically, a few stakeholders communicated that when it comes to surveillance, they do not always have the resources available to conduct their own activities. This affects how much information they can collect and consequently, the amount of work they request that the Agency undertake on their behalf as well as their ability to collaborate on these issues. There were also concerns that funding is at times tied to a specific disease or activity (e.g., WNv, Lyme disease), which limits the Agency's flexibility to adapt to changing priorities.

Despite these challenges, the Agency's surveillance products were cited as the most used non-enteric zoonotic products[vi] by survey respondents (who were aware of and used the products) and were considered to be very accurate (90%) and informative (86%).

4.4.2 Reference Microbiology[vii] and Diagnostic Services (NML)

Reference and diagnostic services are the foundation of the Agency's activities for emerging zoonotic diseases. Testing allows for a direct impact on Canadians through the diagnosis of diseases and provides scientific evidence for public health materials such as surveillance and Travel Health notices.

Reference microbiology and diagnostics are at the core of the NML's activities. In relation to zoonotic diseases, the NML is home to the first facility in the world to have high containment laboratories for human and animal health in one building, and is the only facility in Canada to have Biosafety Level 2 to Level 4 laboratories, "allowing it to accommodate the most basic to the most deadly infectious organisms."[102]

---

vi Survey respondents were asked about the following Agency products: Lyme disease surveillance, West Nile virus surveillance, reference/diagnostic services, risk assessments (e.g., risk maps), and public awareness/education materials (e.g., posters, pamphlets, websites).

vii Reference services at the Agency include co-ordinating projects associated with cross-cutting issues at the NML; providing NML representation in support of various public health initiatives and activities; coordinating external quality control monitoring; coordinating external laboratory training programs; -developing policies; and coordinating contractual agreements with external reference centres where specific microbiological reference services are not provided by the NML.

Reference and diagnostic services are critical for three primary reasons. First, they are used to directly diagnose patients who are suspected of having a particular disease. Second, they indicate where the disease is occurring in Canada and therefore form an important component of the Agency's surveillance and risk assessment products. Third, diagnostic information is used in Travel Health Notices, which outline diseases that are not necessarily endemic to Canada, but that can be brought into Canada by people travelling abroad.

Internally, the number of diagnostic tests conducted at the NML has increased over the past few years. In 2012-13, NML conducted 6,554 tests for West Nile, Lyme, Hantavirus and Rabies detection. By 2014-15, testing increased to 9,553, including a surge in testing for Chikungunya. Though the number of tests required for a specific pathogen can fluctuate substantially from year to year, an increase in testing is logical since the NML is the leading laboratory for high-risk pathogens and tests for emerging or re-emerging pathogens when they appear, such as with Chikungunya and more recently, Zika virus. The NML regularly receives specimens when medical practitioners see patients (particularly travellers) with unusual symptoms that may be related to a zoonotic disease.

As with other zoonotic activities, the Agency works collaboratively with stakeholders where possible on reference services and diagnostics. For example, the Agency has formal and informal agreements with the U.S. CDC for the development of diagnostic tests/assays, thus ensuring the best quality tests. The Agency similarly works with P/Ts by testing samples to help determine the prevalence and spread of infected vectors, confirming P/T diagnoses when laboratories do not have enough resources to update or buy the proper equipment, and by transferring knowledge to ensure that they have the necessary information to carry out their work. To this end, the NML has its Guide to Services available online which includes patient criteria, specimen requirements, accompanying documentation, and turn-around-times.[103] Thus, the NML sets the standard for diagnosis, both in doing the diagnoses themselves, and sharing the standards for use in other laboratories across the country.

With few exceptions, stakeholders overwhelmingly commended the NML staff for their professionalism and quality work, as well as their willingness to provide expert advice to other laboratories. Survey respondents who were aware of and used the service noted that reference and diagnostic services were both highly accurate (88%) and informative (87%), though some expressed concern around timeliness, with only 54% saying that the information is timely.

This may be explained, in part, by challenges in availability of particular skill sets at specific times of peak activity. The NML often cannot contract out laboratory work when there is an influx of testing due to the special tests involved. When there is a new pathogen, the NML either has to find a validated assay or develop a new one in house, which can mean starting from scratch and then ensuring that the assay is accurate and performs well. This may be exacerbated in the future by newly emerging pathogens (e.g. Zika virus).

4.4.3 Education Activities and Materials (CFEZID & Communications)

Learning from experiences of West Nile, the Agency, through the Action Plan on Lyme Disease, implemented an educational and awareness strategy on Lyme disease, using a variety of approaches. Campaign reach was broad; however, on-going efforts are required to continue educating the public and the medical community on the disease, its prevalence, and diagnosis.

The Agency is involved in a number of educational activities and produces materials for public and health professionals to raise awareness on infectious diseases. Some examples include annual reports, public communication material on the Agency website about existing and emerging zoonotic diseases, and the Canada Communicable Disease Reports (CCDRs). It is important that information is accurate and shared in a timely manner so that public health interventions and other measures can be put in place. According to stakeholder respondents who were aware of and used the products, 88% believe that the Agency's non-enteric zoonotic education/public awareness materials are accurate, 80% thought they were timely, and 72% said they were informative.

Over the course of the evaluation period, the main focus of the Agency's educational activities for zoonotic diseases has been around Lyme disease. This is largely due to the Federal Action Plan on Lyme Disease that includes 'engagement, education and awareness' as one of its 3 pillars. The Action Plan committed the Agency to the following activities:

- an advertising campaign that targets health professionals, Canadians who practice outdoor activities and parents
- stakeholder outreach, including the dissemination of a comprehensive toolkit of educational materials for a range of users, including public health professionals
- media engagement, including interviews with experts
- stakeholder engagement, including conference presentations and webinars
- social media activities, such as messages through Facebook, Twitter and blogs.[104]

In response, the Agency developed a three year social marketing strategy (2013-2016) which includes the development of news and social media materials, education and awareness materials, public health reminders, advertising campaigns, partnerships, and an online toolkit for stakeholders.

Advertising

Launched in February 2014, the campaign initially focused on increasing health professionals' awareness of the emerging vector-borne disease in Canada. Ads appeared in nine print medical journals (total circulation of 374,000) and on websites targeted to the medical community. In the summer of 2014 a new ad campaign was launched to target Canadians practicing outdoor activities. Between mid-May and September 2014, a series of tip-based television spots on the Weather Network/Météo Média appeared approximately 3,500 times while digital ads on their

websites and the Weather Network desktop widget, Google Adwords and Facebook generated almost 140,000 click-throughs. Concurrent advertising focusing on health professionals also took place, using similar media as the winter period.

A new series of ads promoting other preventative measures were produced for the 2015 summer advertising campaign which took place May and early August 2015. This campaign introduced a new target audience (parents of children aged 5-14), applied similar placements, and built in web advertorials[viii] on targeted websites. A total of 90,827 click-throughs were obtained during this time. A modest media buy targeting health professionals was rolled out in late spring, generating 1,272 click-throughs.

Media

In 2014, the Agency developed a series of articles, audio news releases and a general public awareness video on Lyme disease for distribution by News Canada to their network of newspaper, broadcast and online editors across the country. Overall, the combined products were published 175 times. The exercise was repeated in 2015 with the use of a new series of articles, with 89 articles being published. P/Ts received the articles and audio news releases for information and were asked to provide a direct link to the video on their websites, which a few did.

Partnerships

In May 2015, a Collaborative Agreement was signed between Scouts Canada and the Agency to develop, produce and distribute Lyme disease awareness tools. The objective of the five month project was to increase awareness of Lyme disease and knowledge of prevention strategies among scouting youth, volunteers, and their families. In June 2015, tailored safety tips were produced and distributed by Scouts Canada in their communication channels; however, two other deliverables could not be met within the agreement's duration. The partnership, however, is considered an appropriate and promising practice.

Education and Awareness Materials

A key component of the marketing campaign included the development and distribution of a suite of awareness and educational material consisting of brochures, handouts, and posters. These resources were made available free of charge online and in print for individuals, stakeholders, healthcare professionals and other intermediaries. An example of this is an electronic toolkit for stakeholders that was published online and included tip sheets, posters and fact sheets. The toolkit received 3,981 pageviews, and 384 PDF downloads in 2014.

To increase the reach of messaging, the Agency, in collaboration with Parks Canada, engaged National Parks and Historic Sites across the country (18 in 2014 and 15 in 2015) to have the resources available on-site for campers and visitors. In total, 77,500 brochures, 47,000 handouts and 1,500 posters were sent to parks and national historic sites. P/Ts were also sent copies of the

[viii] An advertisement giving information in the form of editorial or journalistic content.

products and were encouraged to share them as part of their outreach activities in their regions. The majority of P/Ts that received the materials did not share them further, though some shared their own materials and messaging with provincial parks, regional public health teams, and academia.

One of the most important lessons from the West Nile virus public education campaigns in 2003 and 2007 was the need for consistent messaging and sharing of information across jurisdictions. During the development of the Lyme Disease Action Plan, the Agency worked through the Public Health Network with P/Ts to ensure consistent messaging, though a few key informants and stakeholder respondents felt that there was not enough input across jurisdictions and that messaging should be better tailored to the needs of each P/T.

Another promising practice in the education campaign for Lyme disease was outreach to veterinarians, where the Agency developed posters specifically targeting Lyme disease in pets. A national mailout was conducted in May 2015, distributing the posters to over 3,750 veterinary clinics.

In addition to reviewing the Action Plan on Lyme Disease, the evaluation reviewed web analytics to indicate the use of the Agency's websites containing information on zoonotic diseases. The web analytics looked at both the Agency's website and the Healthy Canadians website for information on zoonotic diseases that fall within the scope of the evaluation. Between April 2010 and September 2015, the 5 most common zoonotic diseases searched for and viewed online were Lyme disease (2,950,325), West Nile virus (934,745), Avian Influenza (310,419), Chikungunya (289,726), and rabies (176,606). In all cases except for rabies, the websites saw spikes in viewership during specific zoonotic health events, suggesting that the Agency is a trusted source for reliable information. A short summary of the web analytic findings can be found in Table 4.

Table 4: Web Analytics for Zoonotic Diseases

Disease	Web Analytics
Lyme Disease	• The Lyme disease fact sheet ranked 18th overall on the entire Agency's website, and the Lyme disease homepage ranked 6th on the Health Theme website, making this the most popular zoonotic disease across both websites. • There was an 807% traffic increase to the Health theme pages between May and Aug 2015 compared to previous year which was attributed to new pages being posted as well as media coverage of singer Avril Lavigne sharing her Lyme disease diagnosis.
West Nile virus	• There was a 205% spike in Agency website traffic in August 2012 compared to the previous month likely due to media reports that Ontario had the largest number of West Nile virus cases in more than a decade. • The user-friendly Health theme WNv pages launched in June 2015 received 55k page views in 3 months, up from 47k on the Agency site for all of 2014.
Avian Influenza	• There was an 855% spike in Agency website traffic in April 2013 compared to the previous month when the first wave of H7N9 outbreak took place in China. It was during that time that the Agency posted numerous new pages including the public health notice, travel health notices for China and guidance documents for healthcare professionals, all of which received high uptake. • 18% of the total traffic to the Avian Influenza section of the Agency site arrived directly, especially during the first H7N9 wave in April 2013. This is likely a result of Health Professionals bookmarking the Agency's pages to monitor the outbreak and refer to its guidance

Disease	Web Analytics
	documents.
Chikungunya	• A 450% traffic increase took place January 2014 when the Chikungunya virus started to spread across the Caribbean. In December 2014, traffic rose 95% when the media reported that the disease had affected more than 10,000 people in Puerto Rico and over 776,000 people across the Caribbean, Central America and South America.
Rabies	• The average time spent on the rabies website is approximately twice as long as the Agency's site-wide average, which is attributed to 4 out of the top 5 pages containing long detailed content that is targeted at healthcare professionals.

