CANADIAN PANDEMIC INFLUENZA PREPAREDNESS:

Planning Guidance for the Health Sector

Surveillance Annex

December 3, 2015

Pan-Canadian Public Health Network
Partners in Public Health
Réseau pancanadien de santé publique
Partenaires en santé publique

Également disponible en français sous le titre :
PRÉPARATION DU CANADA EN CAS DE GRIPPE PANDÉMIQUE :
Guide de planification pour le secteur de la santé – Annexe traitant de la surveillance

Cat.: HP40-144/2015E-PDF
ISBN: 978-0-660-03088-3
Pub.: 150077

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Background

Influenza surveillance is a long-standing activity that has contributed greatly to the understanding and control of influenza. Seasonal influenza surveillance provides a solid platform for surveillance during an influenza pandemic (subsequently referred to as a pandemic) as well as baseline data against which to compare the pandemic event. Pandemic surveillance gives decision-makers the timely information they need for a pandemic response, using data obtained through routine and enhanced surveillance activities together with the special studies that will be needed for pandemic decision-making.

1.2 Purpose

The purpose of the Surveillance Annex is to outline Canada's pandemic surveillance strategy and to provide surveillance-specific operational and technical guidance for the health sector. It is one of a series of annexes that support *Canadian Pandemic Influenza Preparedness: Planning Guidance for the Health Sector* (CPIP). The Surveillance Annex focuses primarily on disease (epidemiological) surveillance, whereas the Laboratory Annex provides more detail on the laboratory component of influenza surveillance.

The primary audiences for the Surveillance Annex are the federal, provincial and territorial (FPT) ministries of health. The annex also serves as a reference document on the surveillance strategy for other government departments, non-governmental organizations engaged in health issues and other stakeholders.

1.3 Changes in This Version

This version of the Surveillance Annex is considerably changed from the 2010 version in both format and content. Surveillance-specific objectives, assumptions, and roles and responsibilities have been updated. The underlying principles and approaches outlined in CPIP are highlighted throughout the annex, and a risk management approach is applied. The CPIP planning scenarios are used to identify surveillance-specific risk management considerations in pandemics of varying impact, and risks for the surveillance strategy are identified along with potential mitigation strategies.

The annex describes the key elements of the surveillance strategy and identifies triggers for the key surveillance activities. The annex also addresses assessment and evaluation of the surveillance response and identifies surveillance research needs.

2.0 CONTEXT FOR PLANNING

2.1 Role of Surveillance in Pandemic Influenza

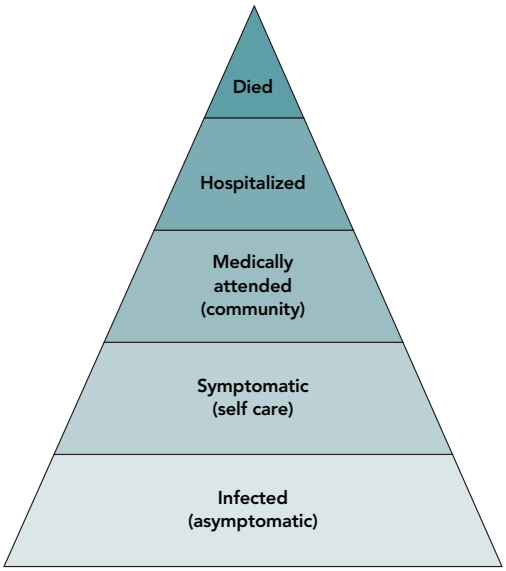
Surveillance is the key to effective action. Timely surveillance information is needed for many key policy decisions, including the use of interventions such as public health measures, vaccines and antiviral medications. Surveillance data are also used in mathematical models to predict pandemic activity, pandemic impact and the need for clinical services; to monitor health care utilization; and to assess the potential impact of interventions.

Comprehensive influenza surveillance involves both laboratory and disease (epidemiological) components and is based on a strong partnership between the provinces and territories (PT) and the Public Health Agency of Canada (PHAC). Surveillance information needs to flow swiftly from local/regional jurisdictions to PTs and, for national purposes, on to PHAC. PHAC analyzes the national situation and provides key information back to PTs and to the World Health Organization (WHO) as required.

Pandemic surveillance will be built on existing surveillance systems for seasonal influenza. These systems include FluWatch (Canada's national influenza surveillance system), Immunization Monitoring Program ACTive (IMPACT), the Canadian Immunization Research Network (CIRN), the Serious Outcomes Surveillance (SOS) Network and the Sentinel Physicians Surveillance Network (SPSN) for virological and vaccine effectiveness monitoring. Modifications to these programs, and special studies that may be needed to provide additional information during the pandemic, should be anticipated, planned and practised in advance, as it is challenging to add new elements or make significant adjustments during an emergency.

Ideally, the pandemic surveillance system will provide information on the full spectrum of disease, as shown in the influenza disease burden pyramid (Figure 1). However, special studies are usually necessary to obtain estimates of the bottom two layers of the pyramid, as this information is not captured in routine surveillance.

FIGURE 1 – INFLUENZA DISEASE BURDEN PYRAMID



The WHO has developed standards for conducting epidemiological influenza surveillance in response to gaps identified during the 2009 influenza A (H1N1) pandemic (subsequently referred to as the 2009 pandemic).[1] These standards identify the following key concepts for pandemic influenza surveillance:

- The importance of monitoring both mild and severe influenza;
- The efficiency of sentinel surveillance in collecting high-quality data in a timely way;
- The need for a standardized approach to data collection;
- Recognition that surveillance case definitions are not intended to be used for diagnostic purposes or for treating influenza or influenza-like illness (ILI);
- The value of having historical (baseline) seasonal surveillance data against which to assess the impact and epidemiological features of the evolving pandemic;
- The integration of influenza surveillance programs into existing public health systems;
- The adaptation of surveillance activities as the pandemic proceeds; and
- Sharing of surveillance data with policy-makers and feedback to those who provided data.

2.2 Uncertainties and Unpredictability

Influenza is unpredictable, which makes it difficult to plan for surveillance and response activities. CPIP outlines major areas of uncertainty about the next pandemic, such as when it will occur, where it will emerge, the nature of spread, what its characteristics will be, what its impact will be and the effect of interventions. These uncertainties highlight the need for flexibility and adaptability in the pandemic response. They also validate the importance of generating surveillance data rapidly in order to identify the pandemic's epidemiological characteristics, predict its impact and monitor its progress.

1 World Health Organization. WHO interim global. Epidemiological surveillance standards for influenza. July 2012. Available at: who.int/influenza/resources/documents/INFSURVMANUAL.pdf

There are also specific uncertainties associated with the pandemic surveillance strategy:

- *Virus characteristics and corresponding pandemic epidemiology* – Characteristics such as virulence and pre-existing population immunity are not predictable. This makes it necessary to start with a broad range of surveillance measures and conduct special studies as needed in order to describe the evolving pandemic accurately.
- *Health-seeking behaviour* – Public concern, distorted perception of risk by the public and health professionals as well as media attention may strongly influence the seeking of health care and medical practice during a pandemic. This could affect surveillance data by increasing the number of individuals who are tested.
- *Laboratory testing practices and test performance* – Increased requests for testing by clinicians may affect surveillance data, as will restrictions within a PT (which may differ from those in other PTs) that may be placed on who can be tested. It is important to understand these PT differences in test guidelines and restrictions on testing over time so that Canadian surveillance results can be properly interpreted. Test performance will also vary, depending on the type and timing of specimen collection, the laboratory methods used and the genetic nature of the novel/pandemic virus.
- Public health surge capacity – The ability to produce high-quality and timely national data will be compromised if PTs and other partners are not able to report surveillance data promptly to PHAC. Some local or regional health units may not have the capacity for timely collection and reporting of surveillance data on an ongoing basis; as well, laboratories may be too busy to report to public health in a timely way. Sentinel clinicians may be too overwhelmed with clinical responsibilities in a high-impact pandemic to continue reporting or to collect laboratory specimens.
- *Status of surveillance systems across Canada* – There are ongoing efforts to have comprehensive automated surveillance infrastructure, including immunization registries, in place in all jurisdictions in Canada, accompanied by appropriate integration of FPT information systems. If these are not in place by the next pandemic, lack of automation and electronic linkages could affect timely collection and transfer of surveillance data. The timely transfer of information could also be compromised if data-sharing agreements are not in place. Similarly, the lack of well-established surveillance protocols (with agreement on core data elements) could result in inconsistent data collection and delays while such protocols are rapidly developed.
- *Coordination of PT decision-making regarding pandemic surveillance* – A number of factors could affect full PT coordination of surveillance programs during a pandemic. Pandemic activity may vary in timing and intensity across the country, meaning that not all surveillance elements need to be activated at the same time. The status of the underlying infrastructure and seasonal surveillance programs will also affect how PTs are able to conduct pandemic surveillance.

