

**Evaluation and Analysis of the Canadian Surveillance
System for West Nile Virus**

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ABSTRACT

West Nile virus (WNV) is an arbovirus and is transmitted by infected mosquitoes after feeding on the blood of birds carrying the virus. The Canadian WNV national surveillance system has just completed its tenth year of operation. The thesis is to evaluate the surveillance system and analyze multi-year human data. The evaluation includes the use of multiple lines of complementary methods such as the US CDC surveillance guidelines, Canadian Evaluation Framework, document review and a survey. Logistic and Poisson regressions were used for data analyses. WNV has become endemic in most parts of Canada since the virus occurred in 2001. The virus activity is peak around August. High numbers of human cases with WNV neurological syndrome identified pose a significant health concern due to the long term sequelae among affected patients. WNV national surveillance met its main objectives and there is a continual need for the surveillance.

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TABLE OF ABBREVIATIONS

Symbol and Abbreviations	Description
%	Percent
CFEZID	Centre for Food-borne, Environmental and Zoonotic Infectious Diseases
CCWHC	Canadian Cooperative Wildlife Health Centre
CFIA	Canadian Food Inspection Agency
CIHI	Canadian Information Health Institute
CMOH	Chief Medical Officer of Health
CNPHI	Canadian Network for Public Health Intelligence
CSF	Cerebral Spinal Fluid
ELISA	Enzyme-linked Immunosorbent Assay
FSA	Forward Sortation Area
FNIHB	First Nations and Inuit Health Branch
F/P/T	Federal / Provincial / Territorial
GIS	Geographic Information System
HC	Health Canada
IgG	Immunoglobulin G
IgM	Immunoglobulin M
JE	Japanese encephalitis
MLISA	Multi-Lateral Information Sharing Agreement
MOH	Ministry of Health
NAT	nucleic acid amplification testing
NML	National Microbiology Laboratory
NOGs	Non-government organizations
P/T	Provincial / Territorial
RHA	Regional Health Authorities
PHAC	Public Health Agency of Canada
PHU	Public Health Units
PIPEDA	Personal Information Protection and Electronic Documents Act
PRNT	Plaque Reduction Neutralization Test
US CDC	United States Center for Disease Control and Prevention
WHO	World Health Organization
WNV	West Nile Virus
WNNS	West Nile Virus Neurological Syndrome
WNNon_NS	West Nile Virus Non-Neurological Syndrome
WNAI	West Nile Virus Asymptomatic Infections
WNV SP	West Nile Virus Surveillance Program
WNV NSC	West Nile Virus National Steering Committee

Chapter One: Background and Introduction

This chapter provides a summary of epidemiology and epizootiology of the emerging zoonotic disease of West Nile virus, as well as debriefs Canada's response to the introduction of the novel virus in the country. Also, introduces the main objectives of this thesis.

1.1 Epidemiology of West Nile Virus

West Nile virus (WNV) was first isolated from the serum of a febrile woman in 1937 in the West Nile district of Uganda (1). Following its original isolation, WNV has caused sporadic outbreaks of mild viral illness in Africa, the Middle East, western Asia, and Australia (2, 3). Since the 1990s, WNV started to spread in Europe. Several outbreaks in humans have been reported in the Mediterranean basin and southern Europe, with fatal cases of encephalitis occurring principally among elderly people. For example, the outbreaks occurred in Algeria in 1994, Romania in 1996, Tunisia in 1997, Russia in 1999, and Israel in 2000 (4, 5). Epizootics in horses were also reported in Morocco in 1996, Italy in 1998, and France and Israel in 2000 (6, 7, 8).

In 1999, the United States Centers for Disease Control and Prevention (US CDC) reported a cluster of viral encephalitis cases caused by West Nile virus in New York City. This outbreak was the first recognized introduction of WNV into North America (9). Since then, WNV has spread rapidly across the contiguous United States and into Canada and has made incursions into Central America and South America. For example, Canada isolated and identified first positive dead birds in 2001 and in the following year the first human cases were confirmed in Ontario (10). In 2002,

WNV-neutralizing antibodies were detected in samples from birds captured in Jamaica, the Dominican Republic, and Guadeloupe (11, 12, 13). Mexico reported positive cases in horses in 2002 and a human case in 2003 (14, 15). Globally, there is a worldwide spread of the virus and has been found in parts of Australia, Asia, Africa, Europe and Northern America including Canada.

Most people with WNV infection have no symptoms, or mild symptoms. It is circa 20% of infected people who do develop symptoms. Of them, approximately 2% infected people develop neurological syndromes (16). Not many publications are available relevant to long term consequences of WNV infection. Increasing age is associated with the risk of neurological syndromes for those with WNV infection (17, 18). The incubation time period in humans for WNV is usually 2 to 15 days (19). Currently, there is no human vaccine against WNV. The best prevention of the diseases is to avoiding mosquito bite and using repellent.

The knowledge of transmission cycle of the disease in humans has become rich over time. Humans typically acquire WNV disease through a bite from infected adult mosquitoes. Human cases with WNV infection usually are incidental hosts because they may not develop sufficient viremia to propagate virus amplification after a mosquito bitten and can not continue to contribute to the transmission cycle. In 2002, however, person-to-person transmission via blood transfusion and possibly through breast milk and intrauterine infection were implicated for the first time in the US (20, 21, 22, 23). These findings enriched the knowledge of WNV transmission cycle and also brought the challenges in terms of prevention and control of the virus to public.

West Nile virus is a single-stranded plus-sense RNA virus. The virus is a member of the Japanese encephalitis (JE) virus serocomplex, which includes JE, St. Louis encephalitis, and Murray Valley encephalitis viruses (24). WNV is mainly classified into two lineages. Lineage 1 viruses are responsible for human disease and have been isolated from the United States, Europe, Israel, Africa, India, Russia, and Australia. In contrast, lineage 2 viruses are found primarily in enzootic cycles and have been isolated only in sub-Saharan Africa and Madagascar (25). One study was shown that the lineage 2 could cause neurologic disease in horses in South Africa (26). Previous experience had shown that the majority of severe human cases of WNV were caused by lineage 1, which is what we have seen in North America to date. In 2010, however, Greece and Russia reported significant WNV outbreaks in humans with severe cases of central nervous system manifestations and almost all strains identified in the two countries were associated with lineage 2.

The European Center for Disease Prevention and Control has been actively working on WNV surveillance as the presence of increased WNV activity and the co-circulation of different WNV strains from lineage 1 and 2 might be indicators that the epidemiology of WNV in Europe is changing (27). Further, as we experienced in 1999, these changes may begin to be seen in North America, Canada.

1.2 Epizootiology of West Nile Virus

West Nile virus is an arbovirus in the family of *Flaviviridae*. The term “arbovirus” refers to **arthropod-borne** viruses that are transmitted by insect vectors or spread as zoonoses. Mosquitoes are the main vector for most arboviruses (28). Arboviruses are mainly classified as: *Flaviviridae* (Latin for yellow); *Togaviridae* (Latin for the garment or the envelope of the virus); *Bunyaviridae* (Latin for a locale in Western Uganda where the virus was isolated); and Reoviridae (Latin for ring-shaped capsomers) (29, 30).

WNV is transmitted by infected mosquitoes after feeding on the blood of birds carrying on the virus. As certain types of female mosquitoes feed on birds to get their blood meal in order to breed, the virus is transmitted back and forth between the “vector” (the mosquito) and the reservoir “host” population (the bird). These “bridge vector” mosquitoes that have fed on a WNV-infected bird become infected with WNV themselves. When they subsequently bite a person or an animal, they can infect them with WNV as well (3, 5, 7).

Birds are the primary habitat for WNV and there are approximately 226 bird species as reservoirs for the virus in North America, most of which show little or no clinical effect. However, members of the corvid family (crows, magpies, ravens, and jays) are unable to effectively control the virus with their immune system. As a result, the virus reproduces quickly in a wide range of tissues, particularly in the brain and spinal cord and results in high death rates (10, 31).

A variety of mosquito species are able to draw the virus from the blood of infected birds and pass it on to others (17, 32). Main species responsible for amplifying the virus between the mosquito population and the bird population are *Culex* species mosquitoes, particularly *Cx. tarsalis*, *Cx. pipiens*, and *Cx. quinquefasciatus*. Thus, *Culex* mosquitoes are the most efficient transmitters of WNV and directly contribute to increasing the amount of virus circulating in the environment. These “bridge vector” mosquitoes, which bite both birds and mammals including humans, are highly dependent on local climate conditions (33, 34).

West Nile virus can also infect other mammals besides humans, especially horses. Horses become infected with WNV when they are bitten by mosquitoes that are carrying the virus. A vaccine manufactured in the United States has become available to protect horses from WNV infection since September 2001. The number of horse infections has reduced significantly after the vaccine produced in United States and Canada.

Gene sequence analysis indicated a high degree of complete genome sequence identical between US WNV in 1999 and those from Israel in 1998. The results support that WNV was likely introduced into the United States from the Middle East — very likely from Israel (25, 35). There are several theories as to how West Nile virus arrived in North America. One theory suggests that the virus arrived in infected migratory or imported birds. Another suggests that mosquitoes infected with the virus were accidentally transported to North America with other cargo (35).

West Nile virus is maintained in an enzootic mosquito-bird-mosquito cycle. When weather or climate condition promotes significant viral amplification in the enzootic cycle, the bridge vectors of mosquitoes become infected and pose an additional threat to mammals such as humans and horses. Further, due to increasing pace of international travel and trade, there is ongoing threat of exotic vectors introduction into Canada as we have experienced on WNV. For example, the mosquito *Aedes albopictus* is a vector capable of transmitting Dengue and Chikungunya. The species was introduced into the United States via the used tire trade and may begin to be seen in Canada under favourable environmental conditions (36).

1.3 Development of Canadian Multi-species West Nile Virus Surveillance, Risk Assessment Plan, Communication Plan and Response Plan

1.3.1 Rationale of Establishment of Enhanced Passive Human Surveillance

In 1999, WNV was emerged in New York City as the first recognized outbreak of the disease in North America. There were 62 confirmed human cases, with 7 deaths, including one Canadian who had visited the city during the time period of the outbreak (9).

Although there were no positive WNV identifications in Canada in 2000, the public and media were interested in WNV symptoms: how it was contracted, how to prevent infection, sentinel chicken flocks and whether there was any positive identification in Canada. Health Canada (HC)

tracked 486 print articles in the time frame from April to November in 2000. The issue was also picked up extensively in electronic media. (Documents reviewed: Risk assessment 2000, Health Canada News Release - Surveillance systems in Canada for West Nile virus Gearing up for Mosquito Season, May 2000)

To deal with public enquiries, HC established a WNV information page on the Population and Public Health Branch website. The site, which received approximately 10,000 hits from May to December in 2000, included a history of WNV in North America, a series of information sheets about WNV including protection and prevention measures, short video clips on sentinel chickens and a mosquito trap, and links to other relevant websites. Health Canada's public enquiries phone line received approximately 250 to 300 media calls between June and September in 2000.

(Document reviewed: Risk Assessment 2000, West Nile virus Facts - Outdoor Workers and recreation Professionals May 2000, West Nile virus Monitor [Closed website] 2000)

Given the level of public and media interest in this issue as well as the potential threat to Canadians, HC convened a meeting in February 2000. Participations included representatives from F/P/Ts and other stakeholders to assess the risk of introduction of WNV into Canada. As a result of the meeting, a West Nile virus National Steering Committee (WNV NSC) was established. The Committee pro-actively developed a comprehensive WNV national surveillance strategy, risk management plan, response plan, and communication plan, which addressed issues such as surveillance, education, response and prevention activities. (Documents reviewed: Health Canada - Communication Strategy April 2000, Health Canada Risk Management Plan May 2000)

One of the sub-committees under WNV NSC is the National WNV human surveillance sub-committee that is responsible for leading and coordinating National WNV human surveillance activities. Initially there were different surveillances in place to identify human cases such as sentinel surveillance in emergency rooms, active surveillance in target hospitals, as well as passive surveillance. Now, the main surveillance in humans is an enhanced passive surveillance with a letter being sent out to clinicians and health professionals at the early WNV season to increase awareness of the disease, and human cases with WNV infection are reported via the surveillance system. (Documents reviewed: Guidelines for Human Surveillance for West Nile virus, May 2000)

1.3.2 Development of Multi-species Surveillance, Risk Assessment Plan and Response Plan.

West Nile virus circulates in a bird-mosquito-bird cycle which can spill over into human and domestic animal populations (e.g. Equine). Surveillance should also include monitoring the presence of the virus in birds, horses and mosquitoes. Human surveillance should not be the sole source of information about the presence of WNV in a community.

At that time, a holistic picture of the emerging disease under surveillance was needed. The WNV NSC developed national guidelines to address multi-species surveillance which includes bird, mosquito, horse and human surveillance. Sub-committees followed up the national guidelines and collaboratively worked with stakeholders on the multi-species surveillance. There were more challenges at that time to conduct the multi-species surveillance. For example, there was little

knowledge on the number of species of birds that could act as the amplifying host for the virus in North America, although it was clear that at least 10 orders of birds (including approximately 25 species) were affected during the New York outbreak. For the mosquito surveillance, it also remained to determine how many species of mosquitoes are competent to transmit WN virus.

Simultaneously, the WNV NSC developed national risk assessment and response plans. The response levels will ramp-up according to the detection of different positive indicators as outlined below. (Documents Reviewed: National Response Plan - West Nile virus Response Sub Committee August 2000).

Level 0 - The absence of confirmed WNV infection in a bird, animal or mosquito pool, and WNV activity is unlikely.

Level 1 - In the absence of confirmed WNV infection in a bird, animal, or mosquito pool, and WNV activity is possible or the risk is unknown.

Level 2a - Based on an assessment of risk following detection of WNV activity in a neighbouring jurisdiction, in Canada or the United States, based on laboratory confirmed identification in a bird, animal, mosquito pool or human.

Level 2b - Based on an assessment of risk following detection of WNV activity within a jurisdiction based on laboratory-confirmed identification in a bird, animal or mosquito pool.

Level 3a - Detection of a single laboratory-confirmed human case of WNV (with no history of travel to an area with confirmed WNV activity within 21 days of onset of symptoms) within a jurisdiction.

Level 3b - Detection of multiple laboratory-confirmed human cases of WNV (with no history of travel to an area with confirmed WNV activity within 21 days of onset of symptoms) within a jurisdiction.

1.3.3 Development of Communication and Prevention Plan

At that time, Health Canada was coordinating / facilitating Canada's response to the potential threat of WNV, with a number of partners at the federal, provincial and local levels - all of whom had varying roles and responsibilities. Coordination amongst the partners, particularly with regard to communication with the media and the public, was crucial to ensuring that messages were accurate and consistent and that jurisdictional boundaries were respected. The need for such a coordinated response - i.e. who says what and when – was particularly acute should a positive identification be made (e.g. first positive cases in a bird, mosquito, horse, or human) within Canadian borders.

In all communications activities, care was taken when developing communications materials and key messages, in order to strike a balance between keeping the public informed while at the same time not raising unwarranted concern. The communications materials were modified appropriately

by considering the broad range of audiences such as the Canadian public, media, human health professionals (e.g. physicians, hospitals, or medical officers of health), Provincial/Territorial governments (e.g. Ministries of Health, Ministries of Environment, Ministries of Agriculture and Rural Affairs), national professional organizations (e.g. Canadian Veterinary Medical Association, Canadian Public Health Association, the Canadian Medical Association), Provincial/Territorial stakeholders (e.g. local health authorities), and NGOs (e.g. Canadian Blood Services / Hema-Quebec).

The learning experience on WNV surveillance is ongoing. Take bird surveillance as an example of some lessons learned from first year 2000 surveillance. Efforts at informing the public and soliciting their involvement in dead bird surveillance activities met with varying degrees of success. For instance, in some jurisdictions, people didn't know what to do or who to call to report dead birds. In other jurisdictions, lag times were reported between the time people called and the time birds were actually picked up by authorities. To better educate the public, a template on basic information on dead bird surveillance (e.g. what birds to look for, how to handle / not handle them, where to call) was developed and posted on the WNV internal / private website. Partners could then customize this template information in accordance with dead bird surveillance activities in their respective jurisdictions for posting on local sites, distribution to local print and electronic media etc.

(Documents reviewed: Health Canada - Communication Strategy April 2000, Report on Mosquito Surveillance in Canada – 2000, Communication Plan - Key Messages May 2001, Communication Strategy 2002)

1.4 Thesis Overview

1.4.1 Rationale:

Since Canada confirmed its first cases of WNV in 2001, the national WNV multi-species surveillance system has run every year during WNV season in the country, include passive surveillance in birds, passive surveillance in horses, active surveillance in mosquitoes and enhanced passive surveillance in humans. National surveillance data is collected and disseminated through the West Nile Virus *Monitor* website by the Public Health Agency of Canada.

According to Auditor General of Canada 2002 report that emphasized on the practices of measuring and reporting of performance on health surveillance in Canada, WNV surveillance system is in need of evaluation to ensure that public health importance of WNV being monitored efficiently and effectively. The current evaluation of the thesis covers the time period of the program activities from 2000 to 2010, particularly the initiates of the program in the first few years. In terms of the evaluation methods, complementary methods were used to collect the data for the evaluation such as the US CDC evaluation surveillance guidelines, document review, and a short survey. By conducting the evaluation, it could help in better understanding the key attributes of the system (e.g. timeliness, sensitivity, flexibility, acceptability and so on) and identify the strengths and limitations of the system for potential improvement in the future.

The WNV national surveillance system has collected data since the first human cases reported in 2002. So far, there is no comprehensive epidemiological analysis of the multi-year data at national level. This thesis presents an epidemiological summary of Canadian human surveillance data from 2002 to 2010 in terms of the distribution and determination of the disease in Canada.

1.4.2 Thesis Objectives

There are five main objectives of the thesis and are described as:

- Background and Introduction of the emerging zoonotic disease of West Nile virus
- To evaluate Canadian West Nile virus surveillance system, particularly in human surveillance.
- To analyze West Nile virus human surveillance data in Canada: 2002-2010.
- To brief other species surveillance on West Nile virus, especially for bird surveillance in Canada.
- To identify strengths and weaknesses of the surveillance system in Canada, and to make recommendations for improvement of the Canadian surveillance system and conclusions.

Chapter Two: Evaluation of Canadian West Nile Virus Surveillance

A need in conducting an evaluation of West Nile virus surveillance is described. Evaluation issues/questions were developed mainly based on the US CDC guidelines for evaluation health surveillance system. Indicators were developed for the evaluation and main findings were highlighted.

2.1 Background and Introduction

Epidemiologic surveillance is the ongoing and systematic collection, analysis, and interpretation of health data in the process of describing and monitoring a health event. Surveillance data are used both to determine the need for public health action and to assess the effectiveness of programs (37). For public health professionals, surveillance is “The eyes and ears of public health” (38). Evaluation of a surveillance system provides an opportunity to look at the system from different aspects such as the objective, design, data flow and operational characteristics of the surveillance system as well as its success in serving the requirements of public health action. Just as addressed by CDC, “The purpose of evaluating public health surveillance systems is to ensure that problems of public health importance are being monitored efficiently and effectively” (39).

The evolution of surveillance in public health can be traced back to 1963, Alexander Langmuir first defined the term of surveillance as “the systematic collection, consolidation, analysis and dissemination of data on specific disease” (40). In 1968, Karel Raska affirmed Langmuir’s view

and indicated that the three main features of surveillance are: a) systematic collection of data, b) analysis and evaluation of data, and c) dissemination of data regarding a health-related event for use in public health action to reduce morbidity, mortality and to improve health (41). In 1988, the United States Centers for Disease Control and Prevention further refined surveillance and published *Guidelines for Evaluating Surveillance Systems* to promote the best use of public health resources through the development of efficient and effective public health surveillance systems (42). These guidelines were updated in 2001 and titled as *Updated Guidelines for Evaluating Public Health Surveillance Systems* and addressed the need for: “a) the integration of surveillance and health information systems; b) the establishment of data standards; c) the electronic exchange of health data; and d) changes in the objectives of public health surveillance to facilitate the response of public health to emerging health threats” (39).

In 2002, the Auditor General of Canada’s report emphasized “*Health Canada should strengthen its evaluation, performance measurement, and reporting of results of its health surveillance activities.*” (43). In the wake of the Severe Acute Respiratory Syndrome (SARS) crisis in Canada in 2003, Health Canada developed documents for guideline on the evaluation of surveillance programs and the guideline was titled as *Framework and Tools for Evaluating Health Surveillance Systems in 2004* (44). The Framework and Tools “is designed to help managers of health surveillance systems identify and document issues relating to the rationale, implementation and effectiveness of their health surveillance systems. The Framework and tools provide standard approaches that managers can apply in their efforts to identify current practices and to enhance the ability of surveillance to provide relevant information for the review of public health objectives. The framework outlines six steps in evaluating health surveillance: 1) establishing the context of

the surveillance system; 2) developing evaluation questions; 3) designing the process for data collection and management; 4) collating and presenting the findings; 5) reviewing an evaluation Report; and 6) following up on the use of findings”.

The landscape in which surveillance is being done has been changing over time. The global context of lingering and emerging zoonotic disease threats such as SARS, Pandemic H1N1 2009, and high pathogenic avian influenza H5N1, as well as the electronic environment require different approaches. There is an urgent need to be able to respond to these changes, to work effectively with multiple partners and prepare for the future. In 2004, the US CDC published a supplement to surveillance evaluation as *Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks* for the purposes of evaluating public health surveillance systems for their timely detection of outbreaks (45). This framework document is added to with a supplement to previous CDC guidelines for evaluating public health surveillance. It emphasizes on the early detection of outbreak and typically the measurement of timeliness and validity for outbreak detection. The framework mainly includes four aspects: 1) System description; 2) Outbreak detection; 3) Experience; and 4) Conclusions and Recommendations. The first aspect is describing the surveillance system being evaluated such as defining the stakeholders, the public health importance of the health-related event under surveillance (e.g. frequency, severity, and public interest), a description of the purpose and operation of the surveillance system (e.g. purpose and objectives of the system), planned uses of the data collected, health-related event under surveillance with case definitions, a response flow chart, and a description of the resources used to operate the surveillance system. The second is concerned with the timely capture and processing of

data from the field and triggering an outbreak investigation, as well as the validity and quality of surveillance data. The third is considered the performance of the surveillance system by indicating the level of usefulness and describing the system's simplicity, flexibility, acceptability, and stability. The final task is concerned with the conclusions from the evaluation and recommends new uses and improvements to the system.

