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FOODBORNE AND ANIMAL CONTACT DISEASE OUTBREAKS

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FOODBORNE AND ANIMAL CONTACT DISEASE OUTBREAKS

TABLE OF CONTENTS

RAPID COMMUNICATION

National influenza mid-season report, 2020–2021

Liza Lee[1], Kelly Butt[1], Steven Buckrell[1], Andrea Nwosu[1], Claire Sevenhuysen[1], Christina Bancej[1]

Abstract

Canada's national influenza season typically starts in the latter half of November (week 47) and is defined as the week when at least 5% of influenza tests are positive and a minimum of 15 positive tests are observed. As of December 12, 2020 (week 50), the 2020–2021 influenza season had not begun. Only 47 laboratory-confirmed influenza detections were reported from August 23 to December 12, 2020; an unprecedentedly low number, despite higher than usual levels of influenza testing. Of this small number of detections, 64% were influenza A and 36% were influenza B. Influenza activity in Canada was at historically low levels compared with the previous five seasons. Provinces and territories reported no influenza-associated adult hospitalizations. Fewer than five hospitalizations were reported by the paediatric sentinel hospitalization network. With little influenza circulating, the National Microbiology Laboratory had not yet received samples of influenza viruses collected during the 2020–2021 season for strain characterization or antiviral resistance testing. The assessment of influenza vaccine effectiveness, typically available in mid-March, is expected to be similarly limited if low seasonal influenza circulation persists. Nevertheless, Canada's influenza surveillance system remains robust and has pivoted its syndromic, virologic and severe outcomes system components to support coronavirus disease 2019 (COVID-19) surveillance. Despite the COVID-19 pandemic, the threat of influenza epidemics and pandemics persists. It is imperative 1) to maintain surveillance of influenza, 2) to remain alert to unusual or unexpected events and 3) to be prepared to mitigate influenza epidemics when they resurge.

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Keywords: influenza, influenza-like illness, surveillance, pandemic preparedness, H1N1, H3N2, outbreaks

Introduction

This article is a summary of Canada's influenza season and is based on data available from August 23 to December 12, 2020 (epidemiologic weeks 35 to 50) in the weekly FluWatch reports prepared by the Public Health Agency of Canada (1).

Since the emergence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (the virus causing coronavirus disease 2019; COVID-19) in Canada in January 2020, the detection and containment of COVID-19 transmission has been the focus of health officials across Canada. In March of 2020, non-pharmaceutical health measures were implemented to reduce the spread of COVID-19. These measures coincided with an abrupt end to the 2019–2020 influenza season in Canada in mid-March (2,3). Seasonal influenza circulation in Canada (and worldwide) has remained at interseasonal-levels since the spring of 2020. The usual start of the annual seasonal influenza epidemic was absent both in the Southern Hemisphere winter season (July 2020), and, thus far, in the Northern Hemisphere winter season (4,5).

As of December 12, 2020, Canada had not reached the national seasonal threshold (positivity rate of at least 5% and a minimum of 15 positive tests) that signals the start of seasonal influenza activity (6). Typically, the influenza season starts around week 47 (mid-November). Over the past six seasons, the influenza season has begun as early as week 43 (mid-October) and as late as week 01 (early-January).

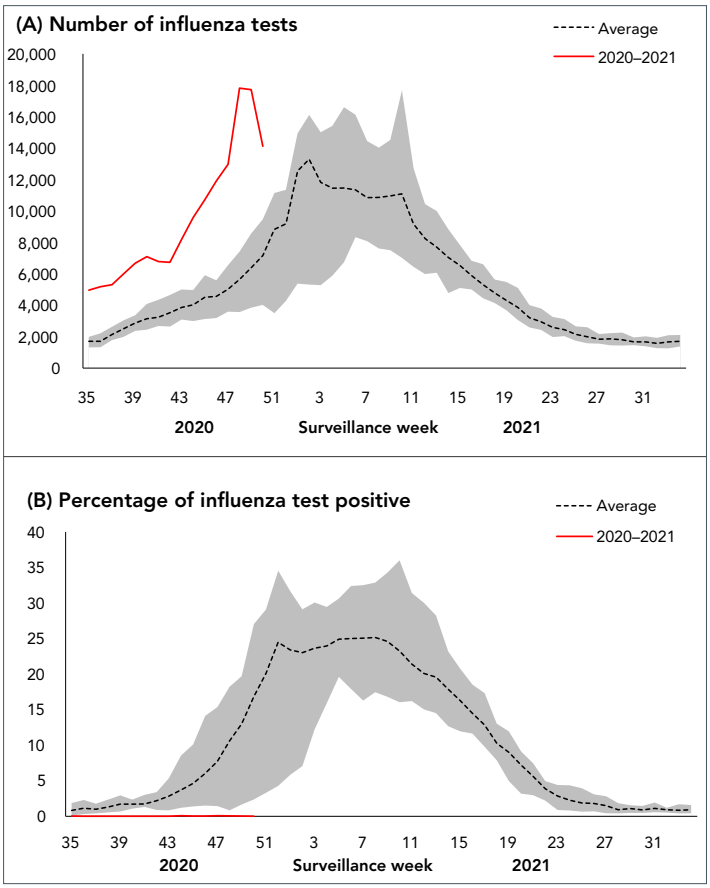
Results

Laboratory-confirmed influenza virus detections

A total of 47 laboratory-confirmed influenza virus detections have been reported since the 2020–2021 influenza surveillance season began at week 35 (August 23, 2020). Influenza A accounted for 64% (n=30) of the influenza viruses detected. Fewer than five influenza A viruses have been subtyped, which was insufficient to ascertain any circulating seasonal subtype

trends. The percentage of laboratory tests that were positive for influenza have remained at exceptionally low levels since March of 2020, despite elevated levels of testing. During weeks 35 to 50, reporting laboratories performed roughly twice the weekly average number of tests compared with the past six seasons (**Figure 1A**). During the same period, the percentage of tests that were positive for influenza were well below average (**Figure 1B**).

Figure 1: Number of influenza tests and percentage of tests positive, by report week, Canada, weeks 35 to 50 in 2020, compared with historical average, seasons 2014–2015 to 2019–2020



Note: The shaded area represents the maximum and minimum (A) number of tests performed or (B) percentage of influenza tests positive by week, from seasons 2014–2015 to 2019–2020

Syndromic

The healthcare practitioners' sentinel influenza-like illness (ILI) surveillance system reported below average percentages of visits due to ILI compared with previous seasons. Weekly percentages of visits due to ILI ranged from 0.1% to 0.8% (compared with the six-year average range of 0.6% to 1.5%). This was not unexpected given the changes in healthcare seeking behavior of individuals, additional healthcare options for individuals with ILI symptoms, a reduction in the number of sentinels reporting and a reduction in the average number of weekly patients seen. In the previous season, between weeks 35 and 50, a weekly average of 94 sentinels reported and an average of 8,775 patients were seen compared with the current season's weekly average of 67 sentinels reported and an average of 5,770 patients seen.

The FluWatchers program reported below average weekly percentages of participants reporting fever and cough compared with previous seasons. Weekly percentages of reports of fever and cough ranged from 0.1% to 0.5%, compared with the four-year average range of 1.5% to 2.9% between week 35 and week 50.

Outbreaks

The majority of ILI outbreaks to date (n=92) have been in schools and/or daycares. An outbreak of ILI in a school or daycare is reported when greater than 10% absenteeism due to ILI is observed.

The reported number of ILI outbreaks in schools and daycares was higher compared with the same period in the previous two seasons. This is not unexpected given changes in outbreak surveillance; specifically, the increased efforts in schools to monitor and report absenteeism due to ILI and the increased restrictions on attendance for children with symptoms of viral respiratory illness.

No laboratory-confirmed influenza outbreaks have been reported this season to date.

Severe outcomes

No influenza-associated hospitalizations have been reported by any of the participating provinces and territories (Alberta, Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Prince Edward Island and Yukon).

Fewer than five paediatric hospitalized cases were reported by the Canadian Immunization Program Active.

Strain characterization and antiviral resistance testing

Due to the exceptionally low influenza circulation to date this season, the National Microbiology Laboratory has not yet received samples of influenza viruses collected during the 2020–2021 season for strain characterization or antiviral resistance testing.

Vaccine monitoring

The World Health Organization (WHO) has recommended that the 2020–2021 Northern Hemisphere egg-based influenza vaccine contain the following strains (7):

- A/Guangdong-Maonan/SWL1536/2019 (H1N1)pdm09-like virus
- A/Hong Kong/2671/2019 (H3N2)-like virus
- B/Washington/02/2019 (B/Victoria lineage)-like virus
- B/Phuket/3073/2013 (B/Yamagata lineage)-like virus (quadrivalent vaccine only)

The federal influenza immunization promotional campaign was launched October 19, 2020, to raise public awareness of the benefits of vaccination and to provide Canadians with the information they need to prevent influenza infections.

The seasonal influenza vaccine coverage survey is set to launch in January 2021. Annual coverage estimates are typically available toward the end of March.

The assessment of the effectiveness of the influenza vaccine, typically available in mid-March, is expected to be limited due to the low number of influenza infections.

Influenza surveillance system performance

Despite the COVID-19 pandemic, Canada's influenza surveillance system remains robust. Programs and/or data providers within the seven components of influenza surveillance (geographical spread, laboratory-confirmed detections, syndromic surveillance, outbreak surveillance, severe outcome surveillance, strain characterization and antiviral resistance testing and vaccine monitoring) continue to operate and/or report weekly. Within these components, measurable surveillance indicators, such as the number of influenza detections, outbreaks, and hospitalizations, are tracked over time and used to monitor influenza trends across Canada. This robust surveillance enabled FluWatch to continue to meet its three main program objectives (detect, inform and enable) while in the midst of the COVID-19 pandemic (8). Additionally, FluWatch has pivoted its syndromic, virologic and severe outcomes system components to support aspects of COVID-19 surveillance important to the national response (9).

Discussion

Influenza activity in Canada has persisted at below-average levels since the 2020–2021 season surveillance began in week 35 (August 23, 2020). Influenza activity between weeks 35 and 50 (late August to mid-December) remained below the national threshold that would normally define the start of the Canadian influenza season.

While robust influenza surveillance continues, indicators this season were influenced by the COVID-19 pandemic, given the changes in healthcare-seeking behaviour, impacts of public health measures and influenza testing practices. All surveillance indicators were at historical lows despite increased testing of influenza and ongoing monitoring of the seven key components of FluWatch surveillance.

Due to the heightened surveillance of influenza and the low number of positive laboratory influenza detections, supplementary information was provided to the FluWatch program. This season, at least 27 of the 47 influenza reported detections were associated with receipt of the live attenuated influenza vaccine and likely represent the vaccine-type virus rather than community circulation of the seasonal influenza. The live attenuated influenza vaccine strains are attenuated but can be recovered by nasal swab in children and adults following vaccination with that product (i.e. "shedding") (10). In addition, one laboratory detection was a human infection with a non-seasonal influenza A virus, A/Alberta/01/2020 (H1N2)v, closely related to swine influenzas that commonly circulate in North American swine herds. This was one of five influenza infections caused by a new influenza subtype reported to WHO globally between October and December 2020 (11).

Currently, influenza activity across the Northern Hemisphere is low and stable (5). The current trend is mirroring the 2020 influenza season of the Southern Hemisphere, where historically low levels of influenza were reported throughout the entire season (4).

Low numbers of influenza detections were reported worldwide, and influenza A and influenza B were detected in roughly equal proportions (5). The United States' clinical laboratories reported higher proportions of influenza B detections (59%) compared with influenza A detections (41%) (12). In Canada, influenza A accounted for 64% of influenza viruses detected however, given low numbers, a small number of detections could significantly alter the findings.

Estimates of vaccine effectiveness and coverage are generally reported in March, but vaccine effectiveness estimates may be delayed or may not be measurable for the 2020–2021 season if low influenza circulation continues. These estimates will be included in the FluWatch Weekly report, if and when they are available.

Despite low levels of influenza activity globally, WHO has stated that the threat of influenza epidemics and pandemics persists (9). Thus, it is imperative to maintain the surveillance of influenza, to remain alert to unusual or unexpected events and to prepare to mitigate influenza epidemics when they resurge (9). Low levels of global influenza may adversely affect decisions regarding which influenza strains to include in the next season's influenza vaccines. This emphasizes the need to maintain routine influenza surveillance during the COVID-19 pandemic and to share these data with the WHO Global Influenza Surveillance Response System.

Over the previous five seasons, Canada has crossed the seasonal influenza threshold as late as week 01. While increasing activity in the new year is possible, if Canada maintains non-pharmaceutical public health measures for COVID-19 and reaches target levels of seasonal influenza vaccine coverage, the circulation of

influenza or other seasonal respiratory viruses could remain at historically low levels through the remainder of the 2020–2021 season. Recent models have shown the importance of containing seasonal influenza circulation to mitigate possible syndemic effects on COVID-19 transmission (13).

As influenza is a predictably unpredictable virus, surveillance of influenza must continue in Canada even when circulation levels are low. An increase in the susceptible population, through reduced natural infection or vaccine-induced immunity against influenza, and an eventual relaxation of public health measures, may create the potential for out-of-season waves of influenza activity (summer 2021) or a high intensity season (fall/winter 2021) in the temperate Northern Hemisphere and for several years thereafter (14). Ongoing influenza surveillance efforts will enable early detection when seasonal influenza epidemics return.

FluWatch reports will continue to be published for the remainder of the season and are available on the Weekly Influenza Reports webpage (1).

Authors' statement

The FluWatch team in the Centre for Immunization and Respiratory Infectious Diseases developed the first draft collaboratively; all authors contributed to the conceptualization, writing and revision of the manuscript.

Competing interests

None.

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COVID-19 outbreak among temporary foreign workers in British Columbia, March to May 2020

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Abstract

Background: During the coronavirus disease 2019 (COVID-19) pandemic, temporary foreign workers (TFWs) provided a critical role to maintaining the food supply in Canada, yet workers faced a number of challenges that made them particularly vulnerable to COVID-19. The objective of this study was to describe the epidemiological investigation and public health response to a COVID-19 outbreak among TFWs in an agricultural setting in British Columbia from March to May 2020.

Methods: An outbreak was declared on March 28, 2020 following detection of two cases of COVID-19 among a group of 63 TFWs employed by a nursery and garden centre. Outbreak control measures included immediate isolation of cases, case finding via outreach screening and testing, cohorting of asymptomatic workers and enhanced cleaning and disinfection. The outbreak was declared over on May 10, 2020.

Results: A total of 26 COVID-19 cases were identified among the group of TFWs; no cases were identified among local workers. Cases were primarily male (77%) with a median age of 41 years. Symptom onsets ranged from March 8 to April 9, 2020. One case required overnight hospitalization for pneumonia.

Conclusion: This was the first COVID-19 community outbreak identified in British Columbia and the first COVID-19 outbreak identified among TFWs in Canada. This outbreak began prior to implementation of provincial and federal quarantine orders for international travellers. A provincial policy was later developed that requires TFWs to quarantine in government-funded accommodation prior to deployment to agricultural settings.

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Keywords: COVID-19, outbreaks, temporary foreign workers, migrant workers, agricultural workers

Introduction

In December 2019, the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) emerged in Wuhan, China and subsequently spread globally. Coronavirus disease 2019 (COVID-19) typically manifests as influenza-like illness and the virus is primarily transmitted between people through respiratory droplets and contact routes causing widespread outbreaks. In response to the rapid spread and need for a coordinated international response, the World Health Organization (WHO) declared the COVID-19 outbreak a Public Health Emergency of International Concern on January 30, 2020 and a pandemic on March 11, 2020 (1).

International travellers are at higher risk of developing and contributing to the spatial spread of COVID-19 (2). As a result, governments around the world implemented strict international travel restrictions to limit the global impacts of the virus. In Canada, certain categories of people who provided essential services were exempt from the travel restrictions, including temporary foreign workers (TFWs) who play a critical role during the crop season by contributing to the economy and maintaining the food supply (3,4). TFWs are migrant workers who travel to Canada every year, typically from Latin America, to work in the agricultural sector. The Okanagan Valley in British Columbia (BC), Canada is a major centre for agriculture production and the operation of the agricultural industry in this region relies on the employment of TFWs.

Early in the pandemic, from March to May 2020, an outbreak of COVID-19 was declared among TFWs in an agricultural setting in the Okanagan region. This outbreak provided an insight into challenges that made TFWs particularly vulnerable during the COVID-19 pandemic. These challenges may include language and cultural barriers, fear of loss of work or even deportation if disclosing symptoms, as well as variability in adequacy of living conditions including access to laundry and food, availability of wages while isolating or sick, access to medical services and coverage of medical costs and access to transportation (5).

This report describes the epidemiological investigation and public health control measures implemented to respond to the outbreak.

Methods

Outbreak investigation team

This outbreak investigation was led by the Interior Health Medical Health Officer with a team that included an epidemiologist, two communicable disease specialists with experience in contact tracing, primary care nursing staff, a nurse practitioner, two environmental health officers and a health administrator. Additional support was provided by a seasonal worker program coordinator employed by the agricultural business affected by the outbreak, a migrant support outreach worker from a local community resource centre and two local primary care physicians.

Outbreak detection and case finding

From March 24 to 27, 2020, two confirmed cases of COVID-19 were reported among a cohort of 63 TFWs employed by a nursery and garden centre in the Okanagan region. An outbreak was declared on March 28, 2020, and declared over on May 10, 2020, following a period of 28 days (two incubation periods) since the testing date of the last identified case.

For this investigation, confirmed outbreak cases were defined as nursery workers with the following:

- Laboratory-confirmed COVID-19 (6)
- Symptom onset date on or after March 1, 2020

Epidemiologically-linked (epi-linked) cases were defined as nursery workers with the following:

- Symptoms compatible with COVID-19
- Symptom onset on or after March 1, 2020
- A known epidemiological link to a confirmed case

Case finding activities included daily symptom checks of all TFWs and a detailed symptom screening questionnaire (see **Supplemental material** information) that was administered four times throughout the investigation. The surveys were administered in person via outreach medical teams. Additional data sources included medical records of cases and interviews initiated through public health follow-up of cases and contacts. TFWs were Spanish-speaking; therefore, information and services were provided in Spanish whenever possible. Translation was provided through the Provincial Language Service (7) as well as the seasonal worker program coordinator, migrant support outreach worker and a primary care physician, all of whom were fluent in both English and Spanish.

All workers who reported symptoms compatible with COVID-19 were referred for testing. A small number of asymptomatic workers who were considered to be at highest risk of COVID-19 infection were also tested. Respiratory specimens collected as nasopharyngeal swabs underwent nucleic acid amplification testing at the regional microbiology laboratory. Extraction was performed on the STARlet liquid handling system (Hamilton) using STARmag 96 universal cartridge kits. Polymerase chain reaction (PCR) testing was carried out using the CFX96 (BioRad), using the Allplex 2019-nCoV assay targeting the E, RdRP and N genes following the manufacturer's instructions (Seegene).

Analysis

Reportable information about cases was available through Panorama, Interior Health's public health information system (8). An additional line list of all 63 TFWs was maintained that included detailed information on age, gender, arrival date to Canada, local accommodation location(s), specific work role(s) at the nursery and COVID-19 testing date(s) and results. Descriptive analyses were performed using Microsoft Excel 2010 and SAS version 9.4 software.

Public health measures

On the day the outbreak was declared, a site inspection was conducted by two environmental health officers to assess the work environment and living conditions of the workers. A public health order under the BC *Public Health Act* (9) was issued to the business operator requiring the following: enhanced cleaning of facilities accessed by employees; screening of staff, contractors and visitors; mandatory reporting of new respiratory illness among employees or contractors; and quarantine of all TFWs. This order was rescinded when the outbreak was declared over.

Case management included daily monitoring as per BC's interim guidelines for public health management of cases and contacts associated with COVID-19 (10). Daily reporting by the seasonal worker program coordinator to Interior Health's Communicable Disease Unit was requested and included the health status of cases and contacts. Any newly symptomatic individuals were reported to the Communicable Disease Unit for public health follow-up. A protocol was established to safely transport any individuals requiring healthcare services to and from healthcare facilities when use of an ambulance was not indicated. All workers also had access to virtual appointments with a primary care physician, if needed.

TFWs lived in employer-provided, shared accommodation consisting of five houses and 11 trailers across five geographically distinct sites. Symptomatic individuals were immediately isolated,

initially within existing housing locations. Due to the increasing number of cases and limited availability of single person self-contained space, symptomatic workers were later relocated to individual hotel rooms. During the outbreak, none of the TFWs were permitted to go into the community or interact with other workers outside of their geographically distinct site.

Within shared housing locations, a rotation schedule was applied for use of common areas to ensure physical distancing. Enhanced cleaning and disinfection of common areas within each housing site, such as kitchens and bathrooms, was implemented. Food and other essential supplies were delivered to each housing unit throughout the outbreak period. Communication with the workers occurred primarily by phone and email, and a mobile app (WhatsApp Inc.) was used to provide messaging to the workers and to conduct the daily symptom checks. Full personal protective equipment was worn by healthcare providers and managerial staff during site visits. Workers had access to phones to maintain connections with family and friends and received regular pay during the quarantine period.

To enable the business to maintain operations, asymptomatic workers were divided into cohorts, both in shared accommodation and at worksites, and enhanced control measures, such as portable hand washing stations and tools for self-use by individual workers, were introduced. In addition, physical distancing and staggering of breaks to prevent congregation were recommended. Lastly, a 72-hour quarantine or spray clean with 10:1 water-bleach solution was implemented to prevent transmission of SARS-CoV-2 from handled products, such as potted trees/plants, prior to being shipped to the retail store.

A medical outreach team conducted four site visits during the investigation. The team included a combination of a nurse practitioner, a registered nurse and/or a physician. The purpose of the visits was case finding, testing, monitoring of cases and education of workers and other employees. During each visit, the medical team asked all TFWs to complete the symptom screening questionnaire. The team collected respiratory specimens and conducted physical assessments of symptomatic workers including those experiencing only mild symptoms (excluding previously identified cases). In the initial stage of the investigation, an additional 12 local workers who interacted with the foreign workers were also screened to determine the extent of the outbreak among the nursery's employees. These workers were also asked to self-isolate for 14 days. During their site visits, the outreach team visited the isolated cases as part of their monitoring and to ensure their well-being. Furthermore, the visits allowed for an opportunity to educate and emphasize prevention measures with the workers and managerial personnel.

Results

Epidemiologic investigation

On March 23, 2020, the Interior Health Medical Health Officer was notified by the Ministry of Health and the Ministry of Agriculture of suspected COVID-19 in a hospitalized TFW. Laboratory-confirmation was received the following day. Routine contact tracing by public health identified one household contact who was also symptomatic and was initially considered an epi-linked case (later confirmed). On March 27, 2020, a second worker from the same nursery/garden centre presented to the hospital and was confirmed to have COVID-19. This individual resided in a separate household with no reported contact with the first confirmed case. This suggested more widespread transmission of COVID-19 among the worker population and prompted the Medical Health Officer to declare the outbreak. Seventeen additional confirmed cases were identified following the first health outreach team visit on March 30, 2020.

A total of 26 COVID-19 cases were identified, including 23 confirmed and three epi-linked cases. All cases were reported among TFWs. Thirty-one of the 63 foreign workers were tested over the course of the investigation resulting in 74% positivity (confirmed cases only) among those tested. The epi-linked cases tested negative for the SARS-CoV-2 virus; however, these individuals were managed as cases, given exposure and symptom histories compatible with COVID-19. No cases were identified among the 12 local workers (67% males; mean age 43 years; median age 44.5 years) possibly due to control measures implemented by the business owner early on, which limited interaction between the local workers and TFWs.

Characteristics of cases are shown in **Table 1**. The majority of outbreak cases were male (77%) with a mean and median age of 41 years. The age and sex distribution of cases reflected that of the full cohort of 63 TFWs. Symptom onsets ranged from March 8 to April 9, 2020. Symptom onsets were not available for five (19%) cases. One case required overnight hospitalization for pneumonia and all cases recovered fully from their illness. **Figure 1** shows an epidemic curve of outbreak cases by episode date from March 8 to May 11, 2020. Key investigation dates are also shown.

Implementation of worker cohorting

All 63 TFWs were considered to be potentially exposed to COVID-19 and were therefore required to isolate. Asymptomatic workers were separated into cohorts within shared accommodations as isolation of all workers in single rooms with private bathrooms (i.e. in hotel rooms) was neither feasible nor practical. Employer-provided accommodations were clean, well maintained and stocked with essential items, such as liquid soap, paper towel and cleaning supplies. Initially, all asymptomatic workers were required to self-isolate in their rooms within the shared housing. Later on, when the outbreak control measures had been fully implemented, asymptomatic workers returned to work within their geographical sites with physical distancing,

Table 1: Characteristics of COVID-19 cases included in the outbreak investigation (N=26)

Characteristics of COVID-19 cases	Number of cases	% of total
Cases		
Confirmed	23	88%
Confirmed epi-linked	3	12%
Total	26	100%
Symptoms		
Onset date range	March 8–April 9, 2020	March 8–April 9, 2020
Asymptomatic/not provided	5	19%
Demographics		
Males	20	77%
Females	6	23%
Age group (years)		
Younger than 35	5	19%
35–39	5	19%
40–44	8	31%
45 and older	8	31%
Hospitalized	1	4%

Abbreviation: COVID-19, coronavirus disease 2019

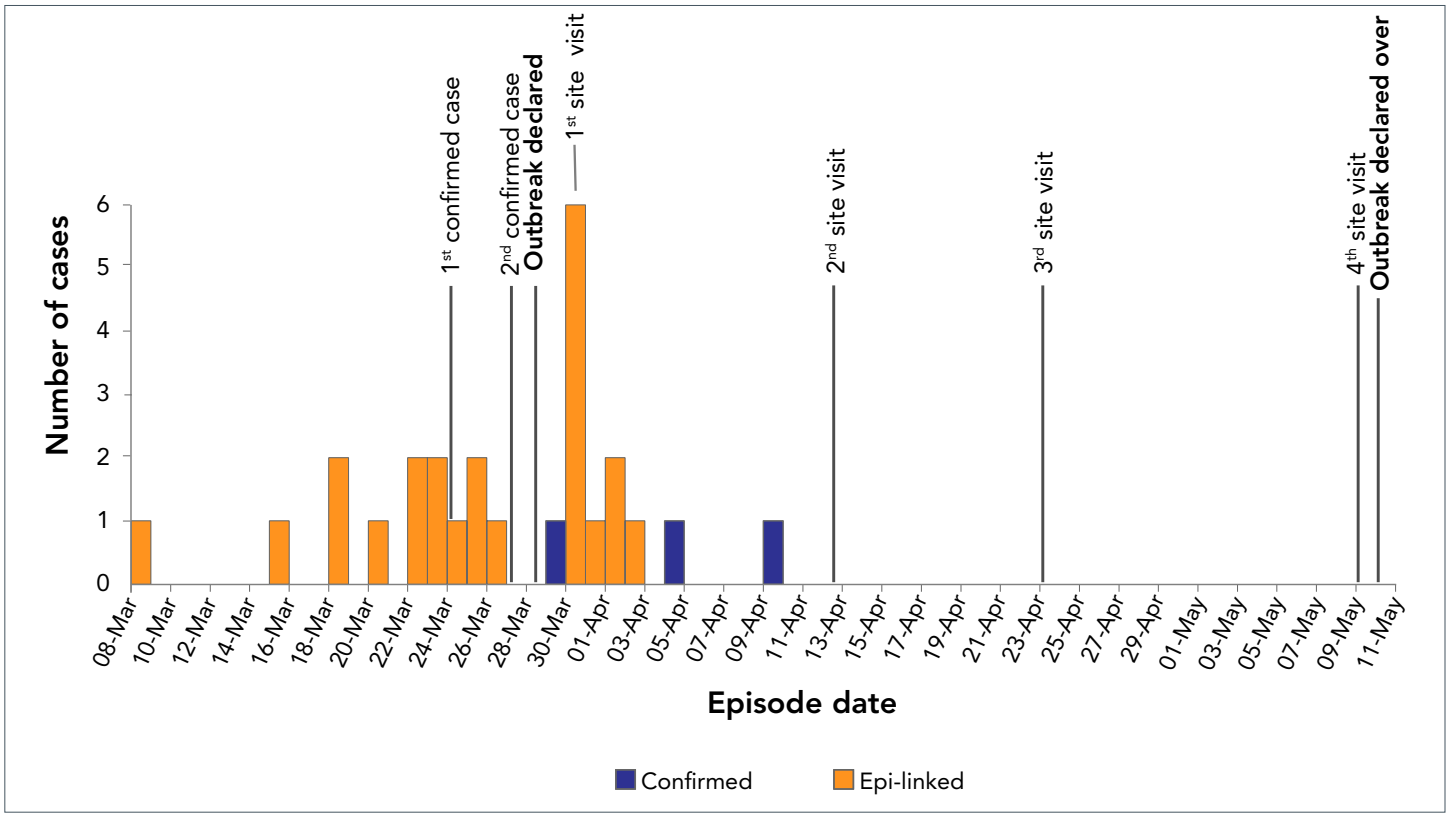
while continuing to isolate in their households when not at work. Their roles consisted of activities in fields and greenhouses that were geographically separated from other nursery facilities and did not include the retail space open to the public. Of note, of the five geographically distinct accommodation sites, only one site did not have any COVID-19 cases identified among the workers (five TFWs). This accommodation/work site was considered more geographically isolated than the other locations with limited interaction with the other workers prior to the outbreak detection.

Discussion

This report summarizes a COVID-19 outbreak affecting a group of TFWs in an agricultural setting. The outbreak was declared shortly after WHO assessed COVID-19 as a pandemic and in the early days of Canada's epidemic. This was the first COVID-19 community outbreak identified in BC and the first COVID-19 outbreak identified among TFWs in Canada. Since this time, other outbreaks affecting agricultural workers have been reported (11–13).

TFWs are generally a healthy workforce. Thus, two COVID-19 cases from different worker households requiring hospital attention suggested the "tip of the iceberg" in terms of the potential for other milder cases in the worker group. This

Figure 1: Epidemic curve of outbreak COVID-19 cases by episode date[a], March 8 to May 11, 2020 (N=26)



Abbreviation: COVID-19, coronavirus disease 2019
[a] Episode date based on symptom onset (n=21); if not available, then specimen collection date (n=5, all March 30)

prompted the outbreak declaration. Subsequent screening of all workers with a symptom screening questionnaire resulted in the detection of several additional cases who, given that their symptoms were mild, had not sought care.

During the investigation, we identified a number of barriers to care among TFWs. Despite daily symptom checks, delayed reporting of symptoms was noted for some individuals and may have been due to health literacy and language barriers, but also fear about missed work, lost wages and lack of healthcare coverage. Access to multilingual service providers was an important factor in delivering culturally safe and appropriate care. Spanish-speaking service providers were included in each outreach visit, which minimized the need for employer-provided staff to translate and potentially deter the workers from fully sharing health concerns. TFWs also had access to a local physician from the same country of origin as the workers, and access to telehealth services with this physician was facilitated by billing changes (14) triggered by the COVID-19 pandemic.

TFWs affected by this outbreak arrived to Canada between January 16 and March 12, 2020, just prior to the provincial and federal quarantine orders for international travellers. On March 17, BC's Provincial Health Officer introduced an order for international travellers returning to, or arriving in, BC to self-isolate for 14 days (15). A week later, on March 24, the federal government enacted a similar mandatory quarantine order for returning travellers (16). At the time of writing this report (July 2020), all TFWs entering BC are required to self-isolate in government-managed accommodation for 14 days prior to their deployment to farms. During this time, employers are responsible for paying workers for a minimum of 30 hours per week and provincial funding is available for hotel and other supporting costs. Workers are also screened before departure from their country of origin and upon arrival in Canada (17). In addition, national guidelines have been developed to assist employers of TFWs in understanding their role in helping to protect the health and safety of their employees in the context of COVID-19 (18).

Strengths and limitations

Strengths of this outbreak investigation include the collaboration between the affected business and health officials throughout the course of the investigation, the coordinated response involving both internal and external stakeholders, and the occurrence of this outbreak in a well-defined cohort of workers. The nursery management was proactive in terms of having measures in place for prevention and early identification of cases in the time leading up to the outbreak declaration. The employer also provided wages and essential supplies to workers throughout the period of isolation as well as single-site accommodation as required for symptomatic workers. A limitation of this investigation was that we did not test all of the 63 TFWs for SARS-CoV-2. We tested only those who were symptomatic and a small number of other workers that we felt were at highest risk of infection given their potential exposure to a confirmed case. At the time of the outbreak, the incidence of COVID-19 was rapidly increasing in BC and there were concerns about a potential shortage of nasopharyngeal swabs. It is likely that broader testing within the foreign worker population would have identified further cases. Risk factor analysis was also limited in this investigation. When the outbreak was detected, significant transmission had already occurred within the TFW cohort. Accommodation and work site groups were also rearranged during the investigation to minimize exposures and transmission. As a result, we were unable to identify particular locations that were risk factors for symptomatic infection and were limited in our ability to identify how the infection might have originated and spread through the group. There is potential for whole genome sequencing to provide additional insights into the disease transmission pattern in a future phase of the outbreak analysis.

Conclusion

TFWs have had unique risks during the COVID-19 pandemic as demonstrated by this outbreak, which occurred in an agricultural setting in BC. Transmission of COVID-19 was confirmed through prompt identification and declaration of an outbreak and repeated symptom screening followed by targeted testing. Immediate quarantine of affected workers, comprehensive follow-up of cases and contacts, and mobilization of an outreach team were effective strategies to manage and control this outbreak. These measures were implemented while still allowing for some continued business operations. Provincial and federal orders and guidance have since been developed to reduce outbreak risk in agricultural settings and to protect the health and safety of both workers and Canadians in the context of the pandemic.

Authors' statement

SCM — Conceptualization
SCM, GF, KH, CY, AA, JJ, AUL, TA, MR — Investigation
SCM, GF — Writing original draft
SCM, GF, KH, CY, AA, JJ, CG, AUL, TA, MR — Writing review and editing

Competing interests

None.

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Supplemental material

Symptom Assessment Survey (English) (https://www.canada.ca/content/dam/phac-aspc/documents/services/reports-publications/canada-communicable-disease-report-ccdr/monthly-issue/2021-47/issue-1-jan-2021/ccdrv47i01a02as-eng.pdf)

Encuesta de Evaluación de Salud (Español) (https://www.canada.ca/content/dam/phac-aspc/documents/services/reports-publications/canada-communicable-disease-report-ccdr/monthly-issue/2021-47/issue-1-jan-2021/ccdrv47i01a02bs-eng.pdf)

The content and view expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

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OUTBREAK

Escherichia coli O121 outbreak associated with raw milk Gouda-like cheese in British Columbia, Canada, 2018

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Abstract

Background: In 2018, a Shiga toxin–producing *Escherichia coli* O121 outbreak that affected seven individuals was associated with raw milk Gouda-like cheese produced in British Columbia, Canada.

Objectives: To describe the *E. coli* O121 outbreak investigation and recommend greater control measures for raw milk Gouda-like cheese.

Methods: Cases of *E. coli* O121 were identified through laboratory testing results and epidemiologic surveillance data. The cases were interviewed on exposures of interest, which were analyzed against *Foodbook Report* values for British Columbia. Environmental inspection of the dairy plant and the cheese products was conducted to ascertain a source of contamination. Whole genome multi-locus sequence typing (wgMLST) was performed on all positive *E. coli* O121 clinical and food isolates at the provincial laboratory.

Results: Four out of the seven cases consumed the same raw milk Gouda-like cheese between August and October 2018. The implicated cheese was aged longer than the required minimum of 60 days, and no production deficiencies were noted. One sample of the implicated cheese tested positive for *E. coli* O121. The seven clinical isolates and one cheese isolate matched by wgMLST within 6.5 alleles.

Conclusion: Raw milk Gouda and Gouda-like cheese has been implicated in three previous Shiga toxin–producing *E. coli* outbreaks in North America. It was recommended product labelling to increase consumer awareness and thermization of milk to decrease the risk of illness associated with raw milk Gouda and Gouda-like cheese.