It is evident from above, that the Agency's products are widely distributed. However, little evidence is available on the impact of these activities, such as potential behaviour change as a result of increased knowledge. The evaluation's media analysis demonstrates that there is still misunderstanding around the prevalence and diagnosis of Lyme disease in Canada by both the general public and physicians. This reinforces the need for continued and consistent messaging from the Agency and its partners beyond the end of the social marketing strategy in 2016.

4.4.4 Outbreak Management (CFEZID & NML)

Non-enteric zoonotic events occur when something unexpected is detected during monitoring or surveillance activities which then determines the necessity for response activities. There are a few examples of the Agency's involvement in these types of situations over the past five years that provide positive anecdotal information on the Agency's skills and expertise in detecting and responding to such events.

Non-enteric zoonotic events differ from foodborne enteric illness outbreaks. These events present themselves as abnormalities in surveillance data that lead one to expect that something is happening and a response is needed. There is currently no formal tracking system of the Agency's activities in this area to provide evidence to assess these activities over a five year period. Upon request, the evaluation was able to obtain a list of 23 cases between 2009-10 and 2015-16 of emerging and re-emerging zoonotic events in which the Agency played a role. Clear articulation of what constitutes a response to a zoonotic event and continuous tracking would allow the Agency to better prioritize and assess the effectiveness of its activities.

An example of a zoonotic event during the evaluation period was the response to a field investigation of Hantavirus cases acquired in Alberta at a military training centre. Activities included the collection and testing of deer mice, a rodent risk assessment, epizootiological support and determination of recommendations to the Department of National Defence (DND) on how to prevent the further transmission of the disease. DND subsequently used the Hantavirus report produced by the Agency to develop a response to the areas of enhanced risk. The Agency's staff estimated that the response took approximately a month, although specific details of the number of staff involved is difficult to determine.

A further example of a zoonotic event response is support provided by the Agency during avian influenza outbreaks in British Columbia in December 2014. The public health response, led by BC, included contact tracing, monitoring and follow-up for household, farmworkers and other community contacts exposed to the farms. As part of the multi-jurisdictional response and

support efforts, the Agency's role consisted of providing technical briefings and guidance, as well as acting as a liaison between various jurisdictions (including senior management at the Agency).

This last event highlights the impact an unexpected zoonotic event can have on Agency staff. During the outbreak, one of the CFEZID senior epidemiologists went to the Canadian Food Inspection Agency (CFIA)'s Emergency Operations Centre (EOC) as the Public Health Liaison; however, CFEZID staff had to cover off the ongoing work at the Agency. Emerging diseases or outbreaks, whether large or relatively small, can quickly change the nature of the work undertaken by Agency staff and have an impact on existing resources and ongoing operations.

The examples above speak to more recent activities, however, a few interviewees and survey respondents commented on the longstanding professionalism of Agency staff, citing the work done on the West Nile virus outbreaks in the early 2000s, including scientific and organizational leadership, setting up surveillance systems, collaboration with various national and international organizations and obtaining the necessary equipment for molecular diagnosis.

4.4.5 Research / Risk assessments (NML)

Risk assessments, knowledge syntheses, novel surveillance methods and decision analysis tools have supported both Agency and P/T adaptation to increasing risks from emerging zoonotic and vector-borne diseases and respond to climate change requirements.

Along with surveillance, reference and diagnostic services, and outbreak investigations, research and risk assessments are conducted by NML in order to better understand how Canadians are affected by zoonotic diseases as well as the distribution and prevalence of these diseases in Canada. These activities are used to "better inform interested parties (including the general public, non-governmental and governmental agencies) about the relative risks of contracting these zoonotic diseases in Canada and form the basis for recommendations about how best to prevent or minimize exposure to these pathogens."[105] An example of this would be the *Federal Framework on Lyme Disease Act*, which cited two papers from Agency employees.[106]

The Agency uses the research produced by its staff, which may be laboratory, epidemiological or field-based, for many reasons, including evidence-informed decision making and policy development, the identification of effective interventions that may be used to reduce the risk of exposure to zoonotic diseases, approaches that can be used successfully in field studies and outbreak settings,[107] as well as to inform external reporting such as the Chief Public Health Officer's report[108] (i.e., the 2014 report cited seven papers by Agency staff), and more recently, to study the effects of climate change on the spread of vectors in Canada. In terms of reference and diagnostic services, research is largely used in the development of diagnostic assays for current and emerging pathogens, antivirals, vaccines and therapeutics.

A few notable uses of Agency research by stakeholders include the use of a study by NML on the knowledge and behaviour of Canadians towards Lyme disease to develop provincial public health communication campaigns, as well as using an Agency validation report in the implementation of a Lyme disease prioritization of prevention and control actions tool.

Survey respondents who were aware of and used the products stated that the Agency's risk assessments are both accurate (86%) and have been used to inform their work (86%). This is a demonstration of progress at the Agency as the use of risk assessments and mapping by stakeholders has not always been strong; for example, an evaluation of foodborne enteric illnesses in 2012 speaks to the lack of use of these products in that area.[109] In another example of use, the Agency's risk assessments for Lyme disease are cited on a number of P/T public health websites.[110,111,112,113,114,115,116,117,118,119,120,121] A smaller majority of survey respondents (57%) stated that assessments were timely. The Agency may therefore want to consider how to advance this aspect of its work.

4.4.6 Leadership (CFEZID & NML)

There are many examples of the Agency's leadership role in policies, plans and transferring knowledge to numerous partners nationally and internationally.

The Agency is a national and, in some instances, an international leader in the zoonotic health field. Nationally, the NML staff are seen as experts and play a key role in a number of areas highlighted in the sections above. The NML is often considered the laboratory of first resort for several provinces, as it can test for a variety of agents for which diagnostic support is hard to get at the provincial level. The Agency also has a major role in transferring knowledge to P/Ts, as well as in providing advice and training in order to build capacity as needed. Examples of this would be in the areas of research and diagnostic testing methodologies, emergency response training, bio-containment operations and maintenance. Also, the Agency has demonstrated leadership in its coordination role of national initiatives for P/Ts, such as with Lyme disease.

Internationally, the support and expertise provided by the Agency, and in particular the work of NML scientists, is highly regarded. The Agency's work is cited in a number of international papers and websites,[122,123,124] often in regards to 'One Health.' Agency staff network with international laboratories and organizations regarding zoonotic diseases that are either endemic to Canada or have the possibility of coming to Canada through travellers or other means. The Agency also works closely with the U.S. CDC as appropriate, for example to assess tests, share informal panels, and even to develop a bi-national map of the prevalence of West Nile virus.

Another way the Agency demonstrates leadership is in the development and conduct of six ISO accredited tests for non-enteric zoonotic diseases (West Nile virus, Lyme disease (2), rabies, Hantavirus, and Ebola). Further diagnostic tests have been developed and are expected to be accredited in the future.

Additionally, the Agency is the lead federal department responsible for the development of the Federal Framework on Lyme Disease, the organization of the conference called for in the *Act* and the Action Plan on Lyme Disease, which is a platform for greater collaboration with provincial and territorial health authorities. The Agency[ix] has taken the lead on developing consistent messaging, and has assisted some P/Ts in adapting the message to their needs. This assistance is something the Agency has done on other zoonotic diseases as well, such as West Nile virus, which respondents seemed to appreciate and said that it filled a gap.

The Agency is known for its collaborative efforts and the establishment of formal partnerships between itself and universities to provide research that is both responsive and impartial to the complex realities around public health. Examples of this include collaboration with universities and regional health units to develop ways of trapping vectors for surveillance, adjunct appointments with the University of Manitoba, as well as the Research Group on Epidemiology of Zoonoses and Public Health (GREZOSP), created 10 years ago in Quebec between professors of the Faculty of Veterinary Medicine of the Université de Montréal and researchers from the Agency.[125] GREZOSP's 2014-15 Activity Report highlights a multitude of studies and research publications undertaken by Agency staff as well as the work they have done to mentor graduate students and postdoctoral fellows.

Despite its collaborative efforts with a number of universities, many key informants and survey respondents noted their disappointment regarding the disbandment of the National Non-Enteric Zoonotic Diseases Committee in 2011 during the reorganization of the Public Health Network (PHN), whose purpose was to facilitate information sharing, technical expertise and networking among PHN partners in this area. While there are still some active working groups and steering committees regarding zoonotics (e.g.,F/P/T West Nile Virus and Other Mosquito-borne Viruses Working Group, the F/P/T Communicable Disease and Infection Control Steering Committee), stakeholders stated that they are infrequent and do not carry the same weight as the National Committee. In particular, they mentioned the importance of having face-to-face meetings to discuss zoonotic issues globally, to share ideas and create partnerships. Much of the work done for zoonotics is done through informal channels. Stakeholders stated that the mutual trust and respect built between partners during these meetings allowed for effective detection and response activities and that without them, they are concerned that these ties will weaken over time.

4.5 Performance: Issue #5 – Demonstration of Economy and Efficiency

There are efficiencies in the Agency's zoonotic non-enteric activities.

Observations on Economy

The economic burden of non-enteric zoonotic diseases is an important factor for understanding the impact of the diseases within the broader public health and healthcare systems, and the societal context. *The 2008 Economic Burden of Illness in Canada* (EBIC) database provides an estimate of the costs associated with treating zoonotic diseases such as West Nile virus and

ix The Agency's Regional Operations were key internal partners in this area.

Lyme disease. That year, the cost of treatment was $2.5M for hospital and physical care, drug treatment, and mortality. However, the year before (2007), the estimated costs associated with treating WNv was almost double that ($4.4M), reflecting the increase in case numbers that particular year. Therefore, treatment costs associated with certain non-enteric infectious diseases will vary in accordance with climate variability or the variability in disease patterns in any given period of time.

Furthermore, while not specific to non-enteric zoonotic diseases occurring within Canada, the World Bank has estimated that highly fatal zoonotic diseases between 1997 and 2009 cost over $80 USD billion in economic losses. The OECD estimated that "*potential losses resulting from a severe influenza pandemic, for instance, that leads to 71 million human fatalities would be US$3 trillion, or 4.8 percent of the global GDP.*[126] Early detection and diagnosis, as well as rapid response, will therefore reduce both suffering and economic loss.

In the same report, the World Bank also noted the benefits of the 'One Health' approach when addressing non-enteric zoonotic diseases, specifically focussing on the Canadian Science Centre for Human and Animal Health. In 1999, the human (NML) and animal (CFIA) laboratories merged into one location. After more than a decade, several efficiencies were noted in 2011, such as greater collaboration between animal and human health sectors, and sharing of common services costs (estimated at a savings of $5M USD annually).[127]

Regardless of gained efficiencies, detecting and responding to emerging or re-emerging non-enteric zoonotic diseases will be costly. For example, in 2004, the Agency expended about $2.3M to develop the necessary surveillance products to track West Nile virus, which was emerging in Canada at the time. By 2014, however, costs were about 10% of that figure ($230,000), considering the functional system and knowledge transfer and dissemination throughout all partner networks involved in the process.

Funding

There were variances between year-end budgets and actual spending during the period evaluated. As illustrated in Table 5 below, variances remained fairly stable over the evaluation period, but jumped in 2014-15. Part of this variance could be explained by the increase in laboratory testing for diseases such as Chikungunya (as noted on page 15), while still continuing testing for more established diseases such as Rabies and Lyme, as well as surveillance, policy development and public awareness/educational activities delivered through the Action Plan on Lyme Disease. In essence, the general overspend might warrant a review of activities and associated resources, in order to ensure that planning is appropriate for the actual level of spending and resource utilization that is occurring. Through some internal key informant interviews, it was noted that resources have not kept pace with the increasing volume of work on zoonotic activities.