This chapter of the thesis presents the results of the evaluation of the Canadian WNV surveillance system. The chapter is organized into four sections: Section 1 presents an overview of the WNV surveillance system; Section 2 presents the methodology for the evaluation and discusses methodological limitations; Section 3 presents the findings, organized by evaluation issue; and Section 4 presents the overall conclusions and recommendations.

2.2 Overview of Canadian WNV Surveillance System

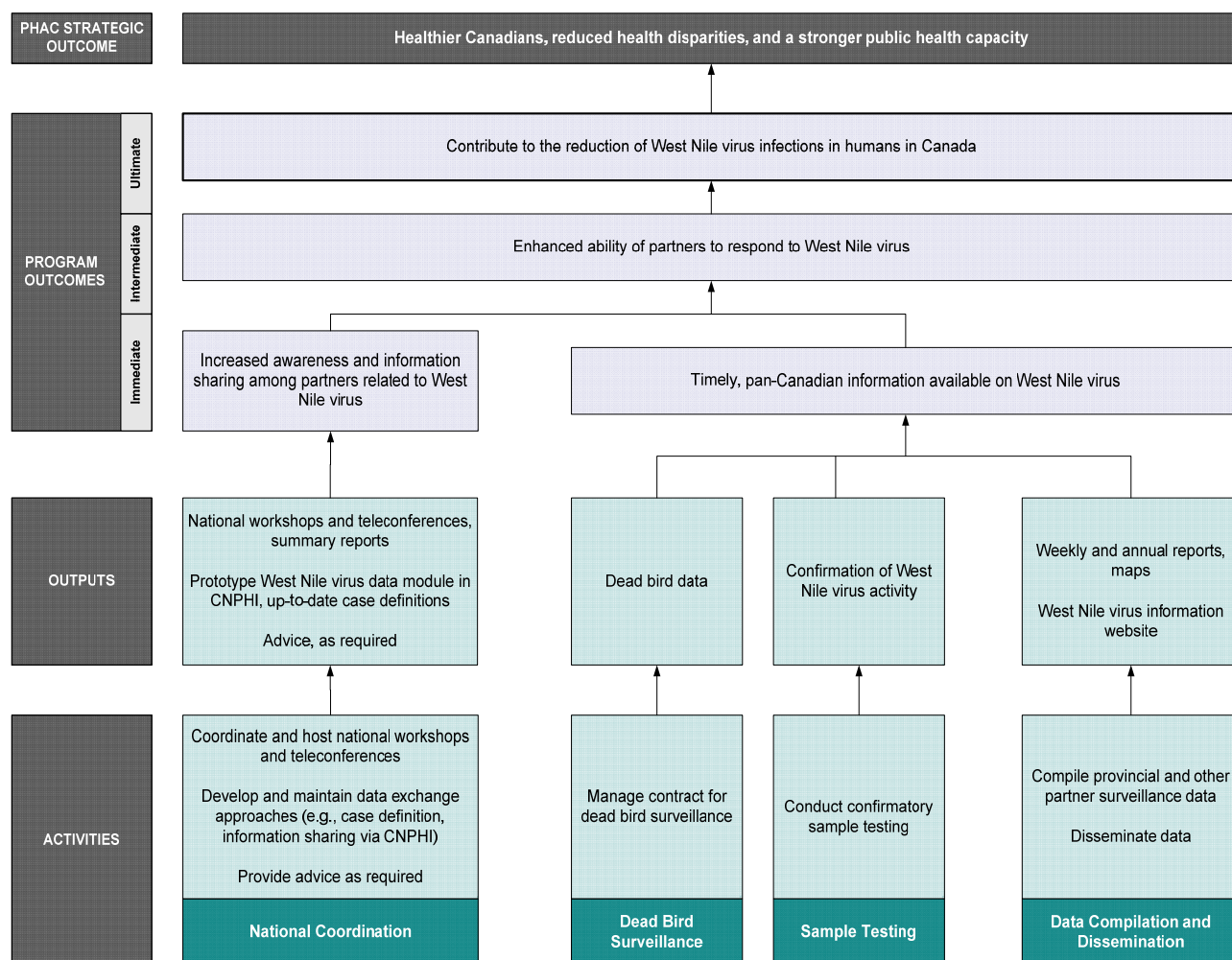
In response to the emerged WNV disease outbreak in New York City in 1999, Canada has a small but significant window of opportunity to prepare for the inevitable arrival of WNV in Canada. Health Canada began to coordinate a national response with provinces/territories and other partners and to establish surveillance, laboratory diagnostics, environmental control and a public education campaign. Surveillance activities focused on humans, dead birds, horses, and mosquitoes. Most of activities were conducted through collaborations with partners such as Canadian Cooperative Wildlife Health Centre, Canadian Food Inspection Agency, Provinces/Territories, and the federal National Microbiology Laboratory. Federal government

played a national coordination role in terms of information sharing and the initiative of WNV programs. Take the evolution of human case definitions for national surveillance as an example. In early 2000, little was known about WNV in Canada and thus there was limited capacity on how to address the emerging issue. As a national reference laboratory, the federal National Microbiology Laboratory developed and provided laboratory diagnostic test criteria for PTs to diagnose human cases. In 2003, the US CDC informed Canada on the transmission of WNV disease via blood transfusion by infected organ/blood. Health Canada shared this new epidemiologic information with Canadian blood operators and PTs in a timely fashion. Consequently, the WNV national human sub-committee revised the case definition by incorporating this epidemiologic information into the national human case definition in 2003.

Over time, with the capacities built in P/T partners, the primary responsibility for surveillance activities, laboratory diagnoses and tests, and public information development and dissemination have been shifted more to provincial partners. With the establishment of PHAC in 2004, the responsibility for the coordination of WNV activities was transferred from HC to PHAC. (Documents reviewed: Human case definitions in 2002, 2003, 2004, 2005 and RODs of human subcommittee teleconference 2003, 2004, 2005, and Evaluation of WNV surveillance program 2010).

The overall activities, outputs, and outcomes of the national WNV surveillance program were highlighted in Figure 2.1.

Figure 2.1 Canadian West Nile virus Surveillance Program Logic Model



Source: Government Consulting Services. *Evaluation of the WNV Surveillance Program*, November 2010, page 4.

2.3 Methodology for the Evaluation and Discussion Methodological Limitations

Various methods were used to get the data and information from different sources relevant to the program activities. The following section outlines: 1) the evaluation issues and questions; 2) data and information collection methods; and 3) methodological limitations for the evaluation. The evaluation examined the program from 2000 to 2010.

2.3.1 Evaluation Issues and Questions

Based on US CDC guidelines, issues and questions for the evaluation were developed and were used to measure the performance of WNV surveillance program (45). Table 2.1 below listed the evaluation issues and questions that are addressed in the evaluation. For each evaluation question, there are specific indicators and methodologies link to the question and can be seen in the complete evaluation matrix (Appendix I).

The US CDC guidelines are described in details in next section of data and information collection method.

Table 2.1. Summary of Evaluation Issues and Questions

Evaluation Issue	Evaluation Question
Program Description	• Public Health importance • Defining the Stakeholders • List the purpose and objectives of WNV surveillance system • Draw a flow chart of the West Nile virus surveillance system • What policies and procedures are in place to ensure patient privacy, data confidentiality, and system security? What is the policy and procedure for releasing data? Do these procedures comply with applicable federal and state statutes and regulations?
Program Data	• What are the reporting sources of data for the system? • What data are collected and how are they collected? • What is the period of time of the data collection? • How are the system's data managed (e.g., the transfer, entry, editing, storage, and back up of data)? Does the system comply with applicable standards for data formats and coding schemes? How are the system's data analyzed and disseminated?
Program Performance	• Timeline • Representativeness • Acceptability • Flexibility • Sensitivity • Usefulness

2.3.2 Data and Information Collection Methods

The following methods were used to develop the evaluation issues/questions and collect data and information for the evaluation:

- the US CDC Updated Guidelines for Evaluation Public Health Surveillance System;
- the PHAC' Framework and Tools for Evaluating Health Surveillance Systems;
- Documents Review;
- Surveillance Data Review;
- Administrative Data Review;
- Survey; and
- CIHI Data

Each of the methods above is described in details in the following section.

2.3.2.1 US CDC Updated Guidelines for Evaluation Public Health Surveillance System

Based on the Task A, B, C, D, E and F (details in appendix II and appendix III) in the US CDC *Updated Guidelines for Evaluating Public Health Surveillance Systems* (40), several evaluation issues and questions were developed and used to assess the Canadian National West Nile virus surveillance system. For example, Task D in the US CDC Update Guidelines for Evaluation Public Health Surveillance System recommends describing system attributes such as flexibility, representativeness, acceptability, sensitivity, usefulness and timeline. All these attributes are presented in the part of program performance. Details can be seen in Table 1.

2.3.2.2 *The PHAC' Framework and Tools for Evaluating Health Surveillance Systems*

PHAC' Framework and Tools for Evaluating Health Surveillance Systems (44) was used to develop the survey questionnaire (see below 2.3.2.6) for the WNV surveillance program, particularly consider the “SMART” rule which includes **Specific, Measurable, Actionable, Relevant, and Timely.**

2.3.2.3 *Document Review*

A volume of documents related to the WNV program activities were reviewed and summarised. The information was primarily used to answer the evaluation issues/questions. The following types of documentation were reviewed during the evaluation:

Strategic documents: included PHAC's Departmental Performance Reports, Reports on Plans and Priorities, and Auditor General Reports.

Program operational documents: included the WNV risk assessment plans, response plans, communication plans, surveillance plans, project plans, human case definitions, record of decision of teleconferences, West Nile virus Occupational Health and Safety Advisory - Final Version, West Nile virus Monitor website, WNV program evaluation report.

Research and academic literature: included information on publications, trends in new pathogens, literature of WNV publications.

2.3.2.4. Surveillance Data Review

WNV surveillance program activity/outputs relevant to data collection, data management, data dissemination and surveillance products were reviewed and analyzed to determine what surveillance data is gathered, timeliness of data dissemination to partners, nature of information disseminated, and the breadth of dissemination, as well as PHAC data quality Framework on WNV surveillance.

2.3.2.5. Administrative Data Review

Knowledge-transfer information derived from surveillance data were examined in the evaluation included: presentations, posters and workshops delivered by the Program; information on partnerships and participation on committees; records of decision; mechanisms/protocols for data exchange developed by the Program; and other knowledge products developed.

2.3.2.6 Survey Data

A short survey was conducted. The specific purpose of the survey was to get feedback from stakeholders who participated in the National WNV surveillance on overall usefulness of the surveillance to partners.

There are approximately 235 email receivers on the distribution list of weekly WNV surveillance report. Receivers on the list include representatives from F/P/T, Canadian Blood Operators and NOGs (e.g. CCWHC).

Based on the “SMART” rule in PHAC’ Framework and Tools for Evaluating Health Surveillance Systems (44), the survey questions were developed and mainly associated with four aspects of the program: 1) Dissemination of surveillance information; 2) Publications (or surveillance products); 3) Data collection process; and 4) Communications and Teleconference. The answers to the questions of the survey are categorized as yes, no, and unknown. Also, an open-end question was available for those who would like to provide additional comments and suggestions. A detailed survey questionnaire can be seen in the Appendix IV.

The survey was sent out by email. In order to increase the response rate, a second email was sent out one month later after the first one as a reminder. Finally, a total of 28 individuals provided the feedback, and they represented a broad geographic distribution, including British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Yukon Territory, Newfoundland Labour, Prince Edward Island, Canadian Blood Services, Héma-Québec, First Nation Inuit Health Branch, Health Canada, Environment Canada, Canadian Food Inspection Agency, and Public Health Agency of Canada. The overall response rate of the survey is 12 % (28/235).

2.3.2.7 Hospital Discharge Data in the Canadian Institute for Health Information (CIHI)

Based on the International Classification of Diseases (ICD), hospital cases with WNV infection were extracted for the available time period from 2002 to 2008. The diagnosis code for WNV is 0663 as ICD 9 and A923 as ICD10.

2.3.3. Methodological Limitations for the Evaluation

There are limitations and considerations that should be noted in terms of the evaluation.

A. Gaps existed in some documents available for review.

There were gaps in certain strategic and operational document for the Program from 2000 to 2010. For example, there were no updated national risk assessment plans available after 2004. This may be due to the roles/responsibilities of WNV National surveillance have shifted significantly since its inception, with PHAC currently playing more of a national and international coordinating role. Also, PTs have built the capacity to deal with the disease.

B. Rigorous assessment of longer-term outcomes was limited.

The assessment of the success of WNV surveillance programs is challenging, as it is not normally possible to determine how many WNV cases were prevented because the disease is influenced by many factors such as climate conditions, mosquito abundances, and human behavior. Therefore, it is challenge to complete a rigorous assessment of the contribution of the Program to its longer-term outcomes.

In addition, the knowledge transfer information derived from the WNV program has been applied for other zoonotic diseases surveillance, but it is challenging to be quantified.

C. The survey data was limited.

Although effort was made to gather the opinions from stakeholders, the response rate of the survey is relatively low and there is no information of the characteristics for those non-responses. For example, some of the receivers may no longer work on WNV in their jurisdictions; some of them may be just interested in the topic and never work on WNV. Also, the individuals who provided the feedback have varying degrees and may be not fully aware of how the data contributing to decision making to their jurisdictions, so the overall results from the survey may not be considered wholly objective.

2.4 Evaluation Findings

This section presents the findings of the evaluation of WNV surveillance program. The findings are organized by three main evaluation issues: 1) Program Description, 2) Program Data, and 3) Program Performance.

2.4.1. Program Description

2.4.1.1 Public Health Importance

Findings: West Nile virus is an important health concern in Canada, and the number of human cases is unpredictable from year to year. The epidemiology of WNV infection in humans in Europe appears to be changing and these changes may begin to be seen in Canada.

2.4.1.1.1 Health Concerns and West Nile Virus

In the fall of 2002, a study reports the severity of the disease for the outbreak of WNV in Southern Ontario (18).

“In all, 64 patients met the inclusion criteria; 57 had encephalitis or neuromuscular weakness or both, 5 had aseptic meningitis, and 2 had WNV fever... Ten patients died.”

Due to the health concern, WNV became a nationally reportable disease in Canada in 2003. This means that all medical professionals should report cases of WNV disease to the Public Health Agency of Canada via their provincial public health system. The Agency posts information on reportable, or notifiable, WNV diseases on its website.

Between 2002 and 2010, there were a total of 4,562 WNV cases reported in Canada, including 796 (17%) neurological syndromes and 63 (1.3%) fatalities. The disease has become endemic in central regions (Ontario and Quebec) and prairie regions (Manitoba, Saskatchewan and Alberta) since 2002. British Columbia started to report autochthonal cases in 2009. Currently, there is no human vaccine against WNV.

2.4.1.1.2 Unpredictability of West Nile Virus

As shown on the West Nile virus *Monitor* website in PHAC (10), the number of human cases fluctuates significantly from year to year, ranging from a high of 2,215 cases in 2007 to a low of 5

cases in 2010. The virus activity is unpredictable because it is influenced by a various factors such as climate conditions, mosquito abundances, bird populations, and land use and ecosystem system.

Based on mosquito surveillance data, Canada has shown *Culex* species mosquitoes are the most important vector species carrying on WNV. These mosquito species have adapted to the ecosystem in Canada so it is not likely that the virus will disappear.

2.4.1.1.3 The Epidemiology of WNV Infection in Humans Appears Changing

In 2010, Greece and Russia reported significant WNV outbreaks in humans with severe cases of central nervous system manifestations and almost all cases identified in the two countries were associated with the novel virulent lineage 2 (27). The co-circulation of different WNV strains from lineage 1 and 2 might be indicators that the epidemiology of WNV in Europe is changing. In November 2011, the European Centre for Disease Prevention and Control (ECDC) held an Expert consultation on risk assessment and outbreak mapping tools for West Nile Virus (WNV) Infection in response to the changes of epidemiology. The epidemiology of WNV infection in humans appears changing with emerging novel virulent WNV strain and these changes may begin to be seen in North America, Canada.

(Documents review: West Nile virus plan 2005.2006, P/Ts websites, West Nile virus Monitor on PHAC website, ECDC website and the conference).

2.4.1.2 Defining the Stakeholders

Findings: West Nile Virus National surveillance program includes multi-disciplinary and multi-jurisdiction partners covering animal, human and environmental sectors as a One Health approach.

WNV National surveillance is a collaborative effort amongst multiple organizations / disciplines and multiple jurisdictions including animal, human and ecosystem health. At the F/P/T levels, for example, this includes but not limited to PHAC, P/T Ministries of Health, Pest Management Regulatory Agency, First Nations and Inuit Health Branch in Health Canada, Occupational Health and Safety Agency, Canadian Food Inspection Agency (CFIA), Department of National Defense, and Environment Canada, Natural Resources, and Conservation. Non-governmental organizations such as Canadian Cooperative Wildlife Health Centre, Canadian Blood Services, and Héma-Québec. Some research institutes and universities have been involved in the development of forecasting modelling for WNV by using the surveillance data.

The federal role in public health was set out with the creation of a federal Department of Health in response to the 1918 influenza pandemic. Over time, this role has grown and evolved to include a broad scope of federal action to protect Canadians from threats to their health (46). For WNV surveillance, the federal governments in early 2000 played a leadership and coordination role in terms of the national program initiatives. With the capacities built in PTs over time, provinces/territories take more responsibilities such as risk assessment, surveillance activities, mosquito control, and public education.

(Documents reviewed: Mosquito Surveillance Protocols, in response plan 2001, Guidelines for Human Surveillance for WN virus 2001, 2002, National Response Plan - West Nile virus Response Sub Committee 2000, Guidelines on the prevention of West Nile virus infection in Canada using chemical insecticides to control adult mosquitoes 2000, WNV Monitor website, response plan 2003, and surveillance plan 2003).

2.4.1.3 List the Objectives of WNV Surveillance

Findings: the objectives of the multi-species surveillance were clearly defined in early documents in 2000. Over time, these objectives have been modified with more information of the disease becoming available.

2.4.1.3.1 The Objectives of WNV Human Surveillance

In early 2000, there was limited knowledge on the epidemiology of WNV in North America, including Canada. The virus infects a wide range of vertebrates, and the ecology of the organism including the mechanism of its persistence in a geographic area is poorly understood. In human WN virus causes asymptomatic infection or mild febrile disease, sometimes with a rash, but can cause severe illness and death in a small percentage of patients. The initial objectives of human surveillance focused on severe cases of WNV with encephalitis and briefed as below

(Documents reviewed: Guidelines for Human Surveillance for West Nile virus May 2000, West Nile virus Risk management Plan Draft 2 May 2000, 2001, and 2002).

1. the timely identification of human cases of viral encephalitis caused by WN virus;
2. monitoring the epidemiology among cases of WN encephalitis;
3. providing information about results of human surveillance to the public, health professionals and governments;
4. using the results to step up control measures to reduce mosquito exposure; and
5. monitoring the effectiveness of non-human surveillance.

In addition, it was suggested that all levels of public health agencies formed linkages with the appropriate animal health personnel in their own jurisdiction in early spring to ensure that identification of potential or confirmed illness in birds, wildlife or domestic animals is promptly investigated and that reporting to public health officials occurred.

In 2003, epidemiological evidence indicated new transmission of WNV disease via blood transfusion by receiving donors' organ/blood being infected by the virus. Canadian Blood Operators implemented routine screen testing on WNV for all blood donations (47, 48, 49, 50, 51, 52, 53). The objectives of WNV national human surveillance was modified, not only human cases with encephalitis, but also those with asymptomatic infections which most of them are identified and reported among blood donor population (Documents reviewed: 2003 risk management plan, record of decision from human sub-committee teleconference, CBS website).

2.4.1.3.2 The Objectives of WNV Bird Surveillance

The intention of surveillance in vertebrate was to identify the presence of West Nile virus in other susceptible hosts before the disease was detected in humans. Although in NYC and surrounding areas an unusual number of dead or dying crows was documented in the epicenter of the human outbreak several weeks prior to the earliest human case, bird mortality is not always a precursor to an arthropod-borne disease outbreak. No single sentinel host species or specific surveillance technique is effective in all areas. Therefore, it was planned to use complementary methods of vertebrate surveillance as an early detection system for West Nile virus activity.

In early 2001, chicken were selected as sentinel surveillance for WNV activity. Chicken flocks had frequently been used to monitor activity of arboviruses (e.g., Western equine encephalitis and St. Louis encephalitis) in North America. Chickens made reliable sentinels for arboviruses since they were readily available from commercial sources, frequently bitten by mosquitoes when housed in outdoor cages, typically develop high titres to arboviruses, were relatively easy to maintain and can be repeatedly bled over the mosquito season. (Documents reviewed: West Nile virus Monitor [Closed website] - Sentinel Chicken Surveillance 2000, West Nile virus Risk management Plan Draft 2 May 2000)

Over time, wild dead bird particular American Crow family has been used for early warning WNV activity, because the mortality of these infected birds are high and the relative big body of the birds are visible to be seen (Documents reviewed: West Nile virus Monitor - Enhanced Passive Dead

Bird Surveillance 2000, West Nile virus Risk management Plan Draft 2 May 2000, 2002, 2003, CCWHC website).

2.4.1.3.3 The Objectives of WNV Mosquito Surveillance

Monitoring of seasonal patterns of abundance of mosquitoes with a focus on particular vector species was the cornerstone of mosquito surveillance programs for WNV in 2001. This information is central to implementation of mosquito control efforts (i.e., which species larviciding and/or adulticiding needs to be targeted towards). In order to more clearly define the risk of exposure of humans to WN virus, the objective of mosquito surveillance is to accurately estimate the species composition and relative abundance of mosquito populations. (Documents reviewed: Guidelines on the prevention of West Nile virus infection in Canada using chemical insecticides to control adult mosquitoes 2001, West Nile virus Risk management Plan Draft 2 May 2000, 2001, 2002)

2.4.1.4 Flow Chart of the West Nile virus Surveillance System

Findings: there is a clear path regarding the information flow within the human surveillance system (Figure 2.2).