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Keywords: *Escherichia coli* O121, raw milk, Gouda, cheese, foodborne, disease outbreak

Introduction

Shiga toxin–producing *Escherichia coli* (STEC) is a major cause of foodborne illness in North America. STEC infections cause diarrheal illness and may lead to severe complications, such as hemolytic uremic syndrome, and death (1,2). The incidence rate of O157 STEC illness has been decreasing, whereas the rate of non-O157 STEC, including O121, has been increasing in many countries, likely due to changes in laboratory methods of detection (3,4). Outbreaks of STEC O121 have been associated with raw flour, fresh or frozen produce, dairy and beef products (1,5–8).

The risk of STEC due to unpasteurized dairy products has been previously described (9–11). Between 2002 and 2013, three *E. coli* O157 outbreaks associated with raw milk Gouda cheeses aged for at least 60 days were reported in North America (12–14), including one associated with a British Columbia (BC) dairy plant (13). Following each outbreak, public health professionals recommended strengthening control measures to decrease the risk associated with raw milk Gouda cheeses (12–15). None of these changes had been implemented in Canada by 2018.

In November 2018, another STEC outbreak associated with a raw milk Gouda-like cheese occurred in BC (population: 5.1 million).

The objective of this article is to describe the outbreak investigation and findings and reiterate the need for greater control measures related to raw milk Gouda-like cheese.

Methods

Shiga toxin–producing *E. coli* cases are reportable in BC (16). The local health authorities interview all reported cases using a standard surveillance form, collecting demographic, clinical and exposure data for 10 days, equivalent to the maximum incubation period (17).

A confirmed case was defined as a person infected with *E. coli* O121 between August 1, 2018, and November 30, 2018, visiting or residing in BC, with an isolate matching within 10 alleles by whole genome multi-locus sequence typing (wgMLST). A single interviewer used an outbreak questionnaire focusing on dairy, meat and farm exposures to re-interview cases.

We compared case exposures to those of the BC population using *Foodbook Report* values (18). Binomial probability was used to calculate the risk of exposure by comparing the observed proportion of cases exposed in the outbreak to the expected proportion of individuals exposed in the BC population. A $p<0.05$ was used to denote statistical significance. Case purchase data were collected using grocery store consumer cards and shopping receipts and reviewed to identify similar products as well as purchase dates and brands. Samples of leftover products were collected from case homes and grocery stores. All case data and exposure information were analyzed using Microsoft Excel.

Investigators inspected the dairy plant that was the source of the outbreak ("dairy plant A"), reviewed records related to cheese production and distribution, collected samples and, in collaboration with local health inspectors, investigated potential sources of contamination and any deficiencies in the manufacturing process. They also determined the product distribution pathways for the implicated cheese.

The BC Ministry of Agriculture supplied information about the condition of the cow herd and results of routine raw milk testing including non-hemolytic *E. coli*, total bacterial count and somatic cell count using standard automatic testing methods. Cheese testing by dairy plant A was conducted under a mandatory finished product testing program.

Local BC laboratories with positive molecular assays for *stx* genes submit all the positive samples to the BC Centre for Disease Control (BCCDC) Public Health Laboratory. Other frontline laboratories submit *E. coli* O157 isolates, bloody stools and/or stools from patients with hemolytic uremic syndrome, according to provincial guidelines, to the Public Health Laboratory for *stx1* and *stx2* gene detection and culture (19). All STEC received at, or recovered by, the Public Health Laboratory are routinely serotyped using a gene detection polymerase chain reaction (PCR) targeting the most common serotypes in BC: O26, O45, O111, O103, O121 and O145.

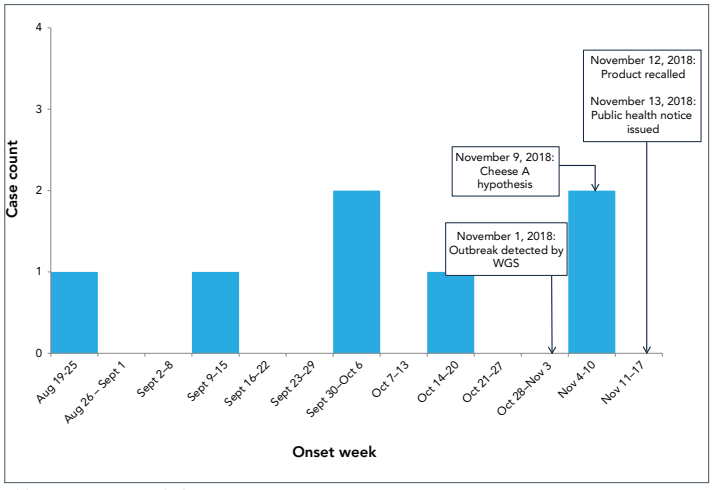
The Public Health Laboratory tested food samples and environmental swabs using an adaptation of published Health Canada *Compendium of Analytical Methods* for *E. coli* O157:H7 (20). The molecular detection of *stx1* and *stx2* genes and O-typing was performed in enrichment broth. Positive detection in enrichment broths necessitated subsequent culture isolation. These isolates were then serotyped as described above.

All STEC isolates underwent wgMLST. The wgMLST schema for *E. coli* compared 17,380 loci in the *E. coli* genome according to standardized procedures used by PulseNet Canada (21). The PulseNet criterion of isolates with 10 or less allele differences was used to define a wgMLST genomic cluster.

Results

There were seven confirmed cases. The onset dates ranged from August 19 to November 9, 2018 (**Figure 1**). Six cases resided in Health Region 1 and one in Health Region 2. The median age was 28 years (range: 22–64 years). Five were female. There were no hospitalizations and no deaths were reported.

Figure 1: Confirmed outbreak cases of *Escherichia coli* O121 infection by week of illness onset and dates of major outbreak investigations and control actions, British Columbia, 2018



Abbreviation: WGS, whole genome sequencing

Based on initial case interviews, all seven cases reported consuming cheese. No secondary interview information was available for one case. Secondary interviews (conducted with six cases) as well as purchase data (available for two cases)

identified five cases who consumed a "spicy" or "spiced" cheese from dairy plant A, and one case who ate cheese but did not recall eating cheese from dairy plant A. Four cases confirmed consuming cheese A, a raw milk Gouda-like cheese with added spices that was produced at dairy plant A in Health Region 1. One of the four cases visited dairy plant A in August to September, where they sampled cheese A, and the other three purchased cheese A from three different grocery stores between September and October.

Outbreak cases were significantly more likely to have consumed Gouda or Gouda-like cheese ($p<0.001$) as well as any unpasteurized cheese ($p<0.001$) than the healthy BC population (6.3%, and 0.9%, respectively) (18). Consumption data on raw milk Gouda-like cheese were unavailable for the healthy BC population.

Dairy plant A was a farmstead operation with approximately 45 dairy cows that supplied all the milk for the plant's cheese production. Cheese A was a raw milk washed curd cheese made following a process similar to that used to make Gouda cheese. The curd, obtained after coagulation and cutting, was washed in a mixture of whey and hot water and mixed with a blend of spices that had been boiled in water. Blocks of cheese curd were vacuum-sealed in bags and aged for at least three months. After aging, cheese blocks were cut and packaged onsite for distribution and sale at farmers' markets, grocery stores, restaurants and at the farmgate store.

Routine testing of the farm's raw milk by the Ministry of Agriculture between May and November 2018 found low total bacterial counts, low somatic cell counts and absence of non-hemolytic *E. coli*. Dairy plant A's product testing of cheese A was in compliance, testing below the detection limit for *E. coli*. Review of the inspection records revealed no major deficiencies.

Lot traceability from dairy plant A to the distributor and direct accounts was maintained, but lot traceability from the distributor to retail accounts was not maintained. The best-before date on the retail sample package of cheese A that tested positive allowed inspectors to identify the production date as March 31, 2018. This batch was cut on August 1, 7 and 8, 2018. Apart from some pieces that were served onsite to visitors, a single distributor received the entire batch on August 8 and 14, 2018, and distributed it to retail locations throughout BC.

Initial detection of an *E. coli* O121 *stx2* cluster of two clinical cases clustering by wgMLST occurred on October 25, 2018. A third *E. coli* O121 case was detected and matched by wgMLST on November 1, 2018. Four additional clinical cases of *E. coli* O121 *stx2* were subsequently identified.

The Public Health Laboratory tested 41 cheese samples from 24 batches between April 27, 2018, and November 2, 2018, as well as three spice samples, one meat sample and 11 environmental samples from dairy plant A. Thirty-eight cheese samples were collected from dairy plant A, one sample of cheese A was collected from a retailer in Health Region 2, and two unopened packages of different dairy plant A cheese were collected from a case's home. One cheese sample tested positive for *stx2* and two for *stx1* (**Table 1**). The *stx2*-positive sample grew *E. coli* O121, whereas the two *stx1* samples were unable to grow. All other samples, including the environmental swabs, tested negative.

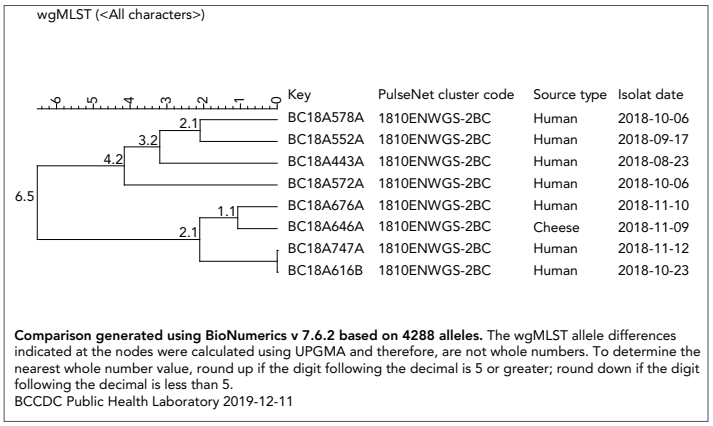
Table 1: Results of food and environmental testing, *Escherichia coli* O121 outbreak, British Columbia, 2018

Sample type, production date	Sample location	Shiga toxin result	Culture result, serotype
Cheese A, March 31, 2018	Retail	Positive; *stx2*	*E. coli*, O121
Cheese A, April 27, 2018	Dairy plant A	Positive; *stx1*	Unable to isolate
Cheese A, August 3, 2018	Dairy plant A	Positive; *stx1*	Unable to isolate
Non–cheese A sample (n=2)	Case home	Negative	N/A
Environmental swabs (n=11)[a]	Dairy plant A	Negative	N/A
Other foods (n=40)[b]	Dairy plant A	Negative	N/A

Abbreviation: N/A: not applicable
[a] Environmental swabs included four swabs of vat pasteurizer outlet valve, two swabs of raw milk line, two swabs of aging room wall and lights, two swabs of raw milk pump and a filter sock used in the raw milk tank
[b] Other foods: cheese wheels of cheese A (n=17), cheese wheels of other cheese types (n=19), spice mixes (n=3), meat sample (n=1)

All clinical and food isolates clustered by wgMLST within 0 to 6.5 alleles (**Figure 2**). The *stx2*-positive cheese isolate clustered within one allele of the nearest clinical isolate and by six alleles of all clinical isolates within the outbreak. The next closest STEC isolate in the PulseNet Canada database was 45 alleles different from the closest isolate in the outbreak.

Figure 2: Phylogenetic tree of *Escherichia coli* O121 outbreak cases and cheese A sample, British Columbia, 2018



Abbreviations: BCCDC, BC Centre for Disease Control; UPGMA, unweighted pair group method with arithmetic mean; wgMLST, whole genome multi-locus sequence typing

Dairy plant A discontinued production of cheese A on November 9, 2018, and all lots of cheese A at the dairy plant were placed on hold. All lots of cheese A were recalled on November 12 and a public health notice was issued on November 13 (Figure 1). No additional cases occurred after these actions were taken. By March 2019, all the detained cheese had been destroyed.

Discussion

An investigation of a STEC outbreak involving seven cases was conducted in BC between August and November 2018. The outbreak was associated with the consumption of a raw milk Gouda-like cheese product and was due to raw milk contamination. This STEC outbreak was the second in BC, the third in Canada and the fourth in North America to be caused by raw milk Gouda or Gouda-like cheese since 2002 (12–14). It was the first to be caused by *E. coli* O121. This investigation adds further evidence to the series of calls to action by public health professionals to improve control measures in the production of raw milk Gouda and Gouda-like cheeses.

Epidemiologic, laboratory and food safety investigations confirmed raw milk Gouda-like cheese to be the source of this outbreak. All seven outbreak cases reported consuming cheese, with five reporting consuming cheese from the same BC dairy plant and four reporting consuming the same cheese product. A sample of this cheese product tested positive for the same strain of *E. coli* O121 as the cases. A single batch of this cheese could explain all the illnesses; cheese from this batch was the only one that tested positive for the outbreak strain among the 16 tested and the implicated batch was available to all cases for consumption. All other cheese products and environment swabs tested negative for STEC. Furthermore, the specific cheese product contained no pasteurization and no kill step for the raw protein, which is a known vehicle for transmission of pathogens. Therefore, contaminated raw milk is believed to be the source of cheese contamination. Cattle are the primary reservoir of STEC, and infected cows are asymptomatic and shed sporadically (22,23).

This outbreak was solved and controlled very rapidly. The outbreak investigation was launched on November 1. The reporting of cheese consumption by four cases on November 5 led to the hypothesis that cheese was the source. Following re-interviews, cheese A was hypothesized as the source of the outbreak on November 9. The food safety investigation started on November 9, a cheese A sample tested positive on November 11 and the product was recalled on November 12. The duration of the outbreak investigation was 11 days, which is much shorter than the median of 39 days for BC outbreak investigations (24). The rapidity of the investigation and actions taken by investigators and the dairy plant minimized the impact on the population.

Dairy plant A was compliant with current Canadian regulatory requirements and aged its raw milk Gouda-like cheese for over 60 days (25). Nevertheless, three separate batches were found to be contaminated with STEC.

This is the third reported STEC outbreak caused by raw milk Gouda or Gouda-like cheese aged longer than the 60-day minimum (13,14,26). Several studies have shown that 60 days of aging is insufficient to inactivate pathogenic bacteria in Gouda cheese (12,15,17,27). Gouda and Gouda-like cheese production involves a curd-washing step to reduce the amount of lactose in the cheese curds. The combined effects from the addition of hot water to the curds dilutes out the lactose in the whey, shrinks the curds to expel moisture and creates an osmotic gradient across the curd membrane to draw out lactose while reabsorbing water. This new state decreases the formation of lactic acid, thus increasing the pH and moisture of the curd. Higher pH and moisture increase the risk of survival and growth of microbial contaminants (28).

This outbreak provides further evidence of the inherent risk of raw milk Gouda and Gouda-like cheeses. This is the fourth call to strengthen the regulatory requirements for such cheeses. At a minimum, we recommend enhancing milk and cheese-processing controls and increasing consumer awareness. As a result of this outbreak, we recommend the thermization of raw milk prior to production of Gouda and Gouda-like cheeses to decrease the risk of microbial contamination yet retain the appeal of unpasteurized milk cheese. Thermization of raw milk at 64.4°C for 17.5 seconds can achieve at least a five-log reduction of *E. coli* O157:H7 (29–31). We also recommend mandatory product labelling to indicate whether raw, unpasteurized or pasteurized milk is used to increase consumer awareness and support informed decision-making. Dairy plant A now uses pasteurized milk, discontinued the curd-washing step and standardized the heating step to prepare the spice mixes, leading to a lower-risk cheese.

Limitations

There are several limitations in this investigation. Neither the health of the cows on the farmstead nor the quality of the milk were examined during the outbreak. Therefore it was not confirm whether *E. coli* O121 *stx2* was present in the herd at the time of the outbreak. In addition, the traceability of the cheese from the manufacturer to retailers was limited by poor records. Lastly, no raw Gouda or Gouda-like cheese exposure data were available for the healthy population controls to allow a direct comparison to outbreak cases.

Conclusion

This outbreak provides further evidence that raw milk Gouda and Gouda-like cheese processed according to regulations in North America is at risk of containing STEC, which contributes to foodborne illness. It is recommended implementing additional control measures for raw milk Gouda and Gouda-like cheese production to minimize the risk to the public.

Authors' statement

EB — Analyzed and interpreted the data and drafted the article
MT — Conceptualized the work, analyzed and interpreted the data and revised the article
JS — Contributed to the acquisition of the data for the work and revised the article
SS — Contributed to the acquisition of the data for the work, drafted certain sections and revised the article
AT — Contributed to the acquisition of the data for the work, drafted certain sections and revised the article
PH — Conceptualized the work, interpreted the data and revised the article
LH — Contributed to the acquisition and interpretation of the data and revised the article
LJ — Contributed to the acquisition and interpretation of the data drafted certain sections and revised the article
SM — Contributed to the acquisition, analysis and interpretation of the work and revised the article
CT — Contributed to the acquisition, analysis and interpretation of the work, drafted certain sections and revised the article
EG — Conceptualized the work, interpreted the data, drafted certain section and revised the article

Competing interests

None.

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Interim guidance on the use of the Abbott Panbio™ COVID-19 Antigen Rapid Test

on behalf of Canadian Public Health Laboratory Network Laboratory Directors Council and the Canadian Public Health Laboratory Network Respiratory Virus Infection Working Group

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Introduction

This document, prepared December 12, 2020, provides interim guidance on the use of the Abbott Panbio™ COVID-19 Antigen Rapid Test in the context of the Canadian public health system and a coordinated national response to the coronavirus disease 2019 (COVID-19) pandemic.

The Panbio COVID-19 Antigen Rapid Test is used for the qualitative detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) antigen in human nasopharyngeal (NP) swab samples collected from individuals who are suspected of COVID-19 by their healthcare provider. The Panbio COVID-19 Antigen Rapid Test Device functions as a lateral flow assay including both a control and COVID-19 specific test line within a results window. After application of a patient specimen to the test device, the presence of a control line within the results window confirms the validity of the test result while the presence of a test line is interpreted as positive for COVID-19.

It should be noted that while Abbott already markets an antigen rapid test that is in widespread use in the United States (BinaxNOW™ COVID-19 Antigen Card), the antigen test, which has been approved for use and is being marketed in Canada (Panbio COVID-19 Antigen Rapid Test), is manufactured in a different facility. Furthermore, the two versions of the Abbott antigen capture test for COVID-19 differ considerably in their design attributes. As such, performance characteristics may not be the same. Canadian clinical data is required to validate the test that is in distribution nationally and at the time of writing, this data has not yet been adequately collected. Prior to authorization of the Panbio COVID-19 Antigen Rapid Test by Health Canada, the Canadian Public Health Laboratory Network formed a working group to verify performance characteristics of various antigen capture technologies coming to market. At the time of writing of this document, the evaluation and verification of the clinical sensitivity of the Panbio COVID-19 Antigen Rapid Test is ongoing. However, preliminary analytical sensitivity data suggest that the Panbio COVID-19 Antigen Rapid Test will likely have a lower sensitivity when compared with nucleic acid amplification tests, including the Abbott ID NOW™ (**Table 1**).

Table 1: Performance comparison between the Abbott ID NOW™ and Abbott Panbio™ Rapid tests for SARS-CoV-2[a]

Patient identification[b]	qPCR test location	E-gene Ct	Adjusted Ct for input[c]	Approximate number of input copies[d,e]	ID NOW result	Panbio result
Patient 1	CPL	16	22.6	1,294,497	**Positive**	**Positive**
Patient 2	CPL	19	25.6	271,908	**Positive**	**Positive**
Patient 3	CPL	19	25.6	383,421	**Positive**	**Positive**
Patient 4	CPL	20	26.6	586,124	**Positive**	**Positive**
Patient 5	NML	20.4	27	ND	**Positive**	**Positive**
Patient 6	NML	22.2	28.8	ND	**Positive**	**Positive**
Patient 7	NML	22.3	28.9	ND	**Positive**	**Positive**
Patient 8	NML	24.6	31.2	ND	**Positive**	Negative
Patient 9	CPL	25	31.6	16,116	**Positive**	Negative
Patient 10	NML	25.2	31.8	ND	**Positive**	Negative
Patient 11	CPL	26	32.6	1,547	**Positive**	Negative
Patient 12	CPL	26	32.6	2,428	**Positive**	Negative
Patient 13	NML	27.9	34.5	3,681	**Positive**	Negative
Patient 14	CPL	30	36.6	164	**Positive**	Negative
Patient 15	NML	30	36.6	ND	**Positive**	Negative
Patient 16	NML	31.6	38.2	272	**Positive**	Negative
Patient 17	CPL	Negative	0	0	Negative	Negative
Patient 18	CPL	Negative	0	0	Negative	Negative
Patient 19	CPL	Negative	0	0	Negative	Negative
Pooled	NML	Negative	0	0	Negative	Negative

Abbreviations: CPL, Cadham Provincial Laboratory; NML, National Microbiology Laboratory; qPCR, polymerase chain reaction; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2
[a] Patient samples in transport media were spiked into the ID Now or Panbio rapid tests, along with a healthy donor nasopharyngeal swab
[b] 19 clinical samples were used as the study panel (16 positive and 4 negative)
[c] Adjusted Ct is the theoretical Ct adjusted for differences in input volume
[d] ND = viral load not determined on GeneXpert
[e] Viral concentration was determined for some patient samples used in this panel with the GeneXpert and an in-house standard curve

The use of a lower sensitivity test carries risks to clinical and public health decision-making that can only be offset by the extent of possible benefits. Careful consideration must be made regarding where and how the Panbio COVID-19 Antigen Rapid Test is used in order to mitigate the heightened degree of diagnostic uncertainty associated with this technology in comparison with the conventional "gold standard" SARS-CoV-2 diagnostic testing in Canada.

These guidelines are meant to be updated periodically as more information is available regarding test sensitivity and specificity in the overall context of infection with SARS-CoV-2.

While this document as currently written is specific for the Abbott Panbio, many of these guidelines may also be applied to any less sensitive molecular and rapid antigen-based tests that are approved for use in the future.

Key messages

- Health Canada provided approval for use of the Panbio COVID-19 Antigen Rapid Test (October 2020).
- The Intended Use for this assay is outlined in the Panbio COVID-19 Antigen Rapid Test kit insert and states the following:
  "The Panbio COVID-19 Antigen Rapid Test Device is an *in vitro* diagnostic rapid test for the qualitative detection of SARS-CoV-2 antigen in human nasopharyngeal swab specimens from individuals who meet COVID-19 clinical and epidemiological criteria. Panbio COVID-19 Antigen Rapid Test Device is for professional use only and is intended to be used as an aid in the diagnosis of SARS-CoV-2 infection. The product may be used in laboratory and non-laboratory environments that meet the requirements specified in the Instruction for Use and local regulation. The test provides preliminary test results. Negative results don't preclude SARS-CoV-2 infection and they cannot be used as the sole basis for treatment or other management decisions. Negative results must be combined with clinical observations, patient history, and epidemiological information. The test is not intended to be used as a donor screening test for SARS-CoV-2."
- Clinical performance of the Panbio COVID-19 Antigen Rapid Test must continue to be carefully monitored due to the anticipated low sensitivity of the assay.
- The performance of the assay should be verified in the field before recommending its use. This is critical since data obtained from pre-market evaluations cannot adequately account for anticipated variability in training or in the quality of sample collection that follows its use in a broader population, and particularly, in point-of-care (POC) situations.
- The Panbio COVID-19 Antigen Rapid Test requires the collection of an NP swab. This test may be less acceptable for serial testing of populations, particularly in low-risk and asymptomatic individuals, as compared with other tests (i.e. Abbott ID NOW, which, in addition to NP swabs, can also be operated with throat or nasal swabs).
- The "in-field" performance characteristics of the Panbio COVID-19 Antigen Rapid Test is still under evaluation in Canada; however, data about the performance of the Panbio COVID-19 Antigen Rapid Test assay in the United States suggest that the tests have lower sensitivity but comparable specificity to laboratory-developed tests and commercial nucleic acid amplification tests.
- Although the rapid nature and the ease of use of the Panbio COVID-19 Antigen Rapid Test makes it suitable for POC applications, the performance characteristics described above combined with the incidence of infection within the population being tested must be considered when interpreting the results.
  - Indications for testing (e.g. symptomatic versus asymptomatic, outbreak vs non outbreak, congregated settings vs general population) are also an important consideration in use of this technology.
- In discussion with provincial and territorial laboratory directors, careful consideration regarding the use of this test must be in place.
  - At this time, until further data is collected, because of the decreased sensitivity, all negatives should be considered preliminary negatives.
  - Owing to an expected higher rate of false negatives (relative to conventional nucleic acid amplitude testing), it is recognized that reflexive laboratory-based testing of preliminary negatives from the Panbio COVID-19 Antigen Rapid Test (depending on its proposed use) will likely introduce an additional burden to reference laboratories already facing enormous testing volumes. The utility of lab retesting using a more sensitive method must take into account the initial indication for testing.
- This document outlines scenarios where the Panbio COVID-19 Antigen Rapid tests may prove useful, should the expected performance characteristics be confirmed.

Current approach to SARS-CoV-2 testing in Canada

Since the emergence of SARS-CoV-2, testing has been a key pillar of Canada's response to the pandemic. The broad use of testing, as part of an array of public health measures, contributed to a flattening of the epidemic curve in the spring of 2020, demonstrating the value of testing as a part of the COVID-19 response. To date, testing has relied on molecular (i.e. reverse transcription polymerase chain reaction; RT-PCR) testing

performed on a NP or alternate respiratory sample collected by a health care professional. **This testing method currently remains the gold standard for detecting SARS-CoV-2 infection in Canada.**

Considerations for the use of the Panbio COVID-19 Antigen Rapid Test

Notwithstanding the difference in the performance profile, other features of the Panbio COVID-19 Antigen Rapid Test (including, but not limited to, faster turnaround time, lower per-test cost, ability to deliver testing in some jurisdictions by non-healthcare professionals and on a more frequent basis) suggest that it could have an important role to play in the next phase of the pandemic response.

It is critically important to understand the timing of specimen collection in relation to symptom onset, since the lower sensitivity of the test is not expected to be uniform over the course of infection. Data suggest that viral shedding may begin 2–3 days before symptoms appear, peaking around the time of symptom onset and then declining gradually over time (1,2). During the first five days of symptom onset, viral loads are most likely to be above the limit of detection for the Panbio COVID-19 Antigen Rapid Test, although the time post-symptom onset still needs to be carefully considered. It is also important to understand test performance relative to the time since a potential exposure (i.e. the number of days after exposure that one might expect to have viral loads that can be optimally detected with the Panbio COVID-19 Antigen Rapid Test) when used for rapid contact tracing.

It is important for public health, microbiology and infectious disease experts to identify the scenarios whereby the use of the Panbio COVID-19 Antigen Rapid Test may further strengthen the public health response by 1) expanding access to testing beyond existing indications and 2) increasing capacity for detection of SARS-CoV-2. Furthermore, establishing mechanisms to allow the results from a new POC test to be efficiently input into the public health system is critical (see Reporting of results and quality control section below).

Balancing test sensitivity against other considerations

The intrinsic performance characteristics of the Panbio COVID-19 Antigen Rapid Test are not the only factors that determine its utility. **The final interpretation of a test must take into account the performance parameters, prevalence of infection, predictive values and intended use of the test result.** Therefore, the tolerance for sensitivity and specificity thresholds will vary based on the reason for testing and the expected action that would follow either a positive or a negative result.

In scenarios where critical decisions and actions rely on a test result (e.g. a symptomatic resident in a long-term care home or a patient in the Intensive Care Unit who requires immediate treatment), the recommended test would be the most accurate test. At the time of writing, the indicated (best) test would be RT-PCR performed on a NP sample or lower respiratory tract samples in those with evidence of pneumonia. However, there may be circumstances where a rapid POC test would be permissible and would enhance testing capacity to support the public health response, particularly when the demand for RT-PCR testing exceeds laboratory capacity, is otherwise unavailable or in situations where a symptomatic individual may otherwise be lost to follow-up.

Proposed use of the Panbio COVID-19 Antigen Rapid Test

One strategy to reduce the sensitivity gap of a technology would be to use repeat serial testing. However, this may not be feasible with the Panbio COVID-19 Antigen Rapid Test. This technology specifically requires the use of a NP swab, which may limit its utility and uptake owing to the uncomfortable nature of the patient specimen collection and the requirement for collection by a healthcare professional. In low prevalence, low-risk settings, serial repeat testing with the Panbio COVID-19 Antigen Rapid Test may not be ideal. This may be particularly relevant in settings involving a paediatric population (daycares, schools, sport teams).

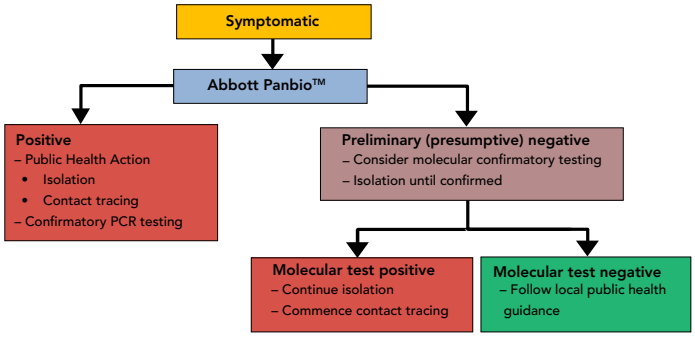
There are, however, specific situations that the Panbio COVID-19 Antigen Rapid Test might be considered as a suitable option: when infection is present (whether symptomatic or asymptomatic) within a community; symptomatic testing in congregated settings; symptomatic testing in Northern, remote and isolated (NRI) communities; and asymptomatic community-based surveillance in the general population.

Infection is prevalent within a community

The Panbio COVID-19 Antigen Rapid Test could be used to test individuals when the prevalence of infection is high within a community and the access to timely RT-PCR testing is significantly limited (**Figure 1**). Positive results could be considered preliminary (presumptive) positive and actioned immediately because of the increased positive predictive value in these settings. Public health action (isolation, contact tracing) should be implemented immediately while laboratory-based PCR tests are conducted to confirm results.

One must take into consideration if an individual who receives a negative result from the Panbio COVID-19 Antigen Rapid Test is symptomatic or asymptomatic, as all negative results are considered to be "preliminary (presumptive) negative".

Figure 1: Scenario 1—symptomatic testing when infection is prevalent within a community



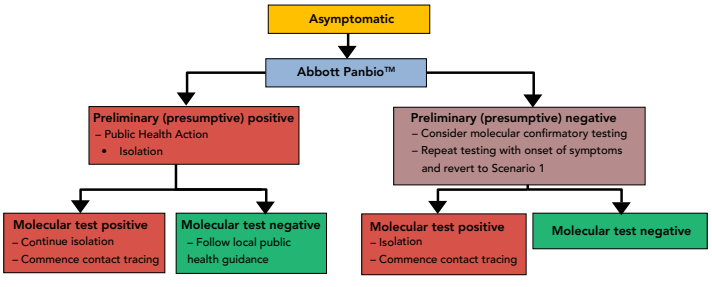
Abbreviation: PCR, polymerase chain reaction

Scenario 1—symptomatic testing within a community: It is recommended that symptomatic individuals who receive preliminary (presumptive) negative results be re-tested and maintained in isolation until confirmatory laboratory-based RT-PCR testing results are available. The flow diagram in Figure 1 depicts one possible approach to testing; however, algorithms are likely to vary across different provinces/territories depending on local factors, including stage of pandemic wave and health system experience with the Panbio assay.

NRI communities face additional barriers to accessing timely test results due to transportation time required to deliver a specimen to a testing laboratory. Given the importance of accurately identifying new cases in NRI communities in order to prevent spread in the face of limited healthcare resources, RT-PCR testing is the recommended test for these settings. The use of the Panbio COVID-19 Antigen Rapid Test may be helpful in NRI communities where access to laboratory-based testing services and rapid results are unavailable or difficult to access.

Scenario 2—asymptomatic testing within a community: The reflexive re-testing of asymptomatic individuals who receive preliminary (presumptive) negative results must take into consideration the burden that will be placed on already overwhelmed laboratory-based testing systems (**Figure 2**).

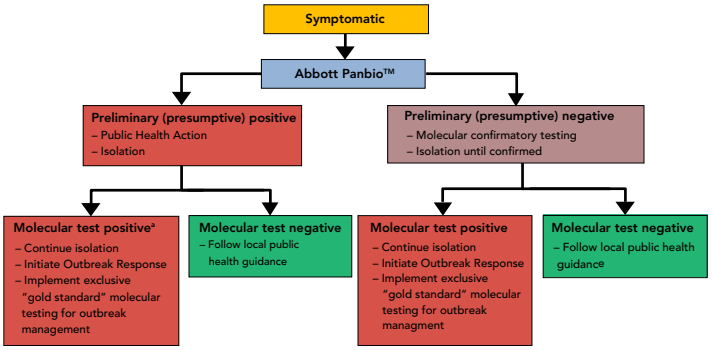
Figure 2: Scenario 2—asymptomatic testing when infection is prevalent within a community



Testing in congregate settings

Scenario 1—symptomatic testing within a congregate setting: While the use of a less sensitive test would not be recommended for the exclusive management of an outbreak, testing of symptomatic individuals and direct contacts with the Panbio COVID-19 Antigen Rapid Test can be a useful tool for the early identification of possible outbreaks in congregate settings (e.g. long-term care and correctional facilities, large processing plants, workers in remote mine settings, homeless shelters) (**Figure 3**). Testing can be part of suspected outbreak identification and investigation where patients can be tested rapidly on site if faster preliminary results will help inform and expedite public health action (triage of patients and contact tracing). All POC antigen tests should be followed up with an in-lab PCR test when done in the setting of an outbreak. This may be particularly relevant in situations where a symptomatic individual may otherwise be lost to follow-up (i.e. homeless shelter).

Figure 3: Scenario 1—symptomatic testing in congregate settings



[a] Single molecularly-confirmed positive case within residents or staff initiates the Outbreak Response

Here the intended use of a POC test is for monitoring infection in individuals who may not otherwise be able to be tested with the same frequency due to challenges with testing capacity. Due to the potential reduction in pre-test probability of a positive result, the test would have to be confirmed using a laboratory-based nucleic acid amplification test. This requirement for confirmation is to reduce the potential for negative factors associated with a false positive test (e.g. unnecessary removal from work, stigma that may be associated with infection).

Scenario 1A—symptomatic testing in isolated northern communities: Panbio COVID-19 Antigen Rapid Tests could be used to screen all individuals in NRI communities presenting with one or more COVID-19 symptoms (within five days of symptom onset) as a means of providing real-time surveillance of a potential COVID-19 outbreak and to expedite public health actions. Due to anticipated delays in the return of laboratory results, two NP swabs would always be collected when a patient first presents for care. One NP swab would subsequently be tested on the Panbio COVID-19 Antigen Rapid Test while the second NP swab would be reflexively sent for testing by

a gold standard molecular method (at a reference laboratory or at a site using the GeneXpert Xpert™ Xpress SARS-CoV-2 molecular test). In this scenario, all Panbio COVID-19 Antigen Rapid Test results (both positive and negative) would be considered preliminary/presumptive until molecularly confirmed. Presumptive negative results would require symptomatic individuals to continue self-isolation until results were confirmed negative by reference testing, while a presumptive positive result would allow for immediate public health actions that could significantly benefit community members at increased risk of severe illness from COVID-19 (i.e. over 65 years of age or underlying medical conditions). If a Panbio COVID-19 Antigen Rapid Test is confirmed as positive by a molecular reference method, the NRI community would initiate an outbreak response that could include ongoing Panbio screening but would also need to incorporate gold standard molecular testing for effective outbreak management.

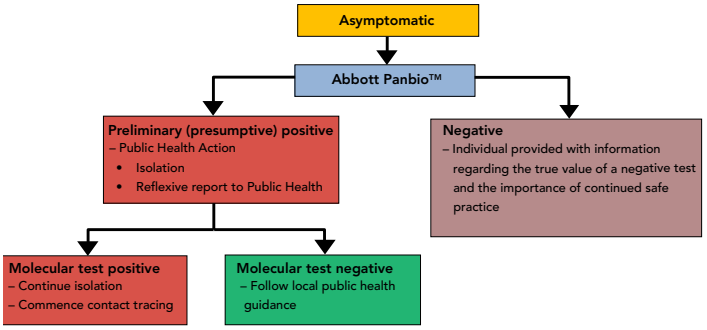
Scenario 2—asymptomatic testing in congregate settings: Monitoring of asymptomatic individuals who are at risk of introducing infection into high-risk settings could be considered. Modelling data suggest that testing protocols that incorporate repeated and frequent re-testing of asymptomatic individuals could be effective (3). The one caveat is that there may be resistance by individuals to undergo repeat NP swab collections due to discomfort. The need for a healthcare professional to obtain NP swabs, combined with a decreased sensitivity of the Panbio COVID-19 Antigen Rapid Test, suggest that this technology may have less utility for the repeat serial testing of asymptomatic individuals in the absence of a known outbreak or in a high prevalence setting. At this time, the market authorization for the Panbio COVID-19 Antigen Rapid Test from Health Canada—Medical Devices Bureau is focussed exclusively on symptomatic testing in the early phase of disease, so the use of the test in a monitoring context will require careful clinical validation. The frequency of repeat testing has not yet been defined.