2.3 Lessons Learned from the 2009 Pandemic

During the 2009 pandemic, multiple surveillance systems were used across Canada to obtain a full picture of pandemic epidemiology. There were, however, many challenges:

- Existing networks, systems and tools, including FluWatch, facilitated exchange of information; however, the lack of integrated surveillance databases for information capture and transfer in many jurisdictions resulted in data gaps and lack of real-time data on key epidemiological variables.
- Differences in local and regional capacity to collect and enter surveillance data and PT differences in laboratory testing guidance affected interpretation and generalization of data.

- Sufficient epidemiology resources to interpret and appraise data rapidly were lacking, also affecting data timeliness.
- At the onset of the pandemic there was no comprehensive surveillance system for First Nations, Metis and Inuit communities. An ad hoc system was developed; however, it ran in parallel and was not linked to existing PT databases.

These and other challenges are described in the reports from the Government of Canada and the Standing Senate Committee on Social Affairs, Science and Technology.[2,3]

The preceding reports also identify lessons learned that have been incorporated into the Surveillance Annex. These key lessons identified the need for the following:

- Sufficient human resources (epidemiologists, methodologists, etc.) to meet intense demands for epidemiological information;
- Standardization of investigations and consistent information capture across PTs;
- Surveillance in acute care settings to support jurisdictional management of the health care response;
- Development of a comprehensive, integrated, national surveillance system (including vaccine registries), with electronic linkages between public health, clinical care and laboratories;
- Finalized agreements on sharing surveillance information between PHAC and PTs;
- Two-way information sharing, so that information relevant to PTs is provided to them in a timely manner (e.g., from sentinel surveillance systems);
- Improved surveillance systems for First Nations, Metis and Inuit communities;
- Formal collaborating agreements between PHAC and the provincial public health agencies (in British Columbia, Ontario and Quebec) as a way to maximize resources and expertise;
- A national process for rapid multi-jurisdictional field studies, including streamlined ethics review procedures and the additional resources required to implement and accomplish these field studies; and
- More advanced capacity to collect and analyze large-scale data sets that would be used to build and inform mathematical and statistical models.

2.4 Surveillance in the Canadian Context

Canada's geographic features present challenges to conducting influenza surveillance. Seasonal influenza activity often varies considerably across the country in intensity, timing and strain dominance, and pandemic activity will likely also vary in timing and intensity. The implications for surveillance include the importance of having a broadly based system to capture these differences and the problems of generalizing results from one part of the country to another.

2 Public Health Agency of Canada. Lessons learned review: Public Health Agency of Canada and Health Canada response to the 2009 H1N1 pandemic. November 2010. Available at: phac-aspc.gc.ca/about_apropos/evaluation/reports-rapports/2010-2011/h1n1/index-eng.php

3 Standing Senate Committee on Social Affairs, Science and Technology. Canada's response to the 2009 H1N1 pandemic. December 2010. Available at: parl.gc.ca/40/3/parlbus/commbus/senate/com-e/soci-e/rep-e/rep15dec10-e.pdf

Canada is diverse in terms of language, religious beliefs, ethnicity, culture and lifestyle. This diversity may be associated with differences in health-seeking behaviour that could affect surveillance results. Vulnerable people (e.g., individuals who are physically or mentally disabled, frail and elderly, housebound or homeless) may be at increased risk of disease or severe outcomes. Targeted surveillance is needed to identify risks in these vulnerable populations and in unique settings. Some remote and isolated communities experienced early and intense outbreaks during the 2009 pandemic, reinforcing the need to strengthen surveillance in these communities.

It is important for FPT pandemic surveillance programs to be consistent to the extent possible; however, it is also recognized that reporting requirements for influenza are not the same in each PT, and that differences in health services delivery and access to laboratory services may affect the information that can be collected. In addition, each jurisdiction will have unique surveillance needs related to the diversity described above. While Health Canada's First Nations and Inuit Health Branch (FNIHB) monitors influenza activity and vaccine uptake in First Nations communities for programming purposes, it is not a comprehensive surveillance system and existing surveillance systems, such as FluWatch, do not capture specific data required. Even in these circumstances, it is important to adopt common approaches and standardized data elements as much as possible. PTs also vary in capacity, particularly for conducting special studies to address their surveillance needs.

2.5 Ethical Considerations

The major ethical considerations for the surveillance strategy revolve around data confidentiality. The process of surveillance may involve the collection of personal information. Therefore, it is important to ensure that individual personal data be kept confidential and to avoid even unintentional stigmatization by guarding against identification of geographic location and ethnic group in a way that may be perceived as negative. It is also important to limit data collection to what is pertinent for analysis and decision-making.

In the Ethical Considerations section, CPIP identifies the components of good decision-making processes as openness and transparency, accountability, inclusiveness and reasonableness. These processes should be followed when making decisions about surveillance strategies and the surveillance response.

2.6 Legal Considerations

Legal issues relevant to the surveillance strategy should be identified and addressed in the interpandemic period. These legal aspects include the following:

- Canada's responsibilities under the International Health Regulations (IHR) (2005), outlined in CPIP.
- PT reporting requirements for influenza – these vary by jurisdiction; for example, in Quebec influenza is not a reportable disease. Influenza cases may also be captured through severe acute respiratory infection (SARI) reporting.
- Data collection and sharing – FPT governments should establish legal mechanisms for the collection and sharing of required surveillance information. To this end, the Multilateral Information Sharing Agreement (MLISA) has been developed and its accompanying technical annexes are being finalized. Jurisdictional privacy legislation must be respected with regard to personal information.

3.0 CANADA'S PANDEMIC INFLUENZA SURVEILLANCE STRATEGY

3.1 Objectives

The surveillance strategy supports Canada's goals for pandemic preparedness and response:

> *First, to minimize serious illness and overall deaths, and second, to minimize societal disruption among Canadians as a result of an influenza pandemic.*

Pandemic influenza surveillance supports decision-making by providing timely and high-quality information. The overall objectives of the surveillance strategy are to:

- Determine when and where influenza activity is occurring and who is affected;
- Determine and monitor underlying risk conditions associated with severe disease and describe the clinical patterns of disease;
- Assess and monitor the relative impact of the pandemic;
- Detect changes in the antigenic and genetic character and antiviral susceptibility of the novel/pandemic virus; and
- Support the implementation of pandemic interventions and evaluation of their impact.

3.2 Guiding Principles and Approaches

The guiding principles and approaches in CPIP are relevant to the surveillance strategy, particularly the following:

- *Collaboration* – Effective pandemic surveillance requires the collaboration of all levels of government and health care stakeholders. Collaboration is particularly important among personnel conducting human disease, laboratory and animal health surveillance.
- *Evidence-informed decision-making* – Timely surveillance data are essential for evidence-informed decision-making, and they must be interpreted and presented in a way that is meaningful to decision-makers.
- *Flexibility* – Flexibility is particularly important given the unknown nature of the epidemiology of the pandemic at its onset and the changing information needs as the pandemic progresses. This means that pandemic surveillance objectives and strategies will likely need to change over time and that surveillance activities should be flexible, responsive and adapted to the evolving situation.

- *Use of established practices and systems to the extent possible* – Pandemic surveillance should be built on existing surveillance systems and practised every year for seasonal influenza. It is almost impossible to introduce new surveillance systems during a pandemic.

There are also some surveillance-specific principles:

- PHAC will follow the notification guidelines required by the IHR (2005).
- There will be timely bilateral sharing of surveillance information between PTs and PHAC.
- Canadian surveillance information will be shared internationally through the WHO.
- PTs will work towards consistency in influenza surveillance (e.g., through the adoption of common data elements and investigation protocols) to make the national surveillance system more robust.
- Each level of government will collect only the surveillance information that is pertinent at that level, citing the rationale for collecting the information.

3.3 Surveillance-Specific Assumptions

Identifying planning assumptions is a way to deal with uncertainty. Assumptions provide a useful framework for planning, but while rooted in evidence as much as possible they ***should not be regarded as predictions***. As the pandemic unfolds, emerging evidence is used to guide the response.

The main body of CPIP contains a number of assumptions related to the epidemiology and impact of the pandemic. Some surveillance-specific assumptions have also been identified to help plan the surveillance response:

- The status of surveillance infrastructure at the time of the pandemic will be as follows:
  - individual electronic PT surveillance systems will not all be in place, and they may not all be integrated;
  - data-sharing agreements (most pertinently MLISA) will be in place, but the accompanying technical annex for influenza may not have been completed;
  - the national protocol for respiratory disease outbreak response will be in place but may need modification at the time of the pandemic.
- Comprehensive influenza surveillance activities will be in place and tested prior to the pandemic.
- Surveillance protocols and case report forms will be ready for use, and common data elements will have been identified.

3.4 Pandemic Roles and Responsibilities

The surveillance strategy requires a collaborative approach with clearly defined roles and responsibilities. Note that some roles and responsibilities, such as FPT decision-making processes, are beyond the scope of this annex. The following roles and responsibilities for the pandemic surveillance strategy are adapted from those set out in CPIP:

The *federal government* is responsible for:

- Coordinating the overall pan-Canadian surveillance response to a pandemic;
- Acting as the national focal point for the WHO on all IHR (2005) matters and liaising with national/international organizations;
- Ensuring that risk assessments for novel and pandemic viruses are prepared and communicated as required, including an early assessment of pandemic impact;

- Disseminating pan-Canadian influenza surveillance information and issuing national public health notices and alerts to provide surveillance and epidemiological information to various audiences;
- Identifying circulating virus strains and antiviral resistance through the National Microbiology Laboratory (NML); and
- Providing liaison with federal animal health authorities, as required.