In Canada 2001, WNV national surveillance system was commenced. In 2002 and early 2003, various methods were explored to identify human cases, including sentinel surveillance, active surveillance and enhanced passive surveillance. Mainly, the WNV national human surveillance is an enhanced passive surveillance. During an early stage of WNV season, a letter or educational

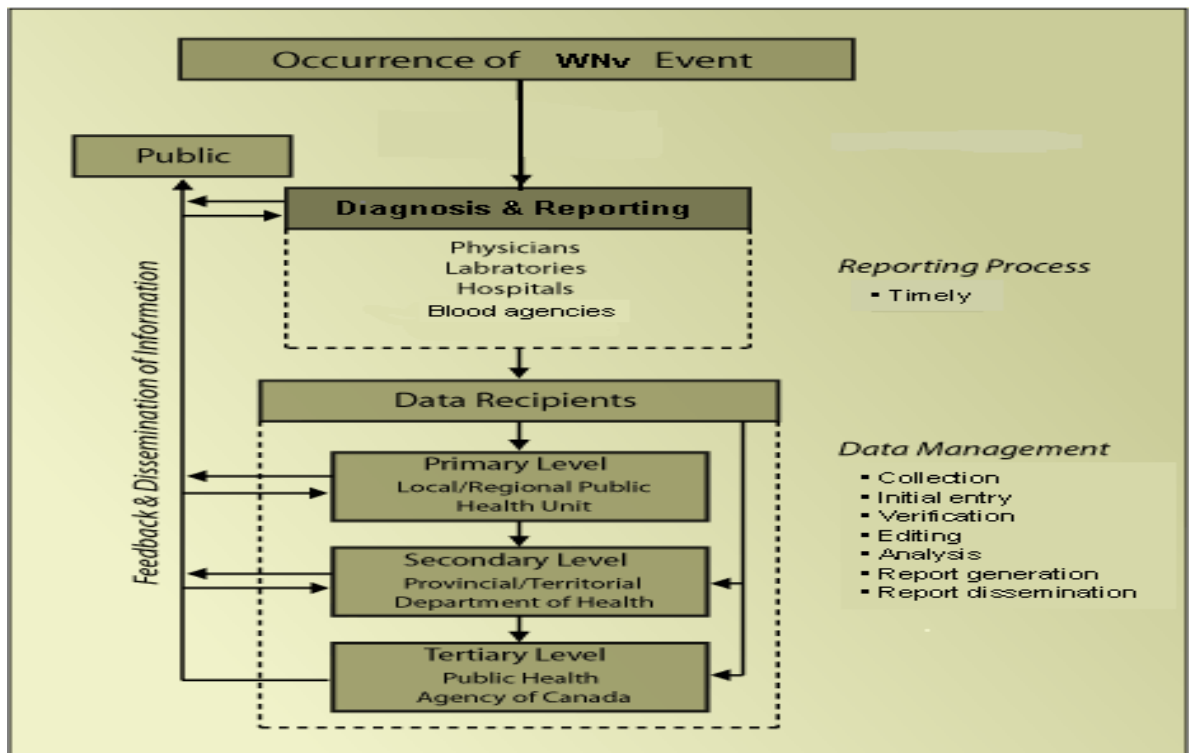
materials are delivered to medical staffs and general public to increase the awareness of WNV. The usual process of information flow in terms of human case identified and reported is an individual feels ill and seeks medical care from a health professional. The health professional makes clinical diagnosis of WNV based on clinical signs and symptoms as well as epidemiological information such as WNV activity in certain areas or travel to certain areas being reported WNV activity. The submitting physician would inform Regional Health Authorities (RHAs) / Public Health Units (PHAs) at local regions, which they would notify their respective jurisdiction at the provincial level. The province further notifies PHAC. Simultaneously, the health professional would send samples to a provincial laboratory or the NML (depends on the provincial lab capacity especially in the early 2003). If the NML received the samples and tested, the NML would notify the submitting provincial laboratory, which would in turn notify the submitting physician and probably the Chief Medical Officer of Health (CMOH) and Ministry of Health (MOH), depending on provincial protocols. The province further informs PHAC. The process would be the same for a case occurred on a reserve, except the notification about the case being sent by a health professional in reserve to FNIHB and then to PHAC.

In 2002, evidence cumulated in the USA that WNV could be transmitted by blood transfusion (49-53). Canadian blood operators (Canadian Blood Services and Héma-Québec) have immediately started to implement screen testing (e.g. nucleic acid amplification testing) for detection of blood donors with asymptomatic WNV infection since 2003. Blood screen testing to all donors for WNV infection is being conducted by mini-pool (6 units). Single unit testing is triggered in a given health region: 1) when positive donations are detected through the mini-pool testing program; or 2) when recent human cases are identified with population rate greater than 1 in 1,000 in rural

areas or greater than 1 in 2,500 in urban areas (47, 48). Once blood donors test positive for WNV, Canadian blood operators will notify the information of positive donors to the local public health authorities in a province, and the province will roll up the data with other WNV cases and submit them to PHAC via the national surveillance system.

The main surveillance products provided by PHAC include summary tables, a Canadian map only and a joint map between Canada and the USA, as well as a comprehensive surveillance weekly report (10). All information is disseminated on a weekly basis via *West Nile Virus Monitor* web page on the PHAC website as well as email to surveillance partners (e.g. surveillance partners and individuals who are interested in the information) who need to know for decision making on control and prevention of WNV disease (Figure 2.2).

Figure 2.2 Overview Flow Chart of West Nile virus Surveillance System



The chart was adopted from the CDC guideline for evaluating public health surveillance system (22).

(Documents reviewed: Guidelines for Human Surveillance for West Nile virus 2000, 2002, West Nile virus Occupational Health and Safety Advisory - Final Version 2001, Draft - National Guidelines for Response to West Nile virus 2000-2002, Record of Decision from human sub-committee teleconference 2000-2010).

2.4.1.5 What policies and procedures are in place to ensure patient privacy, data confidentiality, and system security? What is the policy and procedure for releasing data? Do these procedures comply with applicable federal and state statutes and regulations?

Findings: there are appropriate rules/policies in place to protect individual privacy and confidentiality for the data collection and dissemination in the WNV surveillance system.

2.4.1.5.1 What Policies and Procedures are in Place to Ensure Patient Privacy, Data Confidentiality, and System Security?

For the surveillance data, there are no unique personal identifications for each case in the dataset. Also, when provinces send the weekly data to federal government, they use password protected file and send two separate emails: one includes the database, another includes the password only. All individuals who work on the surveillance databases in the federal government must pass a security clearance check as required (documents reviewed: surveillance data 2002-2010, Record of decision from human sub-committee 2002-2010, surveillance plan 2003).

2.4.1.5.2 What is the Policy and Procedure for Releasing Data?

For human surveillance in the early year 2002 and 2003, when the number of human cases of WNV is less than five within one health unit, the data were then released at a regional level instead of health unit level to avoid potential personal identifications.

In addition, with a number of partners at the federal, provincial and local levels involved in the National WNV surveillance, it is crucial to ensure that messages to public are consistent and jurisdictional boundaries are respected. By achieving this goal in WNV surveillance, an agreed embargo rule (e.g. who says what and when) was clearly set up after consulted with Federal/Provincial/Territorial/Local partners in terms of releasing positive identifications (e.g. positive birds, mosquitoes, other animals, or human cases). For example, during the WNV season

in Canada, federal government updates surveillance information on a weekly basis. The procedure for releasing human cases is the federal government reports the cases one week behind the provincial announcement so jurisdictional roles/responsibilities are respected. (Documents reviewed: Draft - National Guidelines for Response to West Nile virus 2002, Communication Plan 2000, Communication Plan 2001, Communication Strategy 2002)

2.4.1.5.3 Do these Procedures Comply with Applicable Federal and State Statutes and Regulations?

The PHAC is a government agency. As such the PHAC is committed to abiding by the Federal and Provincial Freedom of Information and Protection of Privacy Acts and the Personal Information Protection and Electronic Documents Act (PIPEDA) (54).

2.4.2 Program Data

2.4.2.1 What are the Reporting Sources of Data for the System?

Findings: The data of WNV National human surveillance includes three sources: 1) data are collected by provincial/territorial public health; 2) data are collected by FNIHB; and 3) data are collected by Canadian Blood operators.

The WNV National surveillance data is mainly provided by provincial and territorial Ministries of Health. In each jurisdiction, the data are collected from key health care providers including emergency room physicians, hospital infection control personnel, infectious disease specialists and

neurologists. In addition, the FNIHB in Health Canada also reports aboriginal Canadians who live in reserves and was diagnosed with WNV disease.

Since 2003, Canadian blood operators (Canadian Blood Services and Hemo-Quebec) have started to implement blood screen testing for WNV and reported WNV positives among volunteer blood donors.

(Documents reviewed: surveillance data 2002-2010, record of decision from human sub-committee 2000-2010)

2.4.2.2 What Data are Collected and How are They Collected?

Findings: there are two kinds of data being collected: core data elements and minimum data elements. Over time, PTs collect core data elements only and share them with PHAC.

During the WNV season, provincial and territorial Ministries of Health collect information on both probable and confirmed human clinical cases of WNV illness, as well as asymptomatic infections with WNV in blood donors. Core data elements on both probable and confirmed clinical cases and asymptomatic infections are reported electronically to the PHAC via the national WNV surveillance system on a weekly basis. The core data elements for WNV disease are the basic need to conduct epidemiological analyses in terms of person, place and time. These data elements would be required to all jurisdictions. For example, date of episode, name of provinces, name of health

unit / regional health authority or forward sortation area (FSA), case status, clinical classifications, and travel history. At the end of WNv season, provincial and territorial Ministries of Health provide an agreed on list of core and minimum data elements for reporting to PHAC with additional information such as: report of presence / absence of fever, modification of the status of a case from probable to confirmed, possible exposure or route of transmission, demographic characteristics, date of onset, and travel information. Over time, most jurisdictions stop collecting minimum data elements due to limited resources. A detailed weekly variables collection form can be seen in Appendix VI.

Currently, the mechanism of data collections within the surveillance system from P/Ts to PHAC is electronic either by email or by the Canadian Network for Public Health Intelligence (CNPHI) system as a pilot project (55).

(Documents reviewed: ROD of human teleconferences 2002- 2010, surveillance data).

2.4.2.3 What is the Period of Time of the Data Collection?

Findings: During the WNv season, surveillance data are collected from PTs to PHAC on a weekly basis. Surveillance information is disseminated in a timely fashion. However, the lap time between the date of onset and the date of the cases information being collected at the provincial level cannot be assessed.

During the WNv season in Canada (May to October), the data flow from provinces / territories to PHAC within the WNv national human surveillance system is on a weekly basis. Every season,

when the first human case was detected and reported by a province / territory, the province / territory will start to provide a weekly update of human case report to PHAC. The following steps are considered: 1) On Tuesday, PHAC sends the case report forms to those provinces which have reported human cases; 2) On Thursday, before 10:00 AM in Local Time, the provinces send back their updated forms to PHAC; 3) PHAC staff verify data, clean data and merge different PTs' data together for ONE analysis file. PHAC staff will communicate with the focal contact person in each province when the data needs to be further verified; 4) On Friday/or next Monday, surveillance products (both English and French) such as weekly surveillance reports, tables, and maps are updated on the PHAC website, as well as disseminate to stakeholders by email.

The national data are not included unique case identification, so it is impossible at the national level to compare the lag time for the same cases between date of onset and the dates of information being collected at both provincial and federal level. However, raw estimate of the lag time at the national level between date of onset and date of episode is circus two weeks. Details discussion can be seen in the next part of timeliness in program performance.

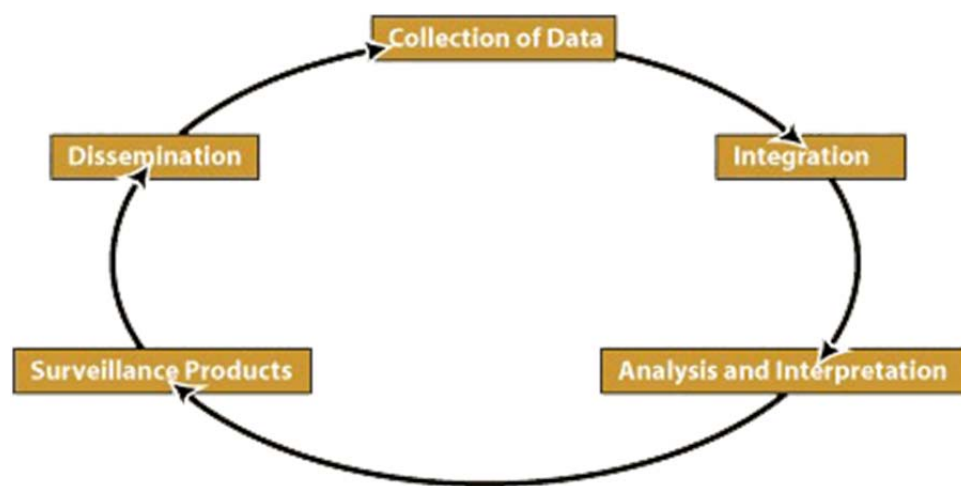
(Documents reviewed: ROD of human teleconference 2006-2010, surveillance products 2006-2010, PHAC West Nile Virus *Monitor* website).

2.4.2.4 How are the System's Data Managed (e.g., the transfer, entry, editing, storage, and back up of data)? Does the System Comply with Applicable Standards for Data Formats and Coding Schemes? How are the System's Data Analyzed and Disseminated?

Findings: the data is managed electronically. The information is disseminated via PHAC website and email. Over time, a standard web-basis application of Canadian Network for Public Health Intelligence (CNPHI) has been developed for the data collection and dissemination as a pilot study.

Early in a WNV season, members of the National WNV Human Sub-Committee have the opportunity to view the methodology of data management and modify the process appropriately. The overall process is described as below (Figure 2.3). (Documents reviewed: Records of Decision from National Human Sub-Committee Teleconferences/workshops/meetings 2000-2010, surveillance products on PHAC website).

Figure 2.3 Overview Data Managed in the National West Nile virus Surveillance System



The chart was adopted from the CDC guideline for evaluating public health surveillance system (22)].

2.4.2.4.1 How are the System's Data Managed (e.g., the transfer, entry, editing, storage, and back up of data)?

To further detail the chart described above, there are several steps in terms of the data management within West Nile virus surveillance:

1) Collection of data: During WNV season, provinces / territories send human cases with core data elements to the PHAC by e-mail or via the CNPHI system on a weekly basis.

2) Integration: In early 2002, various data formats were used by P/T to send the weekly data to PHAC, including Excel spreadsheet, Access database, and Screen capture of website data tables. Since 2003, after consulting with P/T epidemiologists/data analysts, PHAC has developed a weekly feedback form and standardized data formats and coding schemes in order to facilitate data flow from P/T to PHAC and data analysis. (Appendix VI). Most provinces use the standard weekly feedback form, but some provinces still send the data by using their own formats due to limited staff and resources.

3) Analysis and Interpretation: cleaned data are analyzed by seasonal trends, geographical distribution, epidemic curve (Epi curve), clinical manifestations and severity (e.g. hospitalized, death, neurological syndrome). During WNV season, the data is collected on a weekly basis. An “Epi curve” is provided based on available episode dates, instead of onset date only. This is due to the fact that the date of onset for some cases may be not available at that moment, especially in significant years (e.g. a total of 1471 cases in 2003, and 2213 cases in 2007). Limited by the administrated data, the episode date could come from one of the following dates: date of onset,

date of sample collection, date of hospitalization, date of laboratory received, or date of laboratory diagnosis. In explaining the “Episode curve”, two things need to be addressed: 1) the “Episode curve” is generated by episode dates and the curve is comparable to the previous curves drawn based on episode dates during the season. One benefit of these multi-year comparisons of the episode curves is to provide real time information and help to estimate any significant change of trends (Figure 4.4); and 2) when the dates of onset become available for most cases at the end of season, the epidemic curves which are based on the dates of onset only are created. Compared the two curves between epidemic curves and episode curves (Figure 2.4 vs Figure 2.5), the lag time for the same year is approximately two weeks at the national level.

Figure 2.4 West Nile virus Human Clinical Cases and Asymptomatic Infections based on Episode Date in Canada, 2003 to 2010

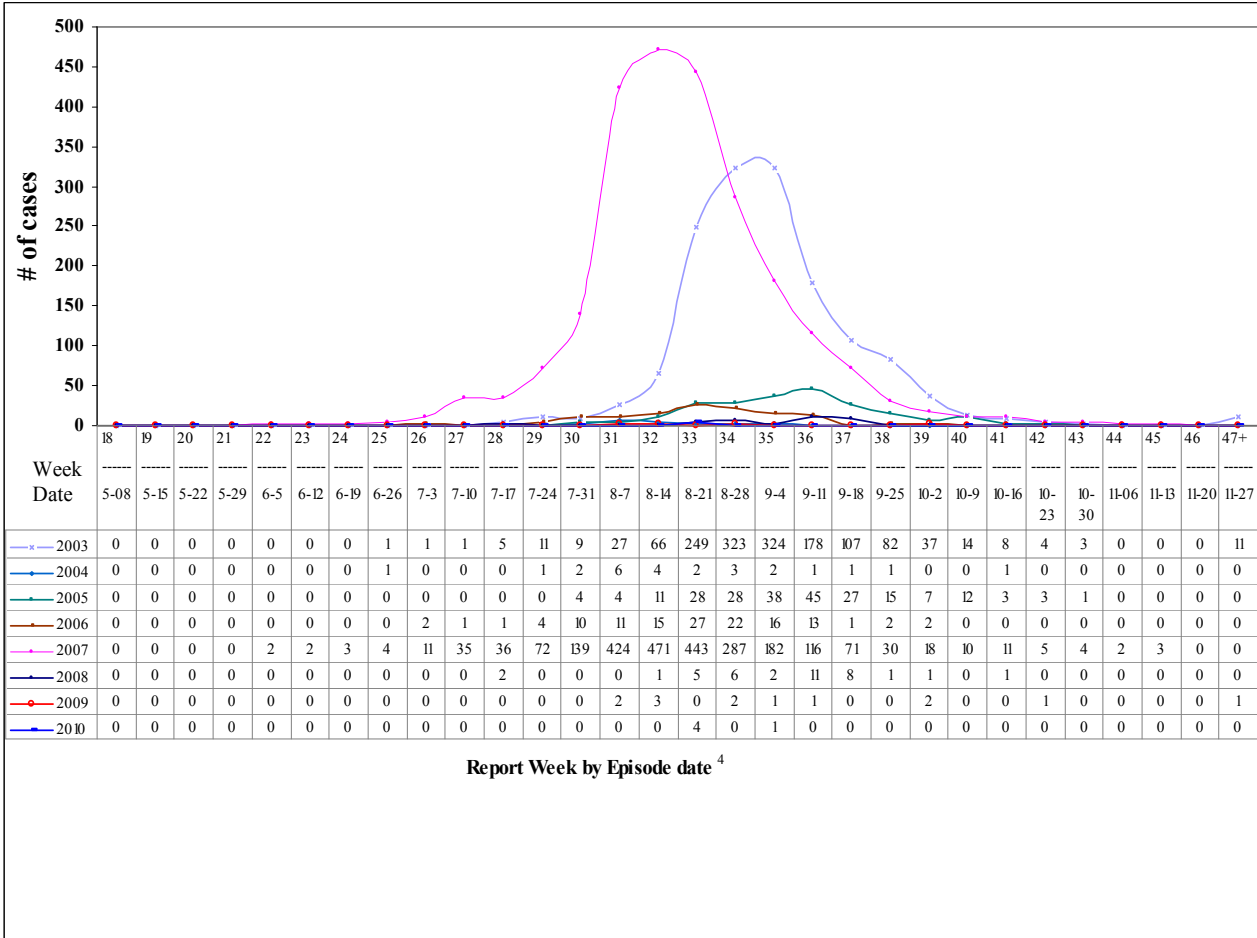
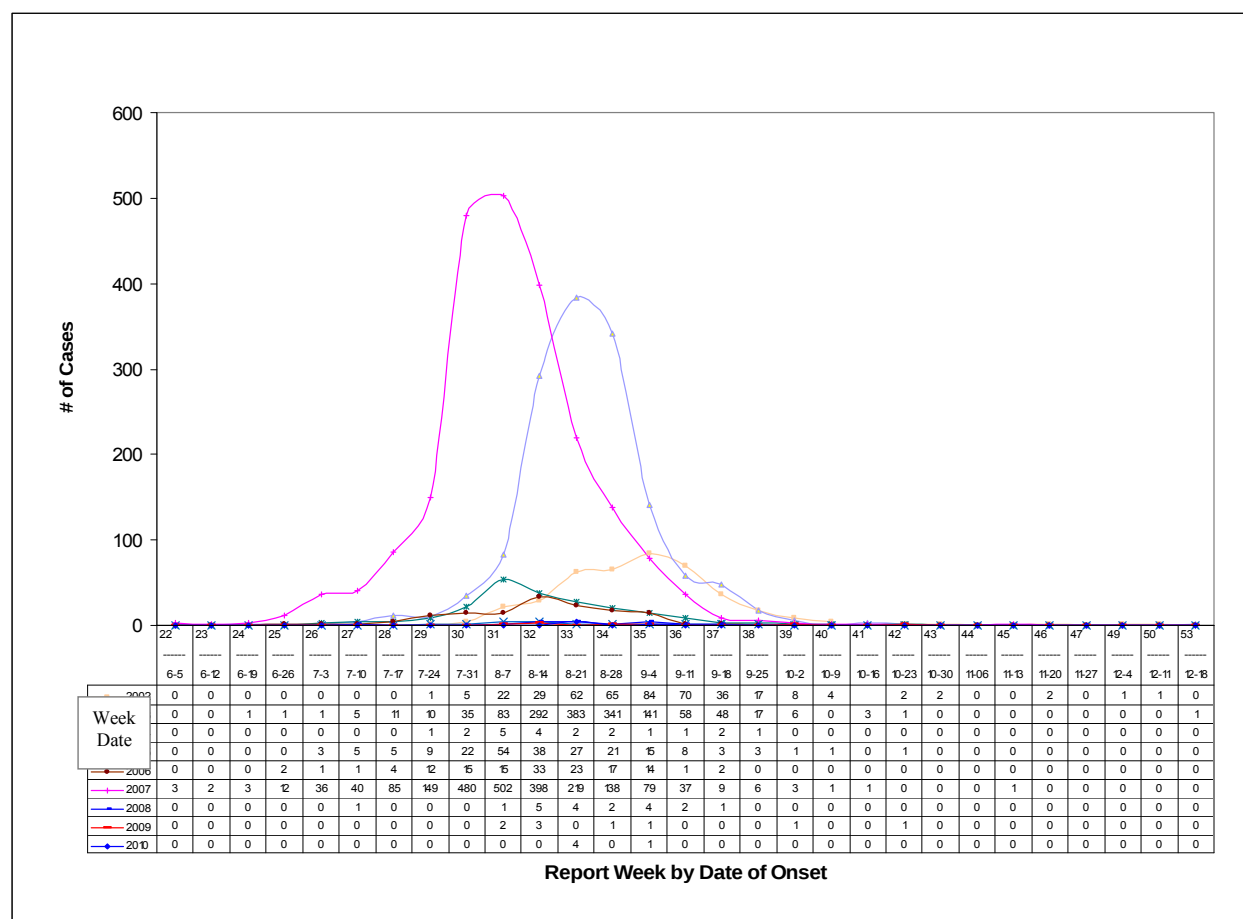


Figure 2.5 West Nile virus Human Clinical Cases and Asymptomatic Infections based on Onset Date in Canada, 2003 to 2010



4) Surveillance Products: Based on weekly surveillance data provided by P/Ts, a large of volume information is produced to become available to various audiences in a timely manner. For example, there are Factsheet, tables and simple maps available to general public. Epidemiological weekly reports and joint maps with presentation of human cases of WNV in Canada and the US are accessible to professionals. In addition, the surveillance information is also used for briefing notes dockets, presentations for senior management as reference information for decision making, as well as international conferences for sharing Canadian experience on WNV.