Asymptomatic community-based surveillance in the general population

There is an abundance of data highlighting the asymptomatic spread of SARS-CoV-2. Up to 40% of all transmissions occurring in the general population, even with hand hygiene, mask use and social distancing, appear to be due to silent or asymptomatic transmission events. Widespread testing of individuals in the general population will provide a better understanding of the extent of asymptomatic spread and prevalence of the infection in the general population and may also help to destigmatize testing for COVID-19. Similar to recent know-your-status programs for sexually transmitted blood-borne infections, widespread screening and the knowledge that is gained from it can help normalize COVID-19 testing and help to inform and reduce behaviours associated with transmission. Widespread community-based testing of asymptomatic individuals must take into consideration the impact this testing may have on both the health care and laboratory systems, ensuring that health care and laboratory resources can remain focussed on the needs of high-risk and symptomatic individuals. As such, community-based testing for COVID-19 will likely require novel approaches to sample collection such as using non-regulated, non-healthcare professionals who are trained to provide testing on site. Tested individuals would either be able to receive results on site or have results returned to them via text or email in a timely manner.

Figure 4 summarizes the steps to be taken for asymptomatic community-based surveillance in the general population.

Figure 4: Asymptomatic community-based surveillance in the general population



In the case of a negative result, text messages can also include information about the limitations of a negative result and reinforce public health measures such as continued vigilance/attention to symptoms. Negative results would not require reflexive testing as it would likely overwhelm an already strained laboratory-based testing program.

In the case of a positive result, the individual would be told to self-isolate and be appropriately linked to provincial/territorial public health systems for confirmatory testing and follow up (i.e. contact tracing). Information can be provided in parallel to public health to expedite effective interventions.

Reporting of results and quality assurance

The use of the Panbio COVID-19 Antigen Rapid Test will most likely occur outside of a laboratory environment. The current anticipated market authorizations are expected to require oversight of the testing procedure by a trained healthcare professional. It will be essential that a mechanism and guidance for reporting of results (particularly positive results) into the public health system and/or laboratory system is established to ensure appropriate data capture and quality control, and to support public health action.

It is critical that quality assurance practices be considered when implementing POC testing, regardless of the perceived simplicity of the test. Where POC testing is implemented outside a hospital environment, sites are recommended to partner with local accredited laboratories for ongoing guidance and oversight. The laboratory director and partnering laboratories will guide sites to ensure important quality assurance practices are in-place.

Examples of quality assurance practices that must be considered:

- Training and ongoing authorization of staff who will perform POC testing
- Initial and ongoing reagent validation prior to clinical use
- Quality control practices for regular monitoring of test performance
- Proficiency testing to monitor overall testing practices at a site
- Troubleshooting issues with tests and/or devices
- Reporting of results

Critical scientific questions

The state of the science continues to evolve daily as unprecedented global investment in research and development continues. Despite this, there remains a number of critical questions to inform the use of new tests such as the Panbio COVID-19 Antigen Rapid Test and sample types.

- How do these tests perform in "real life" situations?
  - Many submissions for regulatory approval have used simulated samples to evaluate tests. This creates uncertainty about the true performance when applied to actual patients. There must be a verification of performance by comparing the real life performance of intended use in the field compared to the traditional nucleic acid amplification methodology.
- How frequently is testing required to close the sensitivity gap?
  - This requires understanding of the dynamics of the test over time. It will be important to determine the frequency of testing to best mitigate the risk of cases being missed due to the lower sensitivity of the Panbio COVID-19 Antigen Rapid Test.
  - At what threshold of community transmission is repeat testing in specific environments beneficial?

Conclusion

This document provides interim guidance on the use of the Abbott Panbio COVID-19 Antigen Rapid Test in the context of the Canadian public health system and a coordinated national response to the coronavirus disease. These guidelines are meant to be updated periodically as more information is available regarding test sensitivity and specificity in the overall context of infection with SARS-CoV-2, 2019 (COVID-19) pandemic.

Competing interests

None.

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SURVEY

The use of an online survey for collecting food exposure information, Foodbook sub-study, February to April 2015

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Abstract

Background: During foodborne illness outbreak investigations, comparing food exposure frequencies of cases to those of a control population can help identify suspect food sources. The Public Health Agency of Canada (PHAC) conducted an online survey between February and April 2015 to collect seven-day food exposures from a convenience sample. The study period overlapped with a national, population-based exposure survey being conducted via telephone using random digit dialling. A subset of the food exposure questions from the telephone-based survey was included in the online survey.

Objective: The online survey study objectives were to: 1) describe the survey methodology, survey respondents and response behaviour; and 2) determine if the online methodology is an appropriate alternative to telephone surveys by comparing food exposures.

Methods: The online survey link was distributed via email to employees and public health partners, and was promoted on the PHAC website and social media channels.

Results: In total 2,100 surveys were completed. The majority of respondents were female, with high income and education, aged 30 to 39 years. The proportion reporting consuming the food items in the online survey was generally higher than those reported in the telephone survey, with a mean difference of 6.0% (95% CI: 4.2, 7.8).

Conclusion: In an outbreak investigation, the 6.0% bias could make it more difficult to detect a difference between the case and control food exposures. Nevertheless, given the speed of response and lower resource expenditure of online surveys as well as the willing, able and convenient sample, a bias of 6.0% is considered small enough to be acceptable for future surveys.

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Keywords: online survey, convenience sample, food exposures, foodborne illness, outbreak investigations, telephone survey

Introduction

During investigations of foodborne illness outbreaks, comparing frequencies of exposures of cases to those of a control population can help identify suspect food sources. Using existing population-based exposure data as "control" data is a useful alternative to traditional case-control studies (1). Typically, telephone surveys are used to obtain exposure data (2), but as they are resource intensive and not timely, exploring alternative ways of acquiring and updating exposure data is necessary.

Online surveys have been increasingly used to collect data for research purposes in recent years. Online surveys require fewer resources and less time to implement than traditional telephone survey methods. They also provide a faster response and greater access to harder-to-reach groups (3–6). On the other hand, the use of online surveys may result in sampling bias and, if a fixed sampling frame is not in place, it may be difficult to track non-response rates (7,8). Online surveys could potentially be utilized to complement telephone surveys for data collection (3,5).

However, assessing the most appropriate sampling frame to use given the impact on results is an important consideration.

Given the rapid administration and low costs of online surveys, the Public Health Agency of Canada (PHAC) sought to assess their potential use in collecting food exposure control information for enteric disease outbreak situations. To compare the results obtained by these two modes of data collection, PHAC conducted an online survey, using a convenience sample, alongside a larger, national, population-based exposure survey conducted via telephone. This is a common approach to evaluating effectiveness (9–12).

The study's objectives were to: 1) describe the survey methodology, survey respondents and response behaviour; and 2) determine if the online methodology used, including the sampling frame, is an acceptable alternative to telephone-based surveys by comparing food exposures.

Methods

Telephone Foodbook survey: Baseline

The national, population-based telephone Foodbook survey was the gold standard used to evaluate the online survey as a method of capturing food exposure information. The telephone Foodbook survey was conducted between April 2014 and April 2015 in all Canadian provinces and territories. The survey included questions about food, water and animal exposures over the past seven days. The telephone-based survey had a robust sampling frame and weighting scheme, making it the ideal comparator. For more details on the methodology used, please refer to the *Foodbook Report* (2).

The Foodbook study was approved by Health Canada and the Public Health Agency of Canada's Research Ethics Board (REB 2013-0025) and the Newfoundland and Labrador Health Research Ethics Authority (HREB 13.238).

Online Foodbook survey

The online survey was designed as a sub-study of the overall Foodbook study for the purpose of evaluating the online-based methodology. To help with this comparison, the timeframe overlapped with the telephone Foodbook survey.

The study population for the online survey included Canadian residents aged 16 years and older (or 18 years and older in Québec), who had not travelled outside of their province or territory of residence in the past seven days. The online survey was launched February 24, 2015, and closed April 10, 2015, with participants recruited using a convenience sample.

Similar to the telephone survey, the online survey included questions about respondent demographics and food exposures. Demographic data collected included age, sex, province/territory of residence, education and income. Only a subset of food exposure questions were included in the online survey (i.e. 168 food items) to reduce survey completion time to under 10 minutes and maximize the response rate. The online survey was created using FluidSurveys and was available in both English and French.

Sampling technique

In an outbreak situation, obtaining timely "control" data is essential. A convenience sample is a useful source of such data. The research team implemented various methods to promote the survey and recruit respondents: initial survey promotion via email to internal team members (approximately 40 employees); distribution through a daily, newsletter-type email to all PHAC and Health Canada employees (approximately 13,800 employees); and email to provincial/territorial public health stakeholders. Recruitment expanded via snowball sampling, that is, requesting recipients to forward the invitations to others. The survey was also promoted via PHAC social media (Facebook and Twitter) and banner advertising on the PHAC website. Overall, the sampling frame included Health Canada and PHAC employees, public health and epidemiologist stakeholder groups (local, provincial/territorial, federal) and the general public.

The survey included Canadian residents older than 16 years (or older than 18 years in Québec) who had not travelled outside of their province or territory of residence in the past seven days. Proxy responses were not allowed. The inclusion criteria for the two survey modes were identical other than the age groups and use of proxies.

Participants were asked if they consented to the collection and use of data for the purpose of helping public health professionals investigate illnesses and outbreaks. Individuals who responded "Yes" proceeded to the next phase of the survey.

Some of the non-random elements of the sample collection scheme were corrected by developing a survey weight. Weights were developed for each sex and provincial combination using population totals from the 2011 Census.

Analysis of survey response, respondent demographics and food exposures

The analyses conducted included: 1) assessment of survey response based on recruitment/referral method; 2) description of respondent demographics for both online and telephone surveys; and 3) comparison of food exposure frequencies between telephone and online surveys.

To assess the impact of the various recruitment methods on online survey response, all completed surveys over the entire study period were included for the initial analysis.

Due to low response rates for individuals aged 16 to 19 and 65 years and older, as well as among those living in the territories, and to ensure sufficient sample size for comparison

purposes, the unit of analysis, or sample population, was refined for further analyses. The Foodbook online survey group used in subsequent analyses included those aged 20 to 64 years residing in the Canadian provinces, with data collection between February 24 and March 24, 2015.

The comparison Foodbook telephone survey group was composed of the same age group and geography, though it had a wider timeframe of February 10 to April 7, 2015. The wider timeframe (two additional weeks on either side of the dates of the online survey group) was selected to increase the sample size and improve the detection of differences between the groups in the two surveys.

To evaluate the accuracy of the online survey method, food consumption proportions from the Foodbook online survey were compared to the Foodbook telephone survey for the same geographic area (Canadian provinces) and age of respondents (aged 20–64) and similar time window.

Analysis was conducted using STATA version 13.1 (StataCorp LP, College Station, Texas, United States). Descriptive analysis was conducted to assess survey response and respondent demographics. Food exposure comparisons were conducted by analyzing mean differences in the weighted exposure proportions in the online versus the telephone survey group and testing of results to determine statistical significance in observed differences using adjusted Wald tests. After weighted proportions were calculated using svy: proportion, the overall mean difference between these proportions was calculated using the lincom command, which provides 95% confidence intervals (CIs) and the *p* value. The effect of income and education on the mean difference was explored by post-stratifying on these factors.

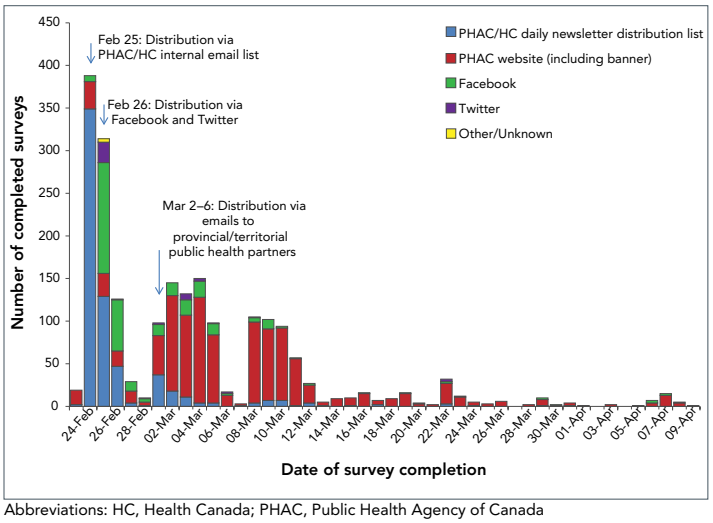
Results

Survey response

The soft launch of the survey on February 24, 2015, included a link on the PHAC website (via a banner) and an email sent to a short-list of employees. On February 25, 2015, all Health Canada (n=12,000) and PHAC (n=1,800) employees were notified via email through the organizations' daily internal newsletter. The response rate for this method was 4.6%. On February 26, 2015, the survey was promoted via PHAC's Facebook and Twitter channels, with subsequent re-sharing and re-tweeting of the posts. During the social media campaign period (between February 26 and April 10, 2015), there were 2,777 page views for the Foodbook survey webpage, with 33% of all traffic coming from Facebook or Twitter. The most successful enrolment method—the email invitations sent out to the provinces and territories on March 2, 2015, and the subsequent invitations sent out to provincial/territorial public health group listservs and other distribution channels—generated over 1,000 completions, comprising approximately 48% of the total responses.

By the end of the campaign (February 24 to April 10, 2015), 2,612 surveys had been submitted. Of these, data for 512 respondents were excluded from further analysis because they did not give consent (n=35), did not meet the inclusion criteria (n=276) or did not complete the survey (n=201). Over three-quarters of respondents (n=2,100; 80%) completed the survey in full. Of those that completed the survey, the majority were referred to the survey via emails sent to stakeholders (which included a link to the Foodbook survey webpage) (n=1,016; 48%), followed by the internal PHAC/Health Canada daily newsletter distribution group who received a direct link to the survey (n=639; 30%), Facebook (n=326; 16%), PHAC website (n=70; 3%), Twitter (n=44; 2%) and other/unknown (n=5; <1%) (**Figure 1**). Because of the snowball approach used to recruit respondents, it was not possible to capture the full extent of survey promotion and distribution.

Figure 1: Number of surveys by date of completion based on the method of referral to the online survey (n=2,100)



Abbreviations: HC, Health Canada; PHAC, Public Health Agency of Canada

The average time for survey completion was approximately 17 minutes (median: approximately 9 minutes).

Online and telephone survey group respondent demographics

The results presented refer to the "online survey group," that is, the 20 to 64-year old participants living in the provinces who completed the survey between February 24 and March 24, 2015 (n=1,954), and the "telephone survey group" with survey completions between February 10 and April 7, 2015 (n=395).

Although the distribution of male and female participants in both the online and telephone survey groups was similar, the age group distributions differed (**Table 1**). The largest proportion of participants in the online survey group were the 30 to 39-year olds (34.6%), and in the telephone survey group, the 50 to 64-year olds (48.0%). The geographic distribution of participants

was similar across the survey methods. The online survey group generally had a higher income and a higher level of education than the telephone survey group.

Exposure comparisons: Foodbook online survey versus telephone survey group results

Food exposures reported by online and telephone survey participants were compared across 168 food items. The difference in the weighted proportions for the food items ranged from 28.6 (spinach) to −9.4 (cauliflower), with a median of 4.6.

Overall, the mean difference in consumption proportions was 6.0% (95% CI: 4.2%, 7.8%), with higher proportions more often reported by the online survey respondents. For foods with over 50% of telephone survey participants reporting consumption (i.e. commonly consumed foods), the mean difference in consumption proportions between the online and telephone survey was 6.8%. **Table 2** lists the top 10 food items where the largest differences were identified between the two groups. Of the food items with the largest observed differences, 50% were vegetables.

Table 1: Demographics of the Foodbook online and telephone survey group participants

Characteristics	Online participants		Telephone participants		*p*-value
	Raw counts (n)	Weighted proportion (%)	Raw counts (n)	Weighted proportion (%)	
Sex					
Men	278	49.1	150	56.5	0.155
Women	1,676	50.9	245	43.5	0.155
Age group, years					
20–29	369	16.5	28	6.3	0.000
30–39	643	34.6	43	19.5	0.000
40–49	437	22.2	69	26.2	0.499
50–64	505	26.8	255	48.0	0.000
Respondents by province[a]					
British Columbia	211	13.6	48	9.2	0.067
Alberta	104	11.1	47	9.3	0.441
Saskatchewan	114	3.0	36	3.4	0.697
Manitoba	163	3.5	33	2.1	0.037
Ontario	818	37.8	75	42.4	0.429
Québec	389	23.9	70	26.8	0.540
New Brunswick	15	2.3	25	3.0	0.543
Nova Scotia	37	2.8	27	2.4	0.599
Prince Edward Island	56	0.4	17	0.35	0.766
Newfoundland and Labrador	47	1.6	17	1.0	0.224
Respondents by income level ($)					
Less than $30 000	73	4.3	51	8.4	0.028
$30 000 or more, but less than $60 000	232	12.0	106	33.5	0.000
$60 000 or more, but less than $80 000	280	16.7	62	16.8	0.985
$80 000 or more	1,150	67.0	138	41.4	0.000
Respondents by education level					
Less than high school diploma or equivalent	8	0.3	34	4.8	0.000
High school diploma or a high school equivalency	98	5.5	90	15.9	0.002
Trade certificate or diploma	59	3.6	19	4.8	0.538
College, CEGEP or other non-university certificate or diploma	288	14.6	97	25.3	0.017
University certificate or diploma below the Bachelors level	93	5.4	29	10.8	0.078
Bachelor's degree	610	33.6	71	28.9	0.464
University certificate, diploma or degree above the Bachelor's level	653	36.9	39	9.5	0.000

[a] The raw counts and weighted proportions for the territories were not included since the raw counts in the online survey group were low (<3)

Table 2: Top 10 food exposures with greatest differences in weighted proportions between online survey and telephone survey group participants

Food category	Food item	Weighted proportions		Difference between online and telephone participants	*p*-value
		Online participants	Telephone participants		
Top ten food exposures where online survey group participants reported higher than telephone participants					
Vegetables	Spinach	56.3	27.7	28.6	0.000
Vegetables	Lettuce on a sandwich	50.2	25.3	24.9	0.000
Herbs and spices	Curry powder	37.9	14.4	23.5	0.000
Vegetables	Mesclun greens	43.3	20.5	22.8	0.000
Vegetables	Cherry or grape tomatoes	48.0	25.3	22.7	0.000
Cheese	Mozzarella	65.2	44.1	21.1	0.000
Nuts and seeds	Peanut butter	67.2	46.7	20.5	0.000
Beef	Beef hamburgers from a restaurant or fast food establishment	31.3	11.4	19.9	0.000
Poultry	Chicken pieces or parts	81.5	62.1	19.4	0.001
Vegetables	Packaged lettuce	69.8	51.3	18.5	0.001
Top ten food exposures where online survey group participants reported lower than telephone participants					
Vegetables	Cauliflower	35.7	45.1	-9.4	0.102
Vegetables	Iceberg lettuce	42.8	48.2	-5.5	0.345
Vegetables	Bean sprouts	7.1	12.4	-5.3	0.090
Vegetables	Sprouts	11.8	16.7	-5.0	0.171
Herbs and spices	Fresh Thai basil	4.7	9.0	-4.3	0.182
Fish and seafood	Fish (e.g. cooked trout or salmon)	63.7	67.3	-3.6	0.429
Beef	Stewing beef	21.4	25.0	-3.6	0.562
Dairy	Any raw dairy	6.2	9.0	-2.8	0.320
Vegetables	Hothouse tomatoes	42.4	45.0	-2.6	0.653
Deli-meat	Bologna	4.5	7.1	-2.6	0.165

Discussion

Survey response

The timeliness of responses varied based on the recruitment approach used. The two approaches that garnered the most immediate responses were the internal newsletter distribution via email to PHAC/Health Canada employees and the social media posting on Facebook. The bulk of the response to the internal newsletter distribution occurred within three days, with most on the day of release, suggesting that it is an excellent platform for gathering time-sensitive information. The response from the social media posting on Facebook was also timely, with most completions within two days. The survey invitations sent via email to the provinces and territories, although accounting for the largest proportion of respondents, took approximately two weeks for the full effect, likely due to the snowball approach used.

Our results show that implementing all three approaches simultaneously could potentially result in 1,600 or more survey completions within five business days. This would be the recommended course of action for time-sensitive outbreak investigations.

Respondent demographics

Weighted results indicated that respondents from each province were similarly represented in the online and the telephone survey (Table 1). This was expected, as the weights were designed to correct for over or under-represented provinces. More importantly, given that previous research has shown that there can be disparities in income and education distributions when using online versus telephone survey methods (13), the research team compared the income and education in the online and the telephone surveys and found that they differed. The online survey had more respondents with higher incomes and higher education status than the telephone survey. This likely reflected the sampling frame, which included a large proportion of government employees and public health professionals.

Exposure comparisons

The second objective of this study was to determine how an online survey performs, compared to a traditional telephone survey, when measuring food exposure proportions for the population. The research team assessed the concordance in results between the two methods by comparing the weighted food exposure proportions of the online survey with those from the telephone survey.

The proportion of those consuming the food items in the online survey tended to be higher than in the telephone survey. When looking at the difference in the exposure proportions from the two surveys, both higher and lower differences were found, reflecting the sampling variation in both surveys. The top ten largest differences where proportions were higher in the online survey than the telephone survey were all statistically significant; the reverse situation, where proportions were lower in the online survey than in the telephone survey, were not significant. If sampling variation alone were at play, then the overall mean of the consumption proportions would be no different between the surveys. However, the mean difference is 6.0% (95% CI: 4.2%, 7.8%), with the higher proportions more often reported by the online survey respondents, suggesting that there was a general trend for the online survey respondents to be more likely to answer that they had eaten a particular food in the past seven days. Other work has indicated that online surveys,

which use questions with two response categories requesting facts as opposed to opinions, have results matching well to the telephone survey (11).

It is apparent that differences exist between the online and telephone survey modes. Online surveys are self-administered (rather than administered by an interviewer), and the questions are presented visually, in writing (rather than asked verbally), both factors that may affect the results. In addition, as Potoglou *et al*. found (5), there is potentially a greater willingness to be honest given the anonymity of an online survey. However, it is also possible that given that an online survey is self-administered, accountability could be decreased and the ease of responding "yes" could be increased. Respondent fatigue may also impact a participant's behaviour in responding, although this may be a factor for both the telephone and the online survey, depending on length. All these factors may have contributed to the overall mean differences between the survey modes.

Another possible explanation for the bias is the distributional effect from having more people with high income or higher education completing the online survey. This was explored further by comparing the online survey group results after stratification by income and education to the same post-stratified results in the telephone survey group. No discernable pattern or trend was found in the types of foods consumed for either income or education. Also, the positive overall bias in the online survey results was still present.

Potential use in outbreak investigations

The 6.0% bias means that proportions calculated from a similar online survey would be larger, on average, than from a telephone survey, which would result in a larger denominator in a case-control odds ratio, resulting in a smaller overall odds ratio. This has the potential to make it more difficult to detect a difference between the case and control food exposure proportions. For more commonly consumed foods (i.e. those with over 50% consumption using the telephone survey results), the difference does not appreciably increase (i.e. 6.8% vs 6.0%). Although commonly consumed foods would already be harder to detect as potential sources or risk factors (in an odds ratio), the 6.8% bias (versus 6.0%) is not considered to be large and would not adversely affect the analysis in most situations.

Limitations

Despite the overall success of the Foodbook online survey in terms of survey response and general comparability of exposure proportions with those of the telephone survey, the convenience sampling strategy used lent itself to potential bias, with certain demographic populations (i.e. females, high income and high education) being over-represented. Also, the online survey recruitment methods did not result in enough responses from the territories, and those younger than 20 or 65 years and older. It is also important to note that in considering limitations and appropriateness of the online survey compared to the telephone survey, the use of a telephone survey also has drawbacks, as it is an increasingly outdated mode of data collection and resource intensive.

Conclusion

Overall, given the speed and lower resource expenditure for the online Foodbook survey using a convenience sampling method, as well as the willing, able and convenient sample, a bias of 6.0% is considered small enough to be acceptable for surveys where timeliness is a key requirement. In addition, given the growing popularity and preference of using online surveys as a data collection tool, which is expected to continue growing, using the online mode of data collection, in concert with other techniques that improve the representativeness of the sampling frame, is also worth exploring for future surveys that seek to be the new gold standard.

Authors' statement

CG — Conceptualization and implementation of study, conceptualization, drafting and/or revising the paper
MH — Conceptualization, analysis and interpretation of data, drafting and/or revising the paper
SS — Conceptualization, analysis and interpretation of data, drafting and/or revising the paper
NC — Assisted with implementation of study, conceptualization, drafting and/or revising the paper

Competing interests

None.

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Country food consumption in Yukon, Northwest Territories and Nunavut, Foodbook study 2014–2015

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Abstract

Background: This article presents a descriptive summary of the consumption of various country food (i.e. locally harvested plant and animal foods) products by residents of Yukon (YT), Northwest Territories (NT) and Nunavut (NU). Data were collected as part of the Foodbook study in 2014–2015.

Methods: The Foodbook study was conducted by telephone over a one-year period. Respondents were asked about consumption of a wide range of food products over the previous seven days. Residents of the territories were also asked about consumption of regionally-specific country food. Data were weighted to develop territorial estimates of consumption. Data on age, gender, location, income and education were also collected.

Results: The national response rate for the Foodbook survey was 19.9%. In total, 1,235 residents of the territories participated in the study (YT, n=402; NT, n=458; NU, n=375). Consumption of any country food during the previous seven days was reported by 77.5%, 60.7%, and 66.4% of participants in NU, NT and YT, respectively.

Conclusion: Responses to country food questions asked alongside the main Foodbook questionnaire provide insight on country food consumption in YT, NT and NU.

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Keywords: food consumption, country food, Nunavut, Northwest Territories, Yukon

Introduction

Accurate, comprehensive, and current food consumption data are important for informing public health programming and policy development regarding food security and nutrition, as well as foodborne disease outbreak investigations. In Canada, national food consumption data are available through the Canadian Community Health Survey conducted in 2004 and 2015 (1,2). Unfortunately, this survey did not collect data on food consumption in Yukon (YT), Northwest Territories (NT) or Nunavut (NU). As a result, there are limited data from national studies that provide insight on food consumption among residents of YT, NT and NU. The Foodbook study was developed to gather comprehensive food consumption data relevant for outbreak investigations in all provinces and territories. The Foodbook study employed a telephone survey to collect food exposure data from residents of all provinces and territories. The Foodbook survey was administered over a one-year period in 2014–2015 using a seven day recall period. Foodbook survey data have since informed the response to outbreaks of foodborne illness in Canada by providing investigators with food exposure reference values which can assist in hypothesis generation (3–6).

In addition to the foods included in the national Foodbook survey, supplementary country foods were included specifically for residents of YT, NT and NU, as recommended by territorial government representatives. Country foods include those that are harvested from the land, water and/or ice, and can include land mammals such as caribou or moose, marine mammals such as seal or walrus, fish and seafood such as Arctic char, clams and mussels, birds such as geese or ptarmigan, and plants such as berries (7–9). Country foods are consumed in YT, NT and NU, as well as in other areas of Canada. While country foods may be

consumed by individuals of diverse cultural backgrounds, the harvesting, preparation, sharing and consumption of country foods support connections to cultural heritage for Indigenous peoples (10). In addition to supporting connections to cultural heritage, country foods are often perceived as tastier, more nutritious and less expensive than store-bought foods (7,11,12). Country foods can be obtained by hunting or gathering, sharing among community, family or friends, from local hunters' and trappers' organizations, or from businesses that or individuals who sell country food (7,11–13).

As with data from the national Foodbook study, country food consumption data were collected with the aim of quantifying the prevalence of consumption of country foods, information that was not available from previous national surveys. In the event of an outbreak of foodborne illness in YT, NT or NU, these data on country food consumption frequencies may assist investigators in evaluating specific country foods as potential food exposures of interest. These data are also potentially useful for work on nutrition, food security, other health research, as well as policy development.

Methods

Data collection

Data on country food consumption were collected as part of the larger national Foodbook study. Foodbook was a population-based telephone survey conducted in all Canadian provinces and territories, from April 2014 to April 2015 with monthly quotas to ensure representativeness over the different seasons. Foodbook interviews were administered in English and French in all provinces and territories, and English, French and Inuktitut in Nunavut. Proxy respondent were used for individual under the age of consent or for individuals with medical or activity limitations. On-demand verbal translation was available for other languages as needed. The study design and sampling methodology for the Foodbook study are described in detail in the published report (14). Briefly, a landline telephone and cell phone sampling frame were used to select respondents from each territory. In addition to demographic questions (e.g. education level, household income, forward sortation area), participants were asked if they consumed various specific food items during the previous seven days. Food consumption questions included items within the categories of fruits, vegetables, herbs and spices, nuts, meats, fish and shellfish, eggs, dairy products and country foods. A copy of the questionnaire is available through Open Data (15). Questions related to country food consumption were asked only of participants in YT, NT and NU. Country food questions were drafted and reviewed with territorial government representatives to ensure that the included country food items were reflective of animal and plant species available and/or consumed in each territory.

The Foodbook study was reviewed and approved by the Health Canada and the Public Health Agency of Canada's Research Ethics Board (REB 2013-0025) and the Newfoundland and Labrador Health Research Ethics Authority (HREB 13.238).

Statistical analysis

Data were cleaned, coded and analysed using Stata 15.1 for Windows (StataCorp LP, College Station, Texas, United States). Missing values, such as respondents declining to answer a question, were removed from the analysis for those specific questions. Proportions were calculated using survey weights, the details of which are described in the *Foodbook Report* (14).

Composite variables describing categories of foods were created based on biological categorization and consultation with territorial government representatives. These composite variables included any country foods, large game, small game, wild poultry, marine mammals, fish, wild eggs and plants. Composite variables were coded as "yes" if the individual reported consuming at least one of the items and "no" if the respondent did not report consuming any of the items.

An adjusted Wald's test was used to assess significant differences in the composite variable "any country food" between categories of demographic variables (i.e. age, education, income and location). The categories reporting the highest proportion of country food consumption served as referent groups. Comparisons with $p<0.05$ were considered statistically significant.

Results

A total of 1,235 individuals from YT (n=402), NT (n=458) and NU (n=375) participated in the Foodbook study. The geographic distribution of survey respondents was reflective of the geographic distribution of residents within the territories. Since location was based on the first three digits of participants' postal codes, it was not possible to separate the data from Iqaluit from the remainder of the Qikiqtani Region in Nunavut. Ninety-nine percent of participants in YT and NT completed the survey in English, and the remaining 1% completed the survey in French. Ninety-three percent of participants in NU completed the survey in English, 6% completed the survey in Inuktitut and 1% completed the survey in French.

The age and gender distribution of Foodbook participants in each territory were adjusted using survey weights to be similar to the age and gender distribution of the populations of their respective territories (**Table 1**).

A larger proportion of Foodbook participants in YT, NT and NU reported a "Bachelor's degree or a degree above the Bachelor's level" than the census populations of their respective territories (Table 1). In addition, a smaller proportion of Foodbook participants, than census populations, in the territories reported

Table 1: Demographics, education and income characteristics of weighted Foodbook respondents compared to census data, Yukon, Northwest Territories and Nunavut, 2014–2015

Demographics, education and income characteristics	Yukon		Northwest Territories		Nunavut	
	Foodbook (%)	Census population (%)	Foodbook (%)	Census population (%)	Foodbook (%)	Census population (%)
Gender[a]						
Male	50.3	50.9	50.8	51.1	51.4	51.5
Female	49.7	49.1	49.2	48.9	48.6	48.5
Age group[a]						
0–9 years	11.5	11.3	14.8	14.1	22.9	22.8
10–19 years	12.4	10.9	15.1	13.2	19.3	18.0
20–64 years	67.1	67.6	64.3	66.2	54.4	55.7
65+ years	9.1	10.2	5.8	6.5	3.3	3.5
Education[b,c]						
Less than high school diploma	9.5	10	28.4	18	45.6	49
High school diploma	17.4	21	14.3	22	5.4	15
Trade, college or non-university certificate/diploma below the Bachelors' level	41.1	39	28.7	37	17.2	23
Bachelor's degree and certificates/degrees above the Bachelors' level	31.2	29	27.0	23.0	29.7	13.0
Not reported	0.8	NA	1.5	NA	2.2	NA
Household income[d]						
Less than $30,000	10.8	17.3	10.4	15.3	21.8	28.0
$30,000–$60,000	18.3	17.2	7.2	15.1	3.9	22.4
$60,000–$80,000	14.1	14.1	13.1	9.1	10.5	8.6
More than $80,000	49.0	51.5	52.2	60.5	42.9	41.0
Not reported	7.8	NA	17.1	NA	21.0	NA
Location[e]						
Territorial capital	80.3	77.1	45.6	48.0	61.9	52.3
Outside capital region	19.2	22.8	50.2	52.0	38.1	47.3
Not reported	0.5	NA	0.2	NA	NA	NA

Abbreviation: NA, not applicable
[a] Territorial population data from Statistics Canada. Table 17-10-0005-01 Population estimates on July 1st, by age and sex (2014 data)
[b] Territorial population data Statistics Canada. Table 37-10-0117-01 Educational attainment in the population aged 25 to 64 years, off-reserve Aboriginal, non-Aboriginal and total population
[c] Question only asked of Foodbook respondents older than 25 years of age
[d] Territorial data from Statistics Canada, Canadian Community Health Survey, 2013–2014
[e] Territorial population data by forward sortation area from Statistics Canada, 2017. Population and Dwelling Count Highlight Tables. 2016 Census. Statistics Canada Catalogue no. 98-402-X2016001. Ottawa. Released February 8, 2017

annual household incomes under $60,000. Survey weights were not used to adjust the distribution of education or annual household income among Foodbook participants.

Consumption of one or more country foods during the previous seven days was reported by 66.4% Foodbook participants in YT, 60.7% in NT and 77.5% in NU (**Table 2**). Foodbook respondents aged 0–9 years in YT and NT were less likely to report eating any country food in the previous seven days compared with those aged 20–64 years. No other statistically significant differences were noted between age categories (Table 2).The proportion of Foodbook respondents reporting any country food consumption with a household income of less than $30,000 was significantly higher than the proportion among respondents with a household income of greater than $80,000 in all three territories.