Table 5: Variance Between Planned Spending vs Expenditures* - 2010-2011 and 2014-2015 ($M)

Year	Planned	Actuals	Variance	% Planned Budget Spent
2010-2011	8.5	8.6	0.1	101%
2011-2012	6.5	6.6	0.1	102%
2012-2013	5.8	6.2	0.4	107%
2013-2014	6.4	6.6	0.2	103%
2014-2015	5.6	7.5	1.9	134%

* Data Source: (CFEZID and NML)

Observations on Efficiency

An audit of the management of non-enteric zoonotic activities, conducted at the same time as this evaluation, focussed on the effectiveness of the management control framework as it related to governance, risk and internal controls for the delivery of non-enteric zoonotic infectious disease activities. Recommendations focussed on the development of a non-enteric zoonotic framework including expectations for governance, roles and responsibilities, risk management and performance measurement, as well as a formalized outbreak response protocol. Both recommendations will serve to clarify governance, roles and responsibilities and will reduce the risk of gaps and duplication to respond to non-enteric zoonotic events by the Centre and the NML.

For science based programs, indicators such as turnaround times tend to be used frequently to assess the efficiency of laboratory services, and can also indicate efficiencies gained from reduced time to address client complaints. Generally, the Agency is meeting stated turn-around service time standards for diagnostic tests. These times varied from 82% - 100%, but in the vast majority of cases, the NML is able to provide diagnostic results as stated in the Guide to Services (average of 93%). Large sample batches and lack of human resourcing were provided as primary rationales for the few instances when turn-around times were not met.

As part of the Rapid Impact Evaluation approach, stakeholders noted that the Agency's reference services, advice and guidance and surveillance activities had the most impact on goals and outcomes of a reduced risk to exposure of zoonotic diseases generally, while risk assessments and public awareness/educational activities were perceived as less impactful. However, when stakeholders were asked to compare the impact on human exposure to non-enteric zoonotic diseases with and without the inclusion of the Agency's activities, it was evident that stakeholders believed the system was stronger with all of the Agency's activities than without them.

Observations on the Adequacy and Use of Performance Measurement Data

The evaluation occurred at a time of logic model re-development at the Branch and there was no finalized logic model of zoonotic activities at the Centre or Laboratory level. Correspondingly, there is no performance measurement strategy, although both of these activities were under development during the course of the evaluation.

The lack of performance measurement information, specifically documented tracking of outbreak response activities, made it difficult to capture the Agency's activities over the past five years. However, both CFEZID and NML were able to retrospectively provide a list of response activities over the past five years, outlining the year, the response event and high level activities involved in the response.

This was helpful in articulating the definition of response for non-enteric zoonotic events. The stakeholder survey also verified that there were no substantial challenges regarding the Agency's response activities over the past few years. However, not tracking these types of activities on an ongoing basis may lead to difficulties in assessing surge needed for these types of events. In addition, or perhaps as a result, there was no documentation of which routine activities could have been de-prioritized during a response situation.

In addition, there is no formal overarching workplan for activities relating to zoonotic non-enteric events. There are, however, various documents outlining roles and responsibilities for specific diseases, such as the workplan created during a surge in Chikungunya cases among Canadians. Evidence suggests that relationship building and informal arrangements over many years has led to the Agency's successful involvement in responding to events.

5.0 Conclusions

The ~~Public Health~~Agency is succeeding in a number of areas to prevent and detect zoonotic diseases and is considered a leader in addressing these activities and collaborating with its health partners. Anecdotally, the Agency appears to do well in responding to public health events though this is not formally tracked. The key to continued success is for the Agency to review activities in light of an increasing need, keep learning from previous outbreaks (West Nile), continue building on inter/intra-sectoral partnerships, and track strategic performance metrics.

5.1 Relevance Conclusions

There is an increasing need for the Agency to address zoonotic diseases. Although there are a small number of human health cases in comparison to other diseases, the majority of emerging pathogens are zoonotic (approximately 75 per cent - although this also includes enteric diseases), they can cause very serious, fatal illness in affected people, and there is the potential for a sudden impact on the Canadian population. Factors such as climate change and variability and global trade and travel increase the likelihood of emerging diseases in Canada.

Zoonotic Disease activities have been indentified as a priority of the Agency as reflected in a variety of planning and corporate documents (e.g., Action Plan on Lyme Disease, Corporate Risk Profile). Program authorities clearly articulate both disease-based (i.e., West Nile virus, Rabies, Lyme, Avian Influenza) and functional (i.e., laboratory, risk assessment and surveillance) activities. Considering the multijurisdictional nature of preventing, detecting and responding to non-enteric zoonotic diseases, the Agency's collaborative approach to zoonotic activities recognizes the importance of collaboration between groups that focus on human, animal and environmental health.

5.2 Performance Conclusions

5.2.1 Achievement of Expected Outcomes (Effectiveness)

The Agency's activities appear to be effective in supporting public health actions, planning and decision making in the prevention and control of non-enteric zoonotic diseases. Many of the products and services developed by the Agency are considered useful and appropriate by stakeholders. Many of these activities are developed through and depend upon successful partnerships with provinces and territories, other government departments and non-governmental organizations:

- Provincial and Territorial governments reference Agency's surveillance data on their websites and in their reports and materials - including risk assessments. This information appears to be timely, and is in line with what other countries are making publically available.
- Diagnostic services (of which the Agency does thousands a year) provide a direct impact on Canadians through diagnosis and scientific evidence for other products and activities, such as surveillance and travel health notices.
- The implementation of the Agency's Action Plan on Lyme Disease's education and awareness campaign has had extensive reach and key messages were used consistently. Online consultations with the public, including key stakeholders, as part of early work to inform the Federal Framework on Lyme Disease suggests that Canadians want to see enhanced diagnostic testing and reporting, better informed physicians and more collaboration with key stakeholders in endemic areas.
- The Agency has provided leadership on many fronts, including training and capacity building (e.g., research and diagnostic testing methodologies, emergency response training, bio-containment operations and maintenance) both nationally and internationally.
- Finally, evidence suggests that relationship building and informal arrangements over many years has led to the Agency's successful involvement in responding to non-enteric zoonotic events.

Yet non-enteric zoonotic disease activities are not organized in the Agency as a distinct program. In addition, current activities appear to be based primarily on pre-established and informal relationships between Agency experts and partners. While these relationships are appreciated and valued by stakeholders, there are concerns that a lack of formal ongoing collaborative activities may impact the ability to share information, exchange ideas and appropriately prevent, detect and respond to emerging and re-emerging non-enteric zoonotic diseases that fall outside of the Agency's priorities of West Nile virus and Lyme disease.

5.2.2 Demonstration of Economy and Efficiency

Efficiencies were demonstrated during the course of the evaluation, such as the natural reduction of the cost to the Agency when developing surveillance for emerging diseases like West Nile virus as knowledge and capacity is transferred to the provinces. The Agency is also meeting, in the vast majority of cases, turn-around times for diagnostic testing as outlined in the Guide to Services. In addition, it was evident that stakeholders perceived the Agency's activities to positively impact the overall prevention, detection and response to non-enteric zoonotic diseases.

During the conduct of the evaluation, the Agency was working on revising the program logic and performance measurement strategy for these activities. However, without these finalized products, it was difficult to determine proper performance measures, although the evaluation was able to provide evidence of the successes and challenges of the Agency's activities in this area.

6.0 Recommendations

Recommendation 1

In light of the increasing need for activities related to non-enteric zoonotic diseases, review the Agency's strategic approach in this area, including formalized structures to support the collaborative efforts consistent with a 'One Health' approach.

There is an increased need for the Agency to address zoonotic diseases as they constitute the largest number of emerging pathogens and have the potential to pose a sudden health risk to Canadians, such as developments associated with Zika virus in the Americas during the course of this evaluation. Moreover, important considerations such as climate change and variability, global trade and travel, and AMR reinforce and augment the need for the activities undertaken by the Agency to prevent, detect and respond to non-enteric zoonotic diseases. As noted previously, the Agency focussed on the prevention, detection of and response to West Nile virus and Lyme disease over the past few years. Stakeholders have noted the need for a wider non-enteric zoonotic set of activities which could address any emerging or re-emerging disease in Canada.

This evaluation found that the Agency recognizes both the multijurisdictional and multidisciplinary nature of zoonotic diseases, including environmental, animal and human health aspects, which is consistent with the 'One Health' approach. Furthermore, the Agency has identified zoonotic diseases as priorities to be addressed, for example the prominence of infectious disease risks (including zoonotic diseases) identified in the Corporate Risk Profile. However, the internal and relevant external stakeholder organisational management and governance structures to strongly support the collaborative approach to zoonotic activities needs to be created (or re-established) to permit effective working partnerships for surveillance and monitoring, reference services, education and awareness raising, outbreak management and research (laboratory, field, epidemiological).

Recommendation 2

Articulate and track the Agency's response to non-enteric zoonotic disease events in order to determine the effectiveness of activities, advance learning and provide necessary information for the prioritization of activities and related surge capacity during a response.

From the limited and retrospective information available, including evidence from some key external interviews, the Agency appears to be effective in responding to zoonotic non-enteric events. However, the lack of performance measurement information, specifically documented tracking of outbreak response activities, made it difficult to capture the Agency's activities over the past five years. Articulating and tracking response activities would provide the evidence required to appropriately assess surge capacity needed for these types of events as well as activities which could be de-prioritized during a response situation.

Appendix 1 – Summary of Findings

Rating of Findings

Ratings have been provided to indicate the degree to which each evaluation issue and question have been addressed.

Relevance Rating Symbols and Significance:

A summary of Relevance ratings is presented in Table 1 below. A description of the Relevance Ratings Symbols and Significance can be found in the Legend.

Table 1: Relevance Rating Symbols and Significance

Evaluation Issue	Indicators	Overall Rating	Summary
Continued need for the program			
What is the current and projected burden of zoonotic infectious diseases in Canada? How has the environment changed?	• Evidence of current and projected burden	**High**	Cases of non-enteric zoonotic diseases in Canada are relatively low but there is a continued risk of a surge in existing or emerging diseases, in part due to factors such as climate variability, travel, and antimicrobial resistance.
Alignment with Federal Roles and Responsibilities			
What is the federal public health role related to zoonotic infectious diseases?	• Evidence that roles and responsibilities are: defined, known, and implemented	**High**	Disease-based and functional non-enteric zoonotic disease activities are aligned with federal roles and responsibilities, as laid out in Program Authorities. In addition, activities are aligned with *International Health Regulations*.
Is the federal public health role aligned with current activities?	• Evidence that activities align with federal roles and responsibilities	**High**	
Do the federal public health role and current activities duplicate the role of other government departments, provincial and territorial governments and stakeholders? Are there any gaps or overlaps?	• Evidence of duplication/overlap/ complementarity of roles between federal public health and stakeholders • Evidence of gaps between federal public health role and stakeholders role	**High**	There is no duplication of roles, however, there is significant collaboration between F/P/T government agencies, NGOs, and other national and international partners.

Legend - Relevance Rating Symbols and Significance:

High	There is a demonstrable need for program activities; there is a demonstrated link between program objectives and (i) federal government priorities and (ii) departmental strategic outcomes; role and responsibilities for the federal government in delivering the program are clear.
Partial	There is a partial need for program activities; there is some direct or indirect link between program objectives and (i) federal government priorities and (ii) departmental strategic outcomes; role and responsibilities for the federal government in delivering the program are partially clear.
Low	There is no demonstrable need for program activities; there is no clear link between program objectives and (i) federal government priorities and (ii) departmental strategic outcomes; role and responsibilities for the federal government in delivering the program have not clearly been articulated.

Evaluation Issue	Indicators	Overall Rating	Summary
Alignment with Government Priorities			
What are the federal priorities related to zoonotic infectious diseases?	• Evidence that activities and objectives align with, and contribute towards, government priorities	**High**	Non-enteric zoonotic disease activities align with federal priorities on the health and safety of Canadians, and the 2014 *Federal Framework on Lyme Disease Act.*
What are the Agency priorities related to zoonotic infectious diseases?	• Evidence that activities and objectives align with, and contribute towards, Agency priorities	**High**	Non-enteric zoonotic disease activities are a priority of the Agency as described in a number of planning and corporate documents.