5) Dissemination: Several vehicles are used to sharing surveillance products with stakeholders such as email, PHAC website, internal website, presentations / posters, dockets and briefing notes.

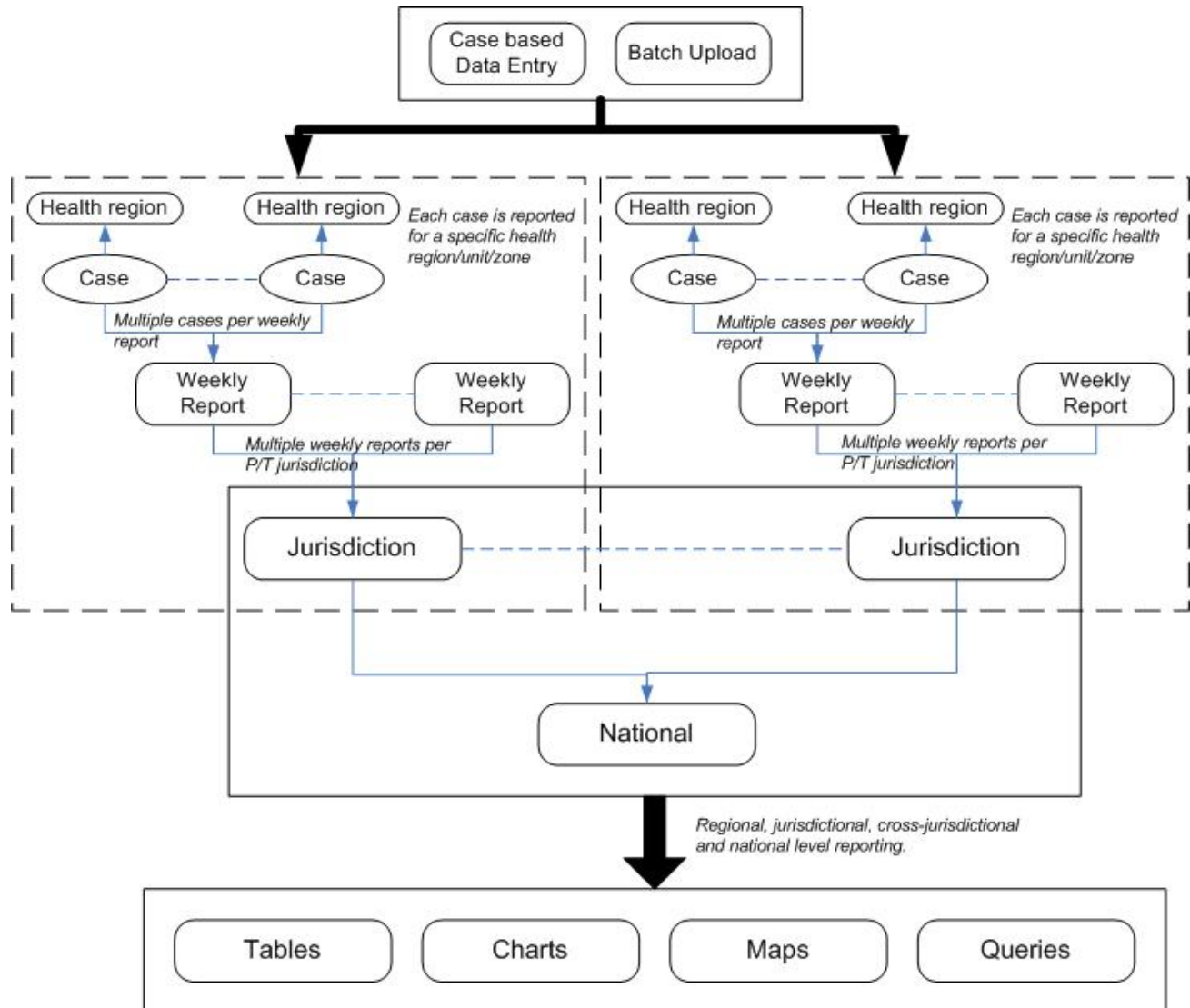
(Documents reviewed: Records of decision teleconferences, surveillance data for the time period from 2003-2010, West Nile Virus *Monitor* in PHAC website).

2.4.2.4.2 Proposed Improvement of the Data Management and Dissemination

To reduce the workload, an on-line web-based data collection, analysis and dissemination process is being piloted by using PHAC's secure network of CNPHI (55). A pilot project of CNPHI has started to be introduced to P/Ts as an optional vehicle for the data collection and dissemination. The application of CNPHI allows data submitters at provinces / local public health to submit their data by uploading from their data files directly into the CNPHI network. This web based application for National WNV surveillance human case reporting would provide a multitude of benefits to stakeholders: 1) standardize data formats and coding schemes, and facilitating real time data analyses; 2) analyze data from horizontal (e.g. national or provincial comparisons) and vertical (e.g. trends over time) levels to make available to multi-stakeholders (e.g. F/P/Ts and local communities) in a timely manner; 3) produce various surveillance products (e.g. tables, charts, maps) to different audiences and disseminate information efficiently; and 4) protect data confidentiality by high security network of CNPHI (Figure 4.6). By applying the electronic application, it will reduce errors due to data manipulation from multiple users and improve the efficiency and effectiveness in terms of data flow within the WNV surveillance system.

Figure 2.6 How Does the Canadian Network for Public Health

Intelligence process work for West Nile virus surveillance



The Figure is cited by the permission from Dr. Shamir N Mukhi, chief engineer on CNPHI

2.4.3 Program Performance

2.4.3.1 Timeline

Findings: The PHAC receives the data from PTs every Tuesday, and analyzes data and disseminates surveillance reports, maps, and tables on Friday in the same week or next Monday via PHAC website and email. However, the time period between the date of a case onset and the date of the case report being completed and received by provincial public health is unavailable from this evaluation.

Timeline refers to assessing time lags for reporting of human cases. The following time period were considered in these assessments.

(1) Completion of data processing: The time period for processing the data and producing the files needed from the field at the local health unit to provincial ministry of health is affected by many factors, such as patients delays in seeking medical consultation, medial professional awareness of the disease or time delay in reporting laboratory results or collecting clinical information and entering these information into electronic database. Currently, the National WNV surveillance has no tracking system in place to monitor this kind of time lag. An effort was made to try to estimate the time period based on available information. At the end of WNV season, we compared the time lag period between the date of onset and the date of episode (PTs reported to PHAC at that moment during the WNV season) and the average time lag is approximately two weeks (Figure 4.4 and Figure 4.5) at the national level overall (Surveillance data 2002-2010). This estimated lag time period could be more accurately accessed at local and provincial levels in the future.

(2) Capture of data in WNV national surveillance system: Once the data is collected by a provincial ministry of health, there is one week delay for the data to be transferred from provinces / territories to PHAC. This one week embargo time period which has been agreed between P/Ts and PHAC allow provinces and local authorities have time to response first (e.g. media and public).

(3) Application of pattern recognition tools/algorithms: When the data is received by PHAC via the national surveillance system, it usually takes 1-2 days to processing certain steps for verification of the data and conduction of the analysis (e.g. verify data with P/Ts, categorization into syndrome categories, application of case definition, and data transformations/merging).

(4) Generation of surveillance products: After received the data from PTs, it takes 1-2 days to produce the surveillance products and disseminate them by various vehicles. During the WNV season, the algorithm runs weekly and surveillance products such as weekly reports, maps and tables are generated and disseminated to surveillance partners via email, and PHAC website.

In 2005, Canada signed onto the World Health Organization's new *International Health Regulations* which obligated member state to report cases of an infectious disease of potential international concern in a timely manner. As a notifiable disease, WNV is reported in a timely manner in Canada.

(Documents reviewed: Record of Decision from human sub-committee teleconference 2000-2010, surveillance data /reports/tables/maps 2002-2010).

2.4.3.2 Representativeness

Findings: although the national WNV surveillance system focuses on severity cases, it presents circa 17% of the cases with non-neurological syndromes.

Representativeness involves assessing the data collection in terms of coverage of the Canadian population. The current WNV National human surveillance system captures human cases of WNV from three aspects: 1) the general population who present with symptoms and are seen by medical consultations (reported by general clinicians); 2) the blood donor population with asymptomatic infection (detected by routine blood screening test); and 3) the aboriginal population who live on a reserve or in a rural area (reported by clinicians in aboriginal communities).

However, the initial design of the human surveillance is an enhanced passive surveillance with focus on those severe cases and not the intention to detect all human cases with WNV infection. The intention of the surveillance is to pick up those individuals who seek medical treatment because of WNV disease, especially severe cases such as WNV neurological syndrome. A serosurvey in New York estimated that approximately one case of neuroinvasive disease occurs per 140 infected persons and approximately 19% of infected persons develop nonneuroinvasive disease (16).

The surveillance case definitions between Canada and the United States are comparable (56).

Therefore, assuming that all neurological syndromes cases were captured (N = 796), an estimated 111,440 WNV infections occurred from 2002 to 2010, resulting in approximately 21,174 (19% of total infections) cases of non-neurological syndromes. However, only 3,596 cases of non-neurological syndromes were captured and being reported to the National WNV surveillance program, which is approximately 17% of the cases with non-neurological syndromes that are estimated to have occurred. In other words, 83% of cases with non-neurological syndromes are not detected by the current WNV surveillance system.

(Documents reviewed: surveillance data 2002-2010, literature review)

2.4.3.3 Acceptability

Findings: Since 2003, PTs have consistently provided surveillance data to federal government on a weekly basis, and actively participated in human sub-committee teleconference during a WNV season.

Acceptability is the willingness of persons and organizations to participate in the National WNV surveillance system, such as the agreements on case definitions and reporting mechanisms.

The collaborative efforts on the development of national standards for the surveillance (e.g. case definitions, reporting protocols, and timeliness of reporting, collection/presentation and dissemination of data) are based on the acceptability among multi-stakeholders (e.g. F/T/P levels). These standards have been very well accepted and adapted by P/T partners. For example,

provinces / territories collect both probable and confirm human cases. They follow the weekly reporting timeliness during the WNV season, and send the core data elements to PHAC at the end of WNV every year since 2002. Also, PHAC and P/Ts have agreed on an embargo time period in terms of releasing positive indicators to media / public so jurisdictional boundaries are respected. Another example is the activity of WNV national human sub-committee teleconference. This teleconference has started since 2000 and the frequency of the teleconference can be weekly, bi-weekly, monthly depends on the WNV activity in that year. Members of the teleconference come from F/P/Ts, Canadian Blood Services and Hema-Quebec, Health Canada and other partners have actively participated in the teleconference over the past ten WNV seasons.

(Documents reviewed: Records of decision from human sub-committee teleconference, workshop, and weekly surveillance data form 2003-2010)

2.4.3.4 Flexibility

Findings: The national WNV surveillance program has been expended and adapted to other mosquito-borne disease surveillances, including the reformation of the WNV committee and data collection system.

Efforts have been made to adapt WNV National human surveillance system to other notifiable zoonotic disease surveillances. For example, the former West Nile virus National Steering Committee which focused on issues relevant to WNV only has been expended and renamed as the National Non-Enteric Zoonotic Diseases Issue Group which includes not only a sub-issues group on WNV, but also groups on Lyme disease and other tick-borne diseases, Arctic zoonoses, and

rabies. Stakeholders who participate in WNV national surveillance from F/P/T support this expanded mandate, given they believe that the WNV surveillance has already put in place the necessary network of multi-disciplinary stakeholders to allow for that information exchange widely and timely. Since 2009, the WNV national human sub-committee teleconference has started to add other zoonoses besides WNV for discussion, as required by the sub-committee members.

In addition, a pilot program of the CNPHI has been implemented for collecting and reporting the Pan-Canadian WNV surveillance data. Further, the CNPHI has been considered a feasible approach in terms of data collection and dissemination for other zoonotic disease surveillances (Figure 2.7).

Figure 2.7 Canadian Network for Public Health Intelligence



Link to the Canadian Network for Public Health Intelligence website: <https://www.cnphi-rcrsp.ca/cnphi/index.jsp>

(Documents reviewed: Records of decision from teleconference, workshop, and weekly surveillance data form 2003-2010, Draft - National Guidelines for Response to West Nile virus 2002-2004)

2.4.3.5 Sensitivity

Findings: It is challenging to estimate the sensitivity of capturing severe cases with WNV, although the number of hospitalization estimated from two separate data sources is close (933 cases in CIHI versus 847 cases in National WNV surveillance). For those cases with mild symptoms, 17% of them could be captured by the National WNV surveillance system.

Sensitivity is the ability of the system to detect the health event of WNV disease. The sensitivity of WNV surveillance system can be considered at two levels. First, at the level of all cases reporting, sensitivity refers to the proportion of WNV disease being detected by the surveillance system. The WNV National human surveillance is an enhanced passive surveillance. Based on our previous estimation, the WNV surveillance system can only detect 17% of all mild symptomatic cases with WNV disease due to the nature of the design.

On the other hand, at the level of detection of severe cases such as WNV neurological syndromes, the surveillance system is designed to capture most severe illness because these individuals are likely to seeking medical consultation and treatment. Based on ICD9 and ICD 10 codes (detail code can be seen in next chapter), human cases with WNV disease were extracted from CIHI data for the available time period of 2002-2008 and there are 933 hospitalized cases with WNV. In contrast, there are 847 cases reported as hospitalization from WNV surveillance database for the same time period. The two databases are very different in terms of data collection mechanism. Coincidentally, the number of hospitalized cases is close between the two databases and it suggested that the WNV national surveillance met its main objective that focus on severe cases. There are several limitations of the comparisons: 1) CIHI data may miss the cases in 2002 as the disease

became a national notifiable in 2003 only, 2) CIHI data not include all provinces for the time period, 3) CIHI data could be duplicated, and 4) CIHI data may not lab confirmed.

(Documents reviewed: surveillance data 2002-2010, CIHI data 2003-2008)

2.4.3.6 Usefulness

Findings: the surveillance information can be accessible both nationally and internationally. The surveillance system has benefited to other zoonotic diseases surveillances.

There is a “West Nile virus *MONITOR*” page on PHAC website (10). During the WNV season, PHAC provides surveillance information to both general public and professionals such as epidemiological reports, tables, and maps including bi-national maps between Canada and US as well as the fact sheets of WNV. A tracking code was added to the PHAC website. Based on the available information from May 2010 to September 2011, there were approximately 12,159 visits to the West Nile virus Monitor page on PHAC website. A total of 53,312 page views, an average of 4.4 pages viewed per visit, average time spent on the website about two minutes. If classified the users by country, visitors represented more than 20 countries and the top ten countries were Canada, Japan, US, France, United Kingdom, Italy, Mexico, Czech Republic, Germany, and Greece. (Document review: Website traffic statistics report 2012, West Nile virus *Monitor* website on PHAC)

In addition, a survey was conducted at the end of WNV season in 2010. A detailed survey questionnaire is listed in the Appendix IV. Among the 28 responses, 12 (43%) appreciated the WNV human sub-committee teleconference, 2 (7%) said not, and 14 (50%) unknown. Regarding

the weekly surveillance reports, 25 (88%) of the 28 individuals appreciated the reports, 1 (4%) did not, and 2 (7%) unknown. Regarding the website and maps, 24 (84%) appreciated, 2 (8%) did not, and 2 (8%) unknown. In terms of overall human surveillance activity, 27 (96%) appreciated and 1 unknown. (Table 2.1)

Table 2.2 Survey results on National West Nile virus Surveillance System
(N = 28, including 18 different FPT organizations)

Component of the program	Appreciation		
	Yes N (%)	No N (%)	Unknown N (%)
Teleconference	12 (43)	2 (7)	14 (50)
Weekly report	25 (90)	1 (3)	2 (7)
Human surveillance	27 (96)	0 (0)	1 (3)
Website and maps	24 (84)	2 (8)	2 (8)

In the survey, the 28 responses filled out the open-end questions and provide additional comments/suggestions and summarized as following three aspects: 1) what was done well? The stakeholders agreed that the national weekly report is well produced and is generally well appreciated. The WNV National human sub-committee teleconferences should be continued. Also, the interactive maps should be produced and distributed; 2) what can be done better? One comment is the bird surveillance might not be a good early indicator at this stage as some jurisdictions stop doing dead birds collection over time. Responses suggest modifying the interactive maps to show 2-3 year trends. The National weekly report should start when the first positive indicators occur in Canada. For a travel related case, provide exposure information if

possible, as this would ensure that the person indeed travelled to a high risk area or not. Stakeholders also pointed out there are inconsistent in terms of bird, mosquito, and horse surveillance among jurisdictions; 3) recommendations / suggestions. There is a strong voice from the responses that suggested to add other zoonoses besides WNV (e.g., Eastern Equine Encephalomyelitis virus) to the program and make the WNV national surveillance more flexible in order to address other lingering or emerging zoonotic disease threats (e.g., California serogroup or exotic arboviruses like Chikungunya virus) in Canada. For example, one concrete suggestion is to add additional topics planned for discussion during the WNV national human sub-committee teleconferences.

(Documents reviewed: Survey results 2011, WNV evaluation report 2011, Record of decision, 2005-2010)

2.5 Overall Conclusions and Recommendations

In this section, the overall conclusions from the evaluation are presented and organized by the evaluation issues: Program description; Program data; and program performance.

2.5.1 Program Description

The emergent disease of WNV has become endemic in Canada since it was first reported in 2002. The virus activity is unpredictable. Particularly, the epidemiology of WNV is appearing changes in Europe, and the changes may be seen in Canada as experience in 1999.

The National WNV surveillance program is a multi-jurisdiction and multi-disciplinary effort and it is aligned with the PHAC mandate for disease surveillance and control and for the coordination of federal policies and programs in area of public health, with emphasis on promoting cooperation and consultation with provincial and territorial (P/T) governments.

2.5.2 Program Data

WNV surveillance data are collected and disseminated in a timely fashion. A national standard data collect application with pass protect has been developed and applied as a pilot stage.

Although the standard data application format has been created by PHAC, it will take some time for all provinces to use the application. Over time, provinces and territories stop collecting minimum data elements because of time consuming and limited resources such as repellent using. These are limited to assess the holistic impact of the program on prevention and control of the disease to public health.

2.5.3 Program Performance

The national WNV program collects data and disseminates information in a timely manner. However, the lag time between date of case onset and date of case report being received by the provincial/federal level is unclear and this lag time could affect timeliness of pan-Canadian information.

Chapter Three: Analysis of Human West Nile Virus

Surveillance Data

An overview of the methods used for the data analysis is provided in this chapter, as well as provides an epidemiological summary of human surveillance data from 2002 to 2010 in Canada.

3.1 Introduction

Following the first WNV outbreak identified in New York City in 1999, Canada pro-actively set up multi-species surveillance for WNV. The human surveillance has run ten year since the first human cases of WNV was detected in Canada in 2002 (10). The current analysis in this thesis summarizes WNV data collected via the national surveillance system for the time period of 2002 - 2010, including demographic characteristics, seasonal patterns, and geographic distribution of reported cases of WNV disease.

3.2 Methods

3.2.1 National Surveillance Case Definitions for West Nile Virus

Human case definition for National WNV surveillance was initially developed by the National WNV Human Surveillance Sub-Committee and was approved by the National WNV Steering

Committee in 2002. It has evolved as more information became available over time. The latest version is the 2006 case definitions (Appendix V) and can be viewed via the PHAC website:

<http://www.phac-aspc.gc.ca/wnv-vwn/index-eng.php>

A probable or confirmed case must meet clinical criteria and at least one of the case laboratory criteria in the following sections.

3.2.1.1 Clinical Criteria for Diagnosis

A case with WNV Neurological syndrome requires onset of fever with history of exposure in an area where WNV activity is occurring or history of exposure to an alternative mode of transmission, as well as recent onset of at least one of the following: 1) encephalitis (acute signs of central or peripheral neurologic dysfunction); 2) viral meningitis (pleocytosis and signs of infection e.g., headache, nuchal rigidity); 3) acute flaccid paralysis (e.g., poliomyelitis-like syndrome or Guillain-Barré-like syndrome); 4) movement disorders (e.g., tremor, myoclonus); 5) Parkinsonism or Parkinsonian-like conditions (e.g., cogwheel rigidity, bradykinesia, postural instability); 6) other neurological syndromes.

A case with WNV Non-Neurological syndrome requires a history of exposure in an area where WNV activity is occurring or history of exposure to an alternative mode of transmission, as well as at least two of the following: fever; myalgia; arthralgia; headache; fatigue; lymphadenopathy; or maculopapular rash.

3.2.1.2 Laboratory Criteria for Diagnosis

A confirmed case requires at least one of the following conditions: 1) A 4-fold or greater change in WNV neutralizing antibody titres (using a Plaque Reduction Neutralization Test (PRNT) or other kind of neutralization assay) in paired acute and convalescent sera, or Cerebral Spinal Fluid (CSF); 2) Isolation of WNV from, or demonstration of WNV antigen or WNV specific genomic sequences in tissue, blood, CSF or other body fluids; 3) Demonstration of flavivirus antibodies in a single serum or CSF sample using a WNV IgM Enzyme-linked immunosorbent assay (ELISA) confirmed by the detection of WNV specific antibodies using a PRNT (acute or convalescent specimen); 4) A 4-fold or greater change in flavivirus HI titres in paired acute and convalescent sera or demonstration of a seroconversion using a WNV IgG ELISA AND the detection of WN specific antibodies using a PRNT (acute or convalescent serum sample).