There were no significant differences in the composite variable "any country food" reported among categories of the education variable in YT and NT. In contrast, in NU, the prevalence of country food consumption was significantly higher among respondents with "less than high school diploma" and those with a "trade, college or non-university certificate/diploma" when compared with respondents with a "Bachelor's degree or a degree above the Bachelor's level". The proportion of

Table 2: Characteristics of Foodbook respondents reporting consuming any country food in the previous seven days, Yukon, Northwest Territories and Nunavut, 2014–2015

Characteristics of respondents	Yukon			Northwest Territories			Nunavut		
	%	95% CI	*p*	%	95% CI	*p*	%	95% CI	*p*
Any country food consumption	66.4	57.6–74.2	NA	60.7	52.2–68.5	NA	77.5	70.2–83.5	NA
Gender									
Male	64.58	51.3–75.9	0.6636	57.0	43.5–69.6	0.3704	73.7	63.3–82.0	0.2460
Female[a]	68.2	56.6–78.0	NA	64.5	54.5–73.3	NA	81.6	70.4–89.1	NA
Age group									
0–9 years	53.3[b]	41.6–64.7	0.0452	47.0[b]	36.3–58.0	0.0445	69.3	36.3–58.0	0.3644
10–19 years	61.0	46.8–73.6	0.3112	56.8	44.3–68.5	0.4291	88.5	44.3–68.5	0.1119
20–64 years[a]	70.3	57.5–80.5	NA	63.7	51.1–74.7	NA	76.4	51.1–74.7	NA
65+ years	61.6	50.0–71.9	0.2877	71.4	57.7–82.1	0.378[c]	88.6	57.7–82.1	0.1619
Education									
Less than high school diploma	86.9	68.1–95.3	0.0709	73.1	38.5–92.2	0.5064	94.5[b]	73.7–99.0	0.0007
High school diploma	65.1	39.0–84.5	0.9847	60.6	37.6–79.7	0.9467	57.4	20.8–87.4	0.9469
Trade, college or non-university certificate/diploma below the Bachelor's level	72.8	52.1–86.8	0.5599	58.8	41.0–74.5	0.8246	83.7[b]	62.7–94.0	0.0303
Bachelor's degree and certificates/ degrees above the Bachelor's level[a]	64.8	43.1–81.7	NA	61.6	42.8–77.5	NA	55.9	36.0–74.0	NA
Income									
Less than $30 000	84.9[c]	67.0–93.9	0.0088	76.9[b]	56.1–89.7	0.0124	89.7[b]	73.3–96.5	0.0137
$30,000–$60,000	69.5	50.5–83.6	0.3981	53.6	35.2–71.1	0.8884	68.4	39.6–87.8	0.8512
$60,000–$80,000	67.5	48.3–82.2	0.5159	51.3	24.8–77.1	0.9609	67.1	38.6–86.9	0.7802
More than $80,000[a]	60.3	47.0–72.2	NA	52.1	42.7–61.4	NA	71.1	59.8–80.2	NA
Location									
Territorial capital[b]	62.0[b]	51.6–71.4	0.0018	47.8[b]	37.8–58.0	0.0039	73.1	63.1–81.3	0.1031
Outside capital region[a]	84.2	72.1–91.6	NA	71.0	57.9–81.3	NA	83.8	72.8–90.9	NA

Abbreviation: NA, not applicable
[a] Referent group
[b] Significantly different from the referent group using an adjusted Wald's test
[c] Unable to separate data from Nunavut's capital (Iqaluit) from other communities in the remainder of the Qikiqtaaluk Region. This group includes all communities in the X0A forward sortation area

respondents consuming any country food was significantly higher in areas of YT and NT that are outside of the capital regions of Whitehorse and Yellowknife (Table 2).

The specific country foods consumed in the previous seven days varied by territory (**Table 3**). In YT, the most commonly reported country food was moose (46.0; 95% CI 35.9–56.1), followed by berries from the land (28.3; 95% CI 18.3–38.4). In NT, whitefish was the most commonly reported country food consumed (25.8; 95% CI 16.7–34.8) followed by caribou (22.0; 95% CI 13.0–31.1) and moose (19.8; 95% CI 13.0–31.1). In Nunavut, caribou (57.2; 95% CI 48.6–65.9) and Arctic char (52.3; 95% CI 43.4–61.2) were the two most commonly reported country foods. Sea mammals (e.g. seal, walrus, beluga, narwhal and bowhead) were consumed by 43.2% (95% CI 34.1–52.3) of Nunavut participants. Consumption of non-country by residents of YT, NT and NU are reported in the Foodbook report (14).

Table 3: Weighted Foodbook respondents reporting consumption of country food items in the previous seven days, Yukon, Northwest Territories and Nunavut, 2014–2015

Country food items	Yukon		Northwest Territories		Nunavut	
	%	95% CI	%	95% CI	%	95% CI
Any country food	66.4	58.1–74.7	60.7	52.4–68.9	77.5	70.9–84.2
Large game	51.9	42.2–61.6	41.5	32.2–50.8	59.4	50.8–67.9
Caribou	12.6	6.5–18.7	22.0	13.0–31.1	57.2	48.6–65.9
Muskox	NA	NA	3.4	0.6–6.2	9.8	3.8–15.8
Polar bear	NA	NA	0.0	0–0.01	5.6	2.5–8.7
Moose	46.0	35.9–56.1	19.8	13.0–26.7	NA	NA
Bear	0.5	0–1.2	0.9	0–2.5	NA	NA

Table 3: Weighted Foodbook respondents reporting consumption of country food items in the previous seven days, Yukon, Northwest Territories and Nunavut, 2014–2015 (*continued*)

Country food items	Yukon		Northwest Territories		Nunavut	
	%	95% CI	%	95% CI	%	95% CI
Bison	12.1	6.0–18.3	10.3	5.0–15.5	NA	NA
Elk/deer	4.5	0–11.2	2.5	0.1–4.9	NA	NA
Sheep	3.9	0–8.5	1.3	0–3.0	NA	NA
Wild poultry	4.3	0.2–8.5	6.6	3.2–10.1	8.6	5.2–12.0
Geese	NA	NA	2.9	1.0–4.8	6.6	3.6–9.7
Duck	NA	NA	2.7	0.8–4.7	1.7	0.3–3.0
Ptarmigan/ grouse	4.3	0.2–8.5	3.7	0.8–6.6	3.2	1.1–5.4
Sea mammals	NA	NA	3.0	0.3–5.6	43.2	34.1–52.3
Seal	NA	NA	0.8	0–2.3	28.9	20.3–37.5
Walrus	NA	NA	0.0	0–0.01	5.2	2.0–8.4
Beluga	NA	NA	2.2	0–4.4	21.8	14.1–29.4
Narwhal	NA	NA	0	0–0.01	11.6	6.8–16.4
Bowhead	NA	NA	0	0–0.01	0.6	0–1.3
Small land mammals	2.9	0–6.7	5.3	1.9–8.6	NA	NA
Gophers	2.4	0–6.2	0.0	0–0.01	NA	NA
Beaver/ muskrat	0.0	0–0.01	0.8	0–1.7	NA	NA
Rabbit	2.9	0–6.7	5.1	1.7–8.4	NA	NA
Any fish	16.8	8.5–25.0	33.7	24.7–42.7	53.9	45.0–62.8
Arctic char	1.9	0.5–3.3	6.9	3.2–10.7	52.3	43.4–61.2
Whitefish	10.0	1.8–18.1	25.8	16.7–34.8	10.8	3.6–18.0
Trout	9.5	2.9–16.2	7.9	4.3–11.5	8.2	3.6–12.7
Herring	NA	NA	0.5	0–1.0	0.4	0–1.0
Inconnu	NA	NA	0.9	0–1.9	0.2	0–0.3
Salmon	NA	NA	12.0	8.1–15.9	NA	NA
Cod	NA	NA	1.8	0.7–2.8	5.9	2.6–9.2
Pike	6.9	0–15.0	4.5	1.5–7.4	NA	NA
Wild eggs	NA	NA	2.5	0–5.1	4.9	1.5–8.2
Duck eggs	NA	NA	1.1	0–2.6	3.9	0.8–7.0
Geese eggs	NA	NA	0	0–0.01	2.4	0.3–4.6
Other wild eggs	NA	NA	1.7	0–3.9	1.3	0–2.6
Berries from the land	28.3	18.3–38.4	14.4	8.5–20.3	13.6	8.1–19.1
Other plants	6.8	2.0–11.7	6.2	2.7–9.7	5.8	2.4–9.1
Seaweed	NA	NA	6.8	2.2–11.4	5.9	2.3–9.5

Abbreviation: NA, not applicable

Discussion

The Foodbook study captured data on food consumption, including country food, among residents of YT, NT and NU. This information fills a gap in national food consumption data. In total, over 60% of Foodbook respondents in each territory reported consuming one or more country foods in the previous seven days. These data show that country foods comprise a part of the diet for the majority of YT, NT and NU residents. The data reported here, and other data collected through the Foodbook surveys, may be used to fill gaps in knowledge for those pursuing research in the areas of food safety, food security, climate change or nutrition.

Given the diversity of climate, landscape, populations and cultural practices across the three territories, it is difficult to make meaningful comparisons between the territories regarding the types of country food reported. However, some general trends were observed regarding which residents were reporting consuming county foods. In all three territories, the percentage of Foodbook survey respondents consuming country foods increased with age, with the exception of individuals between 20 and 64 years of age in Nunavut. This association between country food and age aligns with the finding of surveys of indigenous populations (16,17). There also appeared to be a link between income and country food consumption. The reasons for this link are unclear but the cost of store-bought foods in some remote communities is quite high so participants with lower annual incomes may be supplementing expensive store-bought food with inexpensive country food. Conversely, other studies have noted that costs associated with hunting can be a barrier to consumption of country foods (7).

Several studies have investigated the frequency and amount of country food consumption in specific region and communities in YT, NT and NU (**Table 4**). While there are some commonalities between the methods employed in these studies and in the Foodbook study, key differences include the recall periods and method of survey administration. These previous studies also differ from the Foodbook study by target population. The studies included in Table 4 focused on specific Indigenous communities. In contrast, the Foodbook study collected data for the whole territorial population, regardless of ethnicity. These methodological differences make it challenging to compare results between studies. Rather, these studies, taken together, may be seen as complementary, and increase understanding of country food consumption among residents of YT, NT and NU.

The main limitations of the Foodbook study are listed in the Foodbook report (14). One of the specific limitations in the territories was that the survey was administered solely by telephone. This likely affected the representativeness of the study respondents: while 99% of Canadian households have telephone access, in the territories the number of households with telephone access is likely to be lower than

Table 4: Select food consumption surveys conducted in Yukon, Northwest Territories and Nunavut

Food consumption surveys	Inuit Health study (11,18,19)	Inuit Child Health study (20)	Sharma Nunavut study (21)	Foodbook study
Data collection period	Summer 2007, summer 2008	Summer 2007, summer 2008	September–December 2006	One-year period in 2014–2015
Number of participants	1,569	338	188	1,235
Participant criteria	Inuit adults living in communities in Inuit settlement region	Inuit children 3–5 years old from 16 communities in Nunavut	Inuit over 19 years of age, not pregnant in four communities in NT and NU	Residents of YT, NT and NU; selected to meet quotas based on age groups
Survey method	In-person	In-person	In-person	Telephone
Recall period	12 months and 24 hours	One month	24 hours	Seven days

Abbreviations: NT, Northwest Territories; NU, Nunavut; YT, Yukon

southern Canada (22). Another key limitation was the lack of ethnicity data. These data would have provided information on the number of Indigenous people included in the survey and would help to understand links between ethnicity and food consumption habits.

Conclusion

Overall, the 2014–2015 Foodbook study provided a comprehensive picture of food consumption in Canada and included the territories, which had not been included in previous national studies. It is also important to note that Foodbook study is one of the few national surveys to provide the option to be completed in Inuktitut, which may have resulted in the survey reaching a segment of the population that would not be represented otherwise. Data presented here can provide information to support nutrition, food security, outbreak investigations and other research projects. The addition of country foods to other food consumption studies should be considered in other geographical areas, especially rural and remote areas, to understand the role of country foods in the diet of Canadians.

Authors' statement

V Morton and J Cutler conceived the idea for this manuscript. V Morton and A Manore developed the first draft. All authors contributed to the development and revision of this manuscript and approved the final draft for submission.
A Mullen is currently associated with Nova Scotia Department of Health and Wellness.

Competing interests

None.

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SURVEY

Findings among Indigenous participants of the Tracks survey of people who inject drugs in Canada, Phase 4, 2017–2019

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Abstract

Background: The Tracks survey of people who inject drugs (PWID) collected data in 14 sentinel sites across Canada (2017–2019). These findings describe the prevalence of human immunodeficiency virus (HIV), hepatitis C and associated risk behaviours among Indigenous participants.

Methods: Information regarding socio-demographics, social determinants of health, use of prevention services and testing, drug use, risk behaviours, and HIV and hepatitis C testing, care and treatment was collected through interviewer-administered questionnaires. Biological samples were tested for HIV, hepatitis C antibodies and hepatitis C ribonucleic acid (RNA). Descriptive statistics were calculated and reviewed by an Indigenous-led advisory group using the Two-Eyed Seeing approach.

Results: Of the 2,383 participants, 997 were Indigenous (82.9% First Nations, 14.9% Métis, 2.2% Inuit). Over half (54.5%) were cisgender male and the average age was 38.9 years. A large proportion (84.0%) reported their mental health as "fair to excellent". High proportions experienced stigma and discrimination (90.2%) and physical, sexual and/or emotional abuse in childhood (87.5%) or with a sexual partner (78.6%). Use of a needle/syringe distribution program (90.5%) and testing for HIV (87.9%) and hepatitis C (87.8%) were high. Prevalence of HIV was 15.4% (78.2% were aware of infection status) and 36.4% were hepatitis C RNA-positive (49.4% were aware of infection status).

Conclusion: High rates of HIV and hepatitis C were identified. Challenges in access to and maintenance of HIV and hepatitis C care and treatment were noted. This information informs harm reduction strategies, including the need to scale-up awareness of prophylaxis in a culturally relevant manner.

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Introduction

In Canada, Indigenous peoples represent 4.9% of the total Canadian population (1); however, they are disproportionately affected by human immunodeficiency virus (HIV) and hepatitis C infections. In 2016, it was estimated that 11.3% of new HIV infections in Canada were among Indigenous peoples (2) and newly diagnosed hepatitis C infections among First Nations people living on reserve were three-fold higher compared with new diagnoses in the overall Canadian population (3). National case-based HIV surveillance for 2017 found that 68.1% of cases attributed to people who inject drugs (PWID) reported Indigenous ethnicity, among the 49.3% of reported HIV cases with available ethnicity data (4).

The Public Health Agency of Canada (PHAC), in collaboration with provincial, territorial and local public health partners, monitors trends in the prevalence of HIV and hepatitis C and associated risk factors in key populations, such as PWID, through the Tracks Surveillance Systems. The Tracks survey of PWID (formerly I-Track) involves repeated cross-sectional surveys at selected sites across Canada. This national integrated bio-behavioural surveillance system was first implemented in 2003–2005 (Phase 1) in seven sentinel sites. This was followed by three subsequent data collection periods, including the most recent survey, Phase 4 (2017–2019), in 14 sentinel sites.

Information about risk practices and health-seeking behaviours among the populations most at risk for HIV, including Indigenous PWID, is necessary to better understand the factors driving transmission (5). The objective of this report is to present national surveillance findings among Indigenous participants from Phase 4 of the Tracks survey of PWID in Canada, conducted between January 1, 2017 and May 9, 2019, at participating sentinel sites in Canada. Findings include socio-demographic characteristics, social determinants of health, use of sexually transmitted and blood-borne infection (STBBI) prevention services and testing, drug use and experiences with overdoses, sexual risk behaviours, the HIV and hepatitis C care cascade, and prevalence and awareness of infection status.

Methods

Data source and sampling methods

The data presented in this report are from Phase 4 of the Tracks survey of PWID in Canada. The Tracks survey of PWID makes use of venue-based sampling, in which participants are recruited from settings in which they are likely to gather, most often, but not limited to, where STBBI-related prevention, testing and treatment services are provided including needle and syringe distribution programs. Individuals who had injected drugs six months prior to recruitment and who met the minimum age to provide consent, which was determined at each site according to local research ethics requirements, were eligible to participate in the survey. Eligible and consenting participants completed an interviewer-administered questionnaire and provided a biological sample in the form of a dried blood spot specimen (or oral fluid exudate in the Surveillance des maladies infectieuses chez les utilisateurs de drogues par injection (SurvUDI) network sites).

The surveillance protocol and questionnaire were approved by the Health Canada/PHAC Research Ethics Board, and by local research ethics boards at each sentinel site where required. The same sampling and recruitment strategies and core questionnaire, with minor revisions to question wording, were used across all four phases to ensure comparability over time. Survey methods, sentinel site selection, questionnaire details and laboratory testing algorithms are described elsewhere (6).

Interviewer-administered questionnaire and biological sample

The Tracks PWID questionnaire collects information about socio-demographic characteristics, social determinants of health, use of health and prevention services (including testing), drug use and injecting behaviours, sexual behaviours and care and treatment for HIV and hepatitis C. The questionnaire is interviewer-administered and takes approximately 30 minutes to complete.

Dried blood spot samples were tested for HIV (antibody and antigen) and hepatitis C (antibody and ribonucleic acid; RNA). Participants were not informed of their laboratory test results because no identifying information was collected to ensure participant anonymity. Sentinel sites were asked to provide on-site testing (e.g. point of care testing, full phlebotomy) during recruitment times so that participants who were not aware of their status could get tested, should they wish. Where on-site testing was not feasible, participants were referred to local testing sites and/or health care services.

Analysis

A partnership between the Canadian Aboriginal AIDS Network (CAAN), PHAC and an advisory group comprised of a representative from Pauktuutit Inuit Women of Canada, and people with lived and/or living experience of injection drug use, HIV and/or hepatitis C was formed. Using the Two-Eyed Seeing approach, where both Indigenous and Western worldviews were respected, the advisory group met regularly over a six-month period to review and interpret the survey findings. In addition to writing this article, the advisory group identified key findings and themes that resonated with community priorities for action and prepared complementary culturally relevant infographics targeted for community use. These infographics focused on indicators related to access to harm reduction and health care services including HIV and hepatitis C care and treatment and preexposure prophylaxis (PrEP) and will be released by CAAN at later date.

Descriptive statistics for selected indicators were computed with SAS Enterprise Guide 7.1. Small cell counts were assessed to determine the risk of identifying individual participants and were presented where there was no risk of reidentification, as per PHAC's *Directive for the collection, use and dissemination of information relating to public health* (*unpublished document, PHAC, 2013*). Participants who responded as "not stated", "don't know" or "refused" were excluded from the denominator of each indicator analysis.

Results

A total of 2,383 individuals were eligible and consented to participate in the Phase 4 survey in 14 sentinel sites: Whitehorse Yukon, Central and Northern Vancouver Island British Columbia,

Prince Albert Saskatchewan (SK), Regina SK, Winnipeg Manitoba, Thunder Bay Ontario (ON), London ON, Hamilton ON, New Brunswick, Newfoundland and four geographical zones in the SurvUDI network (Ottawa, ON and the region of Outaouais, Québec (QC); Montréal, QC; Québec, QC; and other urban sites in the province of Québec [Abitibi-Témiscamingue, Montérégie, Saguenay-Lac Saint-Jean, Eastern Townships, Mauricie and Central-Québec]).

Among the 2,360 participants who responded to the question "Are you an Indigenous person, that is First Nations, Métis or Inuk?", 997 (42.2%) identified as Indigenous. The proportion of Indigenous participants within each sentinel site ranged from fewer than 10% in three SurvUDI sites (Montréal, QC, Québec, QC, other urban sites in Québec) to nearly 80% in Whitehorse, over 80% in Winnipeg and Regina and 95% in Prince Albert (**Table 1**). All 997 Indigenous participants completed a questionnaire and 884 (88.7%) provided a biological sample.

Table 1: Proportion of Indigenous participants and participants of other ethnicities by sentinel site in the Tracks survey of people who inject drugs in Canada, Phase 4, 2017–2019 (n=2,383)

Sentinel site	Indigenous participants		Participants of other ethnicities		Total
	n	%	n	%	
Whitehorse, YK	39	79.6	10	20.4	49
Central and Northern Vancouver Island, BC	67	37.6	111	62.4	178
Prince Albert, SK	170	95.0	9	5.0	179
Regina, SK	174	84.9	31	15.1	205
Winnipeg, MN	149	83.2	30	16.8	179
Thunder Bay, ON	137	68.8	62	31.2	199
London, ON	60	29.3	145	70.7	205
Hamilton, ON	38	25.2	113	74.8	151
Ottawa, ON and the region of Outaouais, QC	49	24.6	150	75.4	199
Montréal, QC	16	8.0	184	92.0	200
Québec, QC	11	8.9	113	91.1	124
Other urban sites in Québec[a]	14	8.4	152	91.6	166
New Brunswick	29	14.6	170	85.4	199
Newfoundland	44	34.6	83	65.4	127
Total	997	42.2	1,363	57.8	2,360

Abbreviations: BC, British Columbia; MN, Manitoba; ON, Ontario; QC, Québec; SK, Saskatchewan; YK, Yukon
[a] Other urban sites in the province of Québec included Abitibi-Témiscamingue, Montérégie, Saguenay-Lac Saint-Jean, Eastern Townships and Mauricie-Central Québec

Socio-demographic characteristics

Among Phase 4 Indigenous participants, 82.9% identified as First Nations, 14.9% as Métis and 2.2% as Inuit. A small proportion (13.8%) reported living in a First Nations, Métis or Inuit community at the time of the interview (**Table 2**). Four sentinel sites—three in the prairies and one in western Ontario—comprised over 60% of all Indigenous participants, while the proportion of Indigenous participants in the other sentinel sites was between 1% and 7%.

Table 2: Socio-demographic characteristics of Indigenous participants in the Tracks survey of people who inject drugs in Canada, Phase 4, 2017–2019 (n=997)

Socio-demographic characteristics[a]		n	%
Indigenous subgroup	First Nations	787	82.9
	Métis	141	14.9
	Inuit	21	2.2
Living in a First Nations, Métis or Inuit community[b]		128	13.8
Age group	Younger than 25 years	80	8.0
	25 to 39 years	463	46.5
	40 to 54 years	364	36.6
	55 years or older	89	8.9
Gender identity[c]	Cisgender male	542	54.5
	Cisgender female	426	42.9
	Transfeminine[d]	14	1.4
	Transmasculine[e]	12	1.2
Sexual orientation	Heterosexual or straight	850	85.7
	Bisexual	91	9.2
	Gay or lesbian	26	2.6
	Two-spirit	17	1.7
	Other[f]	8	0.8
Sentinel site	Regina, SK	174	17.5
	Prince Albert, SK	170	17.1
	Winnipeg, MN	149	14.9
	Thunder Bay, ON	137	13.7
	Central and Northern Vancouver Island, BC	67	6.7
	London, ON	60	6.0
	Ottawa, ON and the region of Outaouais, QC	49	4.9
	Newfoundland	44	4.4
	Whitehorse, YK	39	3.9
	Hamilton, ON	38	3.8
	New Brunswick	29	2.9
	Montréal, QC	16	1.6
	Other urban sites in the province of Québec[g]	14	1.4
	Québec, QC	11	1.1

Abbreviations: BC, British Columbia; MN, Manitoba; ON, Ontario; QC, Québec; SK, Saskatchewan; YK, Yukon
[a] Proportion of participants who responded to each individual question varied. Information was missing or not collected for 1% to 5% of the socio-demographic characteristics
[b] This question was not asked at the London site
[c] The Multidimensional Sex/Gender Measure was used to measure gender identity (7)
[d] Transfeminine included both those assigned male at birth who identified with either female or a non-binary gender
[e] Transmasculine included both those assigned female at birth who identified wither male or a non-binary gender
[f] Other included pansexual, exploring and other unclassifiable responses
[g] Other urban sites in the province of Québec included: Abitibi-Témiscamingue, Montérégie, Saguenay-Lac Saint-Jean, Eastern Townships and Mauricie-Central Québec

The average age was 38.9 years. The largest proportion of participants were between the ages of 25 to 39 years (46.5%), with a lower proportion between the ages of 40 to 54 years (36.6%), and smaller proportions of participants younger than 25 years (8.0%) or 55 years or older (8.9%).

Just over half (54.5%) identified their gender as cisgender male, 42.9% identified as cisgender female, 1.4% as transfeminine (i.e. those assigned male at birth who identified with either female or a non-binary gender) and 1.2% as transmasculine (i.e. those assigned female at birth who identified with either male or a non-binary gender). A large proportion reported their sexual orientation as heterosexual or straight (85.7%) and smaller proportions identified as bisexual (9.2%), gay or lesbian (2.6%), Two-spirit (1.7%) or other (0.8%).

Social determinants of health

Among the Phase 4 Indigenous participants, over half (57.9%) completed some high school or less, 26.4% completed high school and 15.8% completed more than high school (**Table 3**). Within the six months prior to the interview, participants most commonly reported being unemployed (70.3%) and/or on social assistance (66.7%) and/or on disability assistance (33.6%). A large proportion (83.7%) experienced financial strain (i.e. difficulty making ends meet) in the 12 months prior to the interview.

Table 3: Social determinants of health of Indigenous participants in the Tracks survey of people who inject drugs in Canada, Phase 4, 2017–2019 (n=997)

Social determinants of health[a]		n	%
Education, highest level	Completed some high school or less	575	57.9
	Completed high school	262	26.4
	Completed more than high school	157	15.8
Experienced financial strain[b,c], past 12 months		707	83.7
Housing status[d], past six months	Unstable housing	659	66.2
	Stable housing	336	33.8
	Ever incarcerated[e]	691	75.2
	Incarcerated, past 12 months[c]	224	26.1
Mental health[f]	Fair to excellent	756	84.0
	Poor	144	16.0
Other social determinants of health	Experience of stigma and discrimination[c,g], ever	753	90.2
	Experience of stigma and discrimination[c,g], past 12 months	704	84.6
	Experience of childhood physical, sexual, and/or emotional abuse[c]	729	87.5
	Experience of sexual partner physical, sexual, and/or emotional abuse[c]	654	78.6
	Placed in a residential school[c]	197	23.7
	Family member placed in a residential school[c]	687	89.8

[a] Proportion of participants who responded to each individual question varied. Information was missing or not collected for 1% to 10% of the social determinants of health indicators
[b] Defined as ever having difficulty making ends meet in the year prior to the interview
[c] This question not asked at the SurvUDI network and London sites
[d] Unstable housing included living in a hotel or motel room, rooming or boarding house, shelter or hostel, transition or halfway house, psychiatric institution or drug treatment facility, public place or correctional facility. Stable housing included living in an apartment or house or a relative's apartment or house
[e] Only partial data available at the SurvUDI network sites
[f] This question was not asked at the SurvUDI network sites
[g] Defined as ever experienced any stigma or discrimination (e.g. avoidance, pity, blame, shame, rejection, verbal abuse, or bullying) based on racial or cultural background, hepatitis C status, HIV status, sexual orientation, use of drugs or alcohol or sex work

Two-thirds (66.2%) of participants reported living in unstable housing in the six months prior to the interview. This included living in a hotel or motel room, rooming or boarding house, shelter or hostel, transition or halfway house, psychiatric institution or drug treatment facility, public place or correctional facility. Overall, 75.2% had ever been incarcerated and 26.1% had been incarcerated in the 12 months prior to the interview.

Most participants (84.0%) reported their mental health as "fair to excellent" with a smaller proportion (16.0%) reporting poor mental health status. Among Indigenous participants, 23.7% had been placed in a residential school and 89.8% had a family member who had been placed in a residential school.

The majority of participants experienced stigma and discrimination (related to racial or cultural background, hepatitis C status, HIV status, sexual orientation, use of drugs or alcohol or sex work) in their lifetime (90.2%) and in the 12 months prior to the interview (84.6%). Large proportions of participants had also experienced physical, sexual and/or emotional abuse in childhood (87.5%) or with a sexual partner (78.6%).

Access to primary health care and use of prevention services and testing

Participants were asked questions about access to primary health care and use of harm reduction and STBBI prevention services, as well as testing patterns for HIV and hepatitis C (**Table 4**). Overall, nearly three-quarters (72.2%) of participants had access to primary health care and a slightly smaller proportion (63.9%) had a regular primary healthcare provider. In the 12 months prior to the interview, one-quarter of participants (25.1%) used health services that included Indigenous health or healing practices such as a Traditional Healer, a Community Elder, the Hope for Wellness Help Line (8) or other Indigenous-specific health services. Mental health counselling services were used by 28.5% of participants in the 12 months prior to the interview.

Table 4: Access and use of health care, prevention services and testing for HIV and hepatitis C of Indigenous participants in the Tracks survey of people who inject drugs in Canada, Phase 4, 2017–2019 (n=997)

Access and use of health care services[a]	n	%
Access to primary health care[b]	594	72.2
Access to a primary healthcare provider[b]	528	63.9
Use of services that included Indigenous health or healing practices, past 12 months[b,c]	206	25.1
Use of mental health counselling services, past 12 months[d]	252	28.5
Use of prevention services and testing		
Use of a needle and syringe distribution program, past 12 months[d]	800	90.5
Tested for HIV, ever	841	87.9
Tested for HCV, ever	833	87.8
Received STBBI prevention counselling, past 12 months[b]	429	54.2
Use of a condom distribution program, past 12 months[b]	402	48.9
Use of methadone, suboxone or other opioid substitution therapy, past 12 months[d]	385	43.6
Use of treatment services for drug or alcohol use, past 12 months[b,e]	224	27.2
Use of a supervised injection or consumption site, past 12 months[d]	88	9.9
Awareness of PrEP and nPEP		
Awareness of oral HIV PrEP[d]	98	11.5
Awareness of nPEP for HIV[d]	88	10.8

Abbreviations: HCV, hepatitis C virus; HIV, human immunodeficiency virus; nPEP, non-occupational postexposure prophylaxis; PrEP, preexposure prophylaxis
[a] Proportion of participants who responded to each individual question varied. Information was missing or not collected for 2% to 10% of these indicators
[b] This question was not asked at the SurvUDI network and London sites
[c] Indigenous health or healing practices included a Traditional Healer, a Community Elder, the Hope for Wellness Help line or other Indigenous-specific services
[d] This question was not asked at the SurvUDI network sites
[e] Included services such as live-in treatment, group counselling or a Traditional Healer

Use of harm reduction and STBBI prevention services in the 12 months prior to interview varied depending on the service in question (Table 4). The majority of participants (90.5%) reported using a needle and syringe distribution program with a small proportion (9.9%) using a supervised injection or consumption site. Less than half of participants (43.6%) used methadone, suboxone or other opioid substitution therapy and just over one-quarter of participants (27.2%) used treatment services for drug or alcohol use in the 12 months prior to the interview. In the same period, 48.9% reported using a condom distribution program and 54.2% received STBBI prevention counselling. A large proportion of participants reported having ever tested for HIV (87.9%) and hepatitis C (87.8%) (Table 4).

Only a small proportion of participants were aware of oral HIV PrEP (11.5%) and non-occupational postexposure prophylaxis (nPEP) for HIV (10.8%) (Table 4). In the 12 months prior the interview, 45.7% of participants avoided healthcare services and among those who had never been tested for HIV and those who self-reported being HIV-negative, 23.1% avoided getting tested for HIV because of stigma and discrimination (defined as fear of or concern about or experienced stigma or discrimination by staff or neighbours, fear of or concern someone may learn they inject drugs, fear of or concern about or experienced violence, fear of or concern about or experienced police harassment or arrest).

Injecting behaviours

The average age participants reported first injecting drugs was 24.5 years. Less the half of all participants (40.5%) reported injecting daily in the month prior to the interview and just over half (53.5%) reported injecting in a public space in the six months prior to the interview. Overall, 93.1% of participants used a sterile needle and syringe at last injection. In the six months prior to the interview, 10.0% of participants had injected with used needles and/or syringes, of whom the majority (85.0%) borrowed needles and/or syringes from people who they knew well (e.g. family, friends or sex partners). Just under one-half (45.7%) injected with used injection equipment other than needles and/or syringes, such as water, filters, cookers, tourniquets, swabs or acidifiers in the six months prior to the interview. Among those who borrowed used injection equipment (other than needles and/or syringes), the majority (85.9%) reported borrowing from people they knew well (family, friends or sex partners). More than half of participants (58.3%) borrowed used non-injection drug paraphernalia such as straws, dollar bills or pipes in the six months prior to the interview (**Table 5**).

Table 5: Injecting behaviours of Indigenous participants in the Tracks survey of people who inject drugs in Canada, Phase 4, 2017–2019 (n=997)

Injecting behaviours[a]	n	%
Injected daily in the past month[b]	375	40.5
Injected drugs in a public space, past six months	526	53.5
Borrowed used needles and/or syringes, past six months	97	10.0
Borrowed used needles and/or syringes from people known well[c], past six months	79	85.0
Borrowed used other injecting equipment (i.e. water, filters, cookers, tourniquets, swabs, acidifiers), past six months	444	45.7
Borrowed used other injecting equipment from people known well[c], past six months	370	85.9
Borrowed used non-injection drug paraphernalia (i.e. straws, dollar bills and pipes), past six months[b]	522	58.3

[a] Proportion of participants who responded to each individual question varied. Information was missing or not collected for 1% to 5% of the injecting behaviour indicators
[b] This question was not asked at the London site
[c] People known well was defined as family, friends or sex partners

Drug use and overdose experiences

Among Indigenous participants, cocaine was the most commonly injected drug in the six months prior to the interview (58.2%), followed by methamphetamine (55.5%), morphine (49.7%), hydromorphone (43.8%) and heroin (30.4%) (**Table 6**). Approximately 20% to 30% of participants injected Ritalin alone (29.3%), fentanyl (23.4%), crack (22.9%), amphetamines (20.7%) or oxycodone (18.7%).

Table 6: Drug use and experiences with overdoses of Indigenous participants in the Tracks survey of people who inject drugs in Canada, Phase 4, 2017–2019 (n=997)

Drug use and experiences with overdoses[a]	n	%
Five most common injection drugs used, past six months[b]		
Cocaine	576	58.2
Methamphetamine	548	55.5
Morphine	491	49.7
Hydromorphone	433	43.8
Heroin	299	30.4
Five most common non-injection drugs used, past six months[b]		
Cannabis	708	71.9
Alcohol	652	66.2
Methamphetamine	503	51.3
Cocaine	490	49.9
Crack	479	48.8
Awareness, access and use of an overdose kit		
Heard of overdose kits[c]	693	83.3
Ever used an overdose kit[c,d]	178	25.7
Overdose kits are available in participants' community[d,e]		
No	28	4.0
Yes	631	91.1
Don't know	34	4.9
Overdose experiences		
Overdosed in the past six months[d,f]	185	20.9
Five most common drugs or substances used at last overdose[b,c,f]		
Fentanyl	67	42.7
Heroin	67	41.6
Methamphetamine	50	30.7
Alcohol	33	21.5
Cocaine	33	20.3

[a] Proportion of participants who responded to each individual question varied. Information was missing or not collected for 1% to 2% for these indicators except for drugs used at last overdose where information was missing or not collected for 10% to 15% of these indicators
[b] Participants recorded all drugs (that they had injected, consumed or used at last overdose) for non-medicinal purposes in the six months prior to interview. The most commonly reported drugs among all participants are presented. Responses are non-mutually exclusive
[c] This question was not asked at the SurvUDI network and London sites
[d] Among participants who had heard of overdose kits
[e] This question was not asked at the SurvUDI network sites
[f] Among participants who overdosed in the past six months and who provided a response

A wide range of non-injection drugs were used in the six months prior to the interview, most frequently cannabis (71.9%), alcohol (66.2%), methamphetamine (51.3%), cocaine (49.9%) and crack (48.8%). Opioid analgesic consumption (non-injection routes) was also reported specifically for codeine (34.7%), methadone (31.0%), morphine (30.9%) and hydromorphone (27.3%) (Table 6).

Most participants (83.3%) had heard of overdose kits, of whom the majority (91.1%) reported that overdose kits were available in their community. Among participants who had heard of overdose kits, one-third (33.8%) of Indigenous participants carried an overdose kit and one-quarter (25.7%) had ever used one on someone else. In the six months prior to the interview, 20.9% of participants had overdosed and the drugs most commonly reported at last overdose were fentanyl (42.7%), heroin (41.6%), and methamphetamine (30.7%) (Table 6).

Sexual risk behaviours

Among participants who had ever had sex, 35.4% had two or more sexual partners in the six months prior to the interview (**Table 7**). Among participants who had a regular sex partner, inconsistent condom use was reported by 85.6% during vaginal and/or anal sex. Among participants who had a casual sex partner, inconsistent condom use was reported by 57.6% during vaginal and/or anal sex. A small proportion (16.0%) had engaged in transactional sex at least once, among whom, 26.3% had condomless sex at last transactional sex (Table 7). Most participants (81.6%) reported substance use before or during sex (Table 7).