Legend - Relevance Rating Symbols and Significance:

High There is a demonstrable need for program activities; there is a demonstrated link between program objectives and (i) federal government priorities and (ii) departmental strategic outcomes; role and responsibilities for the federal government in delivering the program are clear.

Partial There is a partial need for program activities; there is some direct or indirect link between program objectives and (i) federal government priorities and (ii) departmental strategic outcomes; role and responsibilities for the federal government in delivering the program are partially clear.

Low There is no demonstrable need for program activities; there is no clear link between program objectives and (i) federal government priorities and (ii) departmental strategic outcomes; role and responsibilities for the federal government in delivering the program have not clearly been articulated.

Performance Rating Symbols and Significance:

A summary of Performance Ratings is presented in Table 2 below. A description of the Performance Ratings Symbols and Significance can be found in the Legend.

Table 2: Performance Rating Symbols and Significance

Issues	Indicators	Overall Rating	Summary
Achievement of Expected Outcomes (Effectiveness)			
To what extent are partners/stakeholders engaged?	• Evidence of engagement of partners/stakeholders	**Achieved**	The Agency has been active in engaging partners/stakeholders in non-enteric zoonotic disease activities, particularly with regards to Lyme disease, where a number of partnerships were created in order to increase awareness of the disease (e.g., News Canada, Scouts Canada, Parks Canada). However, the disbandment of the National Non-Enteric Zoonotic Disease Working Group in 2011 was a concern for a significant number of survey and interview respondents, who expressed an interest in reinstating a similar group in the future.
To what extent are stakeholders aware of and use the Agency products and services?	• Evidence of awareness and use of the Agency products and services by stakeholders and the general public	**Achieved**	Stakeholders interviewed and surveyed noted awareness and use of the Agency products and services. A review of P/T websites found that all jurisdictions reference the Agency material or data on non-enteric zoonotic diseases, and web analytics found significant access of the Agency information on the Agency's website.
To what extent is there an enhanced zoonotic event detection and response?	• Evidence that the Agency has plans and policies in place to detect and respond to zoonotic events	**Progress Made; Further Work Warranted**	While the Agency's strong relationships with partners/stakeholders has led to successful detection of and response to zoonotic disease events, there is no formal tracking system of the activities. There were concerns about the impact of zoonotic events on the Agency's work and resources.
To what extent is detection and response to zoonotic disease risks timely and continuously improved?	• Evidence of timely detection and response activities that are continuously improved	**Progress Made; Further Work Warranted**	Interview and survey respondents had concerns about the timeliness of some of the Agency's activities, such as reference and diagnostic services, and risk assessments. In addition, while some surveillance data and information is provided in a timely manner (e.g., WNv), other data is not made available as quickly (e.g., Lyme), especially when compared to other countries.
Demonstration of Economy and Efficiency			
Has the program undertaken its activities in the most efficient manner?	• Audit results • Adherence to standard operating procedures	**Achieved**	Audit recommendations focussed on the development of a non-enteric zoonotic framework including expectations for governance, roles and responsibilities, risk management and performance measurement, as well as a formalized outbreak response protocol. Generally, the Agency is meeting stated turn-around service time standards for diagnostic tests.

Legend - Performance Rating Symbols and Significance:

Achieved	The intended outcomes or goals have been achieved or met.
Progress Made; Further Work Warranted	Considerable progress has been made to meet the intended outcomes or goals, but attention is still needed.
Little Progress; Priority for Attention	Little progress has been made to meet the intended outcomes or goals and attention is needed on a priority basis.

Issues	Indicators	Overall Rating	Summary
Has the Agency produced its outputs and achieved its outcomes in the most economical manner?	• Views on if funds are appropriately targeted • Variance between planned and actual expenditures, and implications	**Progress Made; Further Work Warranted**	There were variances between year-end budgets and actual spending during the period evaluated. Variances remained fairly stable over the evaluation period, but jumped in 2014-15 due to increased laboratory testing. Moving forward, budgets should account for an increasing need for Agency activities to respond to new and re-emerging diseases.
Is there appropriate performance measurement in place? If so, is the information being used to inform senior management decision-makers?	• Existence of performance measurement • Adequate collection of performance information • Evidence of use of performance measurement information in decision-making	**Progress Made; Further Work Warranted**	At the time of the evaluation the Branch's logic model was under development, as was the performance measurement strategy. There was no formal tracking system or formal workplan for non-enteric zoonotic disease events.

Legend - Performance Rating Symbols and Significance:

Achieved	The intended outcomes or goals have been achieved or met.
Progress Made; Further Work Warranted	Considerable progress has been made to meet the intended outcomes or goals, but attention is still needed.
Little Progress; Priority for Attention	Little progress has been made to meet the intended outcomes or goals and attention is needed on a priority basis.

Appendix 2 – Evaluation Description

Evaluation Scope

The scope of the evaluation covered the period from April 2010 to November 2015 and included non-enteric zoonotic infectious disease activities - vectorborne and non-vectorborne (CFEZID and NML); vectorborne surveillance and risk Assessment (CFEZID and NML); and laboratory and diagnostic research (NML). The evaluation did not cover foodborne enteric illness activities and waterborne infectious diseases (will be evaluated in 2017-2018 as part of the Foodborne Enteric Illness Activities evaluation); clean air/prion diseases (evaluated as part of the current Clean Air Adaptation evaluation); migration and travel health (evaluated in 2014-2015); and Ebola and anti-microbial resistance (will be evaluated at a future date).

Evaluation Issues

The specific evaluation questions used in this evaluation were based on the five core issues prescribed in the Treasury Board of Canada's *Policy on Evaluation* (2009). These are noted in the table below. Corresponding to each of the core issues, evaluation questions were tailored to the program and guided the evaluation process.

Table 1: Core Evaluation Issues and Questions

Core Issues		Evaluation Questions
Relevance		
Issue #1:	Continued Need for Program	Assessment of the extent to which the program continues to address a demonstrable need and is responsive to the needs of Canadians • What is the current and projected burden of zoonotic infectious diseases in Canada? How has the environment changed?
Issue #2:	Alignment with Government Priorities	Assessment of the linkages between program objectives and (i) federal government priorities and (ii) departmental strategic outcomes • What is the federal public health role related to zoonotic infectious diseases? • Is the federal public health role aligned with current activities? • Do the federal public health role and current activities duplicate the role of other government departments, provincial and territorial governments and stakeholders? Are there any gaps or overlaps?
Issue #3:	Alignment with Federal Roles and Responsibilities	Assessment of the role and responsibilities for the federal government in delivering the program • What are the federal priorities related to zoonotic infectious diseases? • What are the Agency priorities related to zoonotic infectious diseases?
Performance (effectiveness, economy and efficiency)		
Issue #4:	Achievement of Expected Outcomes (Effectiveness)	Assessment of progress toward expected outcomes (incl. immediate, intermediate and ultimate outcomes) with reference to performance targets and program reach, program design, including the linkage and contribution of outputs to outcomes • To what extent are partners/stakeholders engaged? • To what extent are stakeholders aware of and use the Agency products and services? • To what extent is there an enhanced zoonotic event detection and response? • To what extent is detection and response to zoonotic disease risks timely and continuously improved?

Core Issues	Evaluation Questions
Issue #5: Demonstration of Economy and Efficiency	Assessment of resource utilization in relation to the production of outputs and progress toward expected outcomes • Has the program undertaken its activities in the most efficient manner? • Has the Agency produced its outputs and achieved its outcomes in the most economical manner? • Is there appropriate performance measurement in place? If so, is the information being used to inform senior management decision-makers?

Data Collection and Analysis Methods

Evaluators collected and analyzed data from multiple sources. Sources of information used in this evaluation included:

Literature Review

The literature review examined academic literature and focussed on documenting: the need for the program; key drivers/determinants; public, expert and/or stakeholder commentary on the program area; external factors or challenges that could affect the successful delivery; and lessons learned.

An initial search of the literature was performed by the Health Canada library staff, who were provided with questions regarding the continued need for the program, a 10 year time frame, and a list of key words (e.g., specific zoonotic disease names). The library services searched Scopus, CAB Abstracts, Medline, and Embase.

Inclusion/exclusion criteria were used to assess the sources and to ensure the most appropriate, credible, reliable and relevant information needed to address specific evaluation questions were selected and reviewed.

Document Review

The document review included government and program documents from which evaluators extracted the data required for the applicable indicators as per the Data Collection Matrix. Extracted data were compiled in an evaluation-specific database. The documents included but were not limited to:

- Government internal documents such as Treasury Board submissions, Memorandum to Cabinet, Government of Canada budgets, central agencies websites, etc. These documents provided program background and information on program relevance.
- Documents produced by the program, e.g., progress reports and work plans, websites, financial information, policies and plans. These documents provided information pertaining to program delivery and deliverables, and, for the collection of performance data, including uses and impacts, efficiency and economy.
- Other performance review documents were analyzed, including previous performance measurement reviews.

The document review provided evidence in many evaluation areas related to ongoing relevance and performance.

Stakeholder Survey

An electronic survey was sent to 145 external stakeholders in the following categories:

- Canadian Non-Governmental Organization
- Canadian Universities
- Provincial/Territorial Public Health
- Agency and Other Government Departments
- International Universities
- International Public Health

The primary purpose of the survey was to gather information on the uses and impacts of Agency products and services, collaboration with stakeholders, and challenges/areas for improvement. This information was coded and analysed in order to address several evaluation questions.

The survey received a response rate of 30 percent (44 respondents).

Key Informant Interviews

Key Informant interviews were conducted to gather in-depth information, including individual perspectives, explanations, examples and factual information to address many of the evaluation questions related to relevance and performance. The interview guides were based on the lines of inquiry for the Rapid Impact Evaluation pilot (uses and impacts), and included open ended questions. Interviews were conducted in the official language of choice of the respondent.

Eighteen interviews were conducted for this evaluation with the following groups of key informants:

- Agency program staff (n=12)
- External experts (n=5)
- International experts (n=1)

The evaluators conducted interviews using appropriate and feasible approaches for the evaluation budget and required timeframe, such as: in-person interviews, telephone interviews, group interviews, etc. The majority of interviews were conducted by telephone, and only one group interview was conducted in-person.

Data were analyzed by triangulating information gathered from different sources and methods listed above. The data collected was analyzed using the following methods:

- Systematic compilation, review and summarization of data to illustrate key findings
- Statistical analysis of quantitative data from databases
- Thematic analysis of qualitative data
- Trend analysis of comparable data over time
- Comparative analysis of data from disparate sources to validate summary findings

Summary analyses of the data collected were recorded by evaluation question, using an Office of Audit and Evaluation report template and referencing the sources/methods used to collect the data.