FPT governments will work collaboratively to:

- Ensure that appropriate surveillance capacity, standards and protocols are in place for pandemic surveillance, investigations and special studies;
- Establish protocols for the sharing of relevant surveillance information; and
- Coordinate surveillance activities for federal populations (see CPIP section 3.4.2).

PT governments are responsible for:

- Developing a pandemic influenza surveillance strategy for their respective jurisdiction that meets the established FPT surveillance standards and protocols within the parameters of the PTs' resources and legal obligations;
- Identifying circulating virus strains and antiviral resistance through selected laboratories in some PTs;
- Monitoring local and regional influenza activity in their jurisdiction;
- Mobilizing plans and resources for surveillance activities (including case and outbreak investigations);
- Transmitting agreed-upon surveillance information to PHAC in a timely manner;
- Issuing timely surveillance-related communications to public health, laboratories and health care providers in their jurisdiction; and
- Providing liaison with animal health authorities in their respective jurisdiction, as required.

3.5 Risk Management Approach

3.5.1 THE ROLE OF SURVEILLANCE IN RISK MANAGEMENT

Risk management can be defined as a systematic approach to setting the best course of action in an uncertain environment by identifying, assessing, acting on and communicating risks. During a pandemic, a risk management approach would help support a proportional and flexible response. More details about risk management and risk assessment can be found in CPIP and the WHO's pandemic guidance document.[4]

Early assessment of pandemic impact – One of the most urgent needs in the earliest days of a pandemic is to understand the potential impact of the event. This assists health decision-makers to prepare the health care system and plan interventions that are proportional to the situation. Early assessments in countries first affected by the novel virus will inform the global community. However, each country's context and pandemic-related impact will vary. Strategies to produce an early impact assessment for Canada are under development at PHAC.

4 World Health Organization. Pandemic influenza risk management – WHO interim guidance. 2013. Available at: who.int/influenza/preparedness/pandemic/influenza_risk_management/en/

The WHO has provided a framework for the early impact assessment ("severity assessment" in WHO terminology).[5] This framework uses different types of data (virological, epidemiological and clinical) to develop indicators of transmissibility (ability to spread from person to person), seriousness of disease and impact (e.g., on the health care system and society at large). A similar framework has also been published by the United States' Centers for Disease Control and Prevention (CDC).[6] The assessment process should be implemented for seasonal influenza so that the methodology is well-practised before the pandemic.

It is important to note that there may be limitations on the ability to obtain information early in a pandemic; furthermore, data must accumulate over time to contribute to accurate analyses. For example, the case-fatality ratio can vary significantly over the course of a pandemic and is likely to be misleading at first. More useful measures of clinical severity at early stages might be the proportion of laboratory-confirmed cases admitted to an intensive care unit (ICU) or requiring mechanical ventilation. Finally, pandemic impact will not be uniform across Canada and may be higher in some settings (e.g., remote and isolated communities) and in vulnerable populations.

Risk assessments – Risk management during the pandemic will be assisted by timely and credible risk assessments appropriate to the jurisdiction. These should be based on surveillance and modelling information that is analyzed and presented in a way that is useful to decision-makers. PHAC will facilitate development of the risk assessments to support FPT decision-making; producing these formal risk assessments is a specific responsibility of the federal surveillance program. Individual PTs should also conduct their own risk assessment to guide decision-making within the jurisdiction.

The FPT risk assessments will be conducted at the start of the pandemic to inform the initial response and then updated periodically as new information emerges (e.g., at the end of a pandemic wave). Appendix B of the CPIP main body identifies more detailed considerations for pandemic risk assessments and potential sources for supporting information.

Initial public health risk assessments should address key information needs:

- What are the characteristics of the novel/pandemic virus (e.g., virulence, transmissibility, receptor binding)?
- Is the virus sensitive to antiviral medications?
- How rapidly are new cases occurring?
- What types of illnesses and complications are being seen?
- What groups of people (e.g., age or risk groups) are more likely to become severely ill or die?
- How many people will become infected and/or symptomatic?
- What will be the impact on the health care sector (including health care utilization and the health work force) and the community?
- What public health measures might be of use?

As the pandemic progresses, there will be questions about recurrence of pandemic waves, whether new risk factors are emerging, whether the response should be escalated or de-escalated and whether control measures are proving effective.

5 Ibid
6 Reed C, Biggerstaff M, Finelli L, et al. Novel framework for assessing epidemiological effects of influenza epidemics and pandemics. *Emerg Infect Dis* 2013;19:85-91

3.5.2 RISKS FOR THE SURVEILLANCE STRATEGY

Significant risks and uncertainties could affect implementation of the surveillance strategy. It is important to identify these potential risks in order to take action to prevent or mitigate them if possible and to identify ways to deal with them if they occur.

Planning scenarios – Planning scenarios assist with the identification of risks by providing a way to anticipate implications for the response in pandemics of varying impact. CPIP identifies four pandemic planning scenarios that describe pandemic impact varying from low to high. Table 1 identifies implications for the pandemic surveillance strategy in each scenario.

There are some constants in all scenarios:

- Even in a low-impact pandemic, the epidemiological picture is expected to be significantly different from that of seasonal influenza: typically, relatively more severe disease and mortality will occur in the young and in people without underlying health conditions compared with seasonal influenza, in which the most severe outcomes occur in the elderly and those with underlying health conditions.[7] This makes severe outcomes surveillance important in all scenarios.
- Pandemic impact can vary across geographic areas and populations: some settings or vulnerable populations might be experiencing a higher impact than other parts of Canada.
- Surveillance activities may need to be ramped up or down as pandemic activity increases and drops off as part of the pandemic wave pattern.
- Antiviral resistance could develop at any time and needs to be monitored in all scenarios.
- The clinical severity of illness could change during the course of a pandemic if the pandemic virus adapts and develops higher or lower virulence.

7 Simonsen L, Clarke MJ, Schonberger LB, et al. Pandemic versus epidemic mortality: a pattern of changing age distribution. *J Infect Dis* 1998;178:53-60

TABLE 1 – IMPLICATIONS FOR THE PANDEMIC SURVEILLANCE STRATEGY IN PANDEMICS OF VARYING IMPACT

TRANSMISSION	LOW CLINICAL SEVERITY	HIGH CLINICAL SEVERITY
HIGH	**SCENARIO B – MODERATE IMPACT** • Higher viral transmissibility may produce earlier and more intense pandemic waves. • Both community and hospital-based surveillance are important. • Pressure on health care system must be monitored. • Strain on local and PT public health surveillance capacity could lead to delays in data submission. • High case volume will necessitate changes in laboratory testing policies. • Surveillance of antiviral utilization and monitoring of stockpiles are important.	**SCENARIO D – HIGH IMPACT** • Higher transmissibility may produce earlier and more intense pandemic waves. • Most demanding scenario in terms of workload; staff illness could further affect capacity to conduct epidemiological and laboratory surveillance. • Focus will be on severe outcomes surveillance, including mortality. • High number of hospitalized cases will stress laboratory capacity and hospital-based surveillance systems. • Pressure on health care system must be monitored. • Strain on local and PT public health surveillance capacity could lead to delays in data submission. • Surveillance of antiviral utilization and monitoring of stockpiles are important.
LOW	**SCENARIO A – LOW IMPACT** • Focus will be on community surveillance (including paediatric illness) in order to characterize disease occurrence. • Surveillance may identify higher pandemic impact in some settings or vulnerable populations. • Public perceives that there is more disease risk and higher impact than actually exists.	**SCENARIO C – MODERATE IMPACT** • Focus will be on severe outcomes surveillance, including mortality. • Pressure on health care system must be monitored. • High number of hospitalized cases will stress laboratory capacity and hospital-based surveillance systems. • Need for near real-time national mortality surveillance must be anticipated.

Additional risks – In addition to the implications identified in the planning scenarios, there are other risks associated with implementation of the surveillance strategy. These are outlined in Table 2, along with a potential mitigation or response for each risk. Note that many of the risks deal with the inability to access or analyze needed data, thus impeding timely and evidence-informed decision-making.