A probable case requires at least one of the following: 1) Detection of flavivirus antibodies in a single serum or CSF sample using a WNV IgM ELISA 7 without confirmatory neutralization serology (e.g. PRNT) ; 2) A 4-fold or greater change in flavivirus HI titres in paired acute and convalescent sera or demonstration of a seroconversion using a WNV IgG ELISA 7 ; 3) A titre of > 1:320 in a single WNV HI test, or an elevated titre in a WNV IgG ELISA, with a confirmatory PRNT result; 4) Demonstration of JE serocomplex-specific genomic sequences in blood by Nucleic Acid Amplification Technology (NAT) screening on donor blood, by Blood Operators in Canada.

3.2.2 Data Sources

As required by provinces/territories, the WNV National Human Sub-Committee developed a case investigation form of WNV, with a view to its potential adaptation and use for all arboviral infections. After consulting with provincial/territorial epidemiologists, the Sub-Committee made an agreed upon list of core and minimum data elements for nationally reporting and sharing, with clear data flow methods and timelines within a national surveillance system. WNV infection became nationally notifiable in June 2003 in Canada. During a WNV season, provinces/territories report cases of WNV with core data elements to PHAC on the weekly basis. At the end of season, they report all cases with core and minimum data element to National WNV surveillance system electronically. Province and local public authorities are responsible for ensuring that reported cases meet the national case definitions. The most common method being used by provinces to identify cases is enhanced passive surveillance, although various methods such as active surveillance in hospitals, and sentinel surveillance in emergency rooms were implemented to find cases around 2002 and 2003. The core and minimum data variables collected by the National WNV surveillance system include age, gender, clinical manifestations, travel history, fever (yes/no), possible exposure, hospitalization (yes/no), death, and case status, date of onset, date of laboratory diagnosis, date of report and year of surveillance, administrative jurisdictions and health unit/regional health authority.

In addition, Canadian Information Health Institute (CIHI) surveillance dataset were used to extract hospitalized cases of WNV and other arbovirus, based on *International Classifications of Disease, Ninth Revision and Tenth Revision* (ICD09/ICD10).

3.2.3 Analysis

The analysis of cases in this report is limited to those that met the national case definitions for WNV disease (i.e., confirmed and probable cases) and reported to PHAC via the National WNV surveillance system for the time period of 2002-2010.

3.2.3.1 Data Cleaning and Checking

The variables collected via the National WNV surveillance system include core data elements and they are available for this analysis such as date of episode, name of provinces, name of health unit / regional health authority, case status (e.g. confirmed and probable), clinical classifications (e.g. WNV neurological symptom, WNV Non-neurological symptom and Asymptomatic infection), and travel history. Detailed can be seen in appendix IV.

First, cleaning and checking data as described in the weekly data analysis previously. Any data validity issue was discussed with focal point staff in each jurisdiction. Missing data is described in details in the Table 5 below. Then a cleaned database for each jurisdiction was created, and then all these cleaned databases were merged as one national database for analysis.

3.2.3.2 Descriptive Statistics

Descriptive analyses of age-specific outcomes, geographic distribution, and age-sex-specific incidences were conducted. Annual Canada incidences per 100,000 population and rates by provinces / territories, health units / regional health authorities, age groups, and sex were calculated using Canadian Census population estimates for July 1 of each year of the reporting

period (2002-2010). Average annual incidences were calculated by using July 2006 population estimates.

3.2.3.3 Multivariable Logistic Regression Analysis

The total number of cases in 2007 takes accounts 48% of all cases from 2002-2010 in the country. In order to see whether some specific factors associated with the year of 2007 outbreak by comparison with those years around it, we arbitrary defined the year 2007 as the biggest WNV year, and the regular years as those years around it including 2004, 2005 2006 and 2008, 2009, 2010. The dependent variable is the number in the biggest year (2007) versus the number in regular years. The independent variables include age, sex and regions. Univariate logistic regression analysis was first used to determine whether significant associations existed. Odds ratios were calculated and compared between levels of exposure. An unconditional multiple logistic regression model was then developed. This model included age, gender and region exposure variables. Odds ratios for biggest year were calculated and compared between levels of exposure. A p value of 0.05 was used to determine the statistical significant.

3.2.3.4 Poisson Regression Analysis

Poisson regression analysis was used to identify average annual incidence of human cases with WNV neurological syndrome from 2002 to 2010 in Canada, given the count data such as the

number of infections per given unit often follow a Poisson distribution (57). Details of the process include:

1. Small sample comparison and time trend exploration: the incidence rate and 95% confidence intervals was calculated and the predictive time trend graphs plotted. The annual incidence rate of WNV was calculated based on the following formula:

$$\text{Incidence} = \frac{\text{\# Cases with WNV neurological syndrome}}{\text{\# Total population at risk}} \times 100,000$$

2. Confidence intervals were calculated to quantify the amount of uncertainty using the normal approximation for the log-transformation, or the exact method if less than 5 cases were identified. These observed incidence rates and their respective confidence intervals were plotted for each year in order to examine changes in these rates over time.

3. Poisson regression methods were used to evaluate the statistical significance of observed trends; trend lines were added to the plots to ease interpretation. Data was analyzed using Statistical Analysis System (SAS) 9.0 version statistical software.

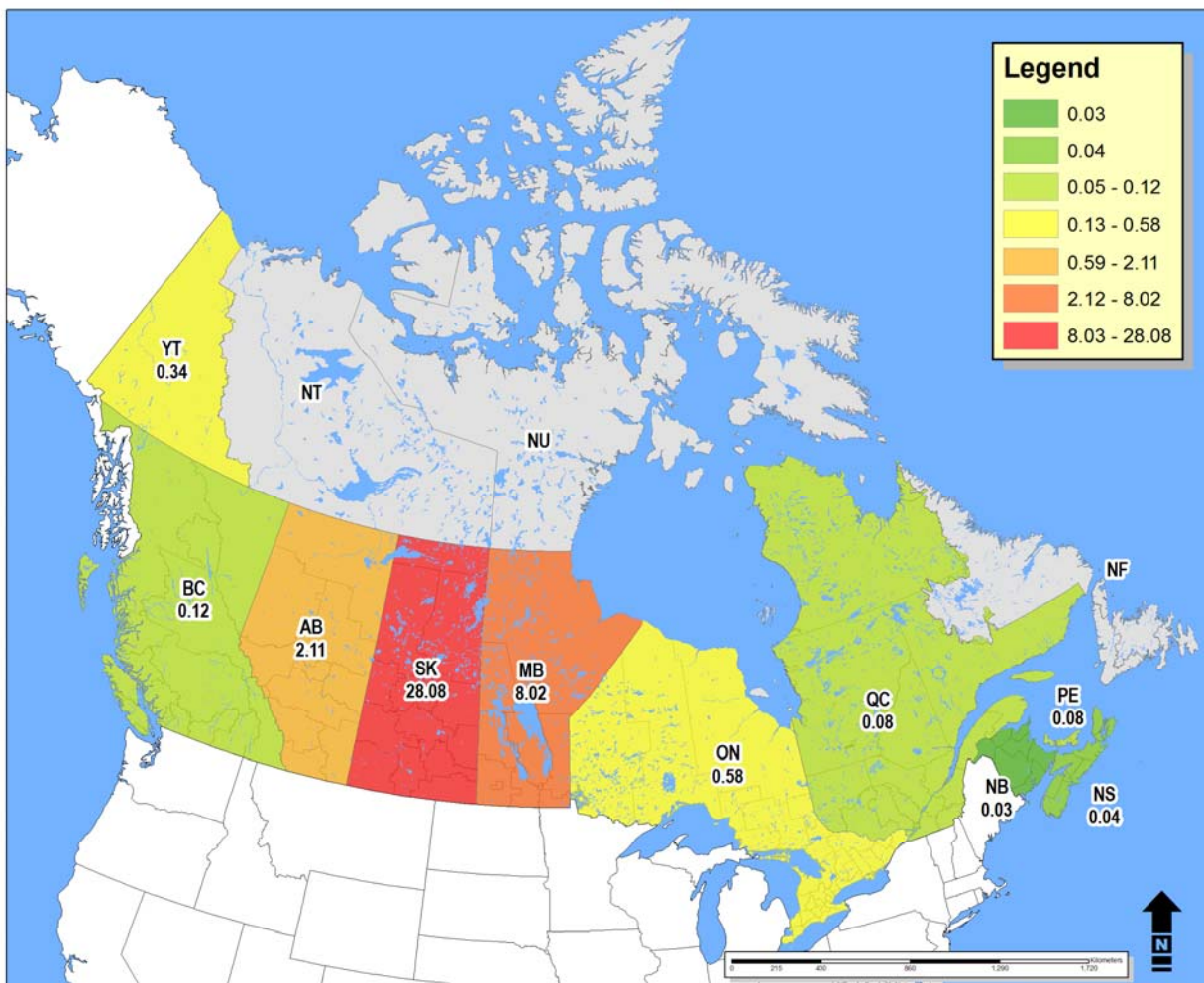
3.3 Results

The results are presented following the order as Place, Time, and Person.

3.3.1 Place

From 2002 to 2010, a total of 4,562 cases with WNV disease were reported from 107 health units/regional health authorities in 10 provinces and territories in Canada. All cases from Atlantic regions (New Brunswick, Nova Scotia, and Prince Edward Island) and Yukon Territory were relevant to travel outside the jurisdictions. 80% of all cases were reported from the five provinces: Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia (Figure 3.1).

Figure 3.1 Average Annual Incidence per 100,000 Population of West Nile virus Disease (N=4,562), by Provinces and Territories in Canada: 2002-2010



The annual average incidence for all provinces ranged from <0.1 per 100,000 population (Prince Edward Island, New Brunswick, Nova Scotia) to 25.6 per 100,000 (Saskatchewan) (Table 3.1). Regions with the highest average annual incidence were reported in the Prairie regions and central regions (Figure 3.1). Further, Alberta, Saskatchewan, Manitoba, and Ontario had an average annual incidence of greater than 0.6 per 100,000 population. Health Units/Regional Health Authorities with highest average annual incidences also were clustered in the prairie region and central region (Figure 3.2).

Figure 3.2 Average Annual Incidence per 100,000 Population of West Nile virus Disease (N=4,562), by Regional Health Authority/Health Unit, in Canada: 2002-2010

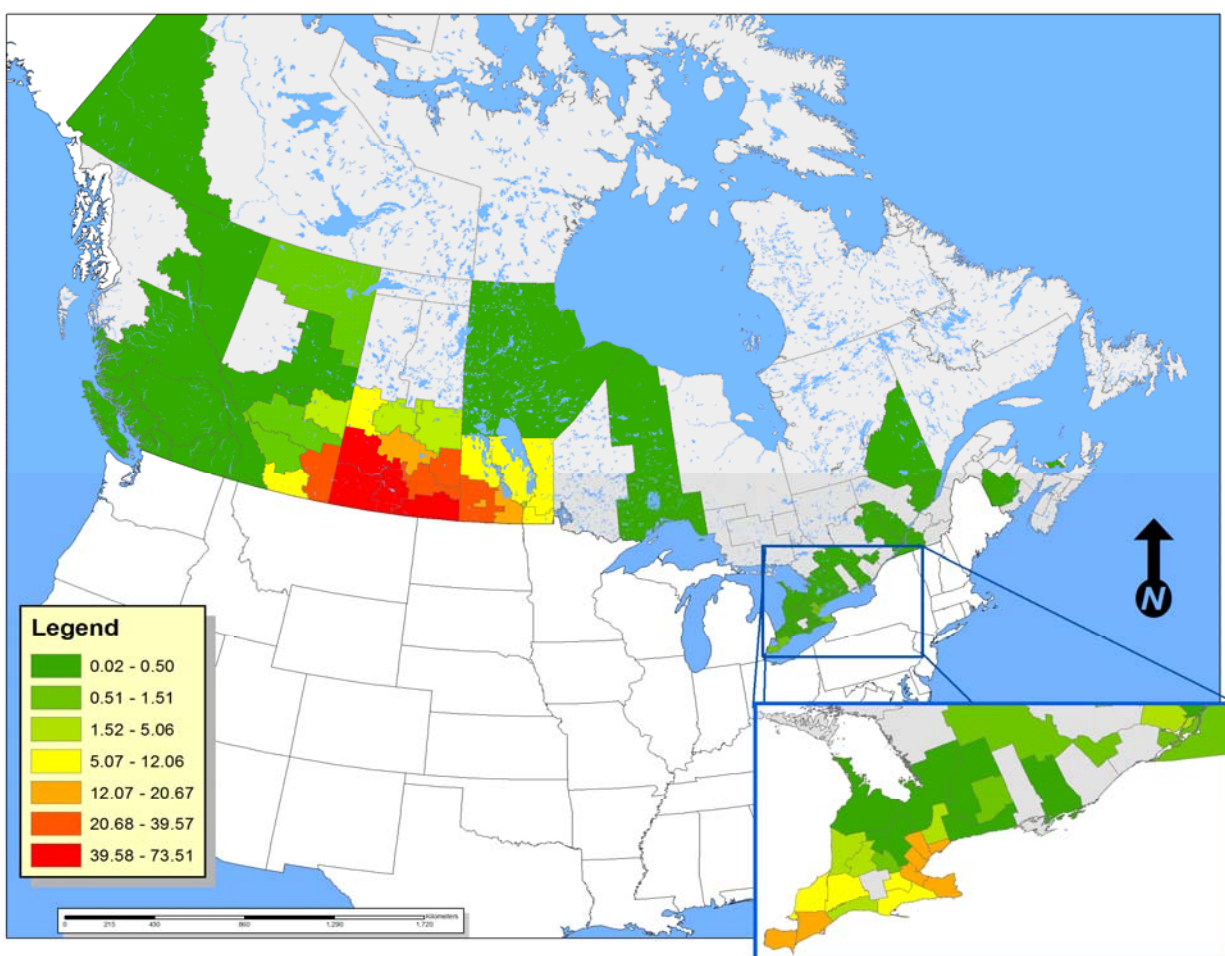


Table 3.1 Average Annual Incidence* per 100,000 Population of West Nile virus Cases, by Year, by Province and Territory in Canada: 2002-2010

Area	Year									Average
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2002-2010
Canada	1.3	4.7	0.1	0.7	0.5	6.7	0.1	<0.1	<0.1	1.6
Atlantic region	**	0.1	**	0.1	**	<0.1	**	**	**	<0.1
Newfoundland & Labrador	**	**	**	**	**	**	**	**	**	**
Prince Edward Island	**	**	**	0.7	**	**	**	**	**	0.1
New Brunswick	**	0.1	**	0.1	**	**	**	**	**	<0.1
Nova Scotia	**	0.2	**	0.1	**	0.1	**	**	**	<0.1
Central region	2.1	0.5	0.1	0.5	0.2	0.1	<0.1	<0.1	<0.1	0.4
Quebec	0.3	0.2	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	**	0.1
Ontario	3.3	0.7	0.1	0.8	0.3	0.1	<0.1	<0.1	<0.1	0.6
Prairie region	**	25.3	0.2	2.2	1.9	38.2	0.5	0.1	<0.1	7.5
Manitoba	**	12.2	0.3	4.7	4.2	48.4	1.0	0.2	**	7.9
Saskatchewan	**	94.0	0.5	5.8	1.9	128.5	1.7	0.1	0.2	25.6
Alberta	**	8.5	<0.1	0.3	1.1	9.1	<0.1	0.1	<0.1	2.1
British Columbia	**	0.5	**	**	**	0.4	<0.1	0.1	<0.1	0.1
Yukon Territory	**	3.2	**	**	**	**	**	**	**	0.3
Northwest Territories	**	**	**	**	**	**	**	**	**	**
Nunavut	**	**	**	**	**	**	**	**	**	**

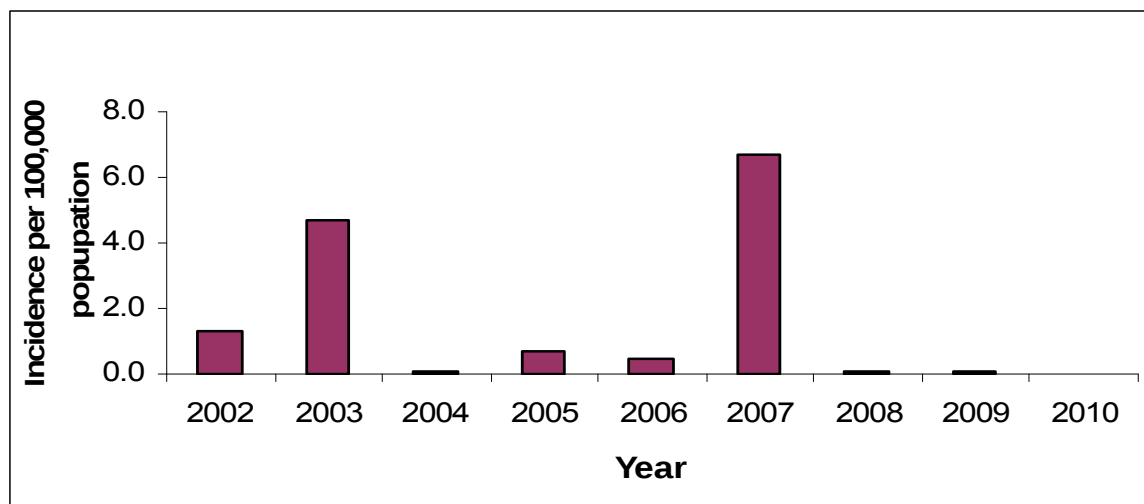
* Calculated using Canadian population estimates for July Canada

** Use for No of cases

3.3.2 Time

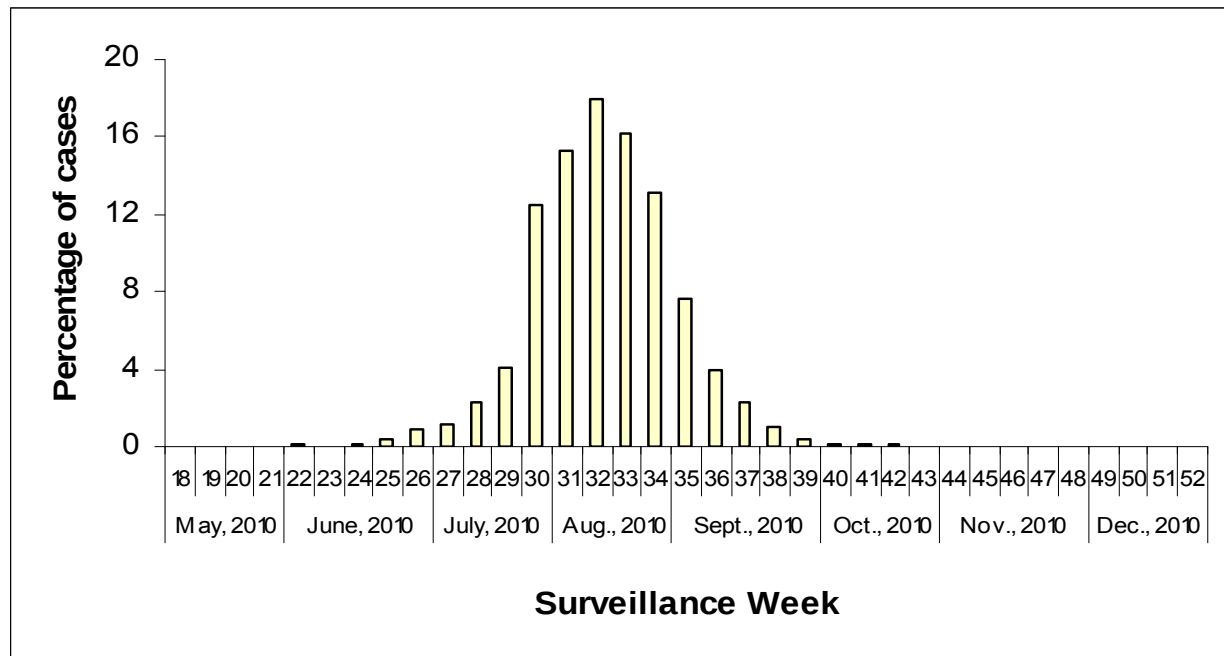
Despite substantial geographic spread of the virus activity during 2002-2010, the incidence fluctuated considerably over time. The incidence was 0.02 per 100,000 population in 2010, versus 4.7 in 2003 and 6.7 in 2007. Overall, the national average annual incidence of WNV disease during 2002-2010 was 1.6 per 100,000 population (range: 0.02-4.7) (Figure 3.3).

Figure 3.3 Annual Incidence of WNV (N=4562), by Year in Canada: 2002-2010



West Nile virus season in Canada usually starts in May and ends around October. Based on date of onset, human cases with WNV infection were reported in all of the season, but 98% of them had onset of illness during three month period from July to September. The annual epidemic peak in Canada consistently occurs in August which takes account more than 60% of the total cases reported (Figure 3.4).

Figure 3.4 Overall West Nile virus disease cases (N= 4,461), by week of illness onset in Canada: 2002-2010



3.3.3 Person

From 2002 to 2010, a total of 4,562 cases with WNV disease were reported in Canada. British Columbia started to see first autochthonal cases in 2009. Of all reported cases, 796 (14%) were classified as neurological syndrome, 3,596 (61%) as non-neurological syndrome, and 170 (3%) as unclassified (Table 3.2). Totally, sixty-three fatal cases with WNV infection were reported.

Table 3.2 West Nile virus neurological syndrome, non-neurological syndrome, unclassified cases and deaths in Canada: 2002-2010

Year	Neurological syndrome			Non-neurological syndrome			Unclassified			Total		
	No. of cases	Deaths		No. of cases	Deaths		No. of cases	Deaths		No. of cases	Deaths	
		No.	(%)		No.	(%)		No.	(%)		No.	(%)
2002	256	21	(8)	20	1	(5)	138	1	(<1)	414	23	(6)
2003	217	10	(5)	1243	2	(<1)	11	0	(0)	1471	12	(<1)
2004	13	2	(15)	17	0	(0)	5	0	(0)	35	2	(6)
2005	48	10	(19)	172	2	(1)	6	0	(0)	226	12	(5)
2006	38	1	(3)	112	1	(<1)	0	0	(0)	150	2	(1)
2007	215	12	(6)	1991	0	(0)	7	0	(0)	2213	12	(<1)
2008	5	0	(0)	29	0	(0)	2	0	(0)	36	0	(0)
2009	4	0	(0)	8	0	(0)	1	0	(0)	13	0	(0)
2010	0	0	(0)	4	0	(0)	0	0	(0)	4	0	(0)
Total	796	56	(7)	3596	6	(<1)	170	1	(<1)	4562	63	(1)

The majority cases, both neurological syndrome and non-neurological syndrome, were classified as confirmed cases (91% versus 83%) (Table 3.3). The proportion of confirmed cases fluctuated over the 10-year reporting time period (median: 65%; range: 53%-100%) and also varied by jurisdictions (median: 78%; range: 0% to 100%). Despite these variations, demographic characteristics and outcomes did not vary by case status. Because confirmed and probable cases meet the national case definitions and have laboratory evidence of WNV infection, confirmed and probable cases are combined for the remainder of this analysis.