Appendix 3 – Further Information on Diseases

Lyme disease is caused by the bacteria *Borrelia burgdorferi*, and is transmitted to humans through the bite of the blacklegged or western blacklegged tick. Death from Lyme disease is not common, but has occurred. The range of the tick that can transmit the disease, and thus the highest number of cases, is noted in Table 3. The ticks are most often found in forests or overgrown areas in the endemic areas, but may be found outside the known endemic areas because it can attach itself to birds. There has been a marked increase in the number of reported cases of Lyme diseases in just over 10 years, from 40 cases in 2004 to 522 in 2014, although there is the possibility that this does not represent the full number of cases due to underreporting. Lyme disease is expected to spread through Canada because of climate variability.[128,129,130,131,132]

West Nile virus (WNv) is transmitted to humans through mosquito bites, although it can also be transmitted from human to human, for example, through blood transfusion, breast milk, and organ transplantation. Because of the ability of the virus to be transmitted via donated blood products, the Canadian Blood Services and Héma-Québec screen for WNv.[133,134,135] WNv was first found in North America, in birds, in 1999, and first seen in Canada in 2001 in birds and mosquitos. The first wave of mass human transmission was in 2003, and there was a significant outbreak of WNv in humans in 2007, largely in Alberta, Saskatchewan, and Manitoba. WNv is now endemic in much of Canada, and is also found in most of North and Central America, the Caribbean, some of South America, and parts of Africa and Eurasia.[136,137,138,139,140]

Chikungunya is a mosquito-borne viral illness, similar to Dengue fever. It was endemic only in parts of Africa, Asia and the Indian and Pacific Oceans until December 2013, when two cases were confirmed to have been locally transmitted in Saint-Martin. In 2014, local transmission of the virus was detected in over 40 countries and territories in the Caribbean, Central and South America, and in Mexico and the United States. While there has been no local transmission of the Chikungunya virus in Canada, there have been an increasing number of confirmed cases in people who have travelled to the affected regions. There are strong concerns about the virus spreading further in the United States, but at this time the Canadian climate is thought to be mostly unsuitable for the particular species of vector mosquito. However, it is noted that some areas, such as southern British Columbia and parts of south central and southeastern Canada, may be at increased risk for the mosquito to survive particularly as the climate warms.[141,142,143,144]

Rabies is a zoonotic virus that is transmitted through close contact with the saliva of an infected animal, such as domestic and wild dogs, foxes, raccoons, skunks, and bats. There are few cases of humans getting rabies in Canada, with only 24 deaths from Rabies since 1924, and vaccination programs have reduced the number of cases in domestic and even wild animals, further reducing the risk to humans. However, there are many more cases in other countries, with over 50,000 rabies-related deaths each year, particularly in Africa and Asia, so vaccinations and other preventive means are recommended to people travelling to these areas. Rabies is almost always fatal in humans, so post-exposure vaccination is essential for people exposed to animals with proven or suspected rabies. There is a concern about the spread of rabies in the Arctic region, and there have been outbreaks in Nunavik and Labrador, as reported to the CFIA in 2011-12.[145,146,147,148,149,150,151]

Hantavirus pulmonary syndrome (HPS) is a rare but very serious respiratory disease caused by the inhalation of aerosolized rodent urine and feces contaminated by Hantavirus particles.[152] There are five types of rodents known to carry the Hantavirus in North America, three of which are widespread in Canada (Deer mouse, white-footed mouse and red-backed vole).[153] There have been 109 confirmed cases and 27 deaths from the virus in Canada since 1989.[154] With one exception, all cases of Hantavirus pulmonary syndrome have been in western Canada, although mice infected with the disease have been detected across Canada.[155]

Brucellosis is an infectious zoonotic disease caused by various species of the *Brucella* bacteria, which is resistant to penicillins and cephalosporin antibiotics. The bacteria most commonly affects cattle, swine, goats, sheep, and dogs, but can be transmitted to humans through direct contact with infected animal material and by inhalation of airborne agents. While it is relatively rare in Canada, it is an endemic disease in many other parts of the world, particularly in the Middle East, the Mediterranean region, western Asia, Africa and Latin America. Some of the reported cases in Canada were among First Nations populations who consumed infected caribou.[156,157,158]

Avian Influenza *(*in Wild Birds*)* is a contagious viral infection that can affect all species of wild and domestic birds which can sometimes be transmitted to humans and some other mammals, and periodically will be transmittable from mammal to mammal.[159,160,161] It is a complex disease which has many different strains with the ability to mutate from low pathogenic to high pathogenic virus after domestic birds have been infected. [162] There are several important concerns about Avian influenza, such as how domestic birds are more susceptible to the disease, where it can rapidly spread within the flocks, which also puts humans, particularly poultry workers, at greater risk of contracting the virus.[163,164,165] In Canada, surveys of AI in dead and live wild birds are done yearly.[x] To date, in 2015, 2,009 dead birds were tested with 29 positive results, and 2,999 live birds were tested, with 493 positive results.[166] Two of the key strains being monitored in Canada and around the world are H5N1 and H7N9, both of which are common in wild birds. H5N1 has been confirmed in birds in countries in Asia, Europe, Africa and the Middle East, and several outbreaks in domestic birds have been confirmed in Canada. H7N9 was confirmed in two wild birds in 2015.[167]

[x] Data for the live bird survey in 2014 was not available on the CWHC website.

Appendix 4 – 'One Health' Model

Copied from: Public Health Agency of Canada (2013). One Health. Retrieved July 20 2015, from http://www.phac-aspc.gc.ca/owoh-umus/index-eng.php.

- One Health approach is a multi-disciplinary / multi-sectoral concept that incorporates human, animal, and environmental health, through the key activities of surveillance, response, and prevention.
- The Agency and a number of partner organizations use the One Health approach when dealing with emerging and existing zoonotic diseases (e.g., Lyme disease, West Nile virus, Avian influenza).
- In the case of Lyme disease, there are a number of federal organizations involved (Agency, CFIA, CBSA, EC, AGR) as well as the CWHC.

Endnote

[1] World Health Organization (2015). *Zoonoses*. Retrieved July 21 2015, from http://www.who.int/topics/zoonoses/en/.

[2] Rowe, Andy (2015-11). *Rapid Impact Evaluation GEF workshop and webinar*. Retrieved December 10, 2015, from https://www.thegef.org/gef/sites/thegef.org/files/EO/GEF%20IEO%20Website%20-%20Events%20-%20Slides%20for%20RIE%20at%20GEF.pdf.

[3] World Health Organization (2015). *Neglected zoonotic diseases*. Retrieved July 21 2015, from http://www.who.int/neglected_diseases/diseases/zoonoses/en/#.

[4] World Bank (2010). *People, pathogens and our planet. Volume 1: Towards a One Health approach for controlling zoonotic diseases*. Retrieved July 15, 2015, from http://siteresources.worldbank.org/INTARD/Resources/PPP_Web.pdf.

[5] Public Health Agency of Canada (2015-07-28). *Notifiable Diseases On-Line*. Retrieved Dec 21 2015, from http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/charts.php?c=yl.

[6] Michigan Sea Grant (n.d.). *Climate variability and climate change: What is the difference?* Retrieved Nov 16 2015, from http://www.miseagrant.umich.edu/downloads/climate/11-703-Climate-Variability-and-Climate-Change.pdf.

[7] Public Health Agency of Canada. (2014-09). *Report on the state of public health in Canada 2014: Public health in the future.* Retrieved Aug 13 2015, from, http://www.phac-aspc.gc.ca/cphorsphc-respcacsp/2014/assets/pdf/2014-eng.pdf.

[8] Ogden, N. H., Lindsay, L. R., & Coulthart, M. (2015). Is there a risk of Chikungunya transmission in Canada? *Canada Communicable Disease Report*, 41(1), 11-14. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-01/comment-eng.php

[9] Canada. Parliament. Senate. *Proceedings of the Standing Senate Committee on Social Affairs, Science and Technology. 41st Parliament, 2nd session. No. 24, November 20 & 26, December 3 & 10, 2014.* Retrieved July 21 2015, from http://www.parl.gc.ca/content/sen/committee/412/SOCI/24EV-51834-E.HTM.

[10] Ogden, N. H., Koffi, J. K., Pelcat, Y., & Lindsay, L. R. (2014). Environmental risk from Lyme disease in central and eastern Canada: A Summary of recent surveillance information. *Canada Communicable Disease Report*, 40(5), 74-82. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/14vol40/dr-rm40-05/assets/pdf/14vol40_05-eng.pdf.

[11] Bryan, H. M., Darimont, C. T., Paquet, P. C., Ellis, J. A., Goji, N., Gouix, M., et al. (2011). Exposure to infectious agents in dogs in remote coastal British Columbia: Possible sentinels of diseases in wildlife and humans. *Canadian Journal of Veterinary Research*, 75(1), 11-17.

[12] Aenishaenslin, C., Simon, A., Forde, T., Ravel, A., Proulx, J.-F., Fehlner-Gardiner, C., et al. (2014). Characterizing rabies epidemiology in remote Inuit communities in Québec, Canada: A "One Health" approach. *Ecohealth*, 11(3), 343-355.

[13] World Veterinary Assocation, World Medical Assocation, Spanish Medical Association & Spanish Veterinary Associations (2015). *WVA/WMA Global Conference on One Health: Drivers towards One Health "Strengthening collaboration between Physicians and Veterianarians."* Retrieved Sept 14 2015, from http://www.worldvet.org/uploads/news/docs/gcoh_report_may_2015.pdf.

[14] American Veterinary Medical Association (2008-07-15). *One Health: A New Professional Imperative. One Health Initiative Task Force: Final Report.* Retrieved July 15, 2015, from https://www.avma.org/KB/Resources/Reports/Pages/One-Health.aspx.

[15] Artsob, H., Gubler, D. J., Enria, D. A., Morales, M. A., Pupo, M., Bunning, M. L., et al. (2009). West Nile virus in the new world: Trends in the spread and proliferation of West Nile virus in the western hemisphere. *Zoonoses and Public Health*, 56(6-7), 357-369.

[16] Canada Border Services Agency. (n.d.). *Sustainable Development Strategy 2014-2017*. Retrieved Aug 11 2015, from http://www.cbsa-asfc.gc.ca/agency-agence/reports-rapports/sds-sdd/sds-sdd-14-17-eng.pdf.

[17] Canadian Food Inspection Agency. (2014). *2014-15 Report on Plans and Priorities*. Retrieved Aug 11 2015, from http://www.inspection.gc.ca/DAM/DAM-aboutcfia-sujetacia/STAGING/text-texte/acco_repparl_rpp_2014-15_1393374601813_eng.pdf.
[18] Drebot, M. A., Holloway, K., Zheng, H., & Ogden, N. H. (2015). Travel-related Chikungunya cases in Canada, 2014. *Canada Communicable Disease Report*, 41(1), 2-5. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-01/rapid-eng.php
[19] World Health Organization (2016). *WHO statement on the first meeting of the International Health Regulations (2005) (IHR 2005) Emergency Committee on Zika virus and observed increase in neurological disorders and neonatal malformations*. Retrieved Feb 3, 2016, from http://www.who.int/mediacentre/news/statements/2016/1st-emergency-committee-zika/en/.
[20] BC Centre for Disease Control (2015-05). *Communicable disease control. Chapter 1 - Management of specific diseases: Rabies*. Retrieved Aug 10 2015, from http://www.bccdc.ca/NR/rdonlyres/961F7CD9-072E-436E-A546-813C915CA4AF/0/BCRabiesGuidelinesMay2015.pdf.
[21] Bui, Y., Sow, M., Cambron-Goulet, E., Levac, E., & Milord, F. (2015). Immunogenicity and feasibility of intradermal vaccination against Rabies in Québec. *Canada Communicable Disease Report*, 41(3), 55-62. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-03/assets/pdf/15vol41_03-eng.pdf.
[22] Craig, J., Klowak, M., & Boggild, A. K. (2015). Diagnostic challenges in Chikungunya infection: Report of an atypical presentation. *Canada Communicable Disease Report*, 41(1), 6-10. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-01/study-etude-eng.php
[23] World Health Organization (2016). *WHO statement on the first meeting of the International Health Regulations (2005) (IHR 2005) Emergency Committee on Zika virus and observed increase in neurological disorders and neonatal malformations*. Retrieved Feb 3, 2016, from http://www.who.int/mediacentre/news/statements/2016/1st-emergency-committee-zika/en/.
[24] World Health Organization. (2015-04). *Antimicrobial resistance*. Retrieved Sept 16 2015, from http://www.who.int/mediacentre/factsheets/fs194/en/.
[25] Finley, R., Reid-Smith, R., Ribble, C., Popa, M., Vandermeer, M., & Aramini, J. (2008). The occurrence and antimicrobial susceptibility of salmonellae isolated from commercially available canine raw food diets in three Canadian cities. *Zoonoses and Public Health*, 55(8-10), 462-469.
[26] Centers for Disease Control and Prevention (2013-10). *History of One Health*. Retrieved July 20 2015, from http://www.cdc.gov/onehealth/people-events.html.
[27] Public Health Agency of Canada (2013-04). *Environmental public health and climate change*. Retrieved July 20 2015, from http://www.phac-aspc.gc.ca/hp-ps/eph-esp/index-eng.php.
[28] Canadian Food Inspection Agency (2011). *One Health: It's what we are called to do*. Retrieved July 15, 2015, from http://www.inspection.gc.ca/animals/cvo-international-standards/cvo-statements/one-health/eng/1328721867511/1336053202506.
[29] Wegener, H.C. (2012). *Antibiotic resistance - linking human and animal health. In Improving Food Safety Through a One Health Approach: Workshop Summary*. Pp 331-349. Retrieved Sept 16 2015, from http://www.ncbi.nlm.nih.gov/books/NBK100665/pdf/Bookshelf_NBK100665.pdf.
[30] Government of Canada (2015). *Symptoms of Lyme disease*. Retrieved Aug 18 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/lyme/symptoms-symptomes-eng.php.
[31] Public Health Agency of Canada. (2015-08-12). *Surveillance of Lyme Disease*. Retrieved Sep 9 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/lyme/surveillance-eng.php.
[32] Public Health Agency of Canada. (2015-08-21). *Public Health Reminder: Lyme disease*. Retrieved Aug 21 2015, from http://www.phac-aspc.gc.ca/phn-asp/2015/lyme-eng.php.
[33] Public Health Agency of Canada. (2015-08-21). *Public Health Reminder: Lyme disease*. Retrieved Aug 21 2015, from http://www.phac-aspc.gc.ca/phn-asp/2015/lyme-eng.php.