Table 7: Sexual behaviours of Indigenous participants in the Tracks survey of people who inject drugs in Canada, Phase 4, 2017–2019 (n=997)

Sexual risk behaviours[a]	n	%
Two or more sex partners, past six months[b]	330	35.4
Inconsistent condom use during vaginal and/or anal sex with a regular sex partner, past six months[c]	540	85.6
Inconsistent condom use during vaginal and/or anal sex with a casual sex partner, past six months[c]	167	57.6
Engaged in transactional sex, past six months	127	16.0
Condomless sex at last transactional sex[d]	31	26.3
Substance use before or during sex, past six months[d]	586	81.6

[a] Proportion of participants who responded to each individual question varied. Information was missing or not collected for 2% to 14% of the sexual risk behaviour indicators
[b] Among participants who had ever had sex
[c] Inconsistent condom use defined as not always using a condom (i.e. never, sometimes or frequently). This question was not asked at the London site
[d] This question was not asked at the SurvUDI network sites

HIV and hepatitis C prevalence and awareness

Among Indigenous participants who provided a biological sample of sufficient quantity for testing (n=879), 15.4% tested positive for HIV, among whom 78.2% were aware of their HIV-positive status (**Table 8**). Lifetime exposure to hepatitis C infection (i.e. the proportion of hepatitis C seropositive respondents) was 65.8% (among n=863 samples of sufficient quantity for testing). Over one-third (36.4%) were hepatitis C RNA-positive (among n=696 samples of sufficient quantity for testing)—an indicator of current hepatitis C infection—of whom, 49.4% were aware of their hepatitis C RNA-positive status. Among participants who provided a biological sample of sufficient quantity for testing for both HIV antibodies and hepatitis C virus (HCV) RNA, 6.0% were HIV-positive and hepatitis C RNA positive.

HIV and hepatitis C care cascade

HIV care cascade indicators were measured among Indigenous participants aware of their HIV-positive status (Table 8). The majority (96.2%) were under the care of a doctor or healthcare

Table 8: HIV and hepatitis C prevalence, awareness of infection status, and care cascade of Indigenous participants in the Tracks survey of people who inject drugs in Canada, Phase 4, 2017–2019 (n=997)

HIV and hepatitis C prevalence[a]	n	%
HIV prevalence and awareness of infection status		
HIV prevalence[b,c]	135	15.4
Awareness of HIV-positive status[d]	104	78.2
HIV care cascade (among participants aware of their HIV-positive status, n=104)		
Linked to care for HIV-related services[e]	100	96.2
Currently taking ART treatment	87	83.7
Adherence to ART, no missed doses in last month[f]	30	43.5
Self-reported undetectable HIV viral load[g]	47	64.4
HIV care cascade (among participants aware of their HIV-positive status, n=104) (*continued*)		
Avoidance of HIV services because of stigma and discrimination, past 12 months[f]	21	25.3
Avoidance of HIV treatment because of stigma and discrimination, past 12 months[f]	18	21.7
Hepatitis C prevalence and awareness of infection status)		
HCV antibody prevalence[c,h]	568	65.8
HCV RNA prevalence[c,i]	253	36.4
Awareness of hepatitis C RNA-positive status[j]	122	49.4
Hepatitis C care cascade (among participants aware of their hepatitis C RNA-positive status, n=122)		
Linked to care for hepatitis C[k]	66	54.1
Ever taken hepatitis C treatment[l]	17	14.1
Currently taking hepatitis C treatment[l]	7	5.8
HIV and hepatitis C co-infection[m]		
HIV-positive and hepatitis C RNA positive	42	6.0

Abbreviations: ART, anti-retroviral therapy; HCV, hepatitis C virus; HIV, human immunodeficiency virus; RNA, ribonucleic acid

[a] Proportion of participants who responded to each individual question varied. Information was missing or not collected for less than 1% of these indicators except for adherence to ART (20%) and self-reported undetectable HIV viral load (26%)

[b] Among participants who provided a biological sample of sufficient quantity for HIV testing (n=879)

[c] HIV and hepatitis C testing algorithms are provided in **Appendix 1**

[d] Among participants who tested positive for HIV antibodies and who reported their HIV diagnosis. Participants who reported that their last HIV test result was positive and who were found to be HIV positive based on testing of the biological specimen provided at the time of interview were classified as being aware of their HIV-positive status

[e] Defined as under the care of a doctor or health care provider for HIV-related services at the time of the interview (in the six months prior to the interview in the SurvUDI network and London sites)

[f] This question was not asked at the SurvUDI network and London sites. The denominator also excludes participants with missing data

[g] Among participants currently on ART at the time of the interview. This question was not asked at the SurvUDI network sites. The denominator also excludes participants with missing data

[h] Among participants who provided a biological sample of sufficient quantity for HCV antibody testing (n=863)

[i] Among participants who provided a biological sample of sufficient quantity for HCV antibody and RNA testing (n=696). HCV RNA testing was not conducted at the SurvUDI network sites

[j] Among participants who tested HCV RNA positive and who reported their current hepatitis C status. Participants who reported being currently infected with hepatitis C and who were hepatitis C RNA positive based on testing of the biological specimen provided at the time of interview were classified as being aware of their hepatitis C RNA-positive status

[k] Defined as under the care of a health care provider for hepatitis C-related services at the time of the interview. The denominator excludes participants with missing data

[l] Denominator excludes participants with missing data

[m] Among participants who provided a biological sample of sufficient quantity for testing for both HIV antibodies and HCV RNA testing. The HCV RNA testing was not conducted at the SurvUDI network sites

provider for HIV-related services at the time of the interview. A large proportion (83.7%) were currently taking antiretroviral therapy (ART) at the time of the interview. Adherence to ART, measured as no missed doses in the month prior to the interview, was 43.5%. Among participants currently taking ART at the time of the interview, 64.4% reported an undetectable HIV viral load. Approximately one-quarter of participants who were aware of their HIV-positive status reported avoiding HIV services (25.3%) or HIV treatment (21.7%) because of stigma and discrimination in the 12 months prior to the interview.

Hepatitis C care cascade indicators were measured among Indigenous participants who were aware of their current hepatitis C infection (Table 8). More than half (54.1%) reported being linked to care for hepatitis C; a smaller proportion (14.1%) had ever taken hepatitis C treatment; and an even smaller proportion (5.8%) were currently taking hepatitis C treatment. Common barriers for not taking hepatitis C treatment included because participants were drinking or using drugs (29.7%), they only recently started to get hepatitis C medical care (23.0%) or their doctor advised them to delay treatment (19.0%).

Discussion

The establishment of an Indigenous-led advisory group was fundamentally important and necessary in the analysis and interpretation of the surveillance findings focusing on Indigenous participants. The team composition and use of the Two-Eyed Seeing approach respected both Indigenous and Western world views while fostering meaningful engagement from diverse stakeholders, including Indigenous people with lived and/or living experience of injection drug use. The collaborative nature of the advisory group is a step towards reconciliation.

A large proportion of Indigenous participants (84.0%) reported fair to excellent mental health—a finding that stands out compared with proportions reported for other survey indicators associated with poor mental health: childhood and sexual partner abuse (87.5% and 78.6%, respectively); family member placed in a residential school (89.8%); incarceration (75.2%); unstable housing (66.2%); and ever experienced stigma and discrimination (90.2%). High levels of reported mental health wellness may be a reflection of the resiliency of Indigenous peoples within the individual and collective experience of trauma.

Regarding prevention indicators, high rates of lifetime testing for HIV and hepatitis C were noted (87.9% and 87.8%, respectively) and the majority of participants (90.5%) had used the services of a needle and syringe distribution program and reported safe injecting practices (93.1% reported using a clean needle and syringe at last injection). Use of other harm reduction services was notably lower: opioid-substitution therapy (43.6%); drug treatment services (27.2%); condom distribution program (48.9%); or receipt of STBBI counselling (54.2%). While the use

of a supervised injection or consumption site in the 12 months prior to the interview was low (9.9%), it should be noted that this service is not available uniformly across Canada. Awareness of PrEP and nPEP was low (11.5% and 10.8%, respectively). Most participants had heard of naloxone kits (83.3%). The lower reported proportions that reported carrying an overdose kit (33.8%) speaks to the ongoing need for scaling up naloxone kit distribution.

Among Indigenous participants of the Tracks survey of PWID, HIV seroprevalence (15.4%), lifetime exposure to hepatitis C (65.8%) and current hepatitis C infection (36.4%) were high. These findings corroborate results from other regional studies that underscore how injection drug use and HIV and hepatitis C disproportionately impact Indigenous peoples and communities across Canada (9–12). The HIV 90-90-90 target indicators measured among Indigenous PWID in this survey (78.2% aware of their HIV-positive status, 83.7% currently taking ART, 64.4% reporting undetectable viral load) are encouraging however these findings signal that better access to HIV care and treatment need to be addressed. Further, hepatitis C care and treatment indicators (i.e. 54.1% linked to care, 5.8% currently on treatment) were substantially lower than those for HIV indicating important gaps in testing, care and treatment of hepatitis C in this key population.

Moving forward

Indigenous peoples and communities are resourceful and resilient. Connection to culture, land, and ceremony has helped Indigenous peoples to understand health and respond individually and collectively to historical and ongoing trauma such as colonialism and residential school experiences. As Indigenous peoples and communities face ongoing health issues such as HIV and hepatitis C infections, the burden of the opioid crisis and other drug-related overdose deaths further emphasize the ongoing need for access to culturally relevant prevention and treatment services including increased distribution of naloxone overdose kits. Prevention interventions are warranted such as comprehensive STBBI sexual health education including increasing awareness and access to PrEP and nPEP among HIV-negative individuals at high risk for infection to lower their risk of becoming infected (13). Ongoing engagement in the interpretation of surveillance findings among Indigenous participants through Indigenous-specific networks, traditional healers and community-based approaches can also contribute to the resilience of Indigenous peoples and communities.

Strengths and limitations

This national integrated bio-behavioural surveillance system provides information on HIV and hepatitis C among PWID from sites across the country for use at the local, provincial and federal levels to inform and guide public health interventions in this population. The Tracks survey of PWID uses non-probability-based sampling; therefore, findings are not representative of all Indigenous PWID at any given site or in Canada. Small numbers of participants who identified as Métis and Inuit, as well as those whose gender identity was transmasculine or transfeminine, precluded specific sub-group analyses to examine associations with other socio-demographic characteristics and indicators. With the exception of the laboratory results, these findings were based on interviewer-administered questionnaires and self-reported data and it is possible that certain risk behaviours were over- or underrepresented.

Conclusion

The shared efforts of the Indigenous-led advisory group facilitated community leadership and collaborative analysis of the Tracks survey of PWID. This collaboration resulted in the development of knowledge products that will disseminate the Indigenous-specific results contextualized to be most relevant for uptake by stakeholders in diverse settings. These surveillance findings signal the challenges in access to and maintenance of effective HIV and hepatitis C care and treatment among Indigenous PWID in Canada. This information is especially important to inform harm reduction strategies and Indigenous-specific STBBI prevention and treatment services in Canada. Further examination of the barriers and facilitators to the access and use of STBBI and harm reduction prevention and treatment services is warranted.

Authors' statement

JT — Conceptualization, formal analysis, methodology, project administration, writing (original draft and review and editing)
MS — Conceptualization, writing (original draft and review and editing)
DB — Conceptualization, writing (original draft and review and editing)
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LJ — Conceptualization, data curation, formal analysis, writing (original draft and review and editing)
MB — Conceptualization, methodology, project administration, writing (review and editing)
DP — Conceptualization, funding acquisition, methodology, writing (original draft and review and editing)
RM — Conceptualization, writing (original draft and review and editing)

Competing interests

None.

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Appendix 1: Human immunodeficiency virus and hepatitis C testing algorithms

HIV testing algorithms

For non-SurvUDI sites, HIV status was initially determined by screening dried blood spot specimens using the Bio-Rad GS HIV Combo Ag/Ab assay followed by confirmatory testing using the Roche COBAS AmpliPrep/COBAS Taqman HIV-1 Quant v2.0 assay (London) or the Roche COBAS AmpliPrep/COBAS Taqman HIV-1 Qualitative Test v2.0 (New Brunswick, Newfoundland and Regina). For the remaining non-SurvUDI sites (i.e. Vancouver Island, Thunder Bay, Whitehorse, Winnipeg, Prince Albert and Hamilton), due to recurrent low volume specimens, HIV status was determined by performing screening and confirmatory testing using two separate enzyme immunoassays (EIAs). As a result, specimen volume was sufficient for HIV and hepatitis C testing in most cases. The change in algorithms is not expected to have an impact on the results. Algorithms are described in more detail below.

London: HIV screening was performed using the Bio-Rad GS HIV Combo Ag/Ab assay. A non-reactive result indicated no HIV infection. Confirmatory testing was performed on screened reactive results using the Roche COBAS AmpliPrep/COBAS Taqman HIV-1 Quant v2.0 assay. A detected result indicated a HIV infection. In instances where the Bio-Rad GS HIV Combo Ag/Ab assay was positive, and the Roche COBAS ApliPrep/COBAS Taqman HIV-1 v2.0 assay result was not detected, a second EIA (AVIOQ HIV-1 Microelisa System) was conducted. A reactive result on both the Bio-Rad GS HIV Combo Ag/Ab assay and the AVIOQ HIV-1 Microelisa System indicated an HIV infection.

New Brunswick, Newfoundland and Regina: HIV screening was performed using the Bio-Rad GS HIV Combo Ag/Ab assay (Bio-Rad). A non-reactive result indicated no HIV infection. Confirmatory testing was performed on screened reactive results using the Roche COBAS AmpliPrep/COBAS Taqman HIV-1 Qualitative Test v2.0 (Roche). A detected result indicated an HIV infection. In instances where the Bio-Rad was reactive, and the Roche result was not detected, a second EIA, the AVIOQ HIV-1 Microelisa System (Avioq), was conducted as a tie breaker. A reactive result on both the Bio-Rad and the Avioq indicated an HIV infection. A reactive result on the Bio-Rad, not detected result on the Roche, and a non-reactive or an indeterminate (i.e. absorbance results that were near, but did not overlap, the cut-off value for a reactive/non-reactive result) result on the Avioq, was interpreted as an overall indeterminate result.

Vancouver Island, Thunder Bay, Whitehorse, Winnipeg, Prince Albert, and Hamilton: HIV screening was performed using the Bio-Rad GS HIV Combo Ag/Ab assay (Bio-Rad). A non-reactive result indicated no HIV infection. Confirmatory testing was performed on screened reactive results using a second EIA, the AVIOQ HIV-1 Microelisa System (Avioq). A reactive result indicated an HIV infection. In instances where the Bio-Rad was reactive, and the Avioq was non-reactive or indeterminate (i.e. absorbance results that were near, but did not overlap, the cut-off value for a reactive/non-reactive result), the Roche COBAS AmpliPrep/COBAS Taqman HIV-1 Qualitative Test v2.0 (Roche) was used as a tie breaker. A reactive result on the Bio-Rad and a detected result on the Roche indicated an HIV infection. A reactive result on the Bio-Rad, non-reactive or indeterminate result on the Avioq, and a not detected result on the Roche, was interpreted as an overall indeterminate result.

For SurvUDI network sites, oral fluid specimens were screened for HIV at the Laboratoire de santé publique du Québec, Institut national de santé publique du Québec, using the Bio-Rad GS HIV1/HIV2 PLUS O EIA, a diagnostic assay approved by Health Canada and validated in the SurvUDI study for use with oral fluid. Confirmatory testing was not performed for samples that tested repeatedly reactive. A positive result indicated an HIV infection.

Hepatitis C testing algorithms

For all non-SurvUDI network sites: hepatitis C screening testing was performed using the Ortho® HCV version 3.0 EIA (Ortho). A non-reactive result indicated never having been infected with hepatitis C. A reactive result indicated lifetime exposure to hepatitis C. Confirmatory testing was performed on screened reactive and indeterminate results (i.e. absorbance results that were near, but did not overlap, the cut-off value for a reactive/non-reactive result) using the Roche COBAS AmpliPrep/COBAS Taqman HCV Quantitative test v2.0 (Roche). A detected result indicated a current hepatitis C infection and a not detected result indicated a lifetime exposure to hepatitis C. For those that screened indeterminate on the Ortho, a detected result on the Roche indicated a current hepatitis C infection and a not detected result on the Roche was interpreted as an indeterminate result.

SurvUDI network sites: hepatitis C antibody testing for oral fluid specimens was performed using the Ortho® hepatitis C version 3.0 EIA at the Institut national de santé publique du Québec laboratories. Confirmatory testing was not performed for samples that tested positive. A positive result indicated past or present hepatitis C infection and did not discriminate acute from chronic or resolved infections. Validation of this test for use with oral fluid was performed in the SurvUDI study.

Sensitivity and specificity of laboratory tests

The specificity of the Bio-Rad GS HIV Combo Ag/Ab EIA, Avioq HIV-1 Microelisa System, and Roche COBAS AmpliPrep/COBAS TaqMan HIV-1 Qualitative Test v2.0 is ≥99.9% on DBS according to kit inserts or internal validation data. Similarly, the sensitivity of each assay is 100% except for the Bio-Rad GS HIV Combo Ag/Ab EIA which is 96.6%. The limit of quantification for the Roche COBAS/AmpliPrep TaqMan HIV-1 Quantitative Test v2.0 on DBS is 616 copies/mL.

The specificity and sensitivity of the ORTHO HCV v3.0 ELISA Test System is 100% according to internal validation data. The limit of quantification for the Roche COBAS AmpliPrep/COBAS TaqMan HCV Test v2.0 is 355 IU/mL.

SCOPING REVIEW

Occupations at risk of contracting zoonoses of public health significance in Québec

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Abstract

Introduction: Climate change plays an important role in the geographic spread of zoonotic diseases. Knowing which populations are at risk of contracting these diseases is critical to informing public health policies and practices. In Québec, 14 zoonoses have been identified as important for public health to guide the climate change adaptation efforts of decision-makers and researchers. A great deal has been learned about these diseases in recent years, but information on at-risk workplaces remains incomplete. The objective of this study is to paint a portrait of the occupations and sectors of economic activity at risk for the acquisition of these zoonoses.

Methods: A rapid review of the scientific literature was conducted. Databases on the Ovid and EBSCO research platforms were searched for articles published between 1995 and 2018, in English and French, on 14 zoonoses (campylobacteriosis, cryptosporidiosis, verocytotoxigenic *Escherichia coli*, giardiasis, listeriosis, salmonellosis, Eastern equine encephalitis, Lyme disease, West Nile virus, food botulism, Q fever, avian and swine influenza, rabies, hantavirus pulmonary syndrome) and occupational health. The literature search retrieved 12,558 articles and, after elimination of duplicates, 6,838 articles were evaluated based on the title and the abstract. Eligible articles had to address both concepts of the research issue (prioritized zoonoses and worker health). Of the 621 articles deemed eligible, 110 were selected following their full reading.

Results: Of the diseases under study, enteric zoonoses were the most frequently reported. Agriculture, including veterinary services, public administration services and medical and social services were the sectors most frequently identified in the literature.

Conclusion: The results of our study will support public health authorities and decision-makers in targeting those sectors and occupations that are particularly at risk for the acquisition of zoonoses. Doing so will ultimately optimize the public health practices of those responsible for the health of workers.

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Keywords: zoonoses, occupations, sectors of activity, workers, public health

Introduction

Climate change plays an important role in the geographic establishment and spread of zoonoses. Projected variations in temperature and precipitation will influence the survival and spread of zoonotic pathogens, as well as the distribution of their vectors, favouring the spread of these diseases over larger geographic areas and for longer periods (1).

In Québec, 14 zoonotic diseases were identified as important to public health. Of these, 12 were prioritized by the scientific experts and public policy decision-makers making up Québec's Multi-Party Observatory on Zoonoses and Adaptation to Climate Change. The other two zoonoses are listeriosis and hantavirus pulmonary syndrome (1–3). These 14 zoonoses are enteric (campylobacteriosis, cryptosporidiosis, Shiga toxi-producing

Escherichia coli, giardiasis, listeriosis, salmonellosis) and non-enteric (vector-borne: Eastern equine encephalitis, Lyme disease, West Nile virus; non-vector-borne: food botulism in Nunavik, Q fever, avian and swine influenza, rabies, hantavirus pulmonary syndrome). The Observatory has published information on populations vulnerable to these diseases, including sealers in Nunavik, who are at risk of acquiring foodborne botulism, and workers in the poultry industry, who are at risk for campylobacteriosis (2,3). However, information targeting workers remains incomplete or even non-existent for some zoonoses, indicating the need to develop this body of knowledge to inform public health policies and practices.

The objective of this study was to identify the occupations and sectors of economic activity most at risk for the acquisition of zoonoses important to public health in Québec in order to contribute to the decision-making process of public health authorities and to optimize the practices of those responsible for workers' health. This synthesis of knowledge from the scientific literature is presented by zoonosis category (enteric, vector-borne non-enteric and non-vector-borne non-enteric).

Methods

The research team conducted a rapid review of the literature using systematic review methodology. The Ovid and EBSCO platforms were used to search the Medline, Embase, Evidence-Based Medicine Reviews (EBMR), Global Health, Forfait Total Access Collection and Environment Complete databases. The searches of the databases were conducted using a series of keywords related to the zoonoses of interest and to workers' health. **Table 1** and **Table 2** show the queries developed using these keywords.

The research was restricted to original peer-reviewed studies published between 1995 and 2018, in English or French. Literature reviews, commentaries, editorials, news, letters of opinion and Q&A were excluded. No restrictions were applied in terms of geographical scope. First, the article was screened by title and abstract; eligible articles had to demonstrate a clear link to the research, i.e. address both concepts of the research issue (prioritized zoonoses and worker health) and minimally address a high-risk sector of economic activity or occupation. Next, a full

Table 1: Queries in Ovid databases

Search #	Requests
S1	botulism/ or "Clostridium botulinum"/ or "Clostridium botulinum type E"/ or campylobacter/ or "Campylobacter infections"/ or "Campylobacter jejuni"/ or Cryptosporidiosis/ or exp Cryptosporidium/ or "Encephalitis Virus, Eastern Equine"/ or "Encephalomyelitis, Eastern Equine"/ or "Shiga-Toxigenic Escherichia coli"/ or "Escherichia coli O157"/ or "Enterohemorrhagic Escherichia coli"/ or "Q fever"/ or Giardiasis/ or Giardia/ or "Giardia lamblia"/ or exp "Lyme disease"/ or Rabies/ or "Rabies virus"/ or "Salmonella Infections"/ or "Salmonella Food Poisoning"/ or "Salmonella Infections, Animal"/ or "Salmonella enterica"/ or "Salmonella enteritidis"/ or "Salmonella typhimurium"/ or "West Nile virus"/ or exp Listeriosis/ or exp Listeria/ or "Hantavirus Infections"/ or "Hantavirus Pulmonary Syndrome"/
S2	("Influenza A virus"/ or "Influenza A Virus, H1N1 Subtype"/ or "Influenza A Virus, H1N2 Subtype"/ or "Influenza A Virus, H3N2 Subtype"/ or "Influenza A Virus, H5N1 Subtype"/ or "Influenza A Virus, H7N9 Subtype"/ or "Influenza in Birds"/) and Zoonoses/
S3	1 or 2
S4	(Botulism* or "Clostridium botulinum" or Campylobacter* or (C adj jejuni) or Cryptosporidios* or Cryptosporidium or "eastern equine encephal*" or (EEE adj virus*) or VTEC or STEC or ((Verocytotox* or Verotox* or "Vero Cytotoxin-Producing" or (shiga adj tox*) or Shigatox*) adj15 ("Escherichia coli" or "E. coli")) or (("Escherichia coli" or "E. coli") adj10 "O157*") or "Q fever*" or "Query fever*" or Coxiellosis or "coxiella burnetii" or Giardia* or lamblias#s or (G adj intestinalis) or (G adj duodenalis) or lyme or ((B or borrelia) adj burgdorferi) or Rabies or Salmonellos#s or (("west nile" or "egypt 101" or kunjin) adj (fever* or virus)) or listerios#s or ((listeria or L) adj monocytoge*) or (hantavirus adj1 pulmonary adj1 syndrome*) or "Sin Nombre virus").ti,ab,kw.
S5	((((A or A-type or "Type A" or Avian or Bird or Swine or H1N1 or H1N2 or H3N2 or H5N1 or H7N9) adj2 (Influenza? or flu or orthomyxovirus)) or ("pestis galli" adj1 myxovirus*) or "fowl plague virus*") and (zoonos* or zoonotic or "emerg* diseas*" or (animal-transmitted adj (infection* or disease*)) or (human adj1 animal adj transmission*))).ti,ab,kw.
S6	4 or 5
S7	3 or 6
S8	*"occupational exposure"/ or *"occupational health"/ or exp *"occupational groups"/ or *"occupational diseases"/ or *"agricultural workers' diseases"/ or "meat-packing industry"/
S9	(occupation* or worker* or workplace* or professional* or employ* or job$1 or labo?r or labo?rs or labo?rer* or personnel or staff).ti,ab,kw.
S10	(farm* or agricultur* or hunter* or (outdoor adj occupation*) or veterinar* or (wildlife adj manag*) or abattoir* or slaughter*).ti,ab,kw.
S11	8 or 9 or 10
S12	7 and 11
S13	12 not (exp animals/ not humans/)
S14	13 and (english or french).lg.
S15	limit 14 to yr=1995-2018
S16	15 not (editorial or letter or comment or news).pt.

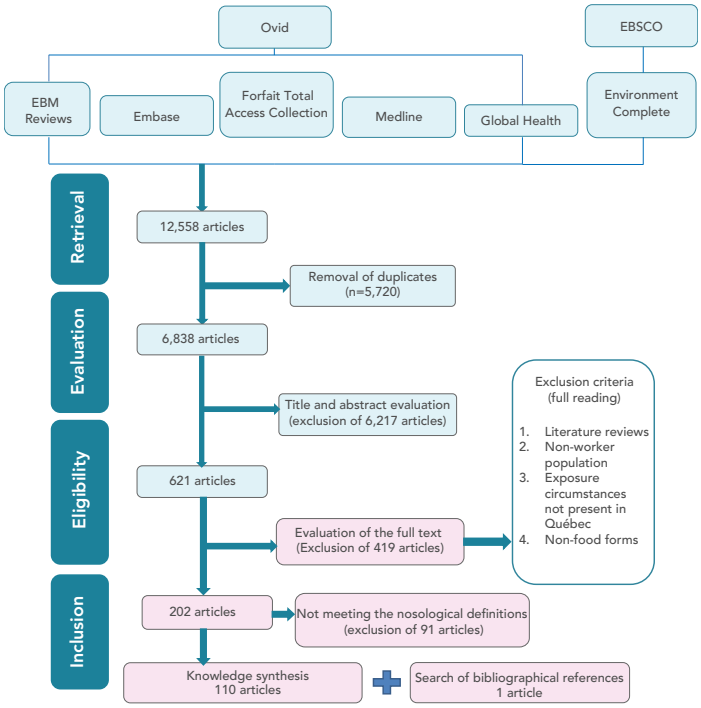
Table 2: Queries in EBSCO database

Search #	Requests
S1	TI (Botulism* OR "Clostridium botulinum" OR Campylobacter* OR (C W0 jejuni) OR Cryptosporidios* OR Cryptosporidium OR "eastern equine encephal*" OR (EEE W0 virus*) OR VTEC OR STEC OR ((Verocytotox* or Verotox* or "Vero Cytotoxin-Producing" or (shiga w0 tox*) OR Shigatox*) W15 ("Escherichia coli" or "E. coli")) OR (("Escherichia coli" or "E. coli") W10 "O157*") OR "Q fever*" OR "Query fever*" OR Coxiellosis OR "coxiella burnetii" OR Giardia* OR lamblias#s OR (G W0 intestinalis) OR (G W0 duodenalis) OR lyme or ((B or borrelia) W0 burgdorferi) OR Rabies OR Salmonellos#s OR (("west nile" OR "egypt 101" OR kunjin) W0 (fever* OR virus)) OR listerios#s OR ((listeria OR L) W0 monocytoge*) OR (hantavirus W1 pulmonary W1 syndrome*) OR "Sin Nombre virus") OR AB (Botulism* OR "Clostridium botulinum" OR Campylobacter* OR (C W0 jejuni) OR Cryptosporidios* OR Cryptosporidium OR "eastern equine encephal*" OR (EEE W0 virus*) OR VTEC OR STEC OR ((Verocytotox* or Verotox* or "Vero Cytotoxin-Producing" or (shiga W0 tox*) OR Shigatox*) W15 ("Escherichia coli" or "E. coli")) OR (("Escherichia coli" or "E. coli") W10 "O157*") OR "Q fever*" OR "Query fever*" OR Coxiellosis OR "coxiella burnetii" OR Giardia* OR lamblias#s OR (G W0 intestinalis) OR (G W0 duodenalis) OR lyme or ((B or borrelia) W0 burgdorferi) OR Rabies OR Salmonellos#s OR (("west nile" OR "egypt 101" OR kunjin) W0 (fever* OR virus)) OR listerios#s OR ((listeria OR L) W0 monocytoge*) OR (hantavirus W1 pulmonary W1 syndrome*) OR "Sin Nombre virus") OR KW (Botulism* OR "Clostridium botulinum" OR Campylobacter* OR (C W0 jejuni) OR Cryptosporidios* OR Cryptosporidium OR "eastern equine encephal*" OR (EEE W0 virus*) OR VTEC OR STEC OR ((Verocytotox* or Verotox* or "Vero Cytotoxin-Producing" or (shiga W0 tox*) OR Shigatox*) W15 ("Escherichia coli" or "E. coli")) OR (("Escherichia coli" or "E. coli") W10 "O157*") OR "Q fever*" OR "Query fever*" OR Coxiellosis OR "coxiella burnetii" OR Giardia* OR lamblias#s OR (G W0 intestinalis) OR (G W0 duodenalis) OR lyme or ((B or borrelia) W0 burgdorferi) OR Rabies OR Salmonellos#s OR (("west nile" OR "egypt 101" OR kunjin) W0 (fever* OR virus)) OR listerios#s OR ((listeria OR L) W0 monocytoge*) OR (hantavirus W1 pulmonary W1 syndrome*) OR "Sin Nombre virus")
S2	TI ((((A OR A-type OR "Type A" OR Avian OR Bird OR Swine OR H1N1 OR H1N2 OR H3N2 OR H5N1 OR H7N9) W2 (Influenza# OR flu OR orthomyxovirus)) OR ("pestis galli" W1 myxovirus*) OR "fowl plague virus*") AND (zoonos* OR zoonotic OR "emerg* diseas*" OR (animal-transmitted W0 (infection* OR disease*)) OR (human W1 animal W0 transmission*))) OR AB ((((A OR A-type OR "Type A" OR Avian OR Bird OR Swine OR H1N1 OR H1N2 OR H3N2 OR H5N1 OR H7N9) W2 (Influenza# OR flu OR orthomyxovirus)) OR ("pestis galli" W1 myxovirus*) OR "fowl plague virus*") AND (zoonos* OR zoonotic OR "emerg* diseas*" OR (animal-transmitted W0 (infection* OR disease*)) OR (human W1 animal W0 transmission*))) OR KW ((((A OR A-type OR "Type A" OR Avian OR Bird OR Swine OR H1N1 OR H1N2 OR H3N2 OR H5N1 OR H7N9) W2 (Influenza# OR flu OR orthomyxovirus)) OR ("pestis galli" W1 myxovirus*) OR "fowl plague virus*") AND (zoonos* OR zoonotic OR "emerg* diseas*" OR (animal-transmitted W0 (infection* OR disease*)) OR (human W1 animal W0 transmission*)))
S3	S1 OR S2
S4	TI (occupation* or worker* or workplace* or professional* or employee* or job or jobs or labo#r or labor#rs or labo#rer* or personnel or staff) OR AB (occupation* or worker* or workplace* or professional* or employee* or job or jobs or labo#r or labor#rs or labo#rer* or personnel or staff) OR KW (occupation* or worker* or workplace* or professional* or employee* or job or jobs or labo#r or labor#rs or labo#rer* or personnel or staff)
S5	TI (farmer* or hunter* or (outdoor W0 occupation*) or veterinar* or (wildlife W0 manager*) or slaughterer*) OR AB (farmer* or hunter* or (outdoor W0 occupation*) or veterinar* or (wildlife W0 manager*) or slaughterer*) OR KW (farmer* or hunter* or (outdoor W0 occupation*) or veterinar* or (wildlife W0 manager*) or slaughterer*)
S6	S4 OR S5
S7	S3 AND S6
S8	S7 and LA (english OR french)
S9	S8 and (DT 1995-2018)
S10	S9 NOT PT (editorial or letter or commentary)
S11	TI (((systematic OR state-of-the-art OR scoping OR literature) W0 (review OR reviews OR overview* OR assessment*)) OR "review* of reviews" OR meta-analy* OR metaanaly* OR ((systematic OR evidence) N1 assess*) OR "research evidence" OR synthes?s OR metasynthe* OR meta-synthe*) OR SU (((systematic OR state-of-the-art OR scoping OR literature) W0 (review OR reviews OR overview* OR assessment*)) OR "review* of reviews" OR meta-analy* OR metaanaly* OR ((systematic OR evidence) N1 assess*) OR "research evidence" OR synthes?s OR metasynthe* OR meta-synthe*)
S12	S10 AND S11
S13	S10 NOT S11

reading of the selected publications led to the selection of only those articles that dealt specifically with the zoonoses of interest and that referred to the workplace as a place of acquisition. Studies not involving a work environment (i.e. community acquisition) or that mentioned exposure circumstances that could not have occurred in Québec workplaces were excluded. Reviewing the references listed in the selected publications allowed for the identification of relevant elements in articles published prior to 1995. Finally, studies for which the descriptions of zoonotic cases did not meet the criteria of the provincial nosological definitions or the diagnostic criteria used in Québec were excluded. The data collected from the selected articles (sectors of economic activity, occupations at risk, risk factors) were recapped in summary analysis grids.

Figure 1 shows the process leading to the selection of information. The research team determined the occupations and sectors of economic activity most at risk for the acquisition of these zoonoses based on the number of articles documenting them.

Figure 1: Illustration of the process for documentation searches and selection of publications Database search algorithms



Note: Five databases were queried on the Ovid platform: Embase, Ovid MEDLINE, Evidence-Based Medicine Reviews (EBMR), Forfait Total Access Collection and Global Health; one database was queried on the EBSCO platform: Environment Complete (EC)
Restrictions applied: 1995–2018; English and French; commentaries, editorials, news, opinion letters and Q&A excluded. No restrictions in terms of geographic scope were applied to initiate the search

Results

A list of the occupations and sectors of economic activity most at risk for the acquisition of prioritized zoonotic diseases is presented in **Table 3**. These are classified according to the National Occupational Classification system version 2016 version 1.3 and the 1984 Québec Economic Activity Classification version 1990, respectively. The distribution of selected articles by prioritized zoonosis is available in **Table 4**

According to the scientific literature evaluated, the most commonly reported zoonoses in workplaces are enteric zoonoses, followed by non-vector-borne non-enteric zoonoses and vector-borne zoonoses. Salmonellosis and cryptosporidiosis are the enteric zoonoses most frequently identified in the literature evaluated. Of vector-borne zoonoses, Lyme disease is the most documented, while very few articles that deal with arboviruses in workers, such as West Nile virus and Eastern equine encephalitis, have been identified. Of non-vector-borne non-enteric zoonoses, most of the scientific articles selected were about Q fever.