Table 3.3 Number of confirmed and probable cases of West Nile virus by classifications in Canada: 2002-2010

Year	Neurological syndrome (N= 796)		Non-neurological syndrome (N=3,596)		Unclassified (N=170)		Total (N=4,562)	
	Confirmed	Probable	Confirmed	Probable	Confirmed	Probable	Confirmed	Probable
2002	256	0	20	0	138	0	414	0
2003	192	25	1,212	31	11	0	1,415	56
2004	9	4	11	6	5	0	25	10
2005	45	3	123	49	5	1	173	53
2006	37	1	90	22	0	0	127	23
2007	175	40	1,500	491	6	1	1,681	532
2008	5	0	17	12	2	0	24	12
2009	2	2	6	2	1	0	9	4
2010	0	0	2	2	0	0	2	2
Total (%)	721 (91)	75 (9)	2,981 (83)	615 (17)	168 (99)	2 (1)	3,870 (83)	692 (17)

Among the 504 patients for whom fever data were available, 457 (91%) were reported having a fever. Among the 781 patients for whom hospitalization data were available, 422 (54%) were hospitalized. Among the 599 patients for whom travel data were available, 85 (14%) cases were likely related to travel outside the province/territory (Table 3.4).

Table 3.4 Characteristics of Individuals with West Nile virus Neurological and Non-Neurological Syndrome Cases in Canada: 2002-2010

	Neurological syndrome cases (N=796)		Non-neurological syndrome cases (N=3,596)		Unclassified (N=170)	
	No.	(%)*	No.	(%)	No.	(%)
Sex						
Male	400	(50)	1,822	(50)	83	(48)
Female	393	(49)	1,772	(49)	81	(48)
Unknown	3	(<1)	2	(<1)	6	(4)
Age						
Median age (range)	54 yrs (0 - 92 yrs)		48 yrs (0 - 93 yrs)		51 yrs (0 - 83 yrs)	
Age group, yrs						
0-9	15	(2)	33	(1)	9	(5)
10-19	18	(2)	217	(6)	6	(4)
20-29	39	(5)	285	(7)	8	(5)
30-39	81	(10)	541	(15)	18	(11)
40-49	159	(20)	948	(26)	39	(23)
50-59	172	(22)	860	(24)	27	(16)
60-69	126	(16)	422	(12)	29	(17)
>= 70	186	(23)	290	(8)	34	(20)
Unknown						
Fever						
Yes	457	(57)	1261	(35)	114	(67)
No	47	(6)	232	(7)	10	(6)
Unknown	292	(37)	2103	(59)	46	(27)
Hospitalization						
Yes	422	(53)	384	(11)	57	(34)
No	359	(45)	3212	(89)	113	(66)
Unknown	15	(2)				
Travel **						
Yes	85	(11)	209	(6)	30	(18)
No	514	(66)	2697	(75)	112	(66)
Unknown	197	(25)	690	(19)	28	(17)

* Percentage might not equal 100 due to rounding

** Likely related to travel outside the jurisdiction

3.3.3.1 Neurological Syndrome Cases: Selected Demographic Characteristics and Clinical Outcomes

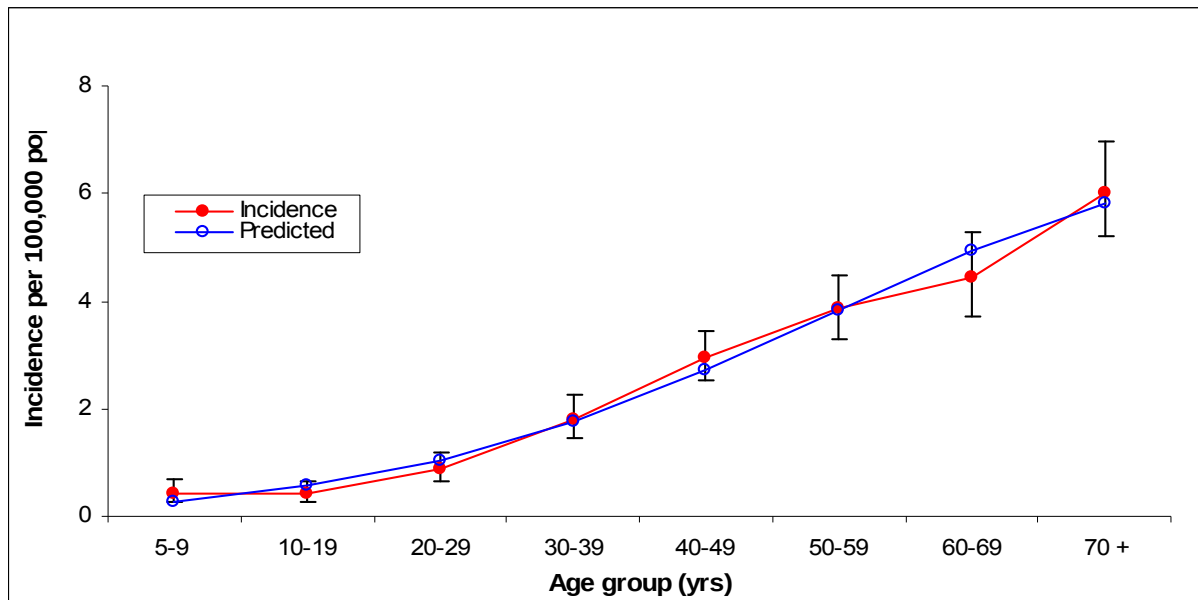
During 2002-2010, a total of 796 cases with neurological syndrome were reported in Canada.

Males accounted for 50% of cases. Of them, the median age was 54 years (range: 0-92 years).

More than half (61%) cases occurred in persons aged over 50 years. Ninety-seven percent of patients had onset of illness during July-September.

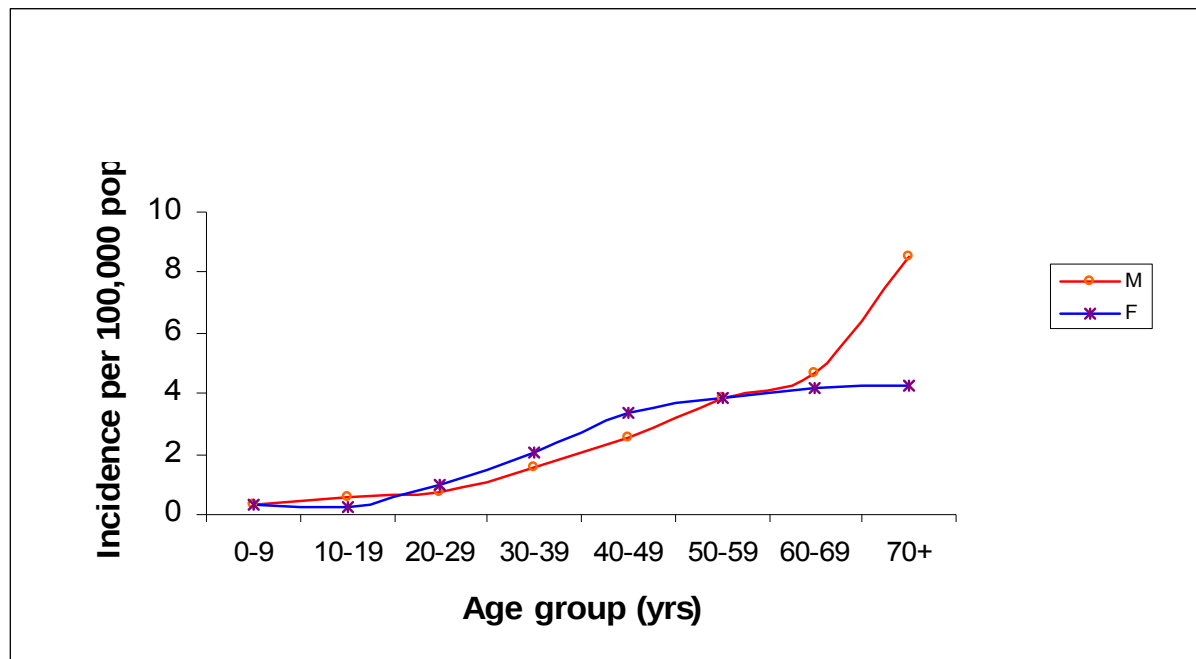
The average annual incidence of WNV neurological syndrome disease increased steadily with increasing age, ranging from 0.42 per 100,000 among persons aged < 10 years to 6.02 among those aged greater than 70 years (Figure 3.5).

Figure 3.5 Average Annual Incidence of West Nile virus Neurological Syndrome Cases (N = 796), by Age Groups in Canada (2002-2010)



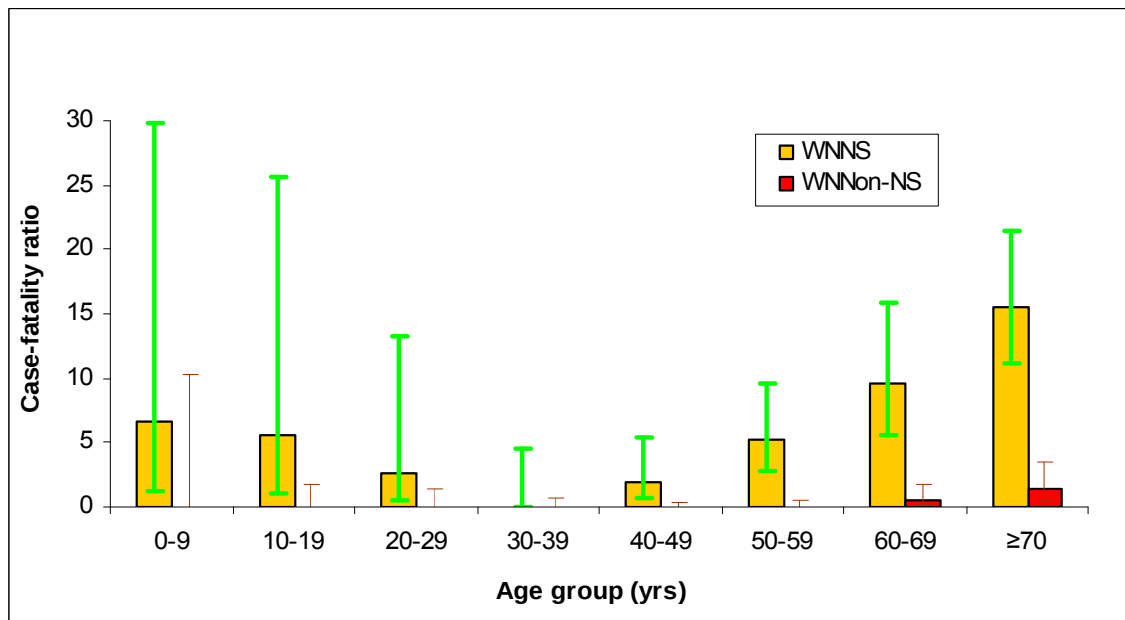
Further, the average incidence of cases with neurological syndrome was slightly higher among males (2.48 per 100,000 pop) than among females (2.39 per 100,000 pop), especially among persons aged greater than 70 years, for whom the incidence in men was twice than that in women (8.52 versus 4.23) (Figure 3.6).

Figure 3.6 Average Annual Incidence of West Nile virus Neurological Syndrome Cases (N=794), by Age and Sex in Canada (2002-2010)



From 2002 to 2010, a total of 56 (7%) fatal cases were reported among people with WNV infection in Canada. The case-fatality ratios increased significantly with increasing age and the trend was identical regardless classifications. For instance, cases with neurological syndromes, 3% of cases among aged less than 59 years (combined) were fatal, compared with 10% of cases among those aged 60-69 years and 16% of those aged greater than 70 years (Figure 3.7).

Figure 3.7 West Nile virus Disease Case-fatality Ratios, by Age Group, by Classification in Canada: 2002-2010



3.3.3.2 Non-Neurological Syndrome Cases: Selected Demographic Characteristics and Clinical Outcomes

During 2002-2010, a total of 3,596 cases with non-neurological syndrome were reported. Males accounted for 50% of cases (Table 3.4). The median age was 51 years (range: 0-83 years). Half of all the cases occurred in persons aged 40-59 years.

Ninety-eight percent of patients reported onset of illness from July to September. Overall, six (0.2%) of the 3,596 cases with non-neurological syndrome were fatal. The case-fatality ratios

increased with increasing age: 0.5% of cases among aged 60-69 and 1% of them aged greater than 70 years (Figure 3.7).

Among the 1,493 patients with fever measurements available, 1,261 (85%) were reported having a fever. Among 3,604 patients for whom hospitalization data were available, 384 (11%) were hospitalized. Among 2,906 patients for whom travel data were available, 209 (7%) cases were likely related to travel outside the province / territory (Table 3.4).

3.3.3.3 Comparison of Case Characteristics between the Outbreak Year and Regular Year

For this analysis, three independent variables were selected as age, sex, and geographical locations. Geographically, all cases were arbitrarily divided into four regions: Western region (British Columbia, Yukon); Prairie region (Alberta, Saskatchewan, and Manitoba), Central region (Ontario and Quebec), and Atlantic region (Newfoundland and Labrador, Prince Edward Island, Nova Scotia, and New Brunswick).

The odd ratio is 1.007 (95% CI: 1.000, 1.014) for age. The odd ratio is 1.166 (95% CI: 0.914, 1.487) for sex. If take prairie as a reference group, the odd ratio is 0.486 (95% CI: 0.180, 1.316) for western region, 0.009 (95% CI: 0.005, 0.016) for central region, and 0.043 (95% CI: 0.004, 0.419) for Atlantic region.

So individuals who live in prairie region seem more likely to exposure WNV than other regions during the biggest year of 2007. However, the conclusion is unstable due to the small sample size in central and atlantic region. Also, we did not account travel related cases. Age is slightly affected, with the odds of exposure increasing with age. Sex is no difference. Detailed results can be seen in the Table 3.5.

Table 3.5 Demographic Characteristics for Human Cases between the Biggest Year and Regular Years.

Demographic	Biggest year (2007)		Regular years (2004,2005,2006, 2008,2009,2010)		OR (95%CI)	OR _{adj} * (95%CI)
	n	%	n	%		
Age						
Mean±SD	48.1	16.56	46.89	18.87	1.004 (0.998, 1.10)	1.007 (1.000, 1.014)
Gender						
Female	1052	47.56	215	47.36	1.001 (0.824, 1.234)	1.166 (0.914 , 1.487)
Male	1160	52.44	239	52.64	1	1
Region						
Prairie	2180	98.51	289	62.28	1	1
Western	19	0.86	5	1.08	0.504 (0.187, 1.359)	0.486 (0.180, 1.316)
Central	13	0.59	167	35.99	0.010 (0.006, 0.018)	0.009 (0.005, 0.016)
Atlantic	1	0.05	3	0.65	0.004 (0.005, 0.426)	0.043 (0.004, 0.419)
Total	2213	100.00	464	100.00	-	-

* Adjusted for age, gender and region simultaneously.

3.3.4 Comparison of Reported Cases of WNV by the National WNV Surveillance Program versus by the Hospital Discharge Database in CIHI

3.3.4.1 Comparison of the Total Number of Severe Cases Reported by the National WNV Surveillance Program versus by the CIHI

From 2002 to 2008, the National WNV surveillance system totally reported 849 cases with hospitalization. In contrast, the CIHI hospital dataset was captured 933 cases for the same time period based on ICD 09 and ICD 10 diagnosis codes. The diagnosis code for WNV is 0663 as ICD 9 and A923 as ICD10. Although the data sources and data flow are different between national surveillance and CIHI, the total number of cases reported by the two databases (849 vs 933) is very comparable. In other words, the National WNV surveillance captures most hospital cases.

The number of cases reported in CIHI is slightly higher than that in the national surveillance system. One potential explanation is that when a case was captured by the national surveillance system, the case may not be hospitalized around that time, but was hospitalized later due to the progress of the disease. Another explanation is the case was hospitalized later due to other medical conditions. Because the national surveillance system collects the data and disseminates the information in a timely manner (weekly), and this may cause the unmatched number because the CIHI data are not timely dissemination. If we continue to follow up those cases that were reported by the surveillance system after the WNV season, that information could be captured. It is not possible to compare the overlap between the national surveillance data and CIHI data, since no unique case identification number is available to link the two data sources.

3.3.4.2 Comparison the Total Number of Hospitalized Cases with WNV versus Other Arbovirus Diseases Reported by CIHI

West Nile virus is an arbovirus in the family of *Flaviviridae*. Many other arboviruses and zoonoses also can cause severe illness in humans. For example, Japanese encephalitis (ICD-09 as of 620 and ICD-10 as of A830), Western equine encephalitis (ICD-09 as of 621 and ICD-10 as of A831),

St. Louis encephalitis (ICD-09 as of 623 and ICD-10 as of A833), other specified mosquito-borne viral encephalitis (ICD-09 as of 628 and ICD-10 as of A838), Far Eastern tick-borne encephalitis or Russian spring-summer encephalitis (ICD09-as of 630 and ICD-10 as of A840), Louping illness (ICD-09 as of 631 and ICD-10 as of A848), Central European tick-borne encephalitis (ICD-09 as of 632 and ICD-10 as of A841), other specified tick-borne viral encephalitis (ICD-09 as of 638 and ICD-10 as of A848), and Venezuelan equine encephalitis (ICD-09 as of 662 and ICD-10 as of A922) are all belong to the *Flaviviridae* family (58).

From 2002 to 2008, a total of 720 human hospitalized cases with arboviral encephalitis were extracted from CIHI based on the ICD09/ICD10 codes mentioned above. Of these records, 711 were coded as WNV and taken into account for 98.8 percent of the total cases with arbovial disease. One limitation of the data is that the data from Quebec for the time period of 2006-2008 were not available in CIHI database when we conducted the analyses.

3.5 Conclusion

Since the first cases reported in 2002, the disease is endemically reported in prairie region (Manitoba, Saskatchewan, and Alberta) and central region (Quebec, and Ontario) in Canada. Especially, the prairie region is likely to see more human cases occur. British Columbia started to reported autochthonal human cases in 2009. The peak of human cases is usually reported around August and September, which are coincident with mosquito peak activity. Age is risk factor for

WNV disease, especially for those over 60 years old. In Canada, the disease of WNV has become a leading cause of arboviral encephalitis.

Chapter Four: Bird and Other Species Surveillance on West Nile Virus in Canada

In this chapter, national West Nile virus surveillance in dead birds in Canada is described.

Descriptive analyses of multi-year dead bird data are summarized, by test results, by species, by time trends, by spatial distributions and by the lag time periods between positive dead birds and human cases of West Nile virus. Contributions of bird surveillance on West Nile virus and the challenges are described in this chapter, as well as, brief mosquito surveillance and horse surveillance on West Nile virus are included.

4.1 Bird Surveillance for West Nile virus

4.1.1 Introduction

Besides humans, surveillance for the presence of WNV in Canada also includes monitoring the virus presence in: birds, mosquitoes, and domestic animals such as horses. Human surveillance is not the sole source of information about the presence of WNV in a community. In late 1999 and early 2000, WNV NSC guided and designed multi-specie surveillance, including bird surveillance, mosquito surveillance, horse surveillance and human surveillance.

The National WNV wild bird surveillance program has been in place since May 2000. It is mainly financed by the Zoonoses Division, Centre for Food-borne, Environmental and Zoonotic Infectious Diseases in PHAC, and is coordinated by CCWHC. The main objective of bird surveillance is to provide an early warning signal of WNV activity in an area and aids in the decision-making on WNV control measures to protect public health. Detailed WNV bird surveillance information can be viewed via the CCWHC website: http://www.ccwhc.ca/wnv_background.php

4.1.2 Methods

Dead birds were identified via a passive surveillance coordinated by CCWHC in Canada. There are five CCWHC local regions: Alberta, Western/Northern, Ontario / Nunavut, Quebec, and Atlantic region as well as a British Columbia Animal health Centre across the country to collection and submission of dead bird samples for laboratory testing on WNV. In each region, there is a submission form (Appendix V) and instructions on packing/shipping samples. Detailed information of the Submission Form and Instruction in each region can be viewed via the CCWHC website as: http://www.ccwhc.ca/west_nile_virus.php

Descriptive statistic were used to assess bird data by seasonality, geographic distribution, temporal relationship between dead birds positive for WNV and human cases of WNV in Canada from 2002 to 2010.

4.1.3 Results

In the first year of 2000, a total of 2,288 dead birds were collected and examined for WNV in Canada and none of them was WNV positives. In 2001, 2,722 birds were tested and 128 (5%) were positive for WNV. From 2000 to 2010, the number of samples tested (with the number of positives and the percentage of positives) in Canada were 2,288 (0%), 2,722 (128, 5%), 3,600 (569, 16%), 11,789 (1851, 16%), 6,648 (446, 7.0%), 3,989 (447, 11%), 3,083 (273, 9%), 1,987 (139, 7.0%), 1,246 (160, 13%), 418 (10, 2%) and 366 (23, 6%) respectively. From 2000 to 2010, a total of 4,046 dead birds were tested positive for WNV. Of them, 99% was the Crow family including 78% American Crow, 13% Blue jay and 8% Black-billed Magpie.

In 2003 and 2007, the first positive dead birds were identified and reported in the early stage of the season (early May and June respectively). Also, positive birds were reported over a relatively long time period from May to October in the two seasons (Figure 4.1). These were coincident with the significant WNV outbreaks in humans in 2003 and 2007 in the country (1,418 human cases in 2003, and 2,215 human cases in 2007, respectively).

At a national level, the temporal relationships between positive birds found and first human cases occurred were explored by seasonality based on available surveillance data for the time period from 2003 to 2010. The pattern is consistent that first human cases are usually occurred 2 to 6 weeks later than the first positive bird presented (range: 2-12 weeks) (Figure 4.2). Similar trends were observed by using the cumulative surveillance data from 2003-2010 (Figure 4.3).