[34] Government of Canada. (2015-06-26). *Symptoms of West Nile virus*. Retrieved Sept 10 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/west-nile-nil-occidental/symptom-symptome-eng.php.

[35] Public Health Agency of Canada. (2015-09-03). *Surveillance of West Nile virus*. Retrieved Sept 10 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/west-nile-nil-occidental/surveillance-eng.php.

[36] Government of Canada (2015-06-26). *Risks of West Nile virus*. Retrieved Aug 25 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/west-nile-nil-occidental/risk-risque-eng.php.

[37] Public Health Agency of Canada. (2015-06-09). *West Nile virus and Other Mosquito-Borne Disease National Surveillance Report*. Retrieved Aug 25 2015, from http://healthycanadians.gc.ca/publications/diseases-conditions-maladies-affections/west-nile-2014-nil-occidental/index-eng.php.

[38] Public Health Agency of Canada (2015-06-26). *Chikungunya: Global update*. Retrieved Aug 6 2015, from http://www.phac-aspc.gc.ca/tmp-pmv/notices-avis/notices-avis-eng.php?id=120.

[39] Drebot, M., Holloway, K. & Lindsay, R. (2015-07-07). *Imported Chikungunya cases among Canadian travellers, 2014 and 2015*. Retrieved Oct 19 2015, from http://www.promedmail.org/direct.php?id=20150712.3505312.

[40] Drebot, M. A., Holloway, K., Zheng, H., & Ogden, N. H. (2015). Travel-related Chikungunya cases in Canada, 2014. *Canada Communicable Disease Report*, 41(1), 2-5. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-01/rapid-eng.php.

[41] Drebot, M. A., Holloway, K., Zheng, H., & Ogden, N. H. (2015). Travel-related Chikungunya cases in Canada, 2014. *Canada Communicable Disease Report*, 41(1), 2-5. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-01/rapid-eng.php.

[42] Government of Canada (2015-06-26). *Hantaviruses*. Retrieved Aug 26 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/hantavirus/index-eng.php?src=diseases_conditions-hantaviruses_15&medium=banner_en&campaign=topic_footer

[43] Drebot, M. A., Jones, S., Grolla, A., Safronetz, D., Strong, J. E., Kobinger, G., et al. (2015). Hantavirus pulmonary syndrome in Canada: An overview of clinical features, diagnostics, epidemiology and prevention. *Canada Communicable Disease Report*, 41(6), 124-131. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-02-eng.php.

[44] Drebot, M. A., Jones, S., Grolla, A., Safronetz, D., Strong, J. E., Kobinger, G., et al. (2015). Hantavirus pulmonary syndrome in Canada: An overview of clinical features, diagnostics, epidemiology and prevention. *Canada Communicable Disease Report*, 41(6), 124-131. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-02-eng.php.

[45] Drebot, M. A., Jones, S., Grolla, A., Safronetz, D., Strong, J. E., Kobinger, G., et al. (2015). Hantavirus pulmonary syndrome in Canada: An overview of clinical features, diagnostics, epidemiology and prevention. *Canada Communicable Disease Report*, 41(6), 124-131. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-02-eng.php.

[46] Drebot, M. A., Jones, S., Grolla, A., Safronetz, D., Strong, J. E., Kobinger, G., et al. (2015). Hantavirus pulmonary syndrome in Canada: An overview of clinical features, diagnostics, epidemiology and prevention. *Canada Communicable Disease Report*, 41(6), 124-131. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-02-eng.php

[47] Drebot, M. A., Jones, S., Grolla, A., Safronetz, D., Strong, J. E., Kobinger, G., et al. (2015). Hantavirus pulmonary syndrome in Canada: An overview of clinical features, diagnostics, epidemiology and prevention. *Canada Communicable Disease Report*, 41(6), 124-131. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-02-eng.php

[48] Public Health Agency of Canada. (2011). *Rabies Virus: Pathogen safety data sheet - infectious substances*. Retrieved Aug 18 2015, from http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/rab-eng.php.
[49] Public Health Agency of Canada (2015-07-28). *Notifiable Diseases On-Line*. Retrieved Aug 6 2015, from http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/charts.php?c=yl.
[50] Canadian Food Inspection Agency. (2015). *Rabies in Canada 2014*. Retrieved Nov 20 2015, from http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/rabies/rabies-in-canada-2014/eng/1424879193262/1424879195231.
[51] Public Health Agency of Canada. (2008). *Fact sheet on Rabies*. Retrieved Aug 18 2015, from http://www.phac-aspc.gc.ca/im/rabies-faq-eng.php.
[52] Canadian Food Inspection Agency. (2015). *Rabies in Canada 2014*. Retrieved Nov 20 2015, from http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/rabies/rabies-in-canada-2014/eng/1424879193262/1424879195231
[53] Canadian Food Inspection Agency (2015). *Rabies in Canada*. Retrieved Nov 20 2015, from http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/rabies/rabies-in-canada/eng/1356156989919/1356157139999
[54] Canadian Food Inspection Agency. (2014). *2011-2013 Positive Rabies in Canada*. Retrieved Nov 20 2015, from http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/rabies/rabies-in-canada/positive-rabies-2011-2013-/eng/1406218460196/1406218461478.
[55] Canadian Food Inspection Agency. (2011). *Positive Rabies in Canada*. Retrieved Nov 20 2015, from http://epe.lac-bac.gc.ca/100/206/301/cfia-acia/2011-09-21/www.inspection.gc.ca/english/anima/disemala/rabrag/statse.shtml.
[56] Drebot, M.A. (2015-06-04). Emerging Mosquito-borne bunyaviruses in Canada. Canada Communicable Disease Report, 41(6), 117-123. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-03-eng.php.
[57] Public Health Agency of Canada. (2014-09-09). California Serogroup - Pathogen Safety Data Sheet. Retrieved Jan 26 2016, from http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/msds27e-eng.php.
[58] Meier-Stephenson V, Langley JM, Drebot M, Artsob H. (2007). *Encephalitis in the summer: a case of snowshoe hare (California serogroup) virus infection in Nova Scotia.* Can Commun Dis Rep. 2007 Oct 1;33(11):23-6.
[59] Meier-Stephenson V, Langley JM, Drebot M, Artsob H. (2007). *Encephalitis in the summer: a case of snowshoe hare (California serogroup) virus infection in Nova Scotia.* Can Commun Dis Rep. 2007 Oct 1;33(11):23-6.
[60] Drebot, M.A. (2015-06-04). Emerging Mosquito-borne bunyaviruses in Canada. Canada Communicable Disease Report, 41(6), 117-123. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-03-eng.php.
[61] Drebot, M.A. (2015-06-04). Emerging Mosquito-borne bunyaviruses in Canada. Canada Communicable Disease Report, 41(6), 117-123. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-03-eng.php.
[62] Pierdomenico, A.D., Borgia, S.M., Richardson, D. & Baqi, M. (2011). Brucellosis in a returned traveller. *Canadian Medical Association Journal*, 183(10):E690-E692.
[63] Public Health Agency of Canada. (2001). *Brucella spp.(B. abortus, B. canis, B. melitensis, B. suis) - Material Safety Data Sheets (MSDS)*. Retrieved Sept 10 2015, from http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/msds23e-eng.php.
[64] Public Health Agency of Canada (2015-07-28). *Notifiable Diseases On-Line*. Retrieved Aug 6 2015, from http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/charts.php?c=yl.
[65] Ministry of Health and Long-Term Care (ON) (2014-12). *Infectious Diseases Protocol. Appendix A: Disease-specific Chapters. Chapter: Brucellosis.* Retrieved Aug 10 2015, from http://www.health.gov.on.ca/en/pro/programs/publichealth/oph_standards/docs/brucellosis_chapter.pdf.

[66] Canadian Food Inspection Agency. (2011). *Fact Sheet - Brucellosis*. Retrieved Nov 17 2015, from http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/brucellosis/fact-sheet/eng/1305673222206/1305673334337.

[67] World Health Organization (2015-07-15). Cumulative number of confirmed cases for avian influenza A(H5N1) reported to WHO, 2003-2015. Retrieved Aug 6 2015, from http://www.who.int/influenza/human_animal_interface/EN_GIP_20150717cumulativeNumberH5N1cases.pdf?ua=1.

[68] World Health Organization (2015-02-01). *Human infection with Avian influenza A(H7N9) virus – Canada*. Retrieved Aug 6 2015, from http://www.who.int/csr/don/01-february-2015-avian-influenza/en/.

[69] Canadian Food Inspection Agency. (2012-12-22). *Fact Sheet - Avian Influenza*. Retrieved Aug 21 2015, from http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/ai/fact-sheet/eng/1356193731667/1356193918453.

[70] Public Health Agency of Canada. (2015-07-02). *Current Avian influenza (H5N1) affected areas.* Retrieved Aug 21 2015, from http://www.phac-aspc.gc.ca/h5n1/index-eng.php.

[71] Canadian Food Inspection Agency. (2012-12-22). *Fact Sheet - Avian influenza*. Retrieved Aug 21 2015, from http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/ai/fact-sheet/eng/1356193731667/1356193918453.

[72] Charania, N. A., Martin, I. D., Liberda, E. N., Meldrum, R., & Tsuji, L. J. S. (2014). Bird harvesting practices and knowledge, risk perceptions, and attitudes regarding Avian influenza among Canadian First Nations subsistence hunters: Implications for influenza pandemic plans. *BMC Public Health*, 14(1113) Retrieved from http://www.biomedcentral.com/content/pdf/1471-2458-14-1113.pdf.

[73] Murti, M., Skowronski, D., Lem, M., Fung, C., Klar, S., Bigham, M., et al. (2015). Public health response to outbreaks of Avian influenza A(H5N2) and (H5N1) among poultry - British Columbia, December 2014-February 2015. *Canada Communicable Disease Report*, 41(4), 69-72. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-04/assets/pdf/15vol41_04-eng.pdf

[74] World Health Organization. (2005). *International Health Regulations*. Retrieved Sept 22 2015, from http://apps.who.int/iris/bitstream/10665/43883/1/9789241580410_eng.pdf.