Agriculture, including veterinary services, was the sector in which the most important zoonoses can be contracted. The public administration service sector, which includes national security and defence, was also specifically identified as at risk for the acquisition of the three categories of zoonoses, enteric, vector-borne non-enteric and non-vector-borne non-enteric. The third most frequently mentioned sector were medical and social services, which includes childcare staff, laboratory personnel,

Table 3: Categories of zoonoses, their main reservoir animals in Québec and main sectors of economic activity and occupations identified as at risk for the acquisition of these zoonoses in the scientific literature

Zoonoses	Main reservoir animals	Main sectors of economic activity	Occupations and references
Enteric zoonoses			
Campylobacteriosisx	Poultry	Agriculture	Farm workers, poultry industry workers (4–13)
		Public administration	Military personnel (14–19)
Cryptosporidiosis	Cattle and other ruminants	Agriculture	Veterinary medicine students (20–27), farm workers (28–33) and agricultural emergency responders (34,35)
		Other business and personal services	Field trip attendants and summer camp employees (36–38)
		Medical and social services	Childcare staff (39) and animal research laboratory personnel (40)
Verocytotoxigenic *Escherichia coli*	Cattle, other ruminant or herbivorous mammals	Agriculture	Agricultural workers (41–48)
		Medical and social services	Childcare staff (49,50), hospital staff (nurses) and nursing home staff (51,52)
		Teaching and related services	School-based employees (teachers and teaching assistants) (53)
		Public administration	Military personnel (54)
Giardiasis	Cattle, wildlife mammals	Medical and social services	Childcare staff (55–57)
Listeriosis	Cattle, sheep, pigs, goats	Agriculture	Veterinarians (58,59) and farm workers (60)

Table 3: Categories of zoonoses, their main reservoir animals in Québec and main sectors of economic activity and occupations identified as at risk for the acquisition of these zoonoses in the scientific literature (*continued*)

Zoonoses	Main reservoir animals	Main sectors of economic activity	Occupations and references
Enteric zoonoses			
Salmonellosis	Poultry, pigs, cattle	Agriculture	Technicians and veterinary medicine professionals (61–64), farm workers (65–67), snake farm employees (68)
		Medical and social services	Healthcare workers (69–71), nursing home staff (72) and childcare staff (73,74)
		Public administration	Military (75,76)
		Miscellaneous manufacturing industries	Pet industry staff (77)
		Food and beverage industry	Workers exposed to raw meat (78)
		Building and public works	Construction workers (79)
		Other business and personal services	Restaurant employees (80)
Vector-borne non-enteric zoonoses			
Eastern equine encephalitis	Wild birds (e.g. passerines)	Agriculture	Veterinary technicians (81)
Lyme disease	White-footed mouse (*Peromyscus leucopus*)	Agriculture	Farm workers (82–85)
		Forestry and sawmills	Forestry workers (85)
		Public administration	Military personnel (86–89)
West Nile virus	Avian (especially passerines)	Medical and social services	Laboratory personnel (90)
		Other business and personal services	Animal control officers (91)
		Agriculture	Veterinary medicine students (92)
Non-vector-borne non-enteric zoonoses			
Foodborne botulism in Nunavik	Seals	No information	No information
Q fever	Domestic ruminants	Public administration	Military personnel (93–97)
		Agriculture	Farm workers (98,99)
		Food and beverage industry	Slaughterhouse workers (100)
		Chemical industry	Cosmetics industry workers (101,102)
		Transportation and warehousing	Drivers (103)
Avian and swine influenza	Avian (wild birds), pigs	Agriculture	Commercial poultry farm workers (104)
Rabies	Arctic foxes, raccoons, bats	Public administration	Military personnel (105,106)
		Agriculture	Veterinary services (107)
		Other business and personal services	Employees in contact with bats (108)
Hantavirus pulmonary syndrome	Deer mouse (*Peromyscus maniculatus*)	Agriculture	Farm workers (109–111)
		Forestry and sawmills	Forest workers (109)
		Public administration	Military personnel (112)
		Other business and personal services	Trapping and handling of rodents for ecological studies (113) Communications, power transmission and other utilities (114)

Table 4: Number of articles retained by prioritized zoonosis

Prioritized zoonoses	Number of scientific publications for which case descriptions meet the criteria of the nosological definitions and diagnostic criteria
Foodborne botulism in Nunavik	0
Campylobacteriosis	16
Cryptosporidiosis	21
Eastern equine encephalitis	1
Verocytotoxigenic *Escherichia coli*	14
Q fever	11
Giardiasis	3
Hantavirus pulmonary syndrome	6
Avian and swine influenza	1
Listeriosis	3
Lyme disease	8
Rabies	4
Salmonellosis	20
West Nile virus	3
Two zoonoses or more	2[a]
Total	**111**

[a] These two articles are included in the number of articles selected for the review of knowledge of the zoonoses concerned, i.e. campylobacteriosis, cryptosporidiosis and salmonellosis, but are counted only once

hospital staff, long-term care centre staff and nursing home staff, among others. This sector was identified as at greater risk for contracting enteric zoonoses such as cryptosporidiosis, verocytotoxigenic E. coli, giardiasis and salmonellosis and one vector-borne zoonosis (accidental transmission of West Nile virus among laboratory personnel).

Discussion

The objective of this study was to describe the occupations and sectors at risk for the acquisition of zoonoses of public health importance in Québec. Different occupations are at varying risk of contracting one of the 14 zoonoses prioritized as important to public health by Québec's Multi-Party Observatory on Zoonoses and Adaptation to Climate. Farm workers and veterinarians, as well as military personnel and medical and social services personnel are among the workers most frequently documented as at risk.

There is shortage of literature documenting at-risk occupations that would guide preventive occupational health measures. Two published studies allowed us to compare certain observations.

A systematic review of the scientific literature (1999–2008, no geographic restriction) by Haagsma *et al.* (115) examined occupational injuries attributable to infectious diseases. The second study presented the extent of occupational injuries attributable to infectious diseases reported in the United States between 2006 and 2015 (116). Su *et al.* (116) conducted a review of 67 peer-reviewed scientific publications (published between 2006 and 2016) by following the methodology used by Haagsma *et al.* (115) and supplemented this research by evaluating 66 case reports of workplace-acquired infectious diseases from the Center for Disease of the National Institute for Occupational Safety and Health.

In this study, the military was identified as being at risk for the acquisition of three categories of zoonotic diseases (enteric and vector-borne non-enteric and non-vector-borne non-enteric), especially during missions abroad. The military was not widely discussed by Su *et al.* (116) or Haagsma *et al.* (115), with the exception of the risk for leishmaniasis, a parasitic infection that is not present in Canada. Several of the studies that focused on the military were published after 2008, i.e. after the time period covered by Haagsma *et al.* (115) and Su *et al.* (116), which explains some of the difference in observations between those studies and our research. This study identified several risk factors for the acquisition of zoonoses by military personnel: being based in endemic areas; participating in training camps in or near wooded areas (Lyme disease) (87,88); living in abandoned structures or barns in which animals have reproduced; and working in deployment sites where dust becomes air-borne because of air turbulence caused by helicopters (Q fever) (93,94,96,97).

Similar to Su *et al.*'s (116) observations, it was found that enteric zoonoses of bacterial etiology are the workplace zoonoses most frequently found from among the zoonoses of importance. This study also showed that three sectors are particularly affected by zoonoses of importance: agriculture, including veterinary services; public administration services including defence; and medical and social services. This was also observed by Haagsma *et al.* (115) and Su *et al.* (116), who reported that healthcare workers and those in contact with animals are most at risk of being infected by a variety of zoonotic pathogens. Healthcare workers are predominantly exposed to pathogens through human-to-human contact (115). Infection occurs accidentally through wounds or needlesticks, and also through direct skin contact or indirectly via oral–fecal contact, often related to hand hygiene. Su *et al.* (116) explain that workers in contact with animals, particularly livestock and/or poultry, are at risk of contracting zoonoses. Haagsma *et al.* (115) identified farmers, slaughterhouse workers, animal care workers, veterinarians, hunters and gardeners as those at risk for the acquisition of zoonoses following contact with animals. All of these occupations were identified in our study as being at risk.

Strengths and limitations

The main limitation of this study hinges on the inclusion and exclusion criteria used in the search strategy. Selecting only those published studies where the description of zoonotic cases meets the nosological definitions or diagnostic criteria may have resulted in the exclusion of studies presenting asymptomatic infection cases diagnosed in the laboratory. Despite this limitation, the conclusions of our review are similar to those reported in two other literature reviews (115,116). However, the results of this study reflect a publication bias. To illustrate, it is not surprising that more articles on Lyme disease were retrieved than on the two other vector-borne zoonotic diseases under study given the amount of recent research on this disease. This therefore calls for a cautious interpretation of the importance of the documentation on each of the zoonoses.

Conclusion

This study has painted a portrait of the occupations and sectors most at risk for the acquisition of prioritized zoonoses in Québec. Agriculture (including veterinary workers), public administration personnel (in particular the military) and medical and social services were identified as the sectors most affected by the prioritized zoonoses. Military personnel have also been identified as at risk of contracting the three categories of zoonoses, with several risk factors were identified for the acquisition of zoonoses in the military.

Overall, risks of acquiring zoonotic diseases in the workplace have not been widely studied. Future studies would include consulting representatives at various workplaces and zoonosis experts to build on observations. It would also be valuable to identify the measures put in place to protect the workforce from zoonoses. This would ultimately help to identify any gaps and better guide public health adaptation efforts in the context of climate change.

Authors' statement

AAP — Concept, writing-original draft, revising the writing, critical review
LMD — Concept, writing-original draft, revising the writing, critical review
SB — Revising the writing and critical review
GG — Revising the writing and critical review
AIC — Revising the writing and critical review
MPS — Revising the writing and critical review
AS — Revising the writing and critical review
JS — Revising the writing and critical review
KT — Revising the writing and critical review
FT — Revising the writing and critical review

Competing interests

None to declare.

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QUALITATIVE STUDY

A qualitative program evaluation of the Publicly Available International Foodborne Outbreak Database

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Abstract

Background: The Publicly Available International Foodborne Outbreak Database (PAIFOD) is a regularly updated repository that contains international outbreak data collected from multiple surveillance systems and sources. As of February 2020, the database contained more than 13,000 entries spanning over 20 years. PAIFOD is the only known database that captures international foodborne outbreak data.

Objective: To explore user perceptions and identify potential directions for PAIFOD and make recommendations for databases with food safety information.

Methods: Between January and March 2020, 16 semistructured telephone interviews were conducted with 24 previous, current and potential PAIFOD users. Interviewees were asked about their knowledge of and experience of using PAIFOD as well as about its strengths and limitations and recommendations for the database. An inductive thematic analysis approach was used to analyze qualitative data and generate themes.

Results: Four main themes were generated based on the 24 interviewees' accounts of their experience with and recommendations for PAIFOD: participants viewed PAIFOD as a useful tool; they weren't familiar with its contents or purpose; they stated it should become an open-access platform or linked with another information-sharing initiative; and they considered that PAIFOD had the potential to enhance the Agency's reputation by becoming widely recognized and used.

Conclusion: This work, along with the ever-changing landscape of foodborne surveillance, supports the need to ensure that PAIFOD is updated to meet the modern-day demands of food safety experts.

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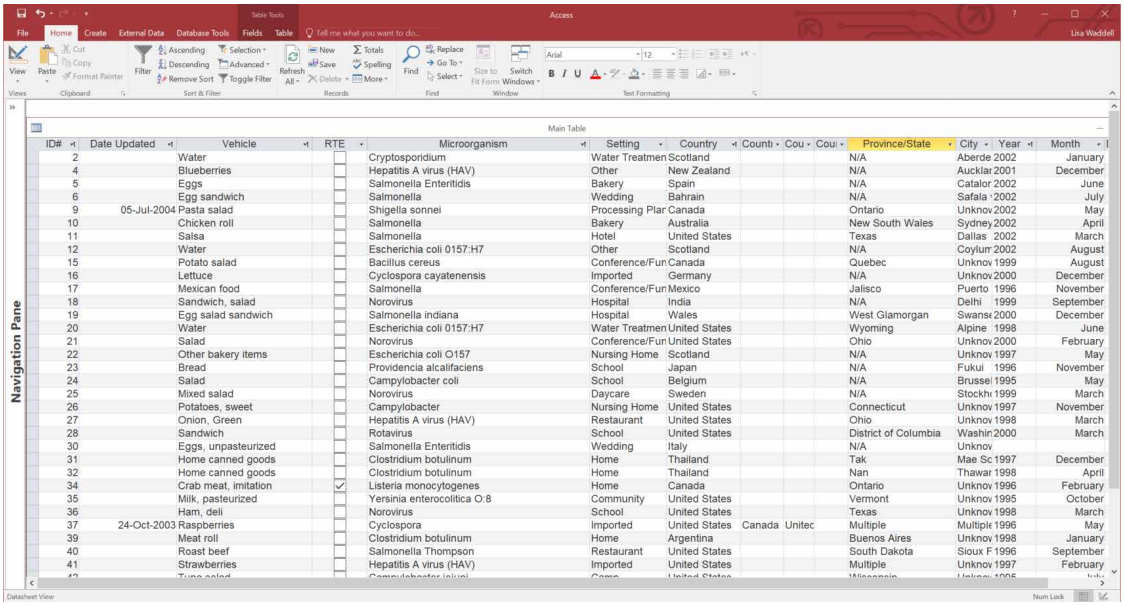
Keywords: database, evaluation, PAIFOD, foodborne outbreaks, thematic analysis, qualitative research

Introduction

Reporting of foodborne outbreak data is important to evaluate lessons learned, identify trends and patterns and inform future public health policies, risk assessments and mitigation strategies (1). In 2000, the Public Health Risk Sciences Division of the National Microbiology Laboratory at the Public Health Agency of Canada (PHAC) launched the Publicly Available International Foodborne Outbreak Database (PAIFOD). PAIFOD is a repository of international foodborne outbreak data recorded through various publicly available surveillance systems and sources such as reports, listservs, press releases, government websites and peer-reviewed journals. To date, PAIFOD is the only known database to capture global foodborne outbreak information.

Academia and federal, provincial and territorial government clients use information from PAIFOD to inform evidence briefs, risk summaries, risk assessments, outbreak analyses and other research projects (2–5). PAIFOD uses Microsoft Access (Redmond, Washington, United States) to store outbreak data (**Figure 1**). As of February 2020, the database contained 13,355

Figure 1: A preview of the Publicly Available International Foodborne Outbreak Database, its columns and outbreak characteristics that are captured



Abbreviation: RTE, ready to eat
Note: The database is hosted on Microsoft Access and only some fields are shown

entries. Recorded outbreaks date from 1945 to the present day. Currently, PAIFOD contains information on 31 bacterial species, 20 parasites, 9 viruses, 7 marine biotoxins and 3 mycotoxins. The most commonly captured foodborne outbreaks are linked to *Salmonella* Enteritidis (n=2,420) and norovirus (n=1,958).

PAIFOD is updated daily. On average, five outbreaks are added weekly to the database, with seasonal variation. A summary of the fields contained in PAIFOD is shown in **Table 1**. The database is not publicly accessible. Instead, customized summary reports are requested by contacting the database manager, at PHAC (see Acknowledgements).

Since its early development, PAIFOD has continually grown in size and frequency of use. However, a stakeholder-needs assessment has never been conducted to evaluate the database and identify opportunities for enhancement.

The authors conducted a qualitative program evaluation to obtain stakeholder input on the database and to gauge interest in a variety of possible changes to PAIFOD. The purpose of this study was to explore users' perceptions on the database, assess its strengths, limitations and areas for improvements.

Methods

Study participants

Semistructured interviews were conducted with previous, current or future users of PAIFOD between January and March 2020. From PAIFOD users and networks, a list of 47 individuals, from 29 different organizational departments and divisions was compiled

Table 1: All the fields captured in Publicly Available International Foodborne Outbreak Database and their description

Category	Field(s)
Food product	• Vehicle • RTE (whether the food product was ready to eat)
Microorganism	• Specific virus, bacterial species, fungi or parasite responsible
Geography	• Country • Province or state • City • Setting (e.g. school, restaurant)
Date	• Year • Month • Day
Case information	• Presumptive cases • Confirmed cases • Age group(s) • Number of hospitalizations • Number of deaths • Symptoms • Major sequelae if reported
Additional information	• Causative reason (e.g. temperature abuse, raw food consumption) • Concentration (e.g. CFU/ml) • Verified (yes/no) • Confirmed (laboratory, epidemiologically)
Other	• Source (e.g. details of journal article, name of newspaper) • Sensitive information (yes/no) • Website URL • Story (i.e. written description of relevant information extracted from source document)

Abbreviations: CFU, colony-forming units; RTE, ready to eat; URL, Uniform Resource Locator

to contact and recruit. For the purpose of the interviews and analysis, each unique organizational department or division as a separate study, was considered "participant" and unit of analysis. The participants were from federal, provincial and municipal government departments and divisions as well as researchers from universities. Participants were recruited via email for either a one-on-one or a group interview, depending on the number of individuals within each contacted department or division.

This study was exempt from review by the Ryerson University Research Ethics Board because it is classified as program evaluation (6).

Data collection

Participants were interviewed over the telephone with the use of a semistructured interview guide. The interview questions were open-ended and asked about (a) users' knowledge of PAIFOD; (b) users' experience with the PAIFOD; (c) strengths and limitations of the database; and (d) recommendations for improvement. The interview guide (available from the authors on request) was modified according to the participants' experience with the database.

Interviews lasted between 15 and 50 minutes, and the number of participants varied between one and four. The interviews were audiorecorded to ensure accuracy. In one case, the interviewer wrote their notes after the interview because they were having technical difficulties with the recording device. The audiorecordings were professionally transcribed, and the transcripts were validated and anonymized prior to analysis.

The names used in this article are arbitrary pseudonyms to protect confidentiality.

Triangulation methods were used: two investigators analyzed and interpreted the collected data to add multiple perspectives, and both in-depth individual and group interviews were conducted (7). Member checking was conducted to increase the validity of findings (8).

Data analysis

The research team analyzed data using an inductive thematic analysis approach within a constructionist framework (9). This consisted of a data-driven process of creating categories (10). The coding process included repeated readings of transcripts to identify trends, inconsistencies and contradictions across the data. Two investigators reviewed five transcripts independently and generated a list of codes. The coding framework was consolidated and refined through discussion. The remaining transcripts were also individually coded, then consolidated. Themes were generated using a latent approach, that is, examining assumptions, ideas and meanings and identified themes based on interpretations of the content of the interviews (10). Themes were mapped, revised, modified, defined and named. Data excerpts were selected (i.e. quotes) to depict the best representation of each theme. Analysis was conducted using NVivo 12 qualitative analysis software (QSR International, Doncaster, Australia).

Results

In total, 16 interviews were conducted with 24 individual interviewees. Most participants were from different departments and divisions of PHAC (n=8, 33%), the Canadian Food Inspection Agency (CFIA; n=5, 21%) and Health Canada (n=5, 21%) (**Table 2**). Most respondents were previous or current users of PAIFOD (n=15, 63%).

Four themes each with three or four subthemes were generated from the coding framework (n=29). The themes are presented below with participants' comments quoted verbatim as illustrations.

A useful tool that guides experts' work

Requests are tailored and timely. Participants who had used PAIFOD (n=16) were quick to mention how important the resource was to their work. They found the service and communication to be fast. For example:

Hannah: [T]hey have been extremely helpful and extremely useful and easy to obtain, the staff at PHAC have been very knowledgeable and very useful and very quick and, yeah, very impressive, very impressive program and useful product.

Reports are detailed, meet needs and expectations. Users generally found the reports were tailored to their needs, often as a result of their conversations with the database manager.

Todd: I've been very happy with how responsive and the turnaround time that are given to us whenever we request information and I find that they are very good about any clarifications or if there are any specifics to our requests and it could [be] ironed out that that's performed in a very timely manner.

A personal relationship with the database manager. Clients mentioned their relationship with the previous and current database managers who helped generate the required outputs. For instance:

Rose: And sometimes they add an element actually to our search. They will say, you know, I looked in the database I couldn't find anything but quickly here's my opinion on X, Y, Z and they can kind of lead us down another path because we've had a human interaction.

Leila: Yeah, a second brain.

Table 2: Interview participants' details

Participant ID	Interview	Pseudonyms	Organization[a]	PAIFOD user status
1	A	Dimitri	Canadian Food Inspection Agency	Past/current
2	B	Hannah	Canadian Food Inspection Agency	Past/current
3	C	Susan	University of Guelph	Never used
4	D	Todd	Canadian Food Inspection Agency	Past/current
5	E	Marie	University of Guelph	Past user
6	F	Anna	Public Health Agency of Canada	Past/current
7	F	Kate	Public Health Agency of Canada	Past/current
8	F	Richard	Public Health Agency of Canada	Past/current
9	G	Rachel	Public Health Agency of Canada	Past/current
10	G	Shelly	Public Health Agency of Canada	Never used
11	G	Luc	Public Health Agency of Canada	Past/current
12	G	Rebecca	Public Health Agency of Canada	Never used
13	H	Rose	Health Canada	Past/current
14	H	Leila	Health Canada	Past/current
15	I	Aaron	Health Canada	Never used
16	J	Yen	Public Health Ontario	Past/current
17	J	Manon	Public Health Ontario	Past/current
18	K	Olivia	Canadian Food Inspection Agency	Never used
19	L	Joon	Ontario Ministry of Agriculture, Food and Rural Affairs	Never used
20	L	Chris	Ontario Ministry of Agriculture, Food and Rural Affairs	Never used
21	M	Kim	Health Canada	Past/current
22	N	Moshe	Health Canada	Past/current
23	O	Farid	Canadian Food Inspection Agency	Never used
24	P	Mark	Public Health Agency of Canada	Never used

Abbreviations: PAIFOD, Publicly Available International Foodborne Outbreak Database
[a] Divisions within organizations are omitted for reasons of confidentiality

Database and its contents not known or opaque

Lack of familiarity with what the database looks like. Respondents were unsure of how outbreak entries were captured in the database, and what fields and categories were included.

Marie: I guess what I'm saying is I plead ignorance, all I know is what's (...) in the reports that I received.

PAIFOD is not publicly available or searchable. When asked about a data dictionary, participants expressed interest or stated that every database should have such a dictionary. In addition, those who had not requested outbreak summary reports before were also unsure of the request process or even where to find information on PAIFOD.

Rachel: I think it would be good for people to also know what is included in the database and know how it is standardly captured.

Inclusion or amendments to data fields or request process. Despite not knowing the full extent of the database, interviewees suggested adding fields (e.g. spatial data, genomic data, gender of cases, chemical and physical agents, common points of purchase) and were open to the idea of implementing a standard request template form.

Joon: I'd rather have it and not need it than need it and not have it.

Manon: Well, we just found that a lot of information I think was, in this one field that was called 'Notes' or something like that, there wasn't really, it was difficult to extract information, in fact it was very time consuming.

Demand for an online, open-access platform

Interest in Cloud-based interface and intention to use it often. Participants suggested that a Web-based platform was the ideal next step for PAIFOD because it would ease access, allow customizable generation of reports and graphical outputs and facilitate on-the-go review of outbreak entries.

Shelly: I agree with Luc and Rachel that if it's easily, readily accessible it's going to be probably easier to use.

Rebecca: I agree with that as well.

Current use is limited or occasional for most clients. Many clients were only occasional users. They stated they would use PAIFOD more often if it were accessible online without having to go through a "gatekeeper."

Kim: I think it would make it easier and more convenient if the database was available to researchers so that they could search it themselves. Like, imagine if you had to ask somebody to search PubMed each time for you, you know, instead of you do it yourself.

Need for flexible data outputs, graphical outputs and report formats. Most users would prefer that the reports be provided as Microsoft Excel spreadsheets rather than PDFs, which is the current standard. For example:

Rose: It would be easier if it were always in Excel.

Susan: I would need an Excel base with the ability to filter, and Excel I like 'cause you can just sort of pull… directly into a stats program…

Human component can be beneficial to guide users. Some participants did acknowledge The value of interacting with the database manager to help individuals with producing the correct outputs.

Olivia: I suppose like, human contact if there's issues or maybe if you have questions. A contact name you could ask for any technical help.

Potential to be well-known and utilized food safety resource

Openness to collaboration. Interviewees suggested that collaboration would improve the number of outbreaks captured in PAIFOD, especially recent ones, thus strengthening the database.

Moshe: I would say for a good start is, one, have a conversation with us...

Rachel: I think we could just be more collaborative with each other about this. It could help serve some of our needs, probably, and we could help serve some of their needs too.

Need to address institutional barriers. Clients acknowledged that some institutional barriers may appear when trying to expand PAIFOD's coverage.

Farid: Yeah, well having memorandums of understanding that permit that data sharing, especially when food safety issues are implicated, may help a little more [with] transparency of information and that it can be instantaneous. If the database is proposing open access to the information that would be ideal.

Strong resource with potential to expand use internationally. Users saw a lot of potential in PAIFOD because it contains information on international foodborne outbreaks.

Moshe: You know like, "Oh you've, what do we know about this? Oh, it's okay, Canadian PAIFOD, yeah, the Canadians have this, Public Health Agency of Canada." ... if I was managing the thing I'd sort of see that as a no brainer, any chance of potential value, organizational value, together that makes it user accessible...

Discussion

Study participants were familiar and comfortable using modern databases such as those within PulseNet Canada, which is also used to identify foodborne disease outbreaks (11), and the publicly available National Outbreak Reporting System (NORS), which reports all waterborne and foodborne disease and enteric disease outbreaks known to the Centers for Disease Control and Prevention (12).

As more food safety databases are moving online (13,14), this platform has proved to be preferred for work-related activities because access can be immediate, reports can be generated flexibly and public health surveillance is more timely and responsive.

It was also clear from the interviews that clients were happy with the depth of detail that PAIFOD provided, but would like access to more fields. An increasing number of scientific techniques and indicators are being used to identify food safety issues and pathogens, some of which allow researchers to conduct in-depth analyses for their work to protect the Canadian food supply. Since PAIFOD gathers information from publicly available reports, the database should consider adding new fields and categories as reports are published.

Another avenue would be for this database to develop partnerships with other agencies. Generally, surveillance systems such as PulseNet Canada, PulseNet USA and the new Government of Canada initiative, Canadian Food Safety Information Network (CFSIN), are shared data repositories that allow local, state and provincial/territorial and federal regulatory agencies to access and share resources quickly (11,15,16). However, the information in these networks is not accessible to the public. PAIFOD should aim to form linkages that will expand the database, yet still make it publicly available.

In the future, PAIFOD should aim to shift to a more updated, user-friendly platform, becoming open access like other successful outbreak databases; be flexible on the types of reports generated; become more comprehensive by including new data fields and categories; serve a wider variety of food safety experts and epidemiologists; and push for collaboration between Canadian and international partners to enhance the depth and promote the use of PAIFOD. Ongoing expansion of PAIFOD can help to reveal trends, identify gaps and determine the effectiveness of future interventions on the reduction of foodborne disease.

Limitations

Most of the participants in this evaluation were federal government employees. Though they appeared to be the main users of the database, their needs may differ from those of other clients, which could have affected the generated themes.

Secondly, it was unclear whether group interviews contained homogenous responses because participants were from the same department or because of existing power structures (17). The investigators observed that voices were disproportionately greater among those with more database experience and those in a leadership role. The absence of disagreements within groups suggests that it may be beneficial to conduct future evaluations exclusively through one-on-one interviews.

Conclusion

This program evaluation explored current user experiences of PAIFOD, including extent of knowledge about the outbreak database, its strengths, limitations and areas for improvement through a qualitative thematic analysis approach. Overall, most stakeholders did not know the entire contents of the database because they only received summary reports; current and previous users believed the database to be a useful tool that helped their food safety activities; and nearly all respondents were interested in an online, open-access platform and believed that PAIFOD was a strong and unique resource that has the potential to expand. The interviewees recommended improvements to the database to enhance their personal use and PAIFOD's legitimacy and reputation.

Many insights from this study were broad and could be applied to other foodborne and infectious disease surveillance databases.

Authors' statement

IY — Conceptualization, funding acquisition, analysis, investigation, methodology, project administration, resources, software, supervision, validation, writing—review & editing
AT — Analysis, investigation, methodology, project administration, validation, writing—original draft
MM — Conceptualization, resources, validation, writing—review & editing
LW — Conceptualization, resources, validation, writing—review & editing

Competing interests

None.

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A time-series analysis of testing and COVID-19 outbreaks in Canadian federal prisons to inform prevention and surveillance efforts

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Abstract

Background: Approximately 14,000 adults are currently incarcerated in federal prisons in Canada. These facilities are vulnerable to disease outbreaks and an assessment of coronavirus disease 2019 (COVID-19) testing and outcomes is needed. The objective of this study was to examine outcomes of COVID-19 testing, prevalence, case recovery and death within federal prisons and to contrast these data with those of the general population.

Methods: Public time-series outcome data for prisoners and the general population were obtained on-line from the Correctional Service of Canada and the Public Health Agency of Canada, respectively, from March 30 to May 27, 2020. Prison, province and sex-specific frequency statistics for each outcome were calculated. A total of 50 facilities were included in this study.

Results: Of these 50 facilities, 64% reported fewer individuals tested per 1,000 population than observed in the general population and 12% reported zero tests in the study period. Testing tended to be reactive, increasing only once prisons had recorded positive tests. Six prisons reported viral outbreaks, with three recording over 20% cumulative COVID-19 prevalence among prisoners. Cumulatively, in prisons, 29% of individuals tested received a positive result, compared to 6% in the general population. Two of the 360 cases died (0.6% fatality). Four outbreaks appeared to be under control (more than 80% of cases recovered); however, sizeable susceptible populations remain at risk of infection. Female prisoners (5% of the total prisoner population) were over-represented among cases (17% of cases overall).

Conclusion: Findings suggest that prison environments are vulnerable to widespread severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission. Gaps in testing merit public health attention. Symptom-based testing alone may not be optimal in prisons, given observations of widespread transmission. Increased sentinel or universal testing may be appropriate. Increased testing, along with rigorous infection prevention practices and the potential release of prisoners, will be needed to curb future outbreaks.

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Keywords: disease outbreak, COVID-19, prisons, prisoners, Canada

Introduction

In the context of the coronavirus disease 2019 (COVID-19) pandemic, several factors place prisoner populations at particularly high risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection and related complications. These include crowded living conditions (1), ageing prisoner populations—particularly in federal prisons (2), high prevalence of chronic disease comorbidities and immunocompromised health status associated with substance use and blood-borne infections (3) and the daily entrance of custodial and healthcare staff from outside communities experiencing possible community-based transmission of the virus. In turn, COVID-19 outbreaks within prisons have implications for broader community health, both as vectors of community transmission and through pressure on local healthcare services (4).

Early reports suggest that several prisons in the United States (US) are experiencing COVID-19 outbreaks (5–7). In this study, Canadian data was used on the number of tests performed and positive tests recorded in the prisoner population to summarize the prevalence of testing and test positivity for each federal prison in Canada and for prisoner populations by province, and to contrast these with prevalence estimates from prisons' respective provincial jurisdictions. As six Canadian facilities were experiencing COVID-19 outbreaks between March 30 and May 27, 2020, data was used on positive tests, case recovery and death among prisoners to describe COVID-19 prevalence, case fatality and the proportion of cases recovered for each of these facilities. These data were then compared with data for the general population in each jurisdiction. Data on prisoners' hospitalization status and admission to intensive care were not available, nor were data on outcomes for prison staff.

Methods

Data and study population

Cumulative data reported between March 30 through May 27, 2020 were obtained from the Correctional Service of Canada (CSC) COVID-19 reporting webpage (8). These data included the number of prisoners tested, positive (i.e. confirmed cases), negative and inconclusive tests, and cases who recovered or died. For reference, data on the total number of individuals' tested, cases, recoveries and deaths for the Canadian population were extracted from the Public Health Agency of Canada's COVID-19 reporting webpage (9). During the study period, all laboratory testing to confirm cases across provinces was conducted using nucleic acid amplification testing assays (e.g. real-time polymerase chain reaction or nucleic acid sequencing) (10). CSC did not disclose publicly, nor in response to repeated requests (*Personal communication, Blair A. to Commissioner Anne Kelly May 21, 2020 and May 26, 2020: Request for additional COVID-19 data and information for CSC institutions. 2020*), their operational definitions of recovered cases. Based on extant guidelines, it was assumed that recovered cases are those for whom 10 to 14 days had elapsed since the start of their symptoms and who were symptom-free for at least two to three days by the end of this waiting period (11,12).

Several measures were assessed (*vide infra*), including the following: total individuals tested and cases; individuals tested per 1,000 population; test-positive rate and prevalence among individuals tested. For test-positive rate and prevalence, we calculated prison, sex and province-specific frequency estimates. No other disaggregated data were available (e.g. by age or risk factors). Prison population denominators were approximated by their maximum capacity (13). Exact prisoner counts were not available publicly, nor following repeated requests to CSC (*Personal communication, Blair A. to Commissioner Anne Kelly May 21, 2020 and May 26, 2020: Request for additional COVID-19 data and information for CSC institutions. 2020*); however, the average daily population of federal prisoners was 13,996 in 2019 (14). As this represents 85% of the total maximum federal prison capacity, all population-denominator estimates in this study were estimated assuming 85% capacity. These estimates were bounded, reflecting a possible range of occupancy levels from 70% to 100%, which represented a population size that was 15% lower and higher, respectively, of the population size in 2019. General population denominator counts were obtained from Statistics Canada population estimates for the first quarter of 2020 (15).

To provide a timeline for the evolution of cases in federal prisons with one or more cases at the time of analysis the Wayback Machine (https://archive.org/) was used. All available previous copies of CSC's COVID-19 reporting webpage were obtained, reporting on data between March 30 and May 9, 2020 (8). Between May 10 and 27, 2020, reported data was extracted daily from the CSC's website. Data updates were not available every day, and CSC did not publicly disclose their reporting schedule, despite several requests (*Personal communication, Blair A. to Commissioner Anne Kelly May 21, 2020 and May 26, 2020: Request for additional COVID-19 data and information for CSC institutions. 2020*). Dates for which cumulative data were available and from which a time-series could be created are described in the **Supplemental material**.

Given that several federal prisons have units that operate under different security levels or that offer distinct services (e.g. treatment facilities), and given that population capacity was not always available for each separate unit, five multi-complex facilities were grouped together in this analyses: the Federal Training Center (Multi-Level Unit and Minimum facilities); Pacific (Pacific Institution, Regional Treatment Center and Reception Center); Millhaven (Millhaven Institution, Regional Hospital and Regional Treatment Center); Collins Bay (Minimum and Regional Treatment Center); and Joyceville (Joyceville Institution and Minimum facilities). Thus, with these groupings data was recorded from 51 facilities. Population capacity data was unavailable for one facility. A complete case analysis of the remaining 50 facilities (98% of facilities) was performed and all data are summarized in the Supplemental material.

Measures

The measures assessed were operationalized as follows:

Total individual tests and cases: From the total number of individuals tested, "positive tests" were considered confirmed cases.

Individuals tested per 1,000 population: Individuals tested per 1,000 population were estimated by dividing the total number of individuals tested by the total population in each facility, in the prisoner population of each province, and the general population of each province, respectively, and multiplying the fraction by 1,000.

Test-positive rate and prevalence: The number of cases was divided by the total number of individuals tested to yield the test-positive rate in each federal prison, provincial federal prisoner population and the provincial general population. The COVID-19 prevalence was obtained by dividing the total number of positive tests by the population of each prison, provincial prisoner population, and general provincial population, respectively.

Population categories in federal prisons with outbreaks—susceptible, infected, recovered and died: As has been done for long term care homes, prisons with one or more COVID-19 cases among prisoners were considered as those experiencing outbreaks (16). For each calendar day of the study period, the prisoner population of each prison facing an outbreak were classified into four categories. We estimated the number of prisoners who were "susceptible" to infection by subtracting the total number of confirmed active, recovered and deceased cases from the maximum population capacity. Prisoners considered "infected" were those with positive tests who had yet to recover or die. Totals for cases who recovered or died from COVID-19 were obtained directly from the data sources (8,17).