Figure 4.1 Percent of positive dead bird tested for West Nile virus, by year in Canada: 2003-2010

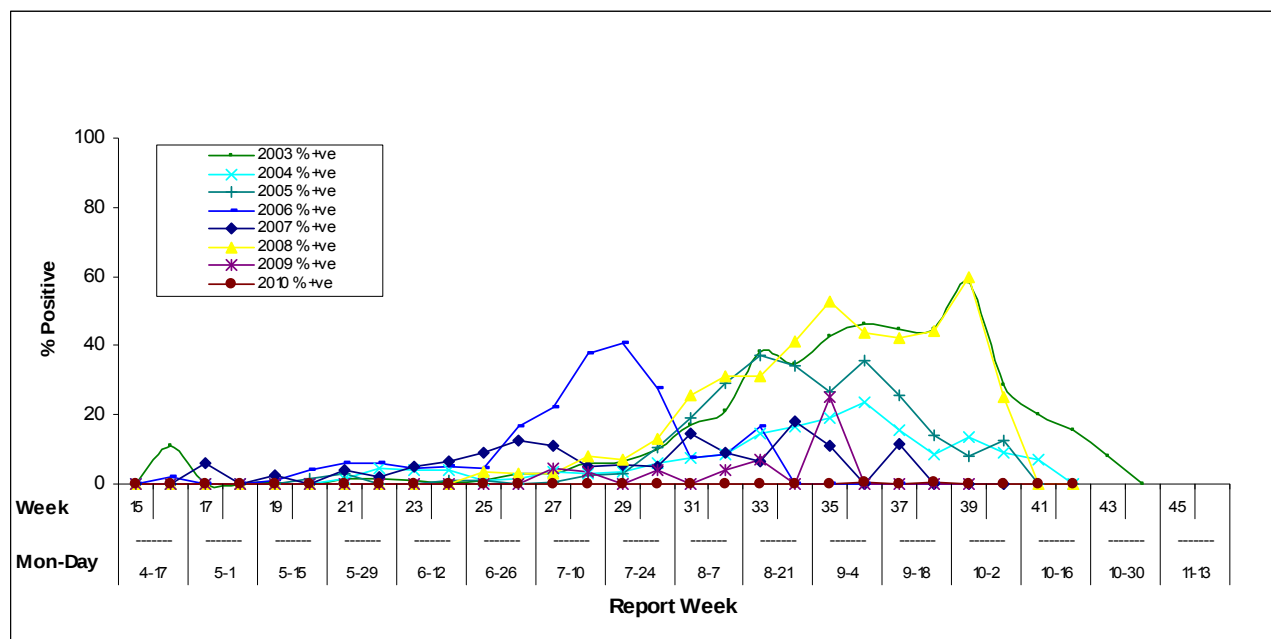


Figure 4.2 Temporal relationship between positive bird indicators and human cases of West Nile virus in Canada: 2003-2010

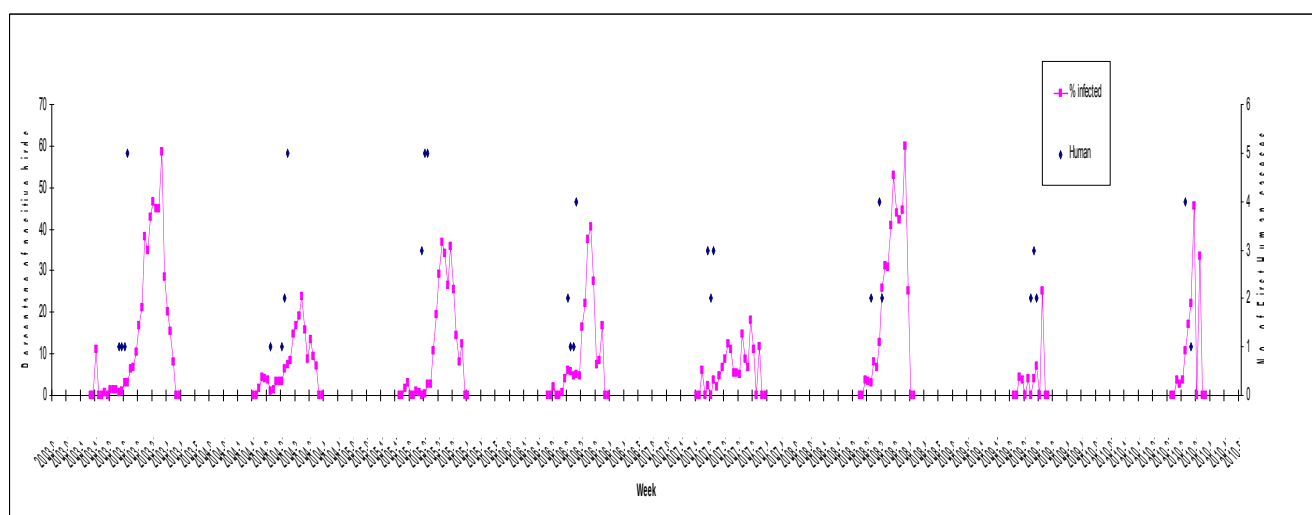
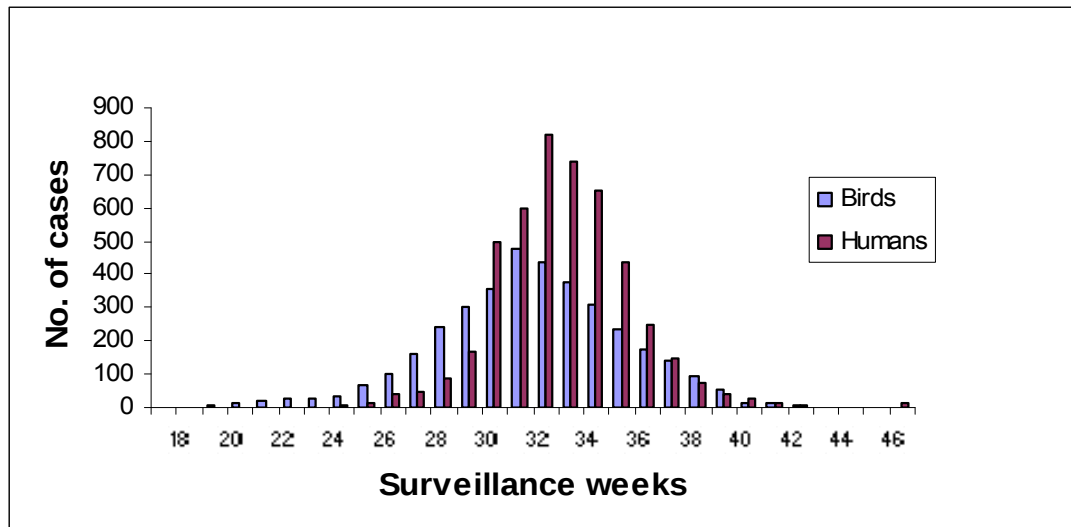


Figure 4.3 Number of Dead Birds Positive for WNV (N=3,685) and Human Cases of West Nile virus (N=4,685) in Canada: 2002-2010



4.1.4 Discussions

It is assumed that positive dead birds of WNV would be found in areas that have suitable ecological environmental conditions for WNV in birds. Consistent with other studies (59, 60), our descriptive multi-year bird data analysis indicates the corvid family has a very high mortality rate after they were infected with WNV. Birds of corvid family are large-bodied and ubiquitous so they are ideal for surveillance. The surveillance data show that American crow die-offs precede an increased risk for human illness by 2 to 6 weeks. Thus, dead crow is an early warning for WNV activity and this sign becomes important especially in the early WNV season, usually from May to June in Canada. Factors such as the density of the human population, the types of birds and the size of the remaining bird population in a given area could affect the number of reported dead bird sightings. Further, some provinces have started to drop from the national bird surveillance program due to

limited resources, so the interpretation of multi-year data comparisons becomes challenging over time.

4.2 Mosquito Surveillance for West Nile virus

In Canada, mosquito surveillances are directed by the Ministry of Health in each jurisdiction. The main purposes of mosquito surveillance are: to monitor mosquito populations associated with WNV; to determine the level of WNV activity among these species; and to use this information to make decisions regarding the risk of transmission to humans and the need to implement mosquito control plans.

Mosquito surveillance data in Canada has shown *Culex* species mosquitoes are the most important vector species for WNV, although multiple species of mosquitoes can serve as vectors. In total, 3,883 positive mosquito pools for WNV have been identified and reported in the country since 2002. The seasonality was fairly consistent across the country, with a slow build-up of numbers through May and June, peaks of activity in July and August and an abrupt drop in numbers in September, with small numbers still appearing until October. For mosquito surveillance, factors such as mosquito trap types, trap locations, and the type of mosquitoes in a given area will affect the number of reported positive mosquito pools. Detailed mosquito surveillance information can be viewed via the link on the PHAC website: <http://www.phac-aspc.gc.ca/wnv-vwn/index-eng.php>

4.3 Horse Surveillance for West Nile virus

Horse surveillance is coordinated by Canadian Food Inspective Agency. The main objectives of horse surveillance are: to determine the number of horses affected with WNV; to determine the location of infected horses; and to determine the clinical signs present in infected horses, as well as the vaccine usage.

A vaccine manufactured in the United States became available to protect horses from WNV infection in September 2001. In Canada, the vaccine was licensed and registered as of February 2003 (61). The number of horse infections has reduced significantly after the vaccine become available. A total of 698 horses positive for WNV have been reported in Canada, including 337 horses with WNV infection in 2002.

Chapter Five: Conclusions

In the last chapter, provides overall conclusions from previous chapters including evaluation, epidemiological analysis and other species surveillance.

5.1 Evaluation Summary

The evaluation shows an overall performance of WNV surveillance met its main objectives. The surveillance system has proven a stable function since its inception in 2002. Over the past ten-year, Canadian WNV surveillance system has collected volume data and disseminated the information to stakeholders in a timely fashion during the WNV season. This timely information helps to identify the national trends and alert the epidemiological change of the disease.

West Nile virus national surveillance has developed standard instruments in terms of human case data collection / analysis / dissemination via a web-based application of CNPHI, as well as a joint map between the US and Canada. These have been used for other zoonotic disease surveillance such as Lyme disease and Rabies.

One additional benefit of the WNV national surveillance programs is that the multi-species surveillance has established new or expanded communication networks among all elements of zoonotic diseases, particularly a renewed integration of wildlife, agriculture, and human health/disease specialists which is a One Health upstream approach to address prevention and control of infectious diseases. These “ancillary” results continue to benefit all stakeholders on

dealing with infection diseases, given approximately 75% of emerging infectious diseases are zoonotic in origin (62). Currently, the national WNV surveillance maintains a minimal function and focus on early detection and early risk communication, because there have been no significant WNV outbreaks over the past three years.

This evaluation also identified several gaps of the National WNV surveillance system. First is the multi-species surveillance data are lack of consistence on location information between species such as the level of geographical information, so it is challenging to link the data between species at national level and limited to use advance analysis such as Geographic Information System (63, 64). Second is the lag time between human case onset and the case report received by provinces remains unclear from this evaluation, although the information is disseminated in timely fashion once the data captured into the national surveillance system. Third is the national WNV surveillance program provides volume information on education and prevention of the emerging disease to public and professionals over the past 10 years, but it is challenging to quantify them. In addition, the current human WNV case reporting mechanism from provinces to federal government is on a voluntary basis. A Multi-Lateral Information Sharing Agreement (MLISA) is under the development by PHAC and P/Ts partners and hope to formalize the information sharing between provinces and federal governments on all infectious diseases in Canada.

5.2 Epidemiological Summary

Although WNV human cases have been detected in most provinces since 2002, the highest incidence consistently occurs in the Prairie and Centre regions in Canada. The higher incidence observed in these regions most likely could result from the high efficiency of *Cx. tarsalis* as both an epizootic and epidemic WNV vector (65, 66). However, the ecology of WNV including the mechanism of its persistence in a geographic area is still poorly understood, and makes challenging in predicting future transmission. For example, whether the incidence reported in 2009 and 2010 represents a decrease that remains unclear. Although some decrease in the rate of WNV infection in humans may be attributable to vector control, other prevention activities, or the variable and sporadic nature of WNV outbreaks, the estimated rates of infection varied widely over time is still unclear. Further studies may be necessary to identify appropriate indicators for assessment of the impact of the disease on humans.

West Nile virus disease has become the leading cause of arboviral encephalitis in Canada. High numbers of cases of WNV neurological syndrome and hospitalizations identified pose a significant health concern due to long term sequelae in affected patients. Although severe cases of WNV neurological syndrome occur in all age groups and in both sexes, disproportionately more older persons and males are affected, particularly older men. However, according to serosurveys and other studies among blood donors, the risk for initial infection with WNV has not been found significantly higher among men than women (67, 68, 69, 70). The association between increasing age and increasing severe case incidence has been well described (56, 71, 72, 73). Consistent with

other studies, our data also show age is a risk factor for severe cases (e.g. patients with neurological syndrome, and fatal cases with WNV infection)

The design of human surveillance is a passive surveillance and focuses on those severe cases. The data indicate that 83% cases with non-neurological syndromes may not be detected by the current WNV surveillance system.

Non-mosquito WNV transmission through blood transfusions and transplanted organs was first identified and reported in the United States in 2002 (49, 50, 51, 52, 53, 74). Although WNV has been known to be in Europe, Asia and Africa for 65 years, there have been no documented cases of transmission through blood, blood products, organs or tissues in those continents. The documented cases in the United States in 2002 could be the result of a more virulent strain of the virus, more sensitive technology, more focused investigations, the largely non-immune (not previously exposed) status of North Americans or any combination of these factors. Starting in 2003, Canadian blood operators have implemented screening test for WNV as part of routine screening for blood donations in Canada.

Other non-mosquito transmission such as transplacentally from mother to fetus and via exposure in a laboratory setting has been reported elsewhere except Canada (75). In 2007 two pregnant women in Canada were laboratory confirmed to have acute WNV non-neurologic syndrome. The women, and subsequently their infants, were followed up specifically for adverse outcomes relating to

WNV. During the follow-up evaluations, no physical or laboratory evidence of congenital WNV infection was found in the infants born from the women.

Canada has appropriate mosquito vectors and vertebrate reservoir hosts of West Nile virus.

Further, the epidemiology of WNV in Europe appears changes with the co-circulating on lineage 1 and lineage 2 (56). These epidemiological changes may begin to be seen in Canada. In the absence of an effective human vaccine, there is a need of the National WNV surveillance to provide timely Pan-Canada data on the virus activity, and alert the trend changes of epidemiology for public action, especially for high risk population.

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APPENDIX I: SPECIFIC INDICATORS AND METHODOLOGIES FOR EACH EVALUATION QUESTION

Evaluation Question	Indicator	Methodologies						
						Surveillance data	Documents review	Details
		CDC guideline	PHAC guideline	Survey	Program data			
1.0 Program Description								
1.1 Public Health Importance	1.1.1 Health Concerns and West Nile virus	x	-	-	-	x	x	US CDC guideline, WN reports, academic research, weekly/annual reports
	1.1.2 Unpredictability of West Nile virus	x	-	-	-	x	x	WN surveillance report, Record of Decision of teleconference
	1.1.3 The epidemiology of WNV infection in humans in Europe appears to be changing with emerging novel virulent WNV strain and these changes may begin to be seen in Canada	x	-	-	-	-	x	ECDC report, WN program documents
1.2. Define the Stakeholders	1.2.1 Degree of alignment of WNV program objectives with agency strategic outcomes/priorities	x	-	-	-	-	x	TB submissions, RPP, DPR, PAA PHAC website on West Nile Virus Monitor
1.3 List the purpose and objectives of WNV surveillance system	1.3.1 Human surveillance	x	-	-	-	x	x	Program documents, annual report and plan, Record of decision
	1.3.2 Bird surveillance	x	-	-	-	x	x	Program documents, annual report and plan, Record of decision
	1.3.3 Mosquito surveillance	x	-	-	-	x	x	Program documents, annual report and plan, Record of decision
1.4 Draw a flow chart for the WNV surveillance system		x	-	-	x	x	x	Program documents, PHAC website on West Nile Virus Monitor
1.5 What policies and procedures are in place to ensure	What policies and procedures are in place to ensure	x	-	-	-	-	x	Speech from the Throne, federal policies and

Evaluation Question	Indicator	Methodologies						
						Surveillance data	Documents review	Details
		CDC guideline	PHAC guideline	Survey	Program data			
patient privacy, data confidentiality, and system security? What is the policy and procedure for releasing data? Do these procedures comply with applicable federal and state statutes and regulations?	patient privacy, data confidentiality, and system security?							regulation. US CDC guideline
	What is the policy and procedure for releasing data?	x	-	-	-	-	x	Record of Decisions, annual report and plan.
	Do these procedures comply with applicable federal and state statutes and regulations?	x	-	-	-	-	x	Speech from the Throne, federal policies and regulation.
2.0 PROGRAM Data								
2.1 What are the Reporting Sources of Data for the System?	2.1.1 Data sources from PTs	x	-	-	-	x	x	PHAC website on West Nile Virus Monitor Records of Decision
	2.1.2 Data Sources from Canadian Blood Operators	x	-	-	-	x	x	PHAC website on West Nile Virus Monitor Records of Decision
	2.1.3 Data sources from FNIHB	x	-	-	-	x	x	PHAC website on West Nile Virus Monitor Records of Decision
2.2 What Data are Collected and How are They Collected?	2.2.1 Core and Minimum Data Elements	x	-	-	-	x	x-	Weekly reports on PHAC website, records of decision
	2.2.2 Mechanism of Data Collection	x	-	-	-	x	x	Weekly reports on PHAC website, records of decision
2.3 What is the Period of Time of the Data Collection?	2.3.1 Number and nature of information products, available to partners and on the PHAC website	x	-	-	-	x	x	records of decision Weekly report, annual report, maps
2.4 How are the system's data managed (e.g., the transfer, entry, editing, storage, and	2.4.1 Collection of Data	x	-	-	-	x	x	records of decision Weekly report annual report,

Evaluation Question	Indicator	Methodologies						
						Surveillance data	Documents review	Details
		CDC guideline	PHAC guideline	Survey	Program data			
back up of data)? Does the system comply with applicable standards for data formats and coding schemes? How are the system's data analyzed and disseminated?								maps
	2.4.2 Analysis and Interpretation	x	-	-	-	x	x	records of decision Weekly report, annual report, maps
	2.4.3 Surveillance Products	x	-	-	-	x	x	records of decision Weekly report, annual report, maps
	2.4.4 Dissemination	x	-	-	-	x	x	records of decision Weekly report, annual report, maps
3.0 Program Performance								
3.1 Timeline	3.1.1 Completion of data processing	x	-	-	x	x	x	Record of decision , Annual report and plan Weekly report
	3.1.2 Capture of data in WNV national surveillance system	x	-	-	x	x	x	Record of decision , Annual report and plan Weekly report
	3.1.3 Application of pattern recognition tools/algorithms	x	-	-	x	x	x	Record of decision , Annual report and plan CNPHI Weekly report
	3.1.4 Generation of surveillance products	x	-	-	-	x	x	Record of decision , Annual report and plan Weekly report
3.2 Representativeness	3.2.1 Number and Nature of Human Cases captured by the System	x	-	-	-	x	x	Weekly report, annual report, maps

Evaluation Question	Indicator	Methodologies						
						Surveillance data	Documents review	Details
		CDC guideline	PHAC guideline	Survey	Program data			
3.3 Acceptability	3.3.1 Frequency and breadth of participation from partners	x	-	-	x	x	x	Records of decision, Weekly report, annual report, maps
3.4 Flexibility	3.4.1 Evolution of the national meeting	x	-	-	x	-	-	Records of decision, Annual report
	3.4.2 Evolution of the WNV application to other zoonoses via CNPHI	x	-	-	x	-	-	Records of decision CNPHI
3.5 Sensitivity	3.5.1 Number, Percent and Nature of Human Cases captured by the System	x	-	-	-	x	-	Weekly report, annual report, maps
3.6 Usefulness	3.6.1 Number and Frequency of visiting PHAC WNV Monitor website	x	-	-	-	-	x	Website traffic statistics
	3.6.2 Perceptions of partners on WNV surveillance system	x	x	x	-	-	-	Survey report PHAC guideline

APPENDIX II: CHECKLIST FOR EVALUATING PUBLIC HEALTH SURVEILLANCE SYSTEMS

Tasks for evaluating a surveillance system*

Task A. Engage the stakeholders in the evaluation

Task B. Describe the surveillance system to be evaluated

1. Describe the public health importance of the health-related event under surveillance

a. Incidences of frequency

b. Incidences of severity

c. Disparities or inequities associated with the health-related event

d. Costs associated with the health-related event

e. Preventability

f. Potential future clinical course in the absence of an intervention

g. Public interest

2. Describe the purpose and operation of the surveillance system

a. Purpose and objectives of the system

b. Planned uses of the data from the system

c. Health-related event under surveillance, including case definition

d. Legal authority for data collection

e. The system resides where in organization(s)

- f. Level of integration with other systems, if appropriate**
 - g. Flow chart of system**
 - h. Components of system**
 - 1) Population under surveillance**
 - 2) Period of time of data collection**
 - 3) Data collection**
 - 4) Reporting sources of data**
 - 5) Data management**
 - 6) Data analysis and dissemination**
 - 7) Patient privacy, data confidentiality, and system security**
 - 8) Records management program**
- 3. Describe the resources used to operate the surveillance system**
- a. Funding source (s)**
 - b. Personnel requirements**
 - c. Other resources**

Task C. Focus the evaluation design

- 1. Determine the specific purpose of the evaluation**
- 2. Identify stakeholders who will receive the findings and recommendations of the evaluation**
- 3. Consider what will be done with the information generated from the evaluation**
- 4. Specify the questions that will be answered by the evaluation**
- 5. Determine standards for assessing the performance of the system**

Task D. Gather credible evidence regarding the performance of the surveillance system

- 1. Indicate the level of usefulness**
- 2. Describe each system attribute**

- a. Simplicity**
- b. Flexibility**
- c. Data quality**
- d. Acceptability**
- e. Sensitivity**
- f. Predictive value positive**
- g. Representativeness**
- h. Timeliness**
- i. Stability**