[75] United States Department of Health and Human Services (n.d.). *One Health.* Retrieved Jan 14 2016, from http://www.globalhealth.gov/global-programs-and-initiatives/one-health/.

[76] Centers for Disease Control and Prevention (2013-10). *History of One Health.* Retrieved July 20 2015, from http://www.cdc.gov/onehealth/people-events.html.

[77] Center for Disease Control (n.d.). *Companion animals practice: Understanding the veterinarian's role in public health. A One Health perspective for veterinarians*. Retrieved July 16 2015, from http://www.cdc.gov/onehealth/resources/index.html.

[78] Public Health Agency of Canada (2009). *One World One Health: From ideas to action. Report of the Expert Consultation.* Ottawa, ON: Author

[79] Public Health Agency of Canada (2009). *One World One Health: From ideas to action. Report of the Expert Consultation*. Ottawa, ON: Author.

[80] American Veterinary Medical Association (2008-07-15). *One Health: A New Professional Imperative. One Health Initiative Task Force: Final Report*. Retrieved July 15, 2015, from https://www.avma.org/KB/Resources/Reports/Pages/One-Health.aspx.

[81] World Health Organization & World Organisation for Animal Health (2014). *WHO-OIE Operational Framework for Good Governance at the human-animal interface: Bridging WHO and OIE tools for the assessment of national capacities*. Retrieved July 15, 2015, from http://www.oie.int/doc/en_document.php?numrec=4428103.

[82] World Bank (2010). *People, pathogens and our planet. Volume 1: Towards a One Health approach for controlling zoonotic diseases*. Retrieved July 15, 2015, from http://siteresources.worldbank.org/INTARD/Resources/PPP_Web.pdf.

[83] Canadian Food Inspection Agency. (2014). *Canadian Food Inspection Agency: Food Program Framework.* Retrieved July 16 2015, from http://www.inspection.gc.ca/about-the-cfia/accountability/consultations/food-program/framework/eng/1400434072910/1400434368706.

[84] Fisman.D.N. & Laupland, K.B. (2010). The 'One Health' paradigm: Time for infectious diseases clinicians to take note? *Canadian Journal of Infectious Diseases & Medical Microbiology*, 21(3), pp.111-114.

[85] Public Health Agency of Canada. (2014-09). Report on the state of public health in Canada 2014: Public health in the future. Retrieved Aug 13 2015, from, http://www.phac-aspc.gc.ca/cphorsphc-respcacsp/2014/assets/pdf/2014-eng.pdf.

[86] Government of Canada. (2015-04-29). *Action Plan on Lyme Disease*. Retrieved Aug 20 2015, from http://www.healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/lyme/plan-eng.php.

[87] Public Health Agency of Canada (2014). *2013-14 Departmental Performance Report*. Retrieved March 16 2015, from http://www.phac-aspc.gc.ca/about_apropos/dpr-rmr/2013-2014/assets/pdf/dpr-rmr-2013-2014-eng.pdf.

[88] One World One Health (2009). *About "One World, One Health."* Retrieved Sept 10 2015, from http://www.oneworldonehealth.org/.

[89] Bhatia, N., Sarwal, S., Robinson, H., Geduld, J., Huneault, F., Schreiner, H., Collins, S. & Hickey, R. (2015-12-17). Federal public health strategies to minimize the importation of communicable diseases into Canada. *Canada Communicable Disease Report*, 41S (6), 3-8. Retrieved Dec 18 2015, from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/index-eng.php.

[90] Government of Canada (2010-03-03). *Speech from the Throne: 40th Parliament, 3rd Session*. Retrieved Aug 6 2015, from http://www.parl.gc.ca/parlinfo/Documents/ThroneSpeech/40-3-e.html.

[91] Government of Canada. (2015-04-21). *Budget Plan: Strong leadership: A Balanced-budget, low-tax plan for jobs, growth and security.* Retrieved July 27 2015, from: http://www.budget.gc.ca/2015/docs/plan/toc-tdm-eng.html.

[92] Government of Canada. (2015-06-01). *News Release: Public Health Agency of Canada launches public consultation on Lyme disease*. Retrieved Aug 21 2015, from http://news.gc.ca/web/article-en.do?nid=982479.

[93] Federal Framework on Lyme Disease Act, S.C. 2014, c.37.

[94] Government of Canada. (2014-04-07). *Statement - World Health Day 2014 - April 7, 2014*. Retrieved Aug 13 2015, from http://news.gc.ca/web/article-en.do?crtr.sj1D=&crtr.mnthndVl=8&mthd=advSrch&crtr.dpt1D=3150&nid=942819&crtr.lc1D=&crtr.tp1D=&crtr.yrStrtVl=2002&crtr.kw=%22west+nile%22&crtr.dyStrtVl=15&crtr.aud1D=&crtr.mnthStrtVl=12&crtr.page=5&crtr.yrndVl=2015&crtr.dyndVl=13.

[95] Government of Canada. (2015-01-26). *Speech: First Case of H7N9*. Retrieved Aug 13 2015, from http://news.gc.ca/web/article-en.do;jsessionid=3d99c4287195792abd32deb61b0af1d42fb3bda038882f8627cf13d675179b58.e38RbhaLb3qNe38Tbhj0?crtr.sj1D=&crtr.mnthndVl=12&mthd=advSrch&crtr.dpt1D=&nid=926029&crtr.lc1D=&crtr.tp1D=970&crtr.yrStrtVl=2014&crtr.kw=Rona+Ambrose&crtr.dyStrtVl=11&crtr.aud1D=&crtr.mnthStrtVl=3&crtr.page=1&crtr.yrndVl=2015&crtr.dyndVl=31.

[96] Public Health Agency of Canada. (2013-05). *Strategic Horizons 2013-2018*. Retrieved Aug 18 2015, from http://publications.gc.ca/collections/collection_2014/aspc-phac/HP55-1-2013-eng.pdf.

[97] Public Health Agency of Canada (2014). *Corporate Risk Profile 2013-15.*

[98] Public Health Agency of Canada (2015). *2015-16 Report on Plans and Priorities*. Retrieved Aug 6 2015, from http://www.phac-aspc.gc.ca/rpp/2015-2016/assets/pdf/rpp-2015-2016-eng.pdf.

[99] World Health Organization (2015). *WHO Report on Global Surveillance of Epidemic-prone Infectious Diseases.* Retrieved Dec 15 2015, from http://www.who.int/csr/resources/publications/introduction/en/index1.html.

[100] World Health Organization (2015). *Alert, response, and capacity building under the International Health Regulations (IHR)*, Retrieved Dec 15 2015, from http://www.who.int/ihr/surveillance/en/.
[101] Public Health Agency of Canada (?). *Corporate Process for PHAC Public Health Surveillance Decision-Making – National West Nile virus Surveillance Activity*. Ottawa, ON: Author.
[102] Government of Canada (2015). *National Microbiology Laboratory (NML) Overview*. Retrieved Dec 21 2015, from https://www.nml-lnm.gc.ca/overview-apercu-eng.htm.
[103] Government of Canada (n.d.). *Guide to Services*. Retrieved Dec 22 2015, from https://qa.cnphi-rcrsp.ca/gts/faces/public/index.xhtml.
[104] Government of Canada (2015). *Action plan on Lyme disease*. Retrieved Dec 21 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/lyme/plan-eng.php.
[105] Government of Canada (2015). *Field Studies, Zoonotic Diseases and Special Pathogens.* Retrieved Dec 22 2015, from https://qa.cnphi-rcrsp.ca/gts/faces/public/laboratory.xhtml?labId=1019&lang=en.
[106] Federal Framework on Lyme Disease Act, S.C. 2014, c.37.
[107] Government of Canada (n.d.). *Guide to Services: Special Pathogens*. Retrieved Dec 29 2015, from https://www.cnphi-rcrsp.ca/gts/faces/public/laboratory.xhtml?labId=1021.
[108] Public Health Agency of Canada (2014). *The Chief Public Health Officer's Report on the State of Public Health in Canada, 2014: Public Health in the Future*. Retrieved Dec 30 2015, from http://www.phac-aspc.gc.ca/cphorsphc-respcacsp/2014/index-eng.php.
[109] Public Health Agency of Canada (2012). *Evaluation of Food-borne Enteric Illness Prevention, Detection and Response Activities at the Public Health Agency*. Retrieved Dec 30 2015, from http://www.phac-aspc.gc.ca/about_apropos/evaluation/reports-rapports/2011-2012/feipdra-pdimeoa/index-eng.php.
[110] Institut National de Santé Publique du Québec (2014). *Proposition d'un programme de surveillance intégré pour la maladie de Lyme et les autres maladies transmises par la tique Ixodesscapularis au Québec*. Retrieved Oct 27 2015, from http://www.inspq.qc.ca/pdf/publications/1819_Programme_Maladie_Lyme.pdf.
[111] Ministère de la Santé et des Services sociaux (2013). *Guide d'Intervention pour la maladie de Lyme*. Retrieved Oct 27 2015, from http://publications.msss.gouv.qc.ca/acrobat/f/documentation/2013/13-271-01W.pdf.
[112] Public Health Ontario (2012). *Technical Report: Update on Lyme Disease Prevention and Control*. Retrieved Oct 27 2015, from https://www.publichealthontario.ca/en/eRepository/PHO%20Technical%20Report%20-%20Update%20on%20Lyme%20Disease%20Prevention%20and%20Control%20Final%20030212.pdf.
[113] Ontario Ministry of Health and Long Term Care (2015). *Publications: Lyme Disease*. Retrieved Oct 27 2015, from http://www.health.gov.on.ca/en/public/publications/disease/lyme.aspx.
[114] Toronto and Region Conversation Authority (2012). *Tick Surveillance and Lyme Disease Prevention Summary Report*. Retrieved on Oct 27 2015, from http://www.trca.on.ca/dotAsset/155663.pdf.
[115] National Collaborating Centre on Infectious Diseases (2014). *Lyme Disease in Canada: An Update on the Epidemiology*. Retrieved Oct 27 2015, from https://cdn.metricmarketing.ca/www.nccid.ca/files/Purple_Paper_Note_mauve/PP_43_EN.pdf.
[116] Ontario Ministry of Natural Resources (2014). *Monitoring Programs Sponsored by the Ontario Ministry of Natural Resources and their Relevance to Climate Change*. Retrieved Oct 27 2015, from http://www.climateontario.ca/MNR_Publications/ccrr38.pdf.
[117] Manitoba Public Health Branch (2013). *Lyme Disease (Lyme Borreliosis).* Retrieved Oct 27 2015, from http://www.gov.mb.ca/health/publichealth/cdc/protocol/lyme.pdf.
[118] Alberta Health (2014). *Tick Surveillance: 2013 Summary*. Retrieved Oct 27 2015, from http://www.health.alberta.ca/documents/Tick-Surveillance-Summary-2013.pdf.
[119] eHealth Saskatchewan (2012). *Section 4: Vector-borne and Zoonotic Disease*. Retrieved Oct 27 2015, from http://www.ehealthsask.ca/services/manuals/Documents/cdc-section-4.pdf.

[120] Nova Scotia Department of Health and Wellness (2015). *Tick Borne Diseases Response Plan*. Retrieved Oct 28 2015, from http://novascotia.ca/dhw/cdpc/documents/100623_CDPC_Tick-Response-Plan.pdf.

[121] Nova Scotia Department of Health and Wellness (2012). *Lyme Disease: A Report on Lyme Disease Epidemiology and Surveillance in Nova Scotia*. Retrieved Oct 28 2015, from http://novascotia.ca/dhw/populationhealth/documents/Lyme-Disease-Epidemiology-and-Surveillance-in-Nova-Scotia.pdf.