Results

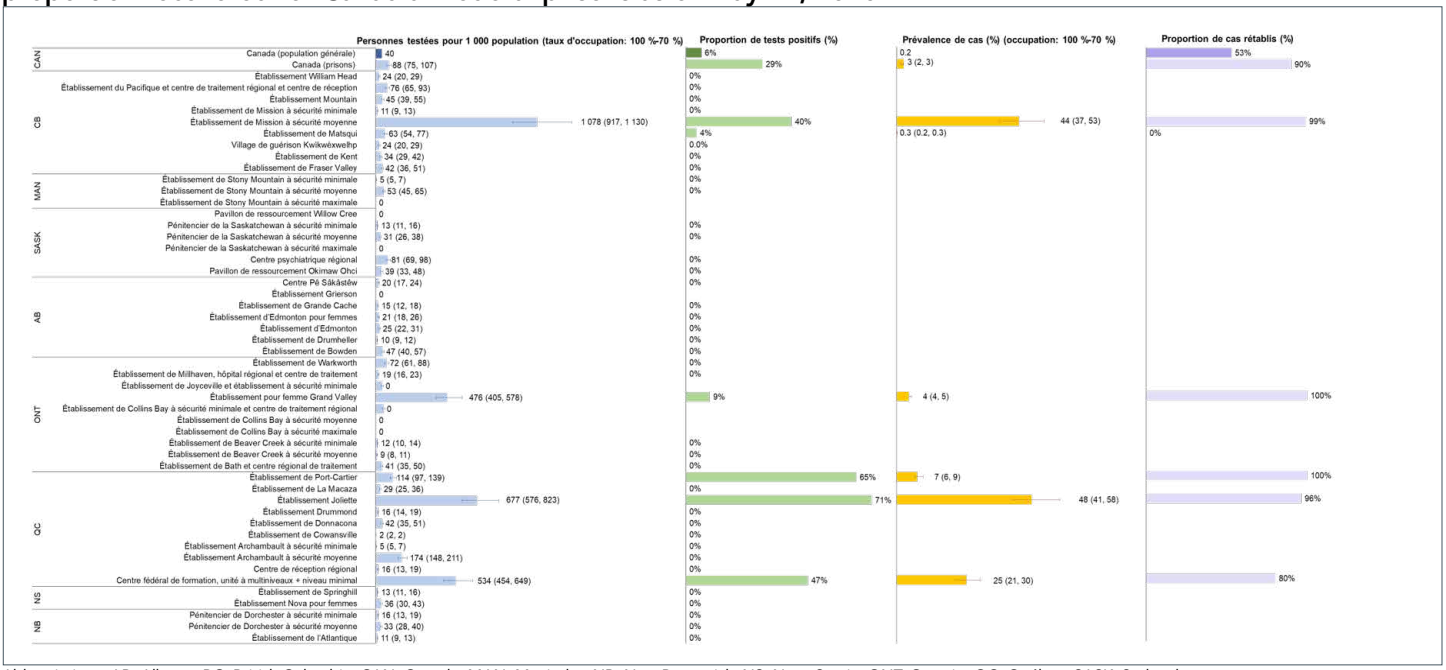
Testing inside versus outside federal prisons

Six of the 50 facilities studied (12%) had recorded a complete absence of testing (**Figure 1**). Assuming 85% occupancy, 64% of all facilities (n=32/50 facilities) recorded fewer tests than the Canadian general population average of 40 individuals tested per 1,000 population (58% to 74% if 100% to 70% occupancy is assumed, respectively). Facilities with higher levels of testing tended to be those that had reported a higher COVID-19 prevalence (Figure 1).

On average, regardless of what level of prisoner occupancy was assumed (70% to 100%), Alberta, New Brunswick and Nova Scotia tested fewer individuals per 1,000 population inside federal prisons than in the general population of each of their respective jurisdictions (**Figure 2**). As an example, on May 27, 2020, these three provinces recorded 52%, 25% and 62% (respectively) fewer individuals tested per 1,000 population inside federal prisons (assuming 85% occupancy) than in their general populations. Under-testing per 1,000 population has been consistent inside the federal prisons of the latter three provinces since late-March 2020 (**Figure 3**).

In the six institutions with outbreaks, the increase in the number of individuals tested largely occurred after COVID-19 outbreaks had already been established, with high test-positive rates among individuals tested, indicating potential systematic under-testing (**Figure 4**). The exceptions were Québec's Federal Training Center and British Columbia's Matsqui Institution, which recorded negative tests among prisoners before the observations of positive tests. Two cases among staff members at Québec's Federal Training Centre were confirmed on April 12, 2020, which may explain early testing efforts in this prison (18). Small changes in cumulative totals of tests were reported for Joliette, Grand Valley, and Port Cartier prisons throughout the study period (Figure 4), which were attributed by the CSC to data reconciliation efforts.

Figure 1: Cumulative totals of individuals tested per 1,000 population, test-positive rate, case prevalence and proportion recovered for Canadian federal prisons as of May 27, 2020[a,b]

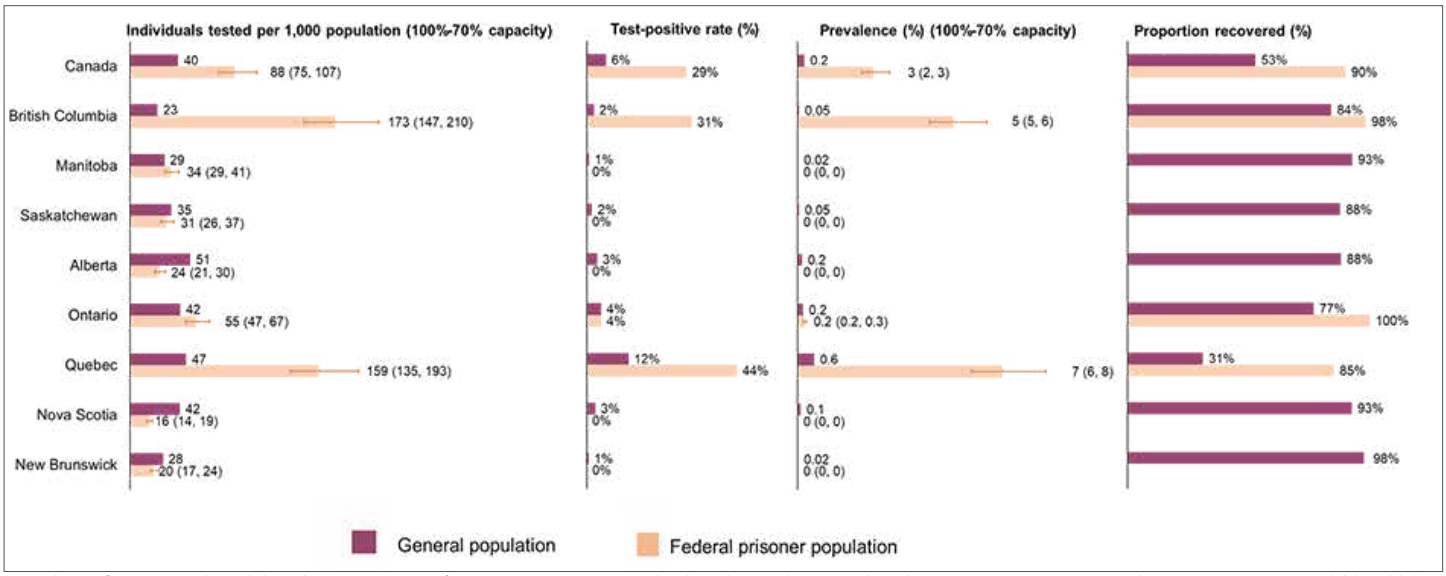


Abbreviations: AB, Alberta; BC, British Columbia; CAN, Canada; MAN, Manitoba; NB, New Brunswick; NS, Nova Scotia; ONT, Ontario; QC, Québec; SASK, Saskatchewan

[a] Missing test-positive, prevalence and recovered proportions indicate an absence of cases as of May 27, 2020

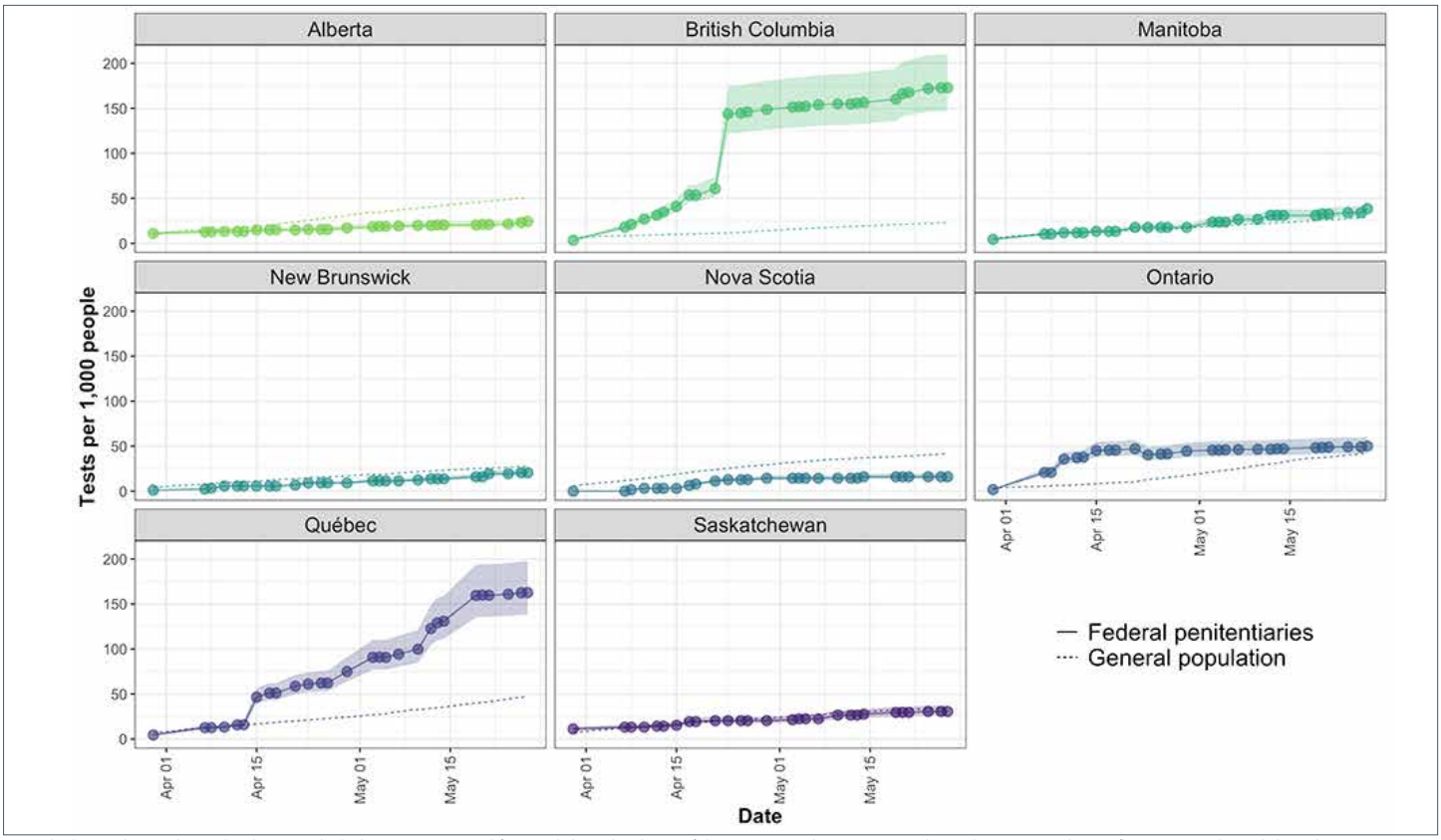
[b] Error bars reflect estimate bounds based on 100% to 70% of maximum prison capacity levels, with central estimates based on 85% occupancy, (exact population counts were not available publicly or following request)

Figure 2: Cumulative totals of individuals tested per 1,000 population, test-positive rate, case prevalence and proportion recovered for federal prison and general populations, by province, as of May 27, 2020[a]



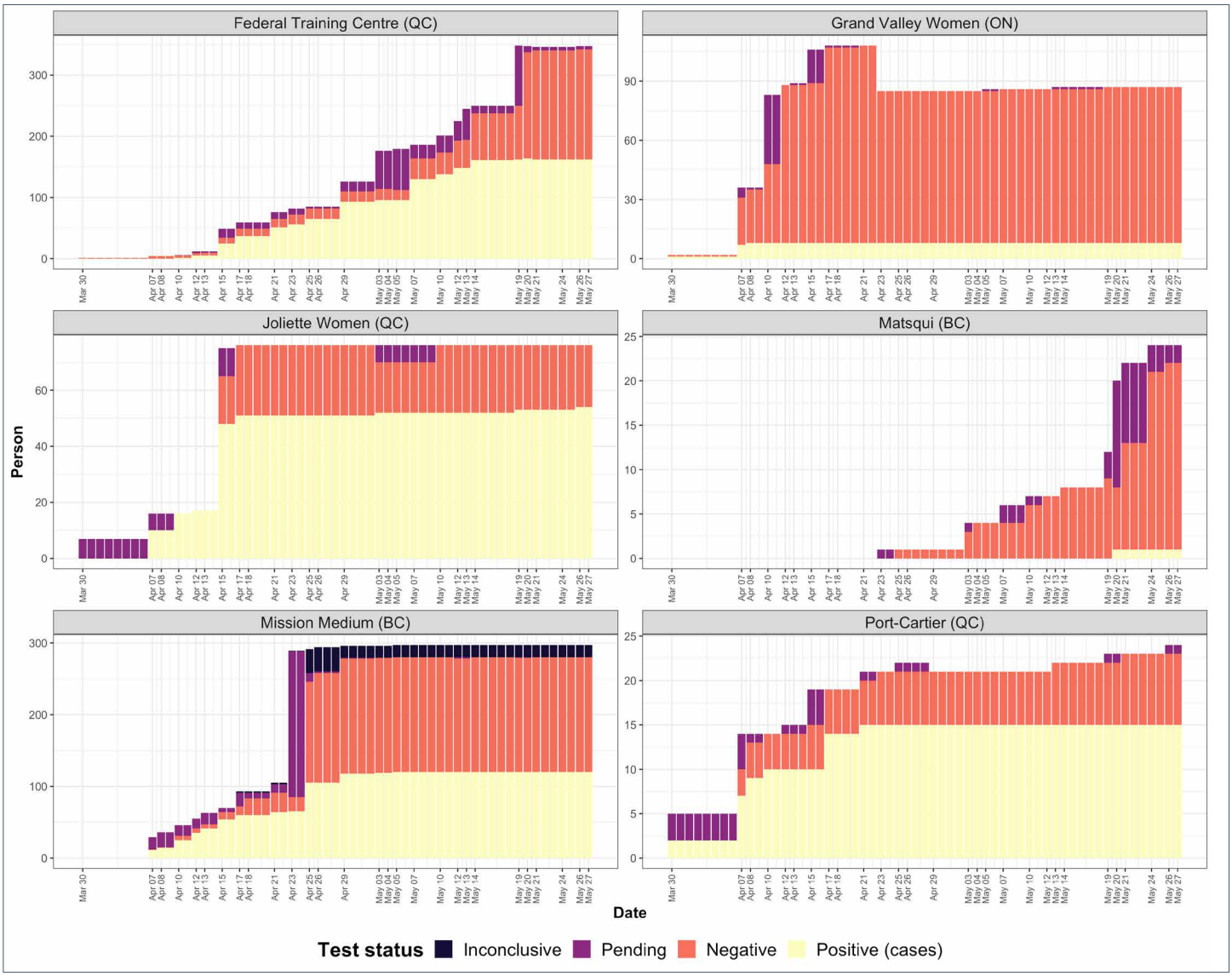
[a] Error bars reflect estimate bounds based on 100% to 70% of maximum prison occupancy levels, with central estimates based on 85% occupancy (exact population counts were not available publicly or following request)

Figure 3: Timeline of cumulative total of individuals tested per 1,000 population in federal prisons and the general population, by province, from March 30 to May 27, 2020[a]



[a] Circular line makers indicate the dates at which data were captured from web-based archives of the Correctional Services Canada's webpage. Error bars reflect estimate bounds based on 100% to 70% of maximum prison capacity levels, with central estimates based on 85% occupancy, (exact population counts were not available publicly or following request)

Figure 4: Testing patterns and outcomes between March 30 and May 27, 2020, in six prisons with one or more recorded COVID-19 cases[a]



Abbreviations: BC, British Columbia; ON, Ontario; QC, Québec

[a] Only dates for which data was captured from web-based archives of Correctional Service of Canada's webpage are indicated. The drop in cumulative negative tests in Joliette and Grand Valley Women's facilities and total cumulative tests at Port Cartier facility may appear as erroneous but represent true values reported by Correctional Service of Canada

Prevalence of COVID-19 inside versus outside federal prisons

Six federal prisons had recorded at least one COVID-19 case (Figure 1). These prisons were mostly located near major city centers (Montréal, Vancouver, Kitchener/Toronto). Three prisons were located in Québec; the Federal Training Center (162 cases, 21% to 30% COVID-19 prevalence, assuming 100% to 70% occupancy, respectively) and Joliette facilities (54 cases, 41% to 58% prevalence based on 100% to 70% occupancy) are located near Montréal, and the Port-Cartier Institution is located in a relatively remote region of the province, Côte Nord (15 cases, 6% to 9% prevalence, assuming 100% to 70% occupancy). In British Columbia, facilities with outbreaks included the Mission Medium Security (120 cases, 37% to 53% prevalence, assuming 100% to 70% occupancy) and Matsqui Facilities (one case, 0.2% to 0.3% prevalence, assuming 100% to 70% occupancy), both near Vancouver. Ontario's Grand Valley Institution, in Kitchener, recorded eight cases (4% to 5% prevalence, assuming 100% to 70% occupancy).

Overall, approximately 3% of the total prisoner population contracted COVID-19 (2% to 3% assuming 100% to 70% occupancy), in contrast to a prevalence of 0.2% in the general Canadian population (Figure 2).

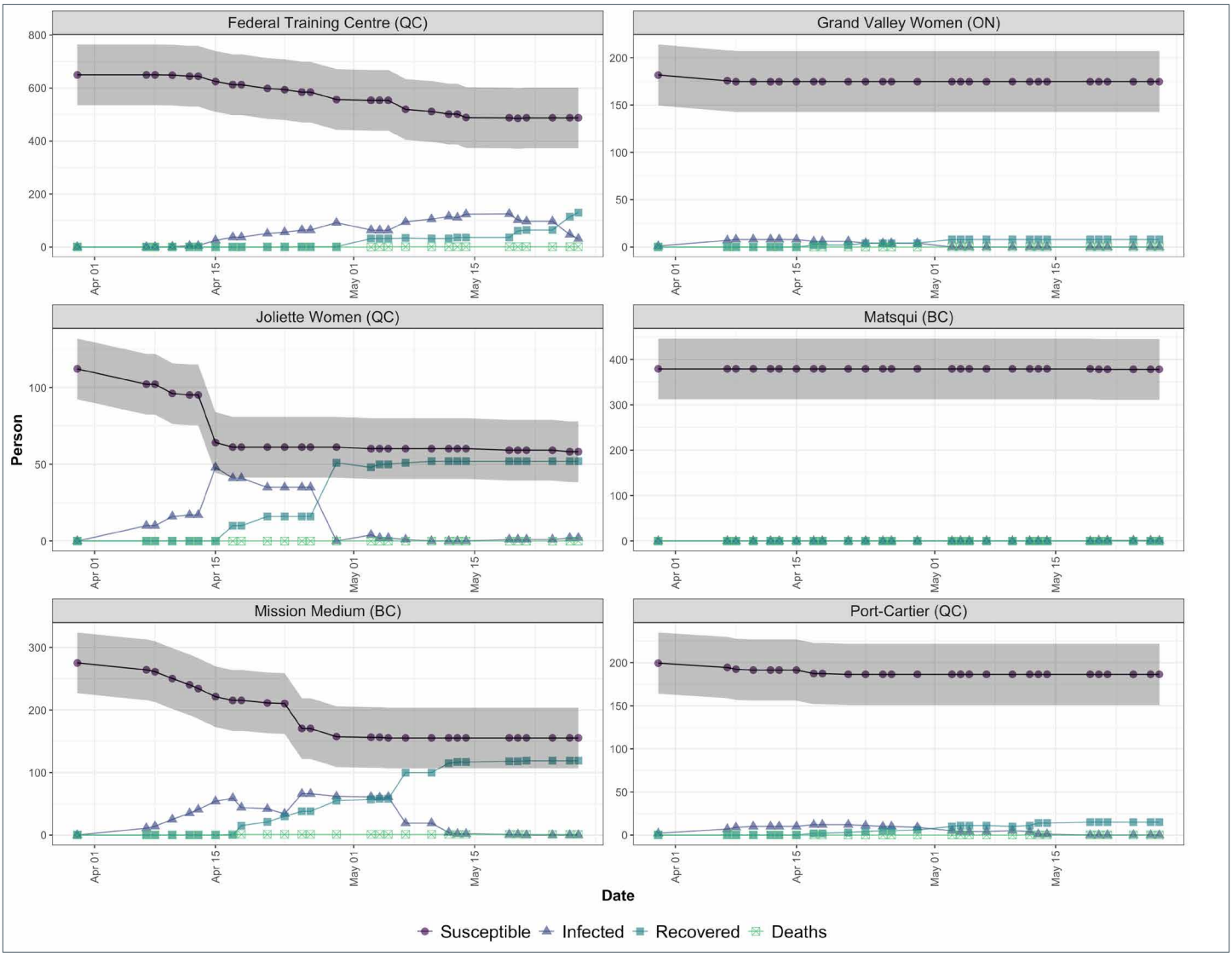
As of May 27, 2020, there were 62 cases of COVID-19 in women's prisons in Canada. These represented 17% of the total of 360 cases in federal prisons, despite women representing only 5% of the total federal prisoner capacity.

Proportion of cases recovered and case fatality inside versus outside federal prisons

The proportion of cases who had recovered inside federal prisons that had experienced outbreaks was 0% in British Columbia's Matsqui Institution and 80% to 100% in the other five prisons with outbreaks (Figure 1). In most of these prisons, a majority of prisoners remained susceptible (**Figure 5**).

As of May 27, 2020, two of the 360 cases across all federal prisons had died (0.6% fatality), which is less than 10% of the crude estimate of case fatality in the general population (7.7% fatality: 6,765 deaths/87,519 cases). Given that up to 80% of COVID-19 deaths in Canada were estimated to have occurred in long term care homes (19), the case fatality in federal prisons is more similar to the crude rate in the general population outside of long term care homes (approximately 1.6%; [6,785 deaths x 20%=1,357 deaths]/87,519 cases). Case fatality estimates should be compared with caution, however, given the likely underestimation of the true number of cases both inside and outside federal prisons.

Figure 5: Number of susceptible prisoners, infected prisoners, recovered cases and deaths between March 30 and May 27, 2020, in Canadian federal prisons with one or more recorded COVID-19 cases[a]



Abbreviations: BC, British Columbia; ON, Ontario; QC, Québec

[a] Line makers indicate the dates at which data were captured from web-based archives of the Correctional Service of Canada's webpage. Error bars reflect estimate bounds based on 100% to 70% of maximum prison capacity levels, with central estimates based on 85% occupancy, (exact population counts were not available publicly nor following request)

Discussion

Between the start of the pandemic and May 27, 2020, the number of individuals tested *per capita* had been consistently lower in the majority (64%, if 85% occupancy is assumed) of federal prisons than in the Canadian general population. Six of the 50 prisons in this study (12%) had conducted zero tests. Six prisons had experienced outbreaks and two of these were women's prisons. These six prisons reported higher levels of testing compared with general provincial and national rates. Increases in the number of individuals tested inside these prisons tended to be in reaction to the emergence of cases. Though most outbreaks appeared to be under control by the end of the study period, with a large proportion of cases having recovered (more than 80%), sizeable susceptible populations remain at risk of future outbreaks.

Findings of the extensive spread of SARS-CoV-2 inside several Canadian prisons, indicated by elevated cumulative prevalence estimates, are consistent with epidemiologic findings from past prison outbreaks of respiratory diseases such as influenza, adenoviruses and tuberculosis (20–22). On April 21, 2020, the proportion of Canadian federal prisons reporting at least one COVID-19 case (10%) was comparable to the 8% observed in a recent census of 420 correctional facilities (covering 69% of jurisdictions) in the US on that date (6). Overall case fatality estimates in correctional facilities in the US (1.4% to 1.8%) (6,7) are higher than those observed in federal prisons in Canada (0.6%). However, these comparisons should be interpreted with caution, given the differences in the characteristics of prisoners, prison facilities and COVID-19 epidemiology between the US and Canada. Though case fatality in prisons is slightly lower than what has been observed for the general population, the observed elevated cumulative COVID-19 prevalence inside federal prisons and the potential for extensive disease spread among susceptible populations are of significant importance for public health and health equity. This is due to the elevated prevalence of morbidity-related risk factors among prisoners, such as older age, chronic conditions and immunocompromised health status (2,3), and to the over-representation of Indigenous and racialized communities within the Canadian correctional facilities system (23).

The finding of six outbreaks among 50 federal prisons highlights the importance of both prisoners and staff upholding rigorous infection prevention and control practices (24). On March 30, 2020, CSC reported that they were collaborating with infection prevention specialists, providing masks, soap and hand sanitizers to staff and prisoners, increasing facility cleaning and disinfection, and delivering education on recommended hygiene practices (25). Though audits of facilities have reportedly been conducted, these have not been made available to the public (26), and inconsistencies in application across facilities have been reported (27). CSC paused all family visits, temporary absences, prisoner transfers and all non-critical programs and services. CSC also implemented lockdowns, isolated cases and symptomatic prisoners, and limited out-of-cell and outdoor time (25). Though these interventions limit potential community and inter-prisoner contact, concerns regarding the violation of statutory obligations, legal rights and potential harm to psychological well-being have been raised by the Office of the Correctional Investigator of Canada (26) and through several lawsuits (28,29). Epidemiology scholars and legal experts have emphasized the need to consider releasing prisoners in order to reduce the proportion of susceptible individuals within correctional facilities (4). Though a decline in federal prisoner population was reported in April and May of 2020, this has been attributable to reductions in sentencing and admissions rather than to prisoner release (26). CSC reported the screening of all staff and prisoners based on symptom presentation, and of prisoners and staff upon arrival to facilities (25). A more proactive testing approach may be needed to help curb the size of potential future COVID-19 outbreaks in Canadian correctional facilities, while avoiding the use of interventions with harmful social or mental health consequences. Since up to 60% of COVID-19 cases may be asymptomatic (30–32), universal testing (24,33) may be prudent in correctional facilities with one or more cases. On April 22, 2020, British Columbia's Mission Institution, which had previously reported a large outbreak, reported the planning of universal testing of all prisoners and staff (34).

An alternative to universal testing within prisons could involve a sentinel surveillance-based approach of identifying a subset of prisons in which regular testing among prisoners and staff, regardless of symptomatology, could be conducted. This approach may be most relevant in jurisdictions with higher SARS-CoV-2 prevalence (to ensure higher positive predictive values of testing, and minimize the unwarranted isolation of prisoners) (33) or where facilities are close to urban centers. Proactive testing may represent a valuable alternative to strategies such as mass long term cell-based confinement, which has been associated with severe mental health risk (35), particularly for Indigenous and racialized populations (1).

Limitations

This study has several limitations. First, an important limitation is the necessity to use the maximum potential capacity of each prison rather than the exact prisoner population for rate calculations. Bias was minimized by estimating bounds based on a range of assumed occupancy levels, from 70% to 100%. The average daily population of federal prisoners was assumed to be approximately 85% of the total capacity, as it was in 2019 (14). If prisoner populations have decreased since 2019, such that occupancy was less than 70%, then our study likely underestimated the upper bounds of prevalence values. Second, missing from this study were detailed outcomes for staff per prison. As of May 29, 2020, 124 cases were recorded among staff at CSC (1% of its approximate 17,310 staff members and 26% of federal prison-related cases overall) (36,37). Detailed

reporting on cases among staff will be essential to understand the true burden of disease in correctional contexts. Third, broad comparisons between federal prisoner populations and the general population within provinces can conceal outcome heterogeneity at smaller areas of aggregation. Unfortunately, local or regional-level testing and outcome data remained largely unavailable in Canada (38), and this therefore remains an important area of future inquiry. Nonetheless, population-scale comparisons like those presented in this study are useful indicators of potential successes or limitations of testing policies and practices across jurisdictions, and heterogeneity in outcomes across provinces merits public health attention. Fourth, testing eligibility criteria or target groups (e.g. travelers, symptomatic individuals, all residents) can vary both in time, and across jurisdictions, which can also bias comparisons. However, in the study period (March 30 to May 27, 2020), across the provinces studied herein, testing was largely recommended for all symptomatic individuals (i.e. not only restricted to travelers or healthcare professionals, and not recommended for asymptomatic individuals), which strengthens the validity of the comparisons across jurisdictions (9,39–46). Fifth, in this study, the total number of individuals tested was assessed rather than the total number of tests or specimens tested. Once available, total tests performed within detention facilities and the general population in Canada, and estimation of corresponding percent positive rates and tests per population also merit evaluation. Sixth, CSC made several small changes to cumulative totals over the study period, reporting that these were due to data reconciliation efforts. No detailed explanation was provided, suggesting that reporting errors may have occurred. Seventh, while other deaths in federal prisons were recorded during the study period (47), it is unclear whether all prisoners have been or will be tested for COVID-19 *post mortem*. Deaths may, therefore, be underestimated. Seventh, the case fatality findings presented herein are crude estimates as they not account for potential lags between the incidence of cases and deaths. Lastly, findings reported herein may not be generalizable to provincial, remand, juvenile or immigration detention facilities, which represented 72% of Canada's approximate 58,300 total prisoner population (48–50) and which may see more population movement given the shorter sentences.

Conclusion

The majority of federal prisons have recorded lower numbers of individuals tested than the Canadian general population average. Gaps in COVID-19 testing and recorded outbreaks in several prisons, with an elevated proportion of prisoners becoming infected, suggest that correctional facilities will likely represent a key battleground against the COVID-19 pandemic as community transmission increases in Canada. There is a need to reduce testing gaps and consider proactive approaches such as universal testing or sentinel-based testing. Along with rigorous infection prevention practices and the potential release of prisoners, increased testing is needed to curb future outbreaks while avoiding undue reliance on long term isolation and confinement of prisoners.

Authors' statement

AB — Collated daily Correctional Service of Canada testing data for this project, designed the study, analyzed the data, drafted and revised the manuscript
AP — Designed the study, analyzed the data, drafted and revised the manuscript
AS — Provided critical input on the design on the study, revised and edited the manuscript

Competing interests

None.

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Supplemental material

These tables can be access at https://www.canada.ca/content/dam/phac-aspc/documents/services/reports-publications/canada-communicable-disease-report-ccdr/monthly-issue/2021-47/issue-1-jan-2021/ccdrv47i01a10s-eng.pdf.

Table 1: Federal prison population data—as of May 27, 2020

Table 2: General population data—as of May 27, 2020[a]

Table 3: Port Cartier Institution, Québec (maximum population estimate: 237 prisoners)

Table 4: Federal Training Center, Québec (maximum population estimate: 764 prisoners)

Table 5: Joliette Women's Institution, Québec (maximum population estimate: 132 prisoners)

Table 6: Mission Medium Security Institution (maximum population estimate: 324 prisoners)

Table 7: Grand Valley Institution for Women (maximum population estimate: 112 prisoners)

Table 8: Matsqui Institution (maximum population estimate: 446 prisoners)

The content and view expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

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HIV in Canada—surveillance report, 2019

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Abstract

Background: Human immunodeficiency virus (HIV) is a global public health issue. HIV has been nationally notifiable in Canada since 1985. The Public Health Agency of Canada (PHAC) monitors trends in new HIV diagnoses.

Objectives: The objective of this surveillance report is to provide an overview of the epidemiology of reported HIV cases in 2019 in Canada. The report highlights 10-year trends (2010–2019). Data on HIV diagnosed through Immigration Medical Exams (IME) and trends in perinatal transmission of HIV are also presented.

Methods: PHAC monitors HIV through the HIV/AIDS Surveillance System, a passive, case-based system that collates non-nominal data submitted voluntarily by all Canadian provinces and territories. Descriptive analyses were conducted on national data. IME data were obtained from Immigration, Refugees and Citizenship Canada (IRCC), and data on HIV-exposed pregnancies were obtained through the Canadian Perinatal HIV Surveillance Program.

Results: In 2019, a total of 2,122 HIV diagnoses were reported in Canada (5.6 per 100,000 population). Saskatchewan reported the highest provincial diagnosis rate at 16.9 per 100,000 population. The 30 to 39-year age group had the highest HIV diagnosis rate at 12.7 per 100,000 population. While the rates for both males and females fluctuated in the past decade, since 2010 the rates among males decreased overall, while the rate among females increased slightly. As in previous years, the diagnosis rate for males in 2019 was higher than that for females (7.9 versus 3.4 per 100,000 population, respectively). The highest proportion of all reported adult cases with known exposure were gay, bisexual and other men who have sex with men (gbMSM, 39.7%), followed by cases attributed to heterosexual contact (28.3%) and among people who inject drugs (PWID, 21.5%). The number of migrants who tested positive for HIV during an IME conducted in Canada was 626. The one documented perinatal HIV transmission related to a mother who had not received antepartum or intrapartum antiretroviral therapy prophylaxis.

Conclusion: The number and rate of reported HIV cases in Canada has remained relatively stable over the last decade, with minor year-to-year variations. As in previous years, the gbMSM and PWID populations represent a high proportion of HIV diagnoses, although a sizable number of cases were attributed to heterosexual contact. It is important to routinely monitor trends in HIV in light of pan-Canadian commitments to reduce the health impact of sexually transmitted and blood-borne infections by 2030.

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Keywords: HIV, surveillance, gay, bixexual and other men who have sex with men, heterosexual contact, people who inject drugs, perinatal HIV, Canada

Introduction

Human immunodeficiency virus (HIV) has a serious economic and social impact globally; an estimated 1.7 million people worldwide were newly infected with HIV in 2019 (1). In Canada, recent estimates indicate that approximately 62,050 people were living with HIV at the end of 2018. Of the people living with HIV, 87% were diagnosed; 85% of those diagnosed were on treatment, and 94% of the people receiving treatment had an undetectable viral load (2).

More recent advances in HIV care, including preexposure prophylaxis (PrEP) with antiretroviral therapy (ART), and the availability of self-testing have the potential to greatly affect HIV incidence in Canada. Despite these advances people living with HIV experience significant challenges such as barriers to effective care, health issues across the lifespan related to HIV infection or its treatment, as well as stigma and discrimination (3).

As part of a global movement to eliminate sexually transmitted and blood-borne infections (STBBI) as a health concern by 2030, the Public Health Agency of Canada (PHAC) published *Reducing the health impact of sexually transmitted and blood-borne infections in Canada by 2030: A pan-Canadian STBBI framework for action* (4). This framework and its associated Government of Canada action plan (5) demonstrate a commitment to reducing the burden of STBBI in Canada through the core pillars of prevention, testing, initiation of care and treatment, and ongoing care and support. Furthermore, the framework delineates the importance of a common approach to addressing key populations disproportionately affected by HIV (4,5). The framework also emphasizes the importance of early HIV diagnosis and reporting to monitor trends in newly diagnosed infections to inform and evaluate prevention and care programs (6–9). Monitoring trends in HIV is important in understanding the burden of HIV in Canada and for monitoring Canada's progress in meeting the goals of the STBBI framework. In 2018, the national diagnosis rate was 6.2 per 100,000 population with a total of 2,296 HIV diagnoses (10). There were six perinatal transmissions, with four of these attributed to mothers who did not receive any ART. A total of 696 migrants tested positive for HIV through Immigration Medical Exams (IMEs) conducted in Canada (10).

The objectives of this surveillance report are to provide updates on the epidemiology of reported HIV cases in Canada from 2010 to the end of 2019, by geographic location, age group, sex and exposure category. In addition, updated information on immigration medical screening results for HIV and on the number of infants perinatally exposed and infected with HIV are presented.

Methods

Data sources

This HIV surveillance report uses data from three different sources: the national HIV/AIDS Surveillance System (HASS) maintained by PHAC; immigration medical screening for HIV by Immigration, Refugees and Citizenship Canada (IRCC); and the Canadian Perinatal HIV Surveillance Program (CPHSP). Details on each data source are outlined below.

HIV/AIDS Surveillance System

HASS is a passive, case-based surveillance system that collates non-nominal data on people diagnosed with HIV infection who meet the national case definition (11). PHAC receives information on data elements including but not limited to age, sex, race/ethnicity and risks associated with the transmission of HIV (exposure categories). These data are voluntarily submitted to PHAC by provincial and territorial public health authorities.

Data on exposure category and race/ethnicity are submitted with varying degrees of completeness across the country. Exposure category data were reported by all jurisdictions except for Québec; by province and territory, completeness of data ranged from 68.6% to 100% in 2019 (57.1% overall). Race/ethnicity data were submitted by all jurisdictions except Québec and British Columbia; for those who did report race/ethnicity data, the completion rate ranged from 22% to 100% (41.5% overall). Newfoundland and Labrador, Yukon and Nunavut submitted race/ethnicity information for all reported cases. Northwest Territories did not have any diagnosed cases of HIV in 2019. In 2019, Saskatchewan submitted only two race/ethnicity subcategories, Indigenous and non-Indigenous. New Brunswick submitted only one subcategory for race/ethnicity category, whether a case was First Nations, and did not provide information on any other race/ethnicity category.