Task E. Justify and state conclusions and make recommendations

Task F. Ensure use of evaluation findings and share lessons learned

APPENDIX III. CROSS-REFERENCE OF TASKS AND RELEVANT STANDARDS

* Adapted from Framework for Program Evaluation in Public Health [CDC. Framework for program evaluation in public health. MMWR 1999;49(RR-110)] and the original guidelines [CDC. Guidelines for evaluating surveillance systems. MMWR 1988;37(No.S-51)]

+ Adapted from Framework for Program Evaluation in Public Health [CDC. Framework for program evaluation in public health. MMWR 1999;48(RR-11)]

Tasks for evaluating a surveillance system*	Relevant standards +
Task A. Engage the stakeholders in the evaluation.	Stakeholder identification. Persons involved in or affected by the evaluation should be identified so that their needs can be addressed. Evaluator credibility. The persons conducting the evaluation should be trustworthy and competent in performing the evaluation to ensure that findings from the evaluation achieve maximum credibility and acceptance. Formal agreements. If applicable, all principal parties involved in an evaluation should agree in writing to their obligations (i.e., what is to be done, how, by whom, and when) so that each party must adhere to the conditions of the agreement or renegotiate them. Rights of human subjects. The evaluation should be designed and conducted in a manner that respects and protects the rights and welfare of human subjects. Human interactions. Evaluators should interact respectfully with other persons associated with an evaluation so that participants are not threatened or harmed. Conflict of interest. Conflict of interest should be handled openly and honestly so that the evaluation processes and results are not

	compromised. Metaevaluation. The evaluation should be formatively and summatively evaluated against these and other pertinent standards to guide its conduct appropriately and, on completion, to enable close examination of its strengths and weakness by stakeholders.
Task B. Describe the surveillance system to be evaluated.	Complete and fair assessment. The evaluation should be complete and fair in its examination and recording of strengths and weaknesses of the system so that strengths can be enhanced and problem areas addressed. System documentation. The system being evaluated should be documented clearly and accurately. Context analysis. The context in which the system exists should be examined in enough detail to identify probable influences on the system. Metaevaluation. The evaluation should be formatively and summatively evaluated against these and other pertinent standards to guide its conduct appropriately and, on completion, to enable close examination of its strengths and weakness by stakeholders.
Task C. Focus the evaluation design.	Evaluation impact. Evaluations should be planned, conducted, and reported in ways that encourage follow-through by stakeholders to increase the likelihood of the evaluation being used. Practical procedures. Evaluation procedures should be practical while needed information is being obtained to keep disruptions to minimum. Political viability. During the planning and conducting of the evaluation, consideration

	should be given to the varied positions of interest groups so that their cooperation can be obtained and possible attempts by any group to curtail evaluation operations or to bias or misapply the results can be averted or counteracted. Cost-effectiveness. The evaluation should be efficient and produce valuable information to justify expended resources. Service orientation. The evaluation should be designed to assist organizations in addressing and serving effectively the needs of the targeted participants. Complete and fair assessment. The evaluation should be complete and faire in its examination and recording of strengths and weaknesses of the system so that strengths can be enhanced and problem areas addressed. Fiscal responsibility. The evaluator's allocation and expenditure of resources should reflect sound accountability procedures by being prudent and ethically responsible so that expenditures are accountable and appropriate. Described purpose and procedures. The purpose and procedure of the evaluation should be monitored and described in enough detail to identify and assess them. The purpose of evaluation a surveillance system is to promote the best use of public health resources by ensuring that only important problems are under surveillance and that surveillance systems operate efficiently. Metaevaluation. The evaluation should be formatively and summatively evaluated against these and other pertinent standards to guide its conduct appropriately and, on completion, to enable close examination of its strengths and weaknesses by stakeholders.
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Task D. Gather credible evidence regarding the performance of the surveillance	Information scope and selection. Information collected should address pertinent questions regarding the system and be responsive to the needs and interests of clients and other specified stakeholders. Defensible information sources. Sources of information used in the system evaluation should be described in enough detail to assess the adequacy of the information. Valid information. Information-gathering procedures should be developed and implemented to ensure a valid interpretation for the intended use. Reliable information. Information –gathering procedures should be developed and implemented to ensure sufficiently reliable information for the intended use. Systematic information. Information collected, processed, and reported in an evaluation should be systematically reviewed and any errors corrected. Metaevaluation. The evaluation should be formatively and summatively evaluated against these and other pertinent standards to guide its conduct appropriately and, on completion, to enable close examination of its strengths and weaknesses by stakeholders.
Task E. Justify and state conclusions, and make recommendations.	Values identification. The perspective, procedures, and rationale used to interpret the findings should be carefully described so that the bases for value judgements are clear. Analysis of information. Information should be analyzed appropriately and systematically so that evaluation questions are answered effectively.

	Justified conclusions. Conclusions that are reached should be explicitly justified for stakeholders' assessment.
Task F. Ensure use of evaluation findings and share lessons learned.	Evaluator credibility. The persons conducting the evaluation should be trustworthy and competent in performing the evaluation to ensure that findings from the evaluation achieve maximum credibility and acceptance. Report clarity. Evaluation reports should clearly describe the system being evaluated, including its context and the purposed, procedures and findings of the evaluation so that essential information is provided and easily understood. Report timeliness and dissemination. Substantial interim findings and evaluation reports should be disseminated to intended users so that they can be used in a timely fashion. Evaluation impact. Evaluations should be planned, conducted, and reported in ways that encourage follow-through by stakeholders to increase the likelihood of the evaluation being used. Disclosure of findings. The principal parties of an evaluation should ensure that the full evaluation findings with pertinent limitations are made accessible to the persons affected by the evaluation and any others with expressed legal rights to receive the results. Impartial reporting. Reporting procedures should guard against the distortion caused by personal feeling and biases of any party involved in the evaluation so that the evaluation reflects the findings fairly. Metaevaluation. The evaluation should be formatively and summatively evaluated against these and other pertinent standards to guide its conduct appropriately and, on completion, to enable close examination of its strengths and

	weaknesses by stakeholders.
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APPENDIX IV: NATIONAL WNV PROGRAM PARTNERS SURVEY FORM

Please answer the following questions by checking the appropriate box;

#	Dissemination of Surveillance Information	Yes	No	Unknown
1	Do you visit the PHAC WNV website for weekly reports/maps/ tables?			
2	Are you satisfied with the information that we provide; weekly reports/maps / tables, etc.?			
3	Do you share this info with other stakeholders, such as local public health, etc., in your area?			
4	Do you like receiving updates in the following manner;			
	Email;			
	Teleconference;			
	Website;			
	Other, (please specify).			
	Publications	Yes	No	Unknown
5	Are the weekly reports/ maps /tables updated in a timely manner?			
6	Are the weekly reports/ maps /tables geographically sensitive enough?			
7	Do you think that the weekly reports/ maps /tables show an accurate picture of the WNV situation in the country?			
8	Are the weekly reports/ maps /tables easy to read / understand?			
9	Are the weekly reports/ maps /tables useful overall?			
	Data Collection	Yes	No	Unknown
10	What is your preferred method for submitting data?			
	By phone;			
	Using WNV data submission form via fax or email;			
	Using CNPHI WNV application;			
	Teleconferences	Yes	No	Unknown

11	Are you satisfied with the content of the teleconferences			
12	Are you satisfied with the frequency of the teleconferences			
13	Are your concerns or questions regarding data collection and dissemination addressed in a timely manner?			
14	Are your concerns or questions regarding the group addressed in a timely manner?			
15	Is the teleconference information (i.e. agendas and records of decision) provided in a timely manner?			

1. Which component(s) worked well this year? (e.g. publications, data collection, teleconferences or others)

2. Which component(s) did not work well this year? (e.g. publications, data collection, teleconferences or others)

3. What would you like to see added for next year?

4. Other comments:

APPENDIX V: WEST NILE VIRUS HUMAN CASE DEFINITIONS

National Surveillance for WNV

Section A: Case Definitions

Section B: WNV Diagnostic Test Criteria

Section A: Case Definitions

The current Case Definitions were drafted with available information at the time of writing. Case Definitions and Diagnostic Test Criteria are subject to change as new information becomes available.

1) West Nile Virus Neurological Syndrome (WNNS):

Clinical Criteria:

History of exposure in an area where WNV activity is occurring¹

OR

history of exposure to an alternative mode of transmission²

AND

onset of fever

AND RECENT ONSET OF AT LEAST ONE of the following:

encephalitis (acute signs of central or peripheral neurological dysfunction), or

viral meningitis (pleocytosis and signs of infection e.g., headache, nuchal rigidity), or acute flaccid paralysis (e.g., poliomyelitis-like syndrome or Guillain-Barré-like syndrome),³ or movement disorders (e.g., tremor, myoclonus), or Parkinsonism or Parkinsonian-like conditions (e.g., cogwheel rigidity, bradykinesia, postural instability), or other neurological syndromes as defined in the Note below

Note:

A significant feature of West Nile viral neurological illness may be marked muscle weakness that is more frequently unilateral, but can be bilateral. WNV should be considered in the differential diagnosis of all suspected cases of acute flaccid paralysis with or without sensory deficit. West Nile virus-associated weakness typically affects one or more limbs (sometimes affecting one limb only). Muscle weakness may be the sole presenting feature of WNV illness (in the absence of other neurologic features) or may develop in the setting of fever, altered reflexes, meningitis or encephalitis. Weakness typically develops early in the course of clinical infection. Patients should be carefully monitored for evolving weakness and in particular for acute neuromuscular respiratory failure, which is a severe manifestation associated with high morbidity and mortality. For the purpose of WNV Neurological Syndrome Classification, muscle weakness is characterized by severe (Polio-like), non-transient and prolonged symptoms. Electromyography (EMG) and lumbar puncture should be performed to differentiate West Nile virus-associated paralysis from acute demyelinating polyneuropathy (e.g., Guillain-Barré syndrome). Lymphocytic pleocytosis (an increase in WBC with a predominance of lymphocytes in the cerebrospinal fluid [CSF]) is commonly seen in acute flaccid paralysis due to WNV whereas pleocytosis is not a feature of Guillain-Barré Syndrome.

Other emerging clinical syndromes, identified during 2002 included, but were not limited to the following: myelopathy, rhabdomyolysis (acute destruction of skeletal muscle cells), peripheral neuropathy; polyradiculoneuropathy; optic neuritis; and acute demyelinating encephalomyelitis (ADEM). Ophthalmologic conditions including chorioretinitis and vitritis were also reported. Facial weakness was also reported. Myocarditis, pancreatitis and fulminant hepatitis have not been identified in North America, but were reported in outbreaks of WNV in South Africa. "Aseptic" meningitis without encephalitis or acute flaccid paralysis occurring in August and September when WNV is circulating may be due to non- polio enteroviruses circulating at the same time. This should be considered in the differential diagnosis. [Sejvar J et al. JAMA (2003) Vol.290 (4) p. 511-515, Sejvar, J. et al. Emerg Infect Dis (2003) Vol 9 (7) p.788-93 and Burton, JM et al Can. J. Neurol. Sci. (2004) Vol.31 (2) p.185-193]

Suspect WNNS Case:

Clinical criteria IN THE ABSENCE OF OR PENDING diagnostic test criteria (see below) AND IN THE ABSENCE of any other obvious cause.

Probable WNNS Case:

Clinical criteria AND AT LEAST ONE of the probable case diagnostic test criteria (see below).

Confirmed WNNS Case:

Clinical criteria AND AT LEAST ONE of the confirmed case diagnostic test criteria (see below).

2) WNV Non-Neurological Syndrome (WN Non-NS):

Clinical Criteria:

History of exposure in an area where WNV activity is occurring¹

OR

history of exposure to an alternative mode of transmission²

AND AT LEAST TWO of the following⁴:

- fever,
- myalgia⁵,
- arthralgia,
- headache,
- fatigue,
- lymphadenopathy,
- maculopapular rash

Suspect WN Non-NS Case:

Clinical criteria IN THE ABSENCE OF OR PENDING diagnostic test criteria (see below) AND IN

THE ABSENCE of any other obvious cause.

Probable WN Non-NS Case:

Clinical criteria AND AT LEAST ONE of the probable case diagnostic test criteria (see below)

Confirmed WN Non-NS Case:

Clinical criteria AND AT LEAST ONE of the confirmed case diagnostic test criteria (see below)

3) WNV Asymptomatic Infection (WNAI)⁶:

Probable WNAI Case:

Probable case diagnostic test criteria (see below) IN THE ABSENCE of clinical criteria

Confirmed WNAI Case:

Confirmed case diagnostic test criteria (see below) IN THE ABSENCE of clinical criteria

Section B: WNV Diagnostic Test Criteria:

Probable Case Diagnostic Test Criteria:

AT LEAST ONE of the following:

Detection of flavivirus antibodies in a single serum or CSF sample using a WN virus IgM ELISA⁷ without confirmatory neutralization serology (e.g. Plaque Reduction Neutralization Test -PRNT)

OR

A 4-fold or greater change in flavivirus HI titres in paired acute and convalescent sera or demonstration of a seroconversion using a WN virus IgG ELISA⁷ OR

A titre of > 1:320 in a single WN virus HI test, or an elevated titre in a WN virus IgG ELISA, with a confirmatory PRNT result OR

[Note: A confirmatory PRNT or other kind of neutralization assay is not required in a health jurisdiction/authority where cases have already been confirmed in the current year]

Demonstration of Japanese encephalitis (JE) serocomplex-specific genomic sequences in blood by NAT screening on donor blood, by Blood Operators in Canada.

Note:

WNV IgM antibody may persist for more than a year and the demonstration of IgM antibodies in a patient's serum, particularly in residents of endemic areas, may not be diagnostic of an acute WN viral infection. Seroconversion (by HI, IgG ELISA or PRNT assays) demonstrates a current WNV infection. Therefore, the collection of acute and convalescent sera for serologic analysis is particularly important to rule out diagnostic misinterpretation early in the WNV season (e.g. May, June) and to identify initial cases in a specific jurisdiction. However, it should be noted that seroconversions may not always be documented due to timing of acute sample collection (i.e. titres in acute sera may have already peaked). If static titres are observed in acute and convalescent paired sera, it is still possible the case may represent a recent infection. To help resolve this the use of IgG avidity testing⁸ may be considered to distinguish between current and past infection. The presence of both IgM antibody and low avidity IgG in a patient's convalescent serum sample are consistent with current cases of viral associated illness. However test results that show the presence of IgM and high avidity IgG are indicative of exposures that have occurred in the previous season.

Immunocompromised individuals may not be able to mount an immune response necessary for a serological diagnosis. WNV diagnostic test criteria for these individuals should be discussed with a medical microbiologist.

Confirmed Case Diagnostic Test Criteria:

It is currently recommended that health jurisdictions/authorities use the Confirmed Case

Diagnostic Test Criteria to confirm index cases (locally acquired) in their area each year; for subsequent cases, health jurisdictions/authorities could use the Probable Case Diagnostic Test Criteria to classify cases in their area as “confirmed”, for the purposes of surveillance.

Throughout the remainder of the transmission season health jurisdictions/authorities may wish to document PRNT antibody titres to WNV in a proportion of cases, to be determined by that health jurisdiction/authority, in order to rule-out the possibility of concurrent activity by other flaviviruses. [For further information on diagnostic testing algorithms for West Nile virus, see the section entitled Laboratory Specimen Diagnostic Testing Algorithm in Appendix 4 of the National Guidelines for Response to West Nile virus.]

AT LEAST ONE of the following:

A 4-fold or greater change in WN virus neutralizing antibody titres (using a PRNT or other kind of neutralization assay) in paired acute and convalescent sera, or CSF. **OR**

Isolation of WN virus from, or demonstration of WN virus antigen or WN virus-specific genomic sequences in tissue, blood, CSF or other body fluids **OR**

Demonstration of flavivirus antibodies in a single serum or CSF sample using a WN virus IgM ELISA^{7, 8}, confirmed by the detection of WN virus specific antibodies using a PRNT (acute or convalescent specimen). **OR**

A 4-fold or greater change in flavivirus HI titres in paired acute and convalescent sera or demonstration of a seroconversion using a WN virus IgG ELISA^{7, 8} AND the detection of WN specific antibodies using a PRNT (acute or convalescent serum sample).

¹ History of exposure when and where WNV transmission is present, or could be present, or history of travel to an area with confirmed WNV activity in birds, horses, other mammals, sentinel chickens, mosquitoes, or humans.

² Alternative modes of transmission, identified to date, include: laboratory-acquired; in utero;

receipt of blood components; organ/tissue transplant; and, possibly via breast milk.

³ A person with WNV-associated acute flaccid paralysis may present with or without fever or mental status changes. Altered mental status could range from confusion to coma with or without additional signs of brain dysfunction (e.g. paralysis, cranial nerve palsies, sensory deficits, abnormal reflexes, generalized convulsions and abnormal movements). Acute flaccid paralysis with respiratory failure is also a problem.

⁴ It is possible that other clinical signs and symptoms could be identified that have not been listed and may accompany probable case or confirmed case diagnostic test criteria. For example, gastrointestinal (GI) symptoms were seen in many WNV patients in Canada and the USA in 2003 and 2004.

⁵ Muscle weakness may be a presenting feature of WNV illness. For the purpose of WNV Non-Neurological Syndrome classification, muscle weakness or myalgia (muscle aches and pains) is characterized by a mild, transient, unlikely prolonged symptoms that are not associated with motor neuropathy.

⁶ This category could include asymptomatic blood donors whose blood is screened using a Nucleic Acid Amplification Test (NAT), by Blood Operators (i.e. Canadian Blood Services or Hema-Quebec) and is subsequently brought to the attention of public health officials. The NAT that will be used by Blood Operators in Canada is designed to detect all viruses in the JE serocomplex. The JE serocomplex includes WN virus and 9 other viruses, although from this group only WN virus and St Louis encephalitis virus are currently endemic to parts of North America. Blood Operators in Canada perform a supplementary WN virus-specific NAT following any positive donor screen test result.

⁷ Both CDC and commercial IgM / IgG ELISAs are now available for front line serological testing. Refer to appropriate assay procedures and kit inserts for the interpretation of test results.

⁸ Early in infection the immune system generates antibodies that bind relatively weakly to viral antigen (low avidity). As the infection proceeds, an increasing percentage of newly generated IgG antibody displays higher binding affinity to virus antigen and thus avidity also rises (Note: avidity is usually measured based upon the ability of IgG to dissociate from antigen preparations after incubation with a solution of urea). As long as high avidity IgG is not yet detected in the serum it can be assumed that the individual was exposed to the viral agent during a recent exposure. With respect to WNV infection it has not been precisely determined when (i.e. post-exposure) high avidity antibodies reach levels in serum that can be accurately detected by serological assays (there may be significant variation depending on the individual). However, it has been shown that greater than 95% of sera collected from individuals exposed to WNV 6-8 months previously will have IgG antibodies that bind strongly to viral antigen and will give high

avidity scores using both IFA and ELISA testing formats. *Note: Avidity testing will not replace confirmatory neutralization testing, non-WNV flavivirus IgG antibody (e.g. dengue, SLE, etc.) may bind to the antigen preparations used in avidity assays.*

The national human case definition for WNV surveillance is available on the West Nile virus Monitor of PHAC's website. For convenience to readers, here is the full context of the case definitions and also can be seen via the link: <http://www.phac-aspc.gc.ca/wnv-vwn/index-eng.php>

APPENDIX VI: WEST NILE VIRUS WEEKLY DATA COLLECTION FEEDBACK

Report Week*: Week 26
 Week ending: 03-Jul-10

YTD Report of Human West Nile Virus Neurological Syndrome, West Nile Virus Non-Neurological Syndrome and West Nile Virus Asymptomatic Infection

Health Region	Province Unique Case I.D. #	Episode Date YYYY MMDD	Episode Date type**	WNv Neurological Syndrome (WNNS)	WN Virus Non-Neurological Syndrome (WN Non-NS)	Did individual have a fever? Yes No Unknown	WN Virus Asymptomatic Infection (WNAI)	Unknown / Unclassified	Total Deaths by Province	Related to travel outside of health region (Yes or No)	Related to travel outside of Province (Yes or No)
				Cases	Cases		Cases				
Total				0	0	0	0		0		

* Sunday through Saturday (the week during which data is collected)

** Episode Date type codes: Onset Date: 1. Date of Diagnosis; 2. Date of lab test; 3. Form completion date; 4. Date of receipt by province/territory; 5. Date of receipt by CIDPC; 6. Other date type: 9

APPENDIX VII: DEATH BIRDS SUBMISSION FORM *

INCIDENT REPORT FORM

(To report wildlife disease/mortality incident, and to accompany any specimen submissions)

Date Received:

Necropsy No.:

CCWHC No.:

CCWHC USE ONLY CCWHC USE ONLY CCWHC USE ONLY

SUBMITTER INFORMATION	
Name of Submitter: Address: Postal Code: email address: Phone # [] FAX # [] REFERENCE # (if applicable):	Copy Report to: if any Address: Postal Code: email address: Phone # [] FAX # []

INCIDENT LOCATION	FINDER LOCATION
Address (or Lot, Concession): City / Town: Postal Code: GPS Coordinates (use degree decimal WGS84 setting & 4 decimal places): LATITUDE: _____ °. _____ deg N LONGITUDE: _____ °. _____ deg W	Name: Mailing Address: City / Town: Postal Code: Phone Number:
Environmental circumstances surrounding incident/mortality: (Example: weather, proximity to buildings, power lines, use of chemicals, human interaction, etc. Use back of page for additional space.)	

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SPECIMEN INFORMATION
(Please use separate form for each species) Species: Age: Sex: (circle one) Male Female Unknown

Incident Dates (yy-mm-dd) Date Occurred: Date Found: Date Picked Up:

Total number of this species at incident: Normal ____ Sick ____ Dead ____

Suspected cause of death (if any):

Behavior/Clinical Signs of Affected Animal(s): (Use back of page for additional space.)

Please circle the appropriate choice(s) when necessary:

Indicate # of each submitted #: Carcasses / Parts: Fresh Frozen Fixed

#: Other: (specify):

Specimen was found: Dead Live/Died Killed If killed, how? _____

Please circle the appropriate choice(s) when necessary:

Indicate # of each submitted #: Carcasses / Parts: Fresh Frozen Fixed

#: Other: (specify):

Specimen was found: Dead Live/Died Killed If killed, how? _____

Submission of this form signifies permission for the retention and use of the personal information contained herein for the purposes of correspondence, follow up investigation, reporting of results and geographic analysis of incidents. Date revised: 2008-03-06

* The form can be downloaded from the CCWHC website:
http://www.ccwhc.ca/forms/IncidentFormON_NU_080306PDF.pdf