[122] World Health Organization (2014-09-14). *Laboratory diagnosis of Ebola virus disease*. Retrieved Jan 4 2016, from http://apps.who.int/iris/bitstream/10665/134009/1/WHO_EVD_GUIDANCE_LAB_14.1_eng.pdf?ua=1.

[123] World Bank (2010). *People, pathogens and our planet. Volume 1: Towards a One Health approach for controlling zoonotic diseases*. Retrieved July 15, 2015, from http://siteresources.worldbank.org/INTARD/Resources/PPP_Web.pdf.

[124] Parmley, E.J., Pintar, K., Majowicz, S., Avery, B., Cook, A., Jokinen, C., Gannon, V., Lapen, D.R., Topp, E., Edge, T.A., Gilmour, M., Pollari, F., Reid-Smith, R. & Irwin, R. (2013-09). A Canadian Application of One Health: Integration of Salmonella Data from Various Canadian Surveillance Programs (2005-2010). *Foodborne Pathogens and Disease*, 10 (9), pp.747-756.

[125] Research Group on Epidemiology of Zoonoses and Public Health (2015). *About the GREZOSP*. Retrieved Dec 29 2015, from https://www.medvet.umontreal.ca/grezosp/grezosp_e.htm.

[126] The World Bank. (2011). *People, Pathogens and our Planet (volume 2), The Economics of One Health*. Report No. 69145-GLB. Page IX. Retrieved December 21 2015, from http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/06/12/000333038_20120612014653/Rendered/PDF/691450ESW0whit0D0ESW120PPPvol120web.pdf.

[127] The World Bank. (2011). *People, Pathogens and our Planet (volume 2), The Economics of One Health*. Report No. 69145-GLB. Retrieved December 21 2015, from http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/06/12/000333038_20120612014653/Rendered/PDF/691450ESW0whit0D0ESW120PPPvol120web.pdf.

[128] Ogden, N. H., Koffi, J. K., Lindsay, L. R., Fleming, S., Mombourquette, D. C., Sanford, C., et al. (2015). Surveillance for Lyme disease in Canada, 2009 to 2012. *Canada Communicable Disease Report*, 41(6), 132-145. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-03-eng.php

[129] Government of Canada. (2015). *Causes of Lyme Disease*. Retrieved Aug 18 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/lyme/causes-eng.php.

[130] Public Health Agency of Canada. (2015-08-21). *Public Health Reminder: Lyme disease*. Retrieved Aug 21 2015, from http://www.phac-aspc.gc.ca/phn-asp/2015/lyme-eng.php.

[131] Ogden, N. H., Koffi, J. K., Pelcat, Y., & Lindsay, L. R. (2014). Environmental risk from Lyme disease in central and eastern Canada: A summary of recent surveillance information. *Canada Communicable Disease Report*, 40(5), 74-82. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/14vol40/dr-rm40-05/assets/pdf/14vol40_05-eng.pdf

[132] Government of Canada (2015). *Symptoms of Lyme disease*. Retrieved Aug 18 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/lyme/symptoms-symptomes-eng.php.

[133] Health Canada. (2012-09-18). *Transmission through blood - Health Canada's Role*. Retrieved Sept 30 2015, from http://www.hc-sc.gc.ca/hc-ps/dc-ma/wnvblood-vnosang-eng.php.

[134] Canadian Blood Services. (2015-06-16). *Customer Letter #2015-17: Circular of Information (June 2015 version) Release of the Red Blood Cells, Leukocytes Reduced (LR), Plasma Components and Platelets Circulars With Updates to West Nile virus Testing at Canadian Blood Services And Release of the Red Blood Cells, Leukocytes Reduced (LR) Circular Updated with the Addition of a Pooled Red*

Blood Cell Component for Neonate Exchange Transfusion. Retrieved Sept 30 2015, from https://www.blood.ca/sites/default/files/CL_2015-17.pdf.

[135] Héma-Québec. (2004-05-28). *Virus du Nil Occidental*. Retrieved Sept 30 2015, from http://www.hema-quebec.qc.ca/publications/communiques/archives/2004/2004-06-28comvirusnil.fr.html.

[136] Artsob, H., Gubler, D. J., Enria, D. A., Morales, M. A., Pupo, M., Bunning, M. L., et al. (2009). West Nile virus in the new world: Trends in the spread and proliferation of West Nile virus in the western hemisphere. *Zoonoses and Public Health*, 56(6-7), 357-369.

[137] Zheng H, Drebot MA, Coulthart MB. West Nile virus in Canada: ever-changing, but here to stay. *Canada Communicable Disease Report* 2014;40(10):173-177

[138] Public Health Agency of Canada. (2011). *West Nile virus: Pathogen Safety Data Sheet - infectious substances*. Retrieved Aug 18 2015, from http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/wnv-vno-eng.php.

[139] Public Health Agency of Canada. (2014-09). *Report on the state of public health in Canada 2014: Public health in the future*. Retrieved Aug 13 2015, from, http://www.phac-aspc.gc.ca/cphorsphc-respcacsp/2014/assets/pdf/2014-eng.pdf.

[140] Epp, T., & Waldner, C. (2012). Occupational health hazards in veterinary medicine: Zoonoses and other biological hazards. *Canadian Veterinary Journal*, 53(2), 144-150.

[141] Drebot, M. A., Holloway, K., Zheng, H., & Ogden, N. H. (2015). Travel-related Chikungunya cases in Canada, 2014. *Canada Communicable Disease Report*, 41(1), 2-5. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-01/rapid-eng.php.

[142] Public Health Agency of Canada (2015-06-26). *Chikungunya: Global update*. Retrieved Aug 6 2015, from http://www.phac-aspc.gc.ca/tmp-pmv/notices-avis/notices-avis-eng.php?id=120.

[143] Ogden, N. H., Lindsay, L. R., & Coulthart, M. (2015). Is there a risk of Chikungunya transmission in Canada? *Canada Communicable Disease Report*, 41(1), 11-14. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-01/comment-eng.php.

[144] Craig, J., Klowak, M., & Boggild, A. K. (2015). Diagnostic challenges in Chikungunya infection: Report of an atypical presentation. *Canada Communicable Disease Report*, 41(1), 6-10. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-01/study-etude-eng.php.

[145] Public Health Agency of Canada. (2008). *Fact sheet on Rabies*. Retrieved Aug 18 2015, from http://www.phac-aspc.gc.ca/im/rabies-faq-eng.php.

[146] Public Health Agency of Canada. (2011). *Rabies Virus: Pathogen safety data sheet - infectious substances*. Retrieved Aug 18 2015, from http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/rab-eng.php.

[147] Bottoms, K., Trotz-Williams, L., Hutchison, S., Macleod, J., Dixon, J., Berke, O., et al. (2014). An evaluation of Rabies vaccination rates among canines and felines involved in biting incidents within the Wellington-Dufferin-Guelph Public Health Department. *Zoonoses and Public Health*, 61(7), 499-508.

[148] Public Health Agency of Canada. (2011). *Rabies Virus: Pathogen safety data sheet - infectious substances.* Retrieved Aug 18 2015, from http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/rab-eng.php.

[149] Boggild, A. K., Geduld, J., Libman, M., Ward, B. J., McCarthy, A., Hajek, J., et al. (2014). Travel-acquired infections in Canada: CanTravNet 2011-2012. *Canada Communicable Disease Report*, 40(16), 313-325. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/14vol40/dr-rm40-16/dr-rm40-16-surv-eng.php.

[150] Bui, Y., Sow, M., Cambron-Goulet, E., Levac, E., & Milord, F. (2015). Immunogenicity and feasibility of intradermal vaccination against Rabies in Québec. *Canada Communicable Disease Report*, 41(3), 55-62. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-03/assets/pdf/15vol41_03-eng.pdf .

[151] Aenishaenslin, C., Simon, A., Forde, T., Ravel, A., Proulx, J. -., Fehlner-Gardiner, C., et al. (2014). Characterizing Rabies epidemiology in remote Inuit communities in Québec, Canada: A "one health" approach. *Ecohealth*, 11(3), 343-355.

[152] Drebot, M. A., Jones, S., Grolla, A., Safronetz, D., Strong, J. E., Kobinger, G., et al. (2015). Hantavirus pulmonary syndrome in Canada: An overview of clinical features, diagnostics, epidemiology and prevention. *Canada Communicable Disease Report*, 41(6), 124-131. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-02-eng.php.

[153] Government of Canada (2015-06-26). *Hantaviruses*. Retrieved Aug 26 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/hantavirus/index-eng.php?src=diseases_conditions-hantaviruses_15&medium=banner_en&campaign=topic_footer

[154] Government of Canada (2015-06-26). *Hantaviruses*. Retrieved Aug 26 2015, from http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/hantavirus/index-eng.php?src=diseases_conditions-hantaviruses_15&medium=banner_en&campaign=topic_footer

[155] Drebot, M. A., Jones, S., Grolla, A., Safronetz, D., Strong, J. E., Kobinger, G., et al. (2015). Hantavirus pulmonary syndrome in Canada: An overview of clinical features, diagnostics, epidemiology and prevention. *Canada Communicable Disease Report*, 41(6), 124-131. Retrieved from http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-06/ar-02-eng.php.

[156] World Health Organization. (n.d.). *Brucellosis*. Retrieved Sept 11 2015, from http://www.who.int/topics/brucellosis/en/

[157] Pierdomenico, A.D., Borgia, S.M., Richardson, D. & Baqi, M. (2011). Brucellosis in a returned traveller. *Canadian Medical Association Journal*, 183(10):E690-E692.

[158] Public Health Agency of Canada. (2001). *Brucella spp.(B. abortus, B. canis, B. melitensis, B. suis) - Material Safety Data Sheets (MSDS)*. Retrieved Sept 10 2015, from http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/msds23e-eng.php.

[159] Public Health Agency of Canada. (2006-09-27). *Human Health Issues related to Avian Influenza in Canada*. Retrieved Aug 21 2015, from http://www.phac-aspc.gc.ca/publicat/daio-enia/pdf/nat-ai-guide-2006_e.pdf.

[160] Canadian Food Inspection Agency. (2012-12-22). *Fact Sheet - Avian Influenza*. Retrieved Aug 21 2015, from http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/ai/fact-sheet/eng/1356193731667/1356193918453.

[161] Public Health Agency of Canada. (2013-05-13). *Avian Influenza*. Retrieved Aug 21 2015, from http://www.phac-aspc.gc.ca/influenza/avian-eng.php.

[162] Canadian Food Inspection Agency. (2012-12-22). *Fact Sheet - Avian Influenza*. Retrieved Aug 21 2015, from http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/ai/fact-sheet/eng/1356193731667/1356193918453.

[163] Public Health Agency of Canada. (2013-05-13). *Avian Influenza*. Retrieved Aug 21 2015, from http://www.phac-aspc.gc.ca/influenza/avian-eng.php.

[164] Charania, N. A., Martin, I. D., Liberda, E. N., Meldrum, R., & Tsuji, L. J. S. (2014). Bird harvesting practices and knowledge, risk perceptions, and attitudes regarding Avian influenza among Canadian First Nations subsistence hunters: Implications for influenza pandemic plans. *BMC Public Health*, 14(1113) Retrieved from http://www.biomedcentral.com/content/pdf/1471-2458-14-1113.pdf

[165] Public Health Agency of Canada. (2015-07-02). *Current Avian influenza (H5N1) affected areas*. Retrieved Aug 21 2015, from http://www.phac-aspc.gc.ca/h5n1/index-eng.php.

[166] Canadian Wildlife Health Cooperative. (2015). *Dead bird survey - 2015*. Retrieved Dec 21 2015, from http://www.cwhc-rcsf.ca/data_products_aiv.php.

[167] Canadian Wildlife Health Cooperative (2015). *Avian Influenza Portal: Latest Testing*. Retrieved Dec 9 2015, from http://www.cwhc-rcsf.ca/aiv.php.