Data in each province and territory are obtained through provincial HIV surveillance systems, which may include both public health and laboratory reporting. Each province or territory provides data to PHAC either through the National Case Report Form (12) or through a secure electronic dataset transmission. All raw data (paper forms and electronic datasets) are retained in compliance with the *Directive for the Collection, Use and Dissemination of Information relating to Public Health* (*PHAC, 2013, unpublished documen*t). Data quality assessment, such as the detection of duplicate entries, is handled by the provinces and territories prior to submission to PHAC.

The data in this surveillance report represent newly reported HIV cases diagnosed on or before December 31, 2019, that were submitted by provincial and territorial surveillance programs to PHAC up to September 18th, 2020, and validated as of October 8, 2020. Additional details on HASS methods can be found elsewhere (12).

Alberta and British Columbia resubmitted revised historical data since 2016 and 2017, respectively. This year, Ontario resubmitted updated historical data since 1985.

Immigration medical screening for HIV

All foreign nationals applying for permanent residence and some applying for temporary residence in Canada must undergo an IME administered by third-party panel physicians on behalf of IRCC, either in Canada or overseas. All applicants aged 15 years and older are screened for HIV during the IME. IRCC provides PHAC with non-nominal data collected during the IME on migrants who tested positive for HIV. The term "migrant" is used broadly and includes the following: immigrants (permanent residents in the economic and family classes); refugees (resettled refugees, protected persons and asylum claimants); and

temporary residents (visitors, international students, temporary foreign workers and temporary resident permit holders). The IME data presented here were obtained from IRCC's Global Case Management System, which contains the IME information for all applicants screened in Canada or overseas who tested positive for HIV. Aggregate data were provided to PHAC in July 2020. Data on individuals tested in Canada were obtained from IMEs conducted in 2019. Data concerning individuals tested overseas were obtained from individuals with an HIV diagnosis on their IME who landed in Canada in 2019.

IRCC shares nominal data from overseas IME test results with participating provinces and territories for all clients who have been diagnosed with HIV and have a valid Canadian residential address on file that indicates their current province/territory of residence. This supports the continuity of care for clients with HIV. These data are incorporated into the provincial/territorial routine HIV case-based surveillance systems to varying degrees, with some jurisdictions reporting these HIV-positive migrant cases as a new diagnosis and others excluding them from provincial/territorial reporting to PHAC.

Canadian Perinatal HIV Surveillance Program

National data on the HIV status of infants exposed perinatally to HIV infection are collected through the CPHSP, an initiative of the Canadian Paediatric AIDS Research Group. The CPHSP is a sentinel-based active surveillance system that collects data on two groups of children: infants born to HIV-positive women and HIV-infected children receiving care at any participating site (whether born in Canada or abroad). Additional information on CPHSP methods are provided elsewhere (10,12). Surveillance data for 2019, including data updates for previous years, were submitted to PHAC in March 2020.

Analysis

We used all HIV case data reported to HASS to complete descriptive analyses for overall trends, geographic location, sex, age and exposure category. Analyses were restricted to cases for which data were available (i.e. not missing). Counts and proportions were calculated from IRCC data. The CPHSP provided aggregated data tables, and selected results are presented in this report.

Microsoft Excel 2016 (Redmond, Washington, United States) and SAS Enterprise Guide v7.1 (Cary, North Carolina, United States) software were used for data cleaning and analysis. Standardized data recoding procedures were applied to all submitted provincial and territorial datasets to create a national dataset for analysis. In this report, the term "adult" is defined as anyone aged 15 years or older. The surveillance data presented in this report were validated by all provinces and territories to ensure accuracy.

No statistical procedures were used for comparative analysis, nor were any statistical techniques applied to account for missing data since analyses were limited to cross-tabulations due to the descriptive nature of the analysis. The population data source used to calculate rates was the Annual Demographic Statistics, issued by Statistics Canada in July 2019 (13).

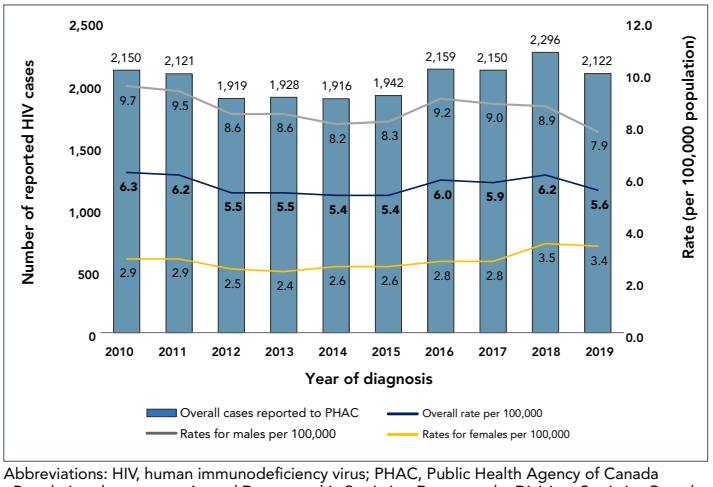
Supplementary tables are listed in the Appendix and are available upon request.

Results

Overall trends

A cumulative total of 88,357 HIV diagnoses have been reported to PHAC since HIV reporting began in Canada in 1985. In 2019, a total of 2,122 HIV diagnoses were reported. The national diagnosis rate was 5.6 per 100,000 population. This rate has slightly decreased since 2010 when it was 6.3 per 100,000 population (**Figure 1**).

Figure 1: Number of reported cases of HIV and diagnosis rates overall, by sex and year, Canada, 2010–2019[a,b]



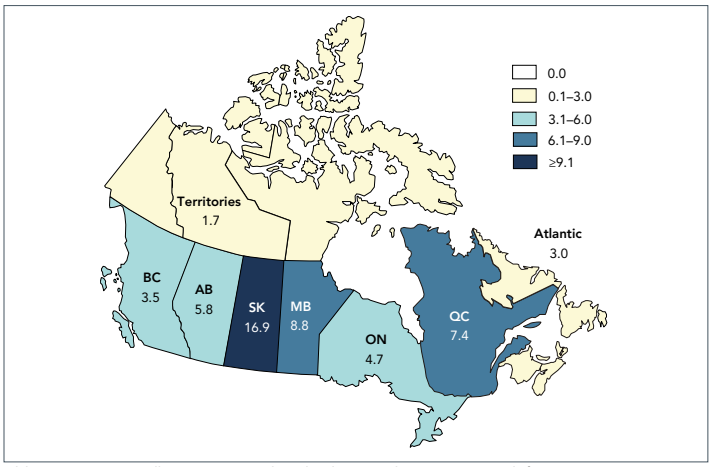
Abbreviations: HIV, human immunodeficiency virus; PHAC, Public Health Agency of Canada
[a] Population data source: Annual Demographic Statistics, Demography Division, Statistics Canada, July 1, 2019
[b] Overall rate excludes cases where sex is transgender, transsexual, not reported or unknown

In 2019, the diagnosis rate for males was 7.9 per 100,000 population and for females was 3.4 per 100,000 population. While the rates for both males and females fluctuated in the past decade, the rates in the male population decreased slightly since 2016 (from 9.2 to 7.9 per 100,000 population) and increased slightly in females since 2015 (from 2.6 to 3.4 per 100,000 population) (Figure 1).

Geographic distribution

In 2019, Saskatchewan had the highest provincial/territorial diagnosis rate at 16.9 per 100,000 population. Manitoba had the second highest provincial/territorial diagnosis rate at 8.8 per 100,000 population, followed by Québec, Alberta, Ontario and

Figure 2: HIV diagnosis rate (per 100,000 population), by province and territory, Canada, 2019[a,b]



Abbreviations: AB, Alberta; BC, British Columbia; HIV, human immunodeficiency virus; MB, Manitoba; ON, Ontario; QC, Québec; SK, Saskatchewan
[a] Rates for the territories (Northwest Territories, Nunavut, Yukon) and Atlantic region (New Brunswick, Newfoundland and Labrador, Nova Scotia, Prince Edward Island) are presented as averages
[b] National rate of 5.6 cases per 100,000 population

British Columbia at 7.4, 5.8, 4.7 and 3.5 per 100,000 population, respectively (**Figure 2**).

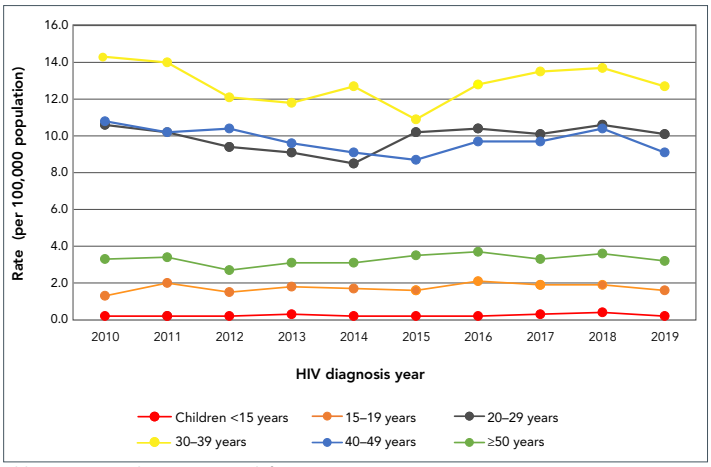
Age and sex distribution

In 2019, data on age groups were available for almost 100% (n=2,120) of all reported HIV diagnoses. The diagnosis rate by age group has remained stable since 2010 for those aged younger than 19 years and those aged 50 years and older. The diagnosis rate has fluctuated slightly over the past 10 years for those in the 20 to 29, 30 to 39 and 40 to 49-year age groups. The 30 to 39-year age group had the highest diagnosis rate throughout the 10-year period; in 2019, the rate was 12.7 per 100,000 population, an overall decrease from 14.3 per 100,000 population in 2010. The 20 to 29-year age group had the second highest rate at 10.1 per 100,000 population in 2019, followed by the 40 to 49-year age group at 9.1 per 100,000 population. In 2019, diagnostic rates of those aged 50 years and older were 3.2 per 100,000 population and of those aged 15 to 19 years were 1.6 per 100,000 population; children less than 15 years old had the lowest diagnostic rate of 0.2 per 100,000 population (**Figure 3**).

In 2019, data on sex were available for almost 100% of all reported HIV diagnoses (n=2,118). Males accounted for 69.8% of the diagnoses where sex was known, while females accounted for 30.2%.

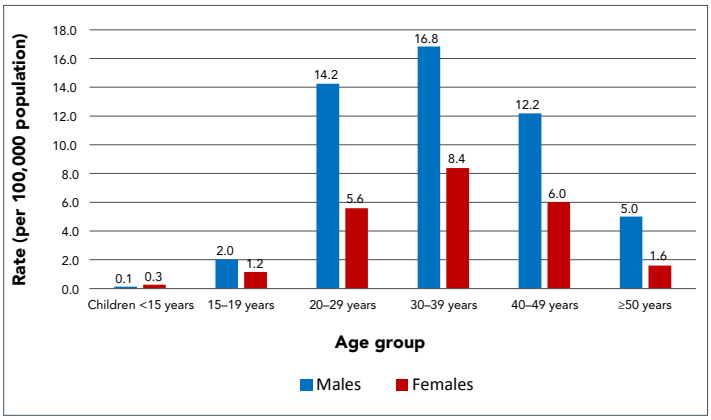
As in previous years, males aged 30 to 39 years old had the highest diagnosis rates in 2019, at 16.8 per 100,000 population; this age group also had the highest rates among females, at 8.4 per 100,000 population. Among both sexes, the bulk of HIV diagnoses occurred in those aged 20 to 49 years old. In all

Figure 3: HIV diagnosis rate, all ages, by age group and year, Canada, 2010–2019[a,b,c]



Abbreviation: HIV, human immunodeficiency virus
[a] Excludes cases where sex is transsexual, transgender, not reported or unknown
[b] Excludes cases where age is not reported or unknown
[c] Population data source: Annual Demographic Statistics, Demography Division, Statistics Canada, July 1, 2019

Figure 4: HIV diagnosis rate, all ages, by sex and age group, Canada, 2019[a,b,c]



Abbreviation: HIV, human immunodeficiency virus
[a] Excludes cases where sex is transsexual, transgender, not reported or unknown
[b] Excludes cases where age is not reported or unknown
[c] Population data source: Annual Demographic Statistics, Demography Division, Statistics Canada, July 1, 2019

age groups, except for those younger than 19 years old, rates among males were at least twice as high as among their female counterparts (**Figure 4**).

Race/ethnicity

Race/ethnicity information was known for 880 cases (41.5%) in 2019. Of cases with known race/ethnicity, 30.7% were reported as White, 25.5% as Black and 24.7% as Indigenous (First Nations, Inuit, Métis or Indigenous not otherwise specified). The distribution of race/ethnicity categories varied by sex; among males, the highest proportion was reported as White (38.5%), while females were mainly reported as Black, at 42.1%, and Indigenous, at 40% (**Table 1**).

Table 1: Number and percentage distribution of HIV cases (all ages) by sex and race/ethnicity, Canada, 2019[a,b]

Race/ethnicity	HIV cases				Total[c]	
	Male		Female			
	n	%	n	%	n	%
Indigenous	104	17.4	112	40.0	217	24.7
First Nations	45	7.5	46	16.4	92	10.5
Métis	4	0.7	0	0.0	4	0.5
Inuit	2	0.3	0	0.0	2	0.2
Indigenous, not otherwise specified	53	8.9	66	23.6	119	13.5
South Asian/West Asian/ Arab[d]	38	6.4	4	1.4	42	4.8
Asian[e]	42	7.0	3	1.1	45	5.1
Black[f]	106	17.7	118	42.1	224	25.5
Latin American[g]	62	10.4	2	0.7	64	7.3
White	230	38.5	39	13.9	270	30.7
Other[h]	16	2.7	2	0.7	18	2.0
Subtotal[b]	598	40.5	280	43.8	880	41.5
Not reported	880	59.5	359	56.2	1,242	58.5
Total	1,478	N/A	639	N/A	2,122	N/A

Abbreviations: HIV, human immunodeficiency virus; N/A, not applicable
[a] Race/ethnicity information is not submitted by Québec or British Columbia; for other jurisdictions, completion rate varies, interpret data with caution
[b] All percentages are calculated using the subtotal value as a denominator (including only cases for which data were available)
[c] Total includes cases where sex is transsexual, transgender and cases where sex was not reported
[d] For example, Armenian, Bangladeshi, Egyptian, Iranian, Lebanese, Moroccan, Pakistani and Sri Lankan
[e] For example, Cambodian, Chinese, Filipino, Indonesian, Japanese, Korean, Laotian and Vietnamese
[f] For example, Haitian, Jamaican and Somali
[g] For example, Central American, Mexican and South American
[h] Includes mixed raced and any other categories

Table 2: Number and proportion of HIV cases (≥15 years old) by sex and exposure, Canada (excluding Québec), 2019[a,b,c,d,e]

Exposure category	HIV cases				Total[e]	
	Male		Female			
	n	%	n	%	n	%
gbMSM	477	56.2	N/A	N/A	478	39.7
gbMSM/PWID	41	4.8	N/A	N/A	41	3.4
PWID	124	14.6	135	38.4	259	21.5
Heterosexual contact	170	20.0	169	48.0	340	28.3
Het-Endemic	36	4.2	75	21.3	111	9.2
Het-Risk	51	6.0	47	13.4	99	8.2
Het-NIR	83	9.8	47	13.4	130	10.8
Other[a]	37	4.4	48	13.6	85	7.1
Subtotal[b]	849	100.0	352	100.0	1,203	100.0
No identified risk[c]	51	3.5	26	4.1	77	3.7
Exposure category unknown or not reported ("missing")[d]	574	38.9	252	40.0	828	39.3
Total	1,474	N/A	630	N/A	2,108	N/A

Abbreviations: gbMSM, gay, bisexual and other men who have sex with men; Het-Endemic, heterosexual contact with a person from an HIV-endemic country; Het-Risk, heterosexual contact with a person at risk; Het-NIR, heterosexual contact with no identified risk; HIV, human immunodeficiency virus; N/A, not applicable; PWID, people who inject drugs
[a] Includes cases from Alberta identified through Immigration Refugees and Citizenship Canada, blood/blood products, perinatal, occupational exposure and other exposure categories
[b] Proportions are based on the subtotal count for known exposure category
[c] No identified risk: Used when the history of exposure to HIV through any of the other modes listed is unknown, or there is no reported exposure history (e.g. because of death or loss to follow-up)
[d] Includes all cases where exposure category was unknown or not reported. As exposure category information was not submitted by Québec, new HIV diagnoses reported by Québec are included here
[e] Total cases includes transsexual, transgender and cases where sex was not reported, whereas "male" and "female" columns exclude these cases

Exposure category distribution

In 2019, 57.1% of adult diagnoses of HIV had a known exposure category (n=1,203). Consistent with previous years, the highest proportion of all reported adult HIV diagnoses in 2019 was among gay, bisexual and other men who have sex with men (gbMSM), at 39.7% (n=478), although the proportion has decreased over time, particularly since 2015, when it was 45.0%. Heterosexual contact was reported among 28.3% (n=340) of cases. The subgroups of the heterosexual contact category followed a consistent pattern, with the proportion of heterosexual contact with no identified risk (Het-NIR) at 10.8% (n=130), followed by heterosexual contact with a person from an HIV-endemic country (Het-Endemic) at 9.2% (n=111), and 8.2% (n=99) attributed to heterosexual contact with a person at risk (Het-Risk). People who inject drugs (PWID) accounted for 21.5% (n=259) of cases (**Table 2**).

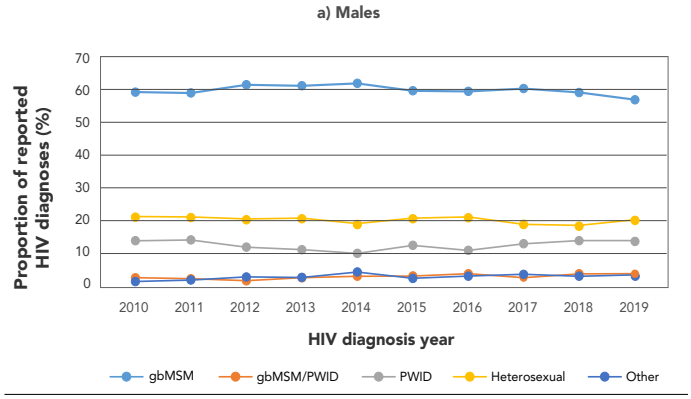
The exposure category variable was analysed separately for males and females. Among adult males in 2019, gbMSM accounted for the highest proportion (56.2%, n=477) of reported cases. Among adult females, exposure through heterosexual contact accounted for the highest proportion at 48.0% (n=169), with 21.3% Het-Endemic (n=75) and 13.4% Het-Risk and Het-NIR each (n=47 each). In addition, PWID accounted for a little over one-third of adult female HIV cases (38.4%, n=135) compared to 14.6% (n=124) of adult males cases (Table 2).

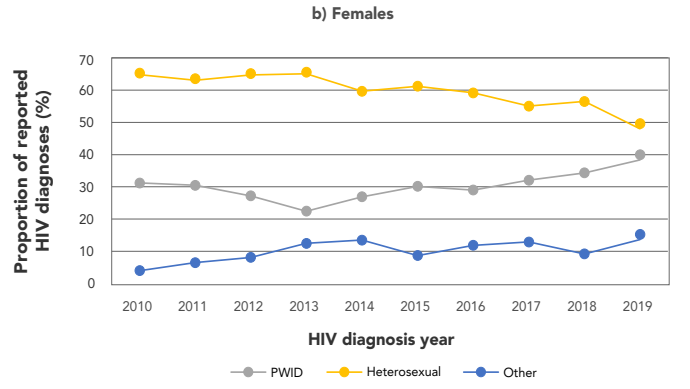
The distribution for exposure categories in males and females for the last 10 years is shown in **Figure 5**. In males, the distribution of HIV infection within the different exposure categories fluctuated slightly since 2010 but remained relatively stable overall. Of note, the gbMSM and heterosexual exposure categories decreased slightly in the last 10 years (percent decrease 26.3% and 27.0%, respectively), while the PWID exposure category remained relatively stable. Exposure attributed to the gbMSM/PWID category increased in the last 10 years (percent increase 10.9%). In females, there was a considerable decrease in the exposure attributed to heterosexual contact (percent decrease 20.3%), while the PWID increased (percent increase 32.4%).

Exposure category distribution by age group

In 2019, of HIV diagnoses with known exposure category, the highest proportion of gbMSM and gbMSM/PWID were in the 20 to 29-year age group at 35.1% (n=168) and 41.5% (n=17), respectively. Among PWID, the highest proportion (35.1%, n=91)

Figure 5: Percentage distribution of HIV cases among (a) males and (b) females (≥15 years old) by exposure category and year of diagnosis, Canada, 2010–2019[a,b]





Abbreviations: gbMSM, gay, bisexual and other men who have sex with men; gbMSM/PWID, gay, bisexual and other men who have sex with men and use injection drugs; HIV, human immunodeficiency virus; PWID, people who inject drugs
[a] Excludes cases with no identified risk, unknown exposure category and cases reported by Québec
[b] Other includes cases from Alberta identified through Immigration Refugees and Citizenship Canada, blood/blood products, perinatal, occupational exposure and other exposure categories

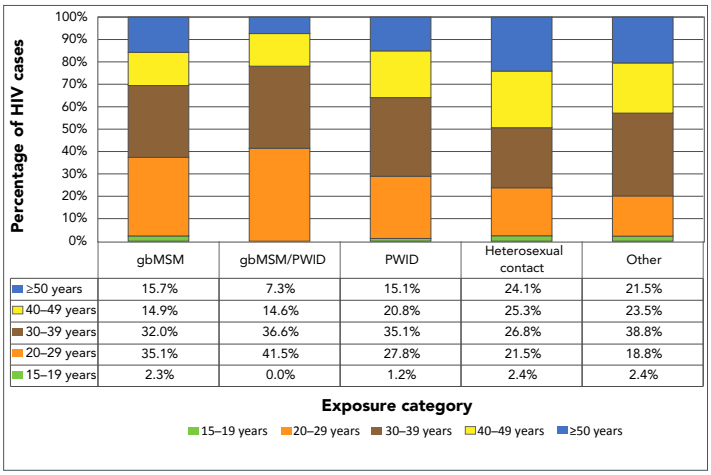
was in the 30 to 39-year age group. Cases reported within the heterosexual contact exposure category were evenly distributed across the different age groups for those aged over 20 years (range: 21.5%–26.8%), with the highest proportion in the 30 to 39-year age group (**Figure 6**).

Immigration medical screening for HIV

Between 2010 and 2019, a total of 4,090 individuals tested positive for HIV on an IME conducted in Canada, at an average of 409 per year (range: 210–696) (**Figure 7**). A total of 1,188 migrants tested positive for HIV through an IME in 2019. Of these cases, 52.7% (n=626) cases were tested in Canada and 47.3% (n=562) were tested overseas prior to their arrival in Canada.

In 2019, of the applicants tested in Canada, a slightly higher proportion of men (54.6%) than of women tested positive on an IME. Those in the 30 to 39-year age group had the highest proportion of positive tests (36.1%), followed by those in the 40 to 49-year age group (26.8%). HIV-positive applicants younger

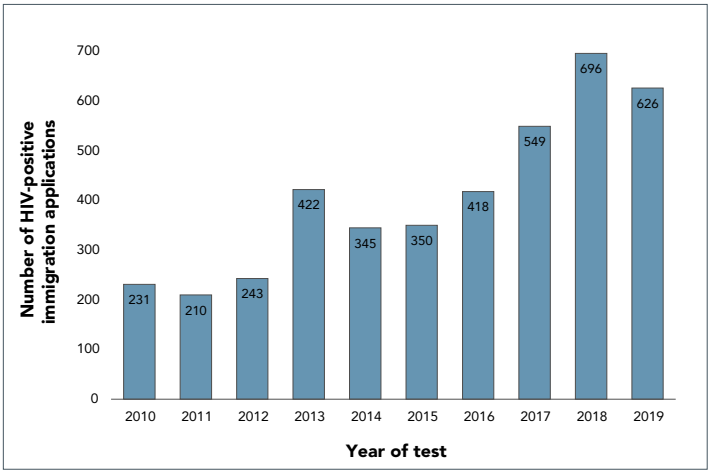
Figure 6: Proportion of reported HIV cases (≥15 years old) by exposure category and age group, Canada, 2019[a,b,c]



	gbMSM	gbMSM/PWID	PWID	Heterosexual contact	Other
≥50 years	15.7%	7.3%	15.1%	24.1%	21.5%
40–49 years	14.9%	14.6%	20.8%	25.3%	23.5%
30–39 years	32.0%	36.6%	35.1%	26.8%	38.8%
20–29 years	35.1%	41.5%	27.8%	21.5%	18.8%
15–19 years	2.3%	0.0%	1.2%	2.4%	2.4%

Abbreviations: gbMSM, gay, bisexual and other men who have sex with men; gbMSM/PWID, gay, bisexual and other men who have sex with men and use injection drugs; HIV, human immunodeficiency virus; PWID, people who inject drugs
[a] Includes cases where sex was transsexual, transgender and not reported
[b] Excludes cases where exposure category was not reported
[c] Other exposure category includes cases from Alberta identified through Immigration Refugees and Citizenship Canada, blood/blood products, perinatal, occupational exposure and other exposure categories

Figure 7: Number of migrants who tested positive for HIV during an Immigration Medical Exam conducted in Canada, 2010–2019



Abbreviation: HIV, human immunodeficiency virus

than 29 years old accounted for 22.2% of the total, whereas those in the 50-year-plus age group only accounted for 14.9% of HIV-positive applicants tested in Canada. The majority of in-Canada HIV-positive applicants were in Ontario (57.0%) and Québec (24.6%). Among the HIV-positive applicants tested in Canada, 65.7% were from an HIV-Endemic country.

In 2019, IRCC public health notifications were most commonly sent to Ontario (35.7%), Québec (28.0%), Alberta (18.9%) and British Columbia (8.4%).

Canadian Perinatal HIV Surveillance Program

According to CPHSP, 250 infants were perinatally exposed to HIV in Canada in 2019. One infant tested positive for HIV in 2019. This infant was asymptomatic and born from a mother who did not receive antepartum or intrapartum ART prophylaxis. Since 2012, there have been an average of 250 perinatal exposures per year (range: 217–268) with an average of 5.5 confirmed infections per year (range: 1–12). The trend in proportion of HIV-positive mothers receiving ART each year has been increasing since 2015 (93.5%), with 96.2% receiving ART in 2018 and 98.0% in 2019.

The most commonly reported exposure category for HIV-positive mothers in 2019 continued to be heterosexual contact (77.0%), followed by injection drug use (16.7%). The most commonly reported maternal race/ethnicity was Black (58.4%). This was followed by mothers identifying as Indigenous (20.4%) and White (13.2%). Most HIV-positive mothers were of African (48.0%) or North American (34.8%) origin.

Discussion

Altogether 2,122 HIV diagnoses were reported in 2019 in Canada, and the national diagnosis rate was 5.6 per 100,000 population. Over the past decade, the rates have remained stable over time, with some minor fluctuations. The 2019 diagnosis rate was slightly lower than that in 2018; more time and data are needed to determine whether this decrease is the beginning of a continuing trend.

A total of 1,188 migrants tested positive for HIV on an IME in 2019. Of these cases, 52.7% cases were tested in Canada and 47.3% were tested overseas prior to their arrival in Canada. There were 250 infants perinatally exposed to HIV in Canada in 2019. The one documented perinatal HIV transmission was related to a mother who did not receive antepartum or intrapartum ART prophylaxis.

As in previous years, gbMSM remained the largest proportion of new HIV diagnoses and accounted for over half of adult male cases (56.2%) in 2019. A slight decrease has been noted in rates among males overall since 2016 and in HIV diagnoses among gbMSM since 2017. This decrease in rates in males overall coincides with Health Canada's approval of PrEP, and may reflect the impact of this new HIV prevention technology in this population. This trend echoes that seen in other developed countries, including Australia and the United Kingdom (14,15). In Australia, there has been a decrease of 25.4% in HIV diagnosis among gbMSM since 2016. In the United Kingdom, there has been a decrease of 47.1% since 2014, a change attributed to a significant decline in HIV diagnoses among gay and bisexual men. As PrEP uptake increases in eligible populations, further reductions in HIV diagnosis may be expected.

The decrease in HIV diagnosis in Canada was not as great as that seen in other countries. This indicates that more can be done to increase awareness and use of PrEP. Based on the results of a 2017 survey of gbMSM in Canada, 51.7% of participants reported that they were likely to use PrEP if affordable and available, and only 8.4% were using PrEP at the time of the survey (16).

The rates of diagnosis in females have increased slightly since 2015. This trend coincides with increasing cases of infectious syphilis in women (17). These overall trends suggest increases in substance use, injection drug use and prevalence of STBBIs in some networks of women at risk for STBBI. These trends also provide additional support for the integrated national approach articulated by the Government of Canada's framework (4) to reduce the health impact of STBBIs in Canada in key populations affected by overlapping epidemics (i.e. syndemics) (18). This increase in rates among women was not observed in other developed countries where information was available. In fact, the rates among women decreased in the United States between 2014 and 2018, with the exception of a slight increase (8%) since 2014 in case counts in women who inject drugs (19). Likewise, in Australia, the rates of HIV diagnoses in females decreased slightly since 2017 (14), while the United Kingdom has shown a consistent annual decrease in new HIV diagnoses counts in females since 2010 (15).

Nearly one-fourth of HIV diagnoses in 2019 were attributed to Indigenous peoples, indicating an overrepresentation of this population in Canadian HIV data. Given that only a limited number of jurisdictions report Indigeneity, these proportions are likely biased. However, it is clear that Indigenous peoples are overrepresented among those living with HIV. New estimates, which rely on HASS data, along with other sources of data indicate that infections among Indigenous people represented 14% of all new infections in 2018, whereas Indigenous people represented only 4.9% of the total Canadian population (2).

Data from IRCC indicate that while the proportion of migrants with positive HIV test results on their IME has remained relatively stable in recent years, the overall number of people migrating to Canada has increased. However, the number of HIV diagnoses identified through IMEs does not necessarily reflect new HIV cases in Canada. Some migrants who tested HIV positive in overseas IMEs may not arrive in Canada, and those identified during in-Canada IMEs may already be accounted for in provincial/territorial reports. Furthermore, it would be difficult to ascertain the timing of HIV acquisition of the 626 migrants who tested positive during in-Canada IMEs in 2019. More information is needed to better understand the epidemiology of HIV among new Canadians, particularly among those from HIV-endemic countries.

In 2019, there were 250 infants perinatally exposed to HIV in Canada. One mother-to-child HIV transmission was confirmed in a mother who did not receive antepartum or intrapartum

ART. Over the years, important mitigation measures have been taken in Canada to prevent mother-to-child HIV transmission. These include an increased access to antenatal care, routine HIV screening of pregnant women and availability of treatment for HIV-positive mothers. Nevertheless, missed opportunities for prevention continue to occur, primarily in vulnerable populations, leading to a small number of perinatal infections (20).

Despite advances in the prevention, diagnosis and treatment of HIV, HIV and other STBBIs remain a significant health concern in Canada. Surveillance data, such as those presented in this report, are a key component in understanding the burden of STBBI in Canada and to monitor Canada's progress toward the stated goals of the framework (4).

Strengths and limitations

The main strength of this report is that it is the only source of national epidemiological data on all reported HIV diagnoses in Canada. It also incorporates data on HIV diagnoses among migrants to Canada and perinatal transmission of HIV, which help build a more complete picture of the state of HIV in Canada.

Limitations of HASS have been described previously (10,12) and are common to most surveillance systems. While it is difficult to ascertain the factors that may contribute to noted fluctuations, changes in reporting practices by provincial and territorial health authorities may have had an impact.

The low completion rate of data elements related to the race/ethnicity and exposure setting of new HIV cases, and the resulting potential biases in the available data, create difficulties in making inferences about the factors that influence HIV transmission in Canada. PHAC continues to work with its surveillance partners to enhance the collection of data elements including race/ethnicity information.

As reported by Popovic *et al.* (21), HIV cases reported by provinces and territories through routine surveillance mechanisms may have been previously diagnosed, either in another Canadian jurisdiction or in another country; such cases affect observed trends in HIV diagnosis rates. Therefore, it is important to understand the overall burden of HIV infection in people currently living in Canada.

Conclusion

The data in this report are considered provisional and may be subject to change in future HIV surveillance reports. If discrepancies exist between the data summarized in this report and provincial and territorial reports, the most recent provincial and territorial report should be used.

Authors' statement

NH — Conceptualization, research, writing, original draft, final draft, review, editing, data validation, visualization, supervision
AW — Data validation, original draft, editing, research
AR — Data management, data validation, research
ST — Review, editing

Competing interests

None.

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Appendix: List of supplementary tables

These tables are available upon request at:
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Table S1: HIV diagnosis rate (per 100,000 population) by province/territory and year of diagnosis (all ages)

Table S2: Number of HIV cases (all ages) by province/territory, sex and year of diagnosis–Canada, 1985–2019

Table S3: Number of HIV cases by age group and province/territory–Canada, 2018–2019

Table S4: Cumulative number of HIV cases among adults (≥15 years old) and children (<15 years old) by sex–Canada, 1985–2019

Table S5: Number of HIV cases among adults (≥15 years old) by year of diagnosis and sex–Canada, 1985–2019

Table S6: Number of cases and HIV diagnosis rate by age group, sex and year of diagnoses–Canada, 1985–2019

Table S7: Number and percentage distribution of HIV cases among adults (≥15 years old) by exposure category and year of diagnosis–Canada, 1985–2019

Table S8: Number and percentage distribution of HIV cases among adult males (≥15 years old) by exposure category and year of diagnosis–Canada, 1985–2019

Table S9: Number and percentage distribution of HIV cases among adult females (≥15 years old) by exposure category and year of diagnosis–Canada, 1985–2019

Table 10: Number and percentage distribution of HIV cases among adults (≥15 years old) by exposure category and age group–Canada, 2018–2019

Table S11: Number and percentage distribution of HIV cases among children (<15 years old) by exposure category and year of diagnoses–Canada, 1985–2018

Table S12: Number of HIV cases by exposure category and province/territory–Canada, 2018–2019

Table S13: Number and percentage distribution of immigration applicants to Canada diagnosed with HIV as a result of an Immigration Medical Exam by year–2002–2019

Table S14: Number and percentage distribution of immigration applicants to Canada diagnosed with HIV as a result of an Immigration Medical Exam by sex, age group and province–2012–2019

Table S15: Number of perinatally HIV-exposed infants by year of birth, current status and use of antiretroviral therapy for prophylaxis–Canada, 1984–2019

Table S16: Number of perinatally HIV-exposed infants by maternal exposure category and year of infant birth–Canada, 1984–2019

Table S17: Number of perinatally HIV-exposed infants by ethnic status and infection status–Canada, 1984–2019

Table S18: Number of perinatally HIV-exposed infants by maternal country of birth and infection status–Canada, 1984–2019

Table S19: Number of perinatally HIV-exposed infants by geographic region and status at last report–Canada, 1984–2019

Table S20: International statistics on reported HIV cases–Canada, 2018

Managing pain and fear: Playing your CARDs to improve the vaccination experience

Anna Taddio[1]*, Anthony Ilersich[2], C Meghan McMurtry[3], Lucie M Bucci[4], Noni E MacDonald[5]

Abstract

Most vaccinations are administered with a needle, which can cause pain and pain-related symptoms such as fear and fainting. At present, interventions aimed at preventing pain and associated symptoms are not systematically integrated in the vaccination delivery process even though they contribute to negative experiences with vaccination and vaccination noncompliance. In this article, a novel framework for vaccination delivery called the CARD™ system was reviewed. CARD is an acronym for **C**omfort, **A**sk, **R**elax and **D**istract, whereby each letter category incorporates evidence-based interventions to reduce pain and fear and related symptoms. CARD can be integrated in usual vaccination planning and delivery activities in many settings to improve the vaccination experience and decrease pain and fear as barriers to vaccination. Immunizers in all settings and organizational leaders are invited to review their vaccination services against CARD to identify opportunities for enhancing the quality of care being provided.

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Keywords: vaccination, pain, fear, pain management, vaccine hesitancy, needlesticks

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Introduction

Vaccine injections are frequently associated with pain and pain-related adverse effects, such as fear, fainting, nausea and other stress-related responses (1,2). Until recently, little attention has been paid to reducing pain and related symptoms during vaccination. However, accumulating evidence shows that negative experiences with