TABLE 2 – RISKS AND EVENTS AFFECTING THE SURVEILLANCE PROGRAM, THEIR IMPLICATIONS AND POTENTIAL MITIGATION OR RESPONSE

FACTOR/EVENT	IMPLICATIONS	POTENTIAL MITIGATION/RESPONSE
SURVEILLANCE INFRASTRUCTURE		
DATA-SHARING AGREEMENTS NOT IN PLACE	• No data or incomplete data received from PTs. • Inability to generate meaningful national reports or risk assessments. • Inability to engage academic partners for research support and publication. • Ability to inform public health response activities is compromised.	• Approve MLISA in all jurisdictions and finalize the influenza technical annex as soon as possible. • Develop agreements for FPT research staff to engage academic colleagues (and share data) for research surge capacity if needed. • Implement interim agreements as quickly as possible if needed during the pandemic.
LACK OF INTEGRATED ELECTRONIC INFORMATION SYSTEMS	• No real-time data. • Need to handle large amount of data in multiple formats (increased time spent on collection, collation and cleaning of data).	• Develop and implement information systems that can handle multiple formats and various data coding. • Plan for surge capacity to handle extra workload.
INFORMATION TECHNOLOGY (IT) MALFUNCTION	• Data input/analysis is compromised. • Inability to provide national data summaries.	• Develop business continuity plans (e.g., back-up systems) or alternative business practices. • Assign dedicated IT resources to deal with surveillance IT issues during the pandemic.
INCONSISTENCY IN DATA REPORTING	• Conflicting surveillance reports. • Reduced confidence and trust of the public in the ability of governments to manage the pandemic.	• Adopt common data elements and investigation protocols. • In advance of the pandemic, obtain PT agreement on date- and time-stamping protocol for case reporting. • Run test scenarios with PTs to identify areas of inconsistency. • Understand laboratory test methods and testing algorithms being used during the pandemic.

FACTOR/EVENT	IMPLICATIONS	POTENTIAL MITIGATION/RESPONSE
SURVEILLANCE INFRASTRUCTURE		
LACK OF ABILITY TO COLLECT OR ACCESS INFORMATION ON ITEMS OF INTEREST	• Inability to collect information on some risk factors (e.g., ethnic status). • Inability of researchers to conduct studies. • Potential inability to access research results until published. • Inability of PTs to access some data relevant to their jurisdiction. • Lack of timely information for decision-making.	• Identify items of population health interest, create a standardized data element list and identify collection methods. • Develop advance agreements for collection and sharing of data. • Have mechanisms in place for rapid multi-jurisdictional/multi-centre hospital studies or other special studies needed to collect specific information.
PROGRAM AND ADMINISTRATIVE ISSUES		
INCREASED DEMANDS ON FPT SURVEILLANCE STAFF (OR LOSS OF STAFF)	• Reporting delays, incomplete reports. • Incomplete data inaccurately representing the national picture. • Lack of timely information for decision-making.	• Determine the scalability of surveillance activities. • Planning for surge capacity, including rapid training if required, by all jurisdictions.
SENTINEL SITES BECOMING OVERWHELMED WITH CLINICAL RESPONSIBILITIES	• Lack of sentinel reporting in some/all sites. • Possible compromise of major source of surveillance data and ability to get a true national picture.	• Encourage business continuity planning. • Consider modifying surveillance format to lessen sentinel workload. • Implement public communication and other strategies to relieve clinical burden on practitioners.
SECURITY BREACHES	• Loss or unintentional release of patient information, affecting public trust.	• Establish protocols for collecting and handling personal patient information in a secure fashion.
PUBLIC OPINION AND RISK PERCEPTION		
MEDIA COVERAGE	• Possible sudden increase in demand for information.	• Establish a dedicated resource to work with communications on data requests. • Develop standard formats for anticipated information and reports. • Develop a schedule for data release.

FACTOR/EVENT	IMPLICATIONS	POTENTIAL MITIGATION/RESPONSE
INTERNATIONAL CONSIDERATIONS		
OTHER COUNTRIES USING DIFFERENT SURVEILLANCE STRATEGIES/CASE DEFINITIONS	• Perception that another country's approach is better. • International results may not be comparable.	• Acknowledge differences and provide rationale for Canadian approach. • Adopt WHO standards and encourage other countries to do the same. • Share surveillance information internationally.

3.6 Key Elements of the Pandemic Surveillance Strategy

A robust, integrated seasonal surveillance system is a necessary part of pandemic planning. Pandemic surveillance will be built on existing surveillance systems such as FluWatch. Collection of additional surveillance elements may be needed; for example, to identify risk factors for severe disease and populations at increased risk, along with special studies such as seroprevalence surveys. These elements should be developed by PHAC in collaboration with appropriate organizations and practised during annual influenza outbreaks to ensure that protocols are prepared, staff trained and laboratories prepared to provide support as needed.

Surveillance needs will differ, depending on the level of jurisdiction and specific use. In general, more detailed information on influenza activity and health system capacity will be needed at local/regional and PT levels. National-level information is needed to develop risk assessments, to guide the overall response (e.g., development of recommendations for vaccine and antiviral use) and for transmission to the WHO to inform the global picture. However, national modelling initiatives (e.g., calculation of the reproductive number [R_0]) require access to detailed PT case information.

Surveillance activities may need to be adapted in response to rapidly evolving situations; they may be streamlined, expanded or scaled down, depending on information needs at particular phases within the evolving pandemic. During the pandemic, existing structures, such as the Influenza and Other Respiratory Diseases F/P/T Surveillance Working Group, will be leveraged to provide recommendations for action on the surveillance program and on modifications, if needed, to surveillance protocols.

This section sets out the important elements of the Canadian pandemic surveillance strategy. The following section describes how these surveillance activities will vary over time as the pandemic evolves.

3.6.1 EARLY DETECTION AND INVESTIGATION

Routine surveillance systems are not necessarily useful for the detection of an unusual event. Rapid detection of emerging novel influenza subtypes and outbreaks requires sensitive detection systems employing methods that differ from those used in routine data collection. These methods primarily involve listing unusual signal events and immediately passing on such information to health authorities.[8] Signal events include the occurrence of cases or clusters of severe acute respiratory infection and laboratory detections of novel influenza viruses. Public health alerts about novel viruses and/or an emerging pandemic will be provided to public health professionals through the Canadian Network for Public Health Intelligence (CNPHI) Public Health Alerts system.

8 Greer AL. Can informal social distancing interventions minimize demand for antiviral treatment during a severe pandemic? *BMC Public Health* 2013;13:669

SARI surveillance – Participation of hospitals in SARI surveillance is important for the detection of novel virus infections, including influenza, and helps identify unusually severe morbidity and mortality caused by these novel viruses. After investigation by public health, confirmed SARI cases should be reported within 24 hours of being classified as such.

SARI case definition: phac-aspc.gc.ca/eri-ire/saricd-dciras-eng.php.

SARI case report form: phac-aspc.gc.ca/eri-ire/coronavirus/form-formulaire-eng.php.

Surveillance of novel influenza viruses – If public health authorities suspect there is a possible case of novel virus infection they should communicate with the laboratory to ensure that the appropriate virus subtyping is done. When the laboratory detects novel influenza virus infections, local public health authorities will conduct case and contact investigations. To meet IHR (2005) obligations, PTs should report the case to PHAC within 24 hours of PT notification using the Emerging Respiratory Pathogens and SARI Case Report Form. The information collected includes case demographics, clinical information, medical and vaccine history, underlying conditions, laboratory findings, exposures and contact summary. PHAC in turn notifies the WHO and provides non-nominal case data to be used as part of a global database.

Investigation and follow-up of the first few hundred cases – In the initial stages of a pandemic, it is important to collect detailed information on enough cases and their contacts to develop a reasonable picture of the epidemiological characteristics of the pandemic and the risk factors for severe disease. Detailed data collection from these early cases, using a standardized questionnaire provided by PHAC, also helps identify potentially unique or unusual aspects of the clinical presentation to aid in the development of case definitions for surveillance and case management purposes. Studies of early clusters and exposed individuals help inform calculation of the incubation period and the period of infectivity. Note that by the time the pandemic reaches Canada (if it originates elsewhere), sufficient information may already be available from other countries, and Canada may not need to repeat these studies.

It is not necessary (or possible) for public health to maintain comprehensive case and contact follow-up beyond the initial period, once sustained and widespread transmission of the pandemic virus is observed in Canada. In consultation with the PTs, PHAC will indicate when it no longer needs individual case reports from PTs, and PTs should switch to aggregate data reporting to PHAC. Resources permitting, PTs may continue with comprehensive case and contact follow-up in special circumstances; for example, for special studies or intensive surveillance of a vulnerable population.

3.6.2 COMMUNITY-BASED SURVEILLANCE

Community-based pandemic surveillance will be based primarily on the seasonal FluWatch components described below in sections A and B. Community-based surveillance provides information on the progress of the pandemic, which allows local authorities to plan appropriately. It also provides information on occurrence of illness, clinical presentation and age groups affected, which allows monitoring of changes in risk factors associated with severe disease and of the relative impact of the pandemic. Additional studies are needed to learn about asymptomatic infection and the extent and pattern of illness that is not severe enough to require care. (These special studies are described in section 3.6.5.)

A. PROVINCIAL/TERRITORIAL REPORTING

Influenza activity levels – PTs assess regional influenza activity levels across Canada each week on the basis of laboratory reports of influenza detection, the presence of ILI and reports of outbreaks of influenza/ILI. Regions are reported to have no activity or sporadic, localized or widespread activity. Influenza activity reports are used to monitor the geographic spread of influenza and trends over time. Definitions will be reviewed and modified if necessary at the time of the pandemic.

Outbreaks of ILI – All PTs report the number of outbreaks of influenza or ILI that occur each week in long-term care facilities. Some PTs also report the number of influenza outbreaks that occur in other settings, such as hospitals, schools and related settings.

B. SYNDROMIC SURVEILLANCE

ILI consultations – Data on ILI consultations (by age group) along with total patient consultations are provided each week by volunteer sentinel practitioners across the country. These data are used to monitor levels (intensity) of ILI in the community. In some PTs sentinel practitioners also collect a laboratory sample and vaccine history in order to participate in virological and vaccine effectiveness studies. The current Canadian ILI surveillance system suffers from under-representation or under-participation in some regions. If practitioners become overwhelmed with clinical responsibilities during the pandemic and are unable to participate in the surveillance program, the representativeness of surveillance data could suffer further. ILI consultations can be tracked at other sites as well, including hospital emergency departments and community health centres.

Telehealth calls – Calls to PT telehealth systems can be used to generate ILI surveillance data and are a sensitive source of information about illness that does not require medical attention, although they must be used in context with other health indicators. Telehealth operated in all PTs during the 2009 pandemic, making it a useful surveillance tool for a pandemic. Telehealth may also be helpful in seasonal influenza surveillance, thus providing an ongoing opportunity to develop baselines and refine methodology.

Antiviral prescriptions and sales of over-the-counter (OTC) medications relevant to influenza – Rx Canada provides daily data through the National Pharmacy Surveillance Portal, including summary data tables, graphs and maps, on antiviral prescriptions (Tamiflu® and Relenza®) and OTC medication sales relevant to influenza. These data indicate the level of ILI in a community and can be used to assess antiviral use during the pandemic. Administrative pharmacy claims from Health Canada may provide a source of data on antiviral use for eligible First Nation and Inuit clients covered under the Non-Insured Health Benefits Program. However, data limitations and capacity for analysis need to be considered. PTs may also have administrative pharmacy systems in place to monitor antiviral utilization.

3.6.3 SEVERE OUTCOMES SURVEILLANCE

Surveillance for severe outcomes of influenza, such as hospitalizations and deaths, is an important component of pandemic influenza surveillance. Severe outcomes surveillance provides the information needed to manage the health care response, identify high-risk conditions for purposes of vaccine prioritization and antiviral recommendations, and help evaluate the need for aggressive public health measures.

Seasonal surveillance for severe outcomes is provided through reports from participating PTs of hospitalizations and deaths and from sentinel systems for paediatric and adult hospitalizations and deaths as described below. These seasonal programs provide baseline data and the platform for pandemic surveillance of severe outcomes.

PT reports of hospitalizations and deaths – For seasonal influenza, many PTs provide aggregate data weekly on the number of influenza-associated hospitalizations, ICU admissions and deaths by age group and influenza type/subtype. These data are used to monitor the clinical severity of circulating influenza strains/subtypes and provide important baseline information. During a pandemic, all PTs should collect these data and make every effort to provide complete information as per the national reporting template. It is recognized that the data may not come through the usual public health reporting systems.

IMPACT – IMPACT is a paediatric hospital-based sentinel surveillance network that is funded by PHAC and administered by the Canadian Paediatric Society. The IMPACT program carries out surveillance of influenza hospitalizations in children and provides detailed case-based information on paediatric

hospitalizations and deaths. IMPACT data are used to monitor the clinical severity of circulating strains/subtypes and identify paediatric groups at high risk of severe outcomes. For more information about IMPACT see www.cps.ca/en/impact.

SOS Network – SOS is a sentinel influenza surveillance network of hospitals administered by CIRN. SOS provides detailed case-based information on adult hospitalizations and deaths due to influenza. SOS data are used to monitor clinical severity and identify adult groups at high risk of severe outcomes. For more information about the SOS Network see cirnetwork.ca/network/serious-outcomes/.

Information on influenza outcomes collected during the pandemic by IMPACT and the SOS Network could be modified, if desired, through additional follow-up or chart review of severe cases; for example, to capture unusual presentations, new risk groups, secondary bacterial infections and timing of initiation of antiviral treatment.

Mortality – The severe outcomes surveillance reporting systems described above provide information on influenza deaths that occur in hospital as well as baseline data from previous seasons. There are, however, significant gaps in mortality data, as the sentinel systems represent a subset of all influenza-associated deaths, and not all PTs participate in severe outcomes surveillance for seasonal influenza (although they should do so during a pandemic). Another gap is the lack of ability in many PTs to capture timely information on influenza-associated deaths that occur in the community. However, unless the situation is very unusual most deaths are expected to occur in medical settings.

Estimates of pandemic mortality are most useful early in the pandemic in order to determine likely pandemic impact and the populations that are most affected, but there are many pitfalls associated with mortality data. Direct counts during a pandemic cannot be compared with influenza-associated mortality calculated through the methodologies used for seasonal influenza, and the direct counts significantly underestimate the true occurrence. While the surveillance systems described provide data on the proportion of hospitalized patients who die, case fatality ratios must be adjusted for time lags. Population-based mortality rates could be substantially underestimated if a significant proportion of ill people die outside the hospital.

3.6.4 LABORATORY SURVEILLANCE

Laboratory detections of novel respiratory viruses and seasonal and pandemic influenza isolates are integrally linked to disease data. The laboratory contributions to seasonal and pandemic influenza surveillance are described in detail in the Laboratory Annex and are highlighted below.

Laboratory detections – Respiratory virus detections are reported weekly to FluWatch through the sentinel laboratory-based Respiratory Virus Detection Surveillance System (RVDSS), which operates year-round. Reports include the number of positive tests for influenza by type and subtype. Data are also provided to the Global Influenza Surveillance and Response System through FluNet (WHO). Information on test volumes may also be useful for directing health policy, for providing clinical guidance and for public health decision-making.

Influenza case-level laboratory findings – Specified information (age, sex, residence, date specimen was received and influenza type/subtype) is provided to FluWatch on a large majority of the laboratory-confirmed influenza cases detected through the RVDSS. During the pandemic, it is important for all jurisdictions to provide the required information as completely as possible.

Influenza strain characteristics and antiviral susceptibility – A proportion of the weekly influenza detections across Canada are referred to the NML for further testing to provide strain characterization and identify antiviral resistance in the circulating influenza virus strains. This information is used to identify which strains are circulating and to determine whether the pandemic strain is undergoing any changes that might affect

the immunization program or antiviral strategy. Initial and ongoing antiviral susceptibility testing is particularly important in light of the plan to treat influenza cases with neuraminidase inhibitors.

Laboratory personnel, in partnership with epidemiologists, should develop testing guidance (who and how to test). It is important to recognize that the ascertainment of laboratory-confirmed cases will be affected by changes in laboratory testing practices, which may occur at different times in individual PTs if laboratory capacity is exceeded. Health-seeking behaviour by the public and physician testing practices can also affect laboratory testing rates and subsequent case detection.

3.6.5 SPECIAL STUDIES

The surveillance programs already described will not provide all the information that is needed to understand the pandemic and make evidence-informed decisions about control measures. For example, special studies or field investigations will be required to obtain information on community transmission and population-based age-specific rates of infection and illness. These studies need to be pre-planned so that they can be quickly implemented when necessary. Note that studies done by other global partners at the time of the pandemic may reduce or eliminate the need to repeat them in Canada.

PHAC is a participant in international efforts that are under way to develop a more comprehensive and standardized approach to influenza studies. The Consortium for Standardization of Influenza Seroepidemiology (CONSISE) is a global partnership, active since 2011, that aims to standardize influenza seroepidemiology methods and develop comprehensive influenza investigation protocols to inform public health policy. The CONSISE epidemiology working group is developing protocols for pandemic studies that will be of use to Canadian epidemiologists and investigators. For more information on CONSISE, see consise.tghn.org/.

The types of special epidemiological studies that will be needed to inform pandemic decision-making in Canada include the following:

Population seroprevalence studies – Seroprevalence studies should be conducted with representative pre-event sera and at intervals during the pandemic (e.g., after pandemic waves). Initial testing determines the prevalence of cross-reactive antibodies in the population that could protect against illness or severe disease in certain age cohorts. Subsequent surveys demonstrate the development of immunity in the population as a result of infection or vaccination (once a vaccine is available) and can be used to calculate rates of subclinical infection.

Field investigations and surveys – Field studies of early clusters and outbreaks (e.g., in households, schools or universities) can provide needed information about the incubation period and period of infectivity of the new virus, as well as the clinical illness it causes. Information about speed of spread and attack rates is gathered through community surveys, household transmission studies and, at later stages in the pandemic, seroprevalence studies. This information will inform decisions about interventions such as school closures or other social distancing measures and will help predict the intensity of the impact on the health care system.

Enhanced surveillance in vulnerable populations – The planning of pandemic surveillance for settings where vulnerable populations may reside (e.g., remote and isolated communities, homeless shelters, group homes) requires consideration of a number of questions:

- What information is needed and why? For example, monitoring disease activity and outbreaks in remote and isolated communities can enable early preventive and treatment measures. Determining which groups are at increased risk of severe disease informs the decision-making process regarding vaccine and antivirals.

- Can the information on the vulnerable populations of interest be collected through regular surveillance systems or are special studies needed? Considerable data are available through seasonal PT surveillance systems; however, it will be necessary to disaggregate the information of interest (e.g., First Nation [on and off reserve] or Inuit rather than Aboriginal).
- How will information flow and data sharing be managed? FPT governments should work with First Nations, Metis and Inuit communities to develop data-sharing agreements and systems that avoid duplicate information collection.

Who is responsible for planning and implementation? This may not be straightforward, as multiple agencies or government departments could be involved for some populations. Local community involvement and public health support are usually necessary for successful planning. FNIHB will endeavour to work with the PTs in planning pandemic surveillance for First Nation communities. FNIHB is not responsible for pandemic surveillance for Inuit communities.

3.6.6 MODELLING

Mathematical models can support pandemic decision-making by helping to address questions such as what the anticipated pandemic impact will be, what interventions might be effective and whether subsequent waves of disease might occur. This is accomplished through a variety of methods:

- Quantitative forecasting (e.g., the projected burden of disease in three or six months);
- Parameter estimation (e.g., the level of transmission that accounts for the observed trends in the surveillance data);
- Qualitative prediction (e.g., how non-pharmaceutical interventions such as school closures might affect the distribution of cases in the population);
- Evaluation of interventions and policies (e.g., identification of which interventions will most reduce transmission or save the most lives, and how to optimize and target interventions to minimize disease transmission, morbidity and/or mortality); and
- Identification of key uncertainties in current knowledge (e.g., the implications of reporting delays and other statistical biases that may exist as a part of the surveillance system itself).

Pandemic modelling projects will be coordinated by the PHAC Modelling and Projection Section in partnership with PHAC surveillance and modelling colleagues in academia and public health agencies. Both statistical modelling and dynamic disease transmission modelling will be used to support pandemic decision-making.

Some of the specific questions that can be addressed by modelling are shown in Table 3, together with the related surveillance data needs and types of models that would be applied to each. One of the most critical early projects for risk assessments is the determination of R_0, which is defined as the average number of cases that each case generates over the course of its infectious period in a wholly susceptible population. R_0 is a measure of virus transmissibility and affects the extent to which public health measures (PHMs) and other interventions will work in decreasing the spread of the pandemic virus. In general, PHMs are more effective when transmissibility is low.[9,10] If transmissibility is very high, currently available intervention efforts have little effect and the focus should be on therapeutic care.

9 Greer AL. Can informal social distancing interventions minimize demand for antiviral treatment during a severe pandemic? *BMC Public Health* 2013;13:669

10 Kelso JK, Milne GJ, Kelly H. Simulation suggests that rapid activation of social distancing can arrest epidemic development due to a rapid strain of influenza. *BMC Public Health* 2009;9:117

TABLE 3 – USE OF MODELLING FOR DECISION-MAKING AND RELATED DATA REQUIREMENTS

QUESTION/ISSUE	FACTORS AFFECTING THE ANSWER	MINIMUM DATA REQUIREMENTS	TYPES OF MODEL
WILL THE PANDEMIC'S IMPACT BE LOW, MODERATE OR SEVERE?	• How transmissible is the virus (requires estimates of R_0, incubation period and duration of infectivity)?	• All initial lab-confirmed cases, age and date of symptom onset, earliest and/or most recent date of possible exposure. • Number of cases that each case generates (for R_0 estimate).	• Cox proportional hazards model • Markov Chain Monte Carlo model
	• How virulent is the virus?	• For initial lab-confirmed cases admitted to hospital: age, dates of admission and discharge, days spent in ICU and outcome.	• Competing risk survival models • Reporting delay adjustment models
WHAT TYPES OF INTERVENTION SHOULD BE USED? **WHEN, WHERE AND HOW SHOULD INTERVENTIONS BE DEPLOYED?**	• Clinical severity. • Available interventions. • Epidemic timing (at what point in the epidemic curve is the jurisdiction compared?).	• R_0 estimate. • Age-specific relative incidence. • Clinical severity estimates (adjusted for ascertainment bias). • Age-specific population sizes. • Reasonable mixing matrix for the population.	• Age-structured disease transmission model
HOW MIGHT INTERVENTIONS AFFECT DISEASE TRANSMISSION?	• What are the key transmitters?	• Age-specific relative incidence. • Information about possible pre-existing immunity (seroprevalence studies).	• Age-structured disease transmission model
HOW MIGHT INTERVENTIONS AFFECT INDIVIDUAL MORBIDITY AND MORTALITY?	• Who is at highest risk of infection? • Who is at highest risk of a severe outcome if infected? • Analysis of severe outcomes in vulnerable populations.	• Age-specific frequencies of severe outcomes. • Frequency of severe outcomes in individuals with chronic underlying conditions.	• Statistical model of severe outcomes (hospitalizations, ICU admissions, deaths)

QUESTION/ISSUE	FACTORS AFFECTING THE ANSWER	MINIMUM DATA REQUIREMENTS	TYPES OF MODEL
SHOULD INTERVENTIONS BE TARGETED AT "TRANSMITTERS" OR THOSE AT HIGHEST RISK OF SEVERE OUTCOMES?	• The amount and availability of pharmaceutical and non-pharmaceutical interventions and whether these tools will affect transmission (depends on R_0, etc.). • What proportions of "transmitters" are also at high risk of a severe outcome? Is there significant overlap between the two groups?	• Same requirements as previous questions.	• Age-structured disease transmission model based on observed epidemic timing with interventions (as deployed or considered) • Statistical predictive models to estimate potential pandemic impact (based on analyses of disease severity and health care utilization)

There are inherent challenges in using surveillance data for modelling:

- The data come from multiple sources and may overlap.
- Data are not necessarily representative of the entire country (e.g., if the required data are available from only one or two provinces).
- Data quantity and quality may vary greatly.
- There are insufficient linkages between laboratory and epidemiological data at the national level.
- Once laboratory testing protocols change, the usefulness of the data for different questions of interest also changes (for better or worse).
- Denominator data (e.g., all infected or all ill people) are usually lacking.

It is important to use the interpandemic period to address these challenges through mechanisms such as strengthening linkages between public health and modellers, developing protocols for data sharing, and establishing data standards and minimum data reporting requirements so that the data needed for modelling will be available as early as possible. The models should be developed and tested using seasonal influenza opportunities.

3.6.7 DATA COLLECTION, REPORTING AND ANALYSIS

The 2009 pandemic highlighted the need for improvements to the national surveillance system. These included consistency of information capture, formal FPT data-sharing agreements, electronic linkages for timely transfer of surveillance data, and sufficient human resources for data analysis and interpretation. Ongoing FPT improvements in these areas are strengthening the national capacity to conduct timely surveillance and produce useful analyses and reports.

Data collection and reporting – Surveillance data reach PHAC primarily from PTs and the NML. Efforts to standardize data collection and improve data transfer should be carried out in the interpandemic period and incorporated into seasonal influenza surveillance where possible. These efforts include adoption of common data elements and common investigation protocols and development of templates for reporting (case reports, line listings and aggregate data reports). It is also important to develop standard reporting and dissemination timelines for use by both PTs and PHAC to achieve consistency in reporting.

As well, it is necessary to make infrastructure improvements, such as establishing electronic databases and immunization registries in all jurisdictions, and to develop secure mechanisms for reporting, preferably through electronic linkages and web-based methodology. Data-sharing agreements need to be finalized to facilitate two-way sharing.

Mechanisms should be in place for collection and sharing of data from other important data sources, such as research networks, hospitals and sentinel sites. Agreements and protocols should be developed in the interpandemic period so that these mechanisms can be initiated as soon as needed.

Data analysis and interpretation – Timely analysis of epidemiological data is important in understanding the pandemic and assessing its impact. Key epidemiological and clinical parameters should be characterized in advance so that appropriate data to inform them can be collected. These parameters include the following:

- Epidemiological – estimation of incubation period and period of infectivity; description of transmission patterns; attack rates by age, sex and exposure history; risks to vulnerable populations; vaccine effectiveness.
- Clinical – spectrum of disease; proportion of cases in whom pneumonia or other complications develop or who require hospitalization, ICU admission or ventilator use or who die; assessment of disease severity; risk factors for severe disease; utilization of health care services.

Because the purpose of surveillance is to provide information for decision-making, timely analysis and dissemination of information is necessary to ensure that information is ready when it will be needed. Particular attention should be paid to the data needs outlined for the pandemic risk assessments (see CPIP main body Appendix B) and the prioritization frameworks that are part of the Vaccine and Antiviral annexes.

Surveillance information reports – During a pandemic, surveillance information will be reported through regular channels such as FluWatch, which is posted weekly. Should the need arise, the frequency of reporting may be revised to provide important information to public health partners in a more timely manner. Additional mechanisms will also be used during a pandemic, such as formal risk assessments and ad hoc reports. PTs will also communicate surveillance information to local/regional public health units, hospitals and clinicians in their jurisdiction, as appropriate.

3.7 Triggers for Action and Key Surveillance Activities

Triggers for action provide guidance for initiation of FPT activities and for their modification and cessation. The initial stages of a pandemic (which might or might not take place in Canada) will be characterized by intense surveillance needs to characterize the pandemic virus and its anticipated impact. As the pandemic progresses, surveillance activities will need to be adapted in response to the situation: they may be streamlined, expanded or scaled down, depending on information needs at particular phases within the evolving pandemic.

Table 4 identifies the triggers for action (modified from CPIP), together with surveillance objectives for each trigger and associated surveillance activities. Note that dissemination of surveillance information and risk assessments to appropriate audiences should begin with detection of a novel virus and continue throughout the pandemic.

TABLE 4 – TRIGGERS FOR ACTION WITH ASSOCIATED SURVEILLANCE ACTIVITIES AND OBJECTIVES

TRIGGER	SURVEILLANCE OBJECTIVES	KEY SURVEILLANCE ACTIVITIES
NOVEL VIRUS CAUSING HUMAN CASES DETECTED ELSEWHERE IN THE WORLD (NO OR LIMITED TRANSMISSION)	• Detect the first introduction of the novel virus into Canada.	• Monitor disease outside of Canada. • Conduct risk assessment to identify potential risk for Canadians. • Prepare for possible virus introduction into Canada. • Develop case definitions, surveillance and testing guidelines, and reporting requirements.
NOVEL VIRUS CAUSING HUMAN CASES DETECTED IN CANADA (NO OR LIMITED TRANSMISSION)	• Describe the epidemiological characteristics of novel virus cases that occur in Canada.	• Develop/refine case definitions, surveillance and testing guidelines, and reporting requirements. • Mobilize resources to conduct investigations. • Conduct case and contact investigations using enhanced questionnaires to determine epidemiology and to inform risk assessment. • Identify and investigate clusters. • Share epidemiological information via CNPHI Public Health Alert, teleconferences, etc.
NOVEL VIRUS WITH SUSTAINED HUMAN TRANSMISSION DETECTED ELSEWHERE IN THE WORLD (PANDEMIC IMMINENT OR UNDERWAY)	• Track the progress of influenza infection and determine who is being affected. • Detect the first cases in Canada.	• Monitor disease outside of Canada. • Prepare for introduction and spread of virus in Canada. • Develop/refine case definitions, surveillance guidelines and reporting requirements. • Conduct risk assessment to identify potential risk for Canadians.

TRIGGER	SURVEILLANCE OBJECTIVES	KEY SURVEILLANCE ACTIVITIES
NOVEL/PANDEMIC VIRUS (WITH SUSTAINED HUMAN TRANSMISSION) DETECTED IN CANADA	• Describe when and where influenza activity is occurring and who is affected. • Determine and monitor underlying risk conditions associated with severe disease. • Describe the clinical patterns of disease. • Assess and monitor the relative impact of the pandemic. • Determine the antiviral susceptibility of the novel/pandemic virus. • Support the implementation of public health measures.	• Refine case definitions, surveillance guidelines and reporting requirements (if not already done). • Mobilize resources to conduct investigations. • Conduct detailed case and contact investigations of the first few hundred cases using enhanced questionnaires to determine epidemiology and inform risk assessment. • Conduct cluster and outbreak investigations. • Conduct modelling to estimate R_0. • Monitor for antiviral resistance. • Prepare risk assessment, including early impact assessment. • Share epidemiological information (reports) via CNPHI Public Health Alert, teleconferences, etc.
LOCALIZED OR WIDESPREAD ACTIVITY IN CANADIAN POPULATION: FIRST PANDEMIC WAVE UNDER WAY	• Track the progress of the pandemic through the population. • Describe when and where influenza activity is occurring and who is affected. • Determine and monitor underlying risk conditions associated with severe disease. • Describe the clinical patterns of disease. • Assess and monitor the relative impact of the pandemic. • Detect changes in the antigenic and genetic character and antiviral susceptibility of the pandemic virus. • Support the implementation of public health measures.	• Conduct ongoing surveillance to monitor influenza activity (community and severe outcomes), antiviral resistance and strain changes. • Monitor outbreaks in long-term care, school and acute-care settings. • Conduct special studies (e.g., household, community transmission, seroprevalence, vaccine effectiveness). • Determine clinical spectrum of illness and mortality. • Determine geographic spread of disease. • Monitor health services utilization to determine the impact on the health care system. • Conduct antiviral utilization surveillance. • Update risk assessment as needed. • Share information via CNPHI Public Health Alert, teleconferences, online, etc.

TRIGGER	SURVEILLANCE OBJECTIVES	KEY SURVEILLANCE ACTIVITIES
THE PANDEMIC WAVE WANES AND DEMAND FOR SERVICE FALLS TO MORE NORMAL LEVELS	• Assess the epidemiological characteristics of the first wave and its impact. • Provide epidemiological support and evaluation of the impact of pandemic interventions. • Detect the resurgence of pandemic activity.	• Summarize epidemiological data from the first wave. • Provide epidemiological information needed for vaccine prioritization decision-making (and antiviral prioritization if necessary). • Conduct ongoing surveillance to detect resurgence. • Update risk assessment as needed.
PANDEMIC VACCINE IS AVAILABLE FOR ADMINISTRATION	• Provide epidemiological support for the pandemic immunization campaign.	• Monitor vaccine uptake, safety and effectiveness.
SECOND OR SUBSEQUENT PANDEMIC WAVE ARRIVES	• As per first wave.	• Conduct ongoing surveillance to monitor influenza activity, antiviral resistance and strain changes. • Update risk assessment as needed. • Undertake additional activities as per the first wave.
PANDEMIC IS OVER AND NORMAL ACTIVITIES RESUME	• Summarize the epidemiological characteristics of pandemic activity in Canada. • Evaluate the surveillance response to the pandemic. • Continue to monitor changes in the pandemic virus. • Resume seasonal influenza surveillance.	• Complete pandemic studies and reports. • Identify lessons learned and incorporate into revised pandemic guidance. • Evaluate response and revise plans as required. • Return to more normal operations. • Prepare for post-pandemic seasonal influenza.

4.0 INTEGRATION WITH OTHER RESPONSE COMPONENTS

4.1 Laboratory Response

Laboratory surveillance plays a key role in Canada's seasonal and pandemic surveillance strategy and is conducted by the NML, provincial public health laboratories and some hospital laboratories. It is important to coordinate laboratory and epidemiological surveillance and to integrate data collection and reporting to the extent possible. Surveillance activities such as vaccine effectiveness studies and seroprevalence studies require joint planning to help establish adequate laboratory support.

Key laboratory pandemic surveillance indicators were identified in section 3.6.4. Several concerns in the early stages of a pandemic could affect surveillance results. Laboratories will have biosecurity concerns in dealing with a novel virus of animal origin until it becomes established as a pandemic virus; this could affect timely availability of testing that requires virus growth and propagation, such as antigenic characterization. In addition, there will be problems in interpreting seroprevalence data until the new laboratory tests are validated (if tests are available), which may not occur until later in the pandemic.

For further details about the laboratory response, see the Laboratory Annex.

4.2 Support for Interventions

The surveillance strategy provides key information needed to implement pandemic interventions effectively and evaluate their effectiveness.

Vaccines – It is essential to understand pandemic epidemiology, particularly risk factors for severe disease, in order to develop evidence-informed vaccine recommendations, especially recommendations for vaccine prioritization. A full list of the data needed for vaccine prioritization decision-making is found in the Vaccine Annex. PHAC is responsible for conducting the required epidemiological analyses and modelling, using surveillance data submitted by PTs. Ongoing monitoring of influenza strain characteristics helps determine whether the vaccine remains well matched. Monitoring of vaccine uptake, safety and effectiveness are additional important surveillance components that are described in detail in the Vaccine Annex.

Antivirals – Ongoing surveillance of antiviral susceptibility by public health laboratories supports the appropriate use of these medications. If prioritization of the use of antivirals becomes necessary (because of antiviral resistance, supply shortages or other reason), knowledge of pandemic epidemiology and risk factors for severe disease is needed for the development of recommendations. Pharmacy surveillance

of antiviral prescriptions (described in section 3.6.2) provides timely information about antiviral utilization that complements other tracking methods for assessing uptake. Population-based antiviral effectiveness can also be studied using surveillance data.

Public health measures – The calculation of R_0 and other epidemiological characteristics helps inform the usefulness of PHMs. In general, PHMs are more effective when virus transmissibility is low. If transmissibility is very high, currently available intervention efforts have little effect, and the focus should be on therapeutic care. Surveillance information also contributes to the development of surveillance case definitions.

Clinical care – Pandemic surveillance will contribute to clinical care in several ways. An early impact assessment provides information that will be useful to the health care system in preparing for the pandemic workload. This assessment will include forecasting of cases, severe cases and deaths, as well as the impact on health care workers. Local surveillance detects circulation of the pandemic virus in the community, which allows clinicians to target antiviral treatment appropriately. Finally, the epidemiological profile also contributes to the development of case definitions for clinical purposes.

> *Surveillance case definitions are not intended to be used for diagnostic purposes or for decision-making regarding treatment.*

4.3 Linkage with Animal Health Authorities

The natural reservoir for the influenza virus is wild birds, although influenza infection can spread and cause illness in many species. Surveillance in wildlife, poultry and other livestock (e.g., pigs) needs to be improved in order to better understand influenza virus evolution in these species and to assess pandemic threats.

Animal and human surveillance activities should be linked and well-coordinated, both for ongoing activities and for special investigations. Novel influenza virus infections or outbreaks in animals may occasionally be associated with human infections, which require investigation by public health. When highly pathogenic avian influenza outbreaks are detected by animal authorities, surveillance of exposed farm families and poultry workers is conducted in order to detect and control any human infection. Guidelines for Human Health Issues related to Avian Influenza in Canada (2006) are available from www.phac-aspc.gc.ca/publicat/daio-enia/index-eng.php. Conversely, when novel virus infections are detected in humans, investigations may be conducted to detect an animal source and potential routes of transmission (e.g., contact with infected poultry or visits to live bird markets). In addition, First Nations and Inuit who rely on traditional foods (including wild birds) should be included in the groups under surveillance when highly pathogenic avian influenza outbreaks are detected.

At the federal level, PHAC provides the formal linkages to the Canadian Food Inspection Agency (CFIA), including CFIA's National Centre for Foreign Animal Disease in Winnipeg. At the PT level, liaison between public health and animal health authorities is also important. Ongoing efforts are needed to strengthen information sharing, including laboratory results.

4.4 Communication

Communication to the public and health care providers is heavily dependent on surveillance information for an accurate picture of the evolving pandemic. Risk assessments provide both the context and content for communications and form the basis of the risk communication plan.

There are some specific concerns involving surveillance information:

- The need for an understanding of how to interpret and use surveillance data by those responsible for developing public communication;
- The value of educating political leaders and decision-makers about the interpretation and use of surveillance information;
- The importance of being able to provide an accurate, early assessment of pandemic impact so as not to mislead the public or create inappropriate complacency or alarm;
- Recognition of the fact that information (and resulting advice) will change over time;
- The desirability of avoiding an obsession with death counts;
- The need to understand that not all influenza cases are reported and that not all influenza-associated deaths are ascertained;
- Care in conveying modelling information so it is not misunderstood;
- Sensitivity in reporting outbreaks or risks involving certain populations or ethnic groups so as to avoid stigmatization; and
- The potential need to explain differences in pandemic impact both within Canada and compared with other countries.

Additional details can be found in the Communications Annex.

5.0 RESEARCH

Seasonal influenza and novel virus outbreaks provide opportunities to develop and pilot surveillance-related research that will be needed during a pandemic. Preparations to conduct rapid research at the time of the pandemic are also required in order to inform decision-making and post-pandemic evaluation.

Infrastructure and logistics – Population-based research and evaluation during a pandemic require the capacity for active data collection and/or agreements to acquire the necessary data from public health or other authorities. The establishment of data standards and minimum data reporting requirements is also essential for generating consistent, high-quality data that will be used in epidemiological and modelling studies. Development of linked databases and immunization registries in all PTs will improve the ability to conduct pandemic research and evaluation.

Existing networks will be in the best position to conduct research during a pandemic. During the 2009 pandemic, ICU studies that were organized by the Canadian Critical Care Trials Group provided data that were used to describe the early epidemiology of the disease, identify those at risk of severe disease, assist in development of immunization policies and assess the effects of treatment. Canadian Institutes of Health Research–sponsored modelling networks also played a major research role during the 2009 pandemic, and the SPSN conducted vaccine effectiveness studies. These networks and others already described (including IMPACT and SOS) will be well placed to provide invaluable information during another pandemic, providing they can be sustained.

Particular attention must be paid to pre-planning the pandemic research that will be conducted. This includes development and prior approval of detailed protocols by the appropriate regulatory agency (for clinical trials) and research ethics boards of participating centres, negotiation of contracts between trial sponsors and centres, training of key personnel, and development of reliable methods for data and logistics management. Intellectual property, copyright and publication issues should be identified and addressed. The influenza investigation protocols being developed by CONSISE, the international consortium that was described in section 3.6.5, will be of use in this pandemic research.

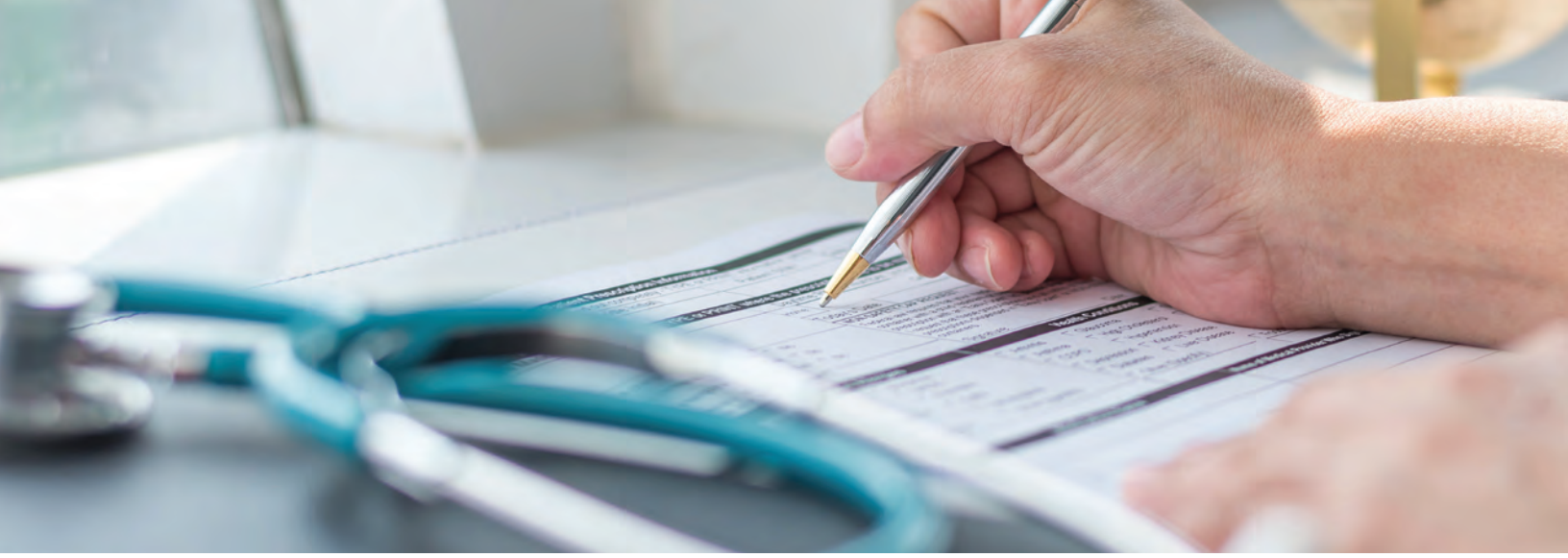
Research needs – Pandemic research needs include the following:

- Studies to elucidate transmission dynamics in different settings (e.g., household and closed settings);
- Studies to provide the information needed for rapid assessment of pandemic impact;

- Studies on factors associated with various outcomes, including deaths in the community; and
- Evaluation of preventive measures (e.g., vaccine, hand hygiene, masks and respirators) and treatment of influenza (e.g., antiviral medications, intensive care interventions).

Knowledge translation – The knowledge translation process involves a number of steps: synthesis of research findings, dissemination to the appropriate audiences using tailored messages and media, interaction between knowledge users and the researcher resulting in mutual learning, and ethically sound application of knowledge.[11] Evidence-informed decision-making requires strong knowledge translation strategies to ensure that research findings are taken into account in pandemic decision-making. In particular, decision-makers should understand the purpose and limitations of modelling. It is also important to convey that information may change over time as a better understanding of the disease dynamics develops.

11 Canadian Institutes of Health Research. Knowledge translation and commercialization; 2015 [cited 2015 December 8]. Available from: cihr-irsc.gc.ca/e/29418.html



6.0 ASSESSMENT AND EVALUATION

Assessing preparedness – Because influenza surveillance is conducted each year there are ongoing opportunities for practice and for piloting and evaluating new strategies and activities to address gaps. To ensure that the surveillance systems are performing well, continuous monitoring of data for completeness and timeliness is recommended, together with thorough periodic reviews. Examples of indicators of influenza surveillance performance are available from WHO.[12] The CDC has also produced evaluation guidelines for surveillance systems.[13]

Outbreaks provide additional opportunities to test the capacity for a coordinated and rapid response. Emergency exercises can also be designed to have a surveillance component.

Post-pandemic evaluation – After the pandemic, the surveillance program should be thoroughly evaluated in each jurisdiction and comparisons made to identify lessons learned and best practices. The evaluation should include items such as the following:

- Completeness and timeliness of reporting;
- Data quality and consistency;
- Information gaps;
- Value of surveillance information for vaccine prioritization and other decision-making and for modellers; and
- Usefulness (and accuracy) of risk assessments and surveillance reports.

12 World Health Organization. WHO interim global. Epidemiological surveillance standards for influenza. July 2012. Available at: who.int/influenza/resources/documents/INFSURVMANUAL.pdf

13 CDC. Updated guidelines for evaluating public health surveillance systems. *MMWR* 2001;50(RR13):135. Available at: cdc.gov/mmwr/preview/mmwrhtml/rr5013a1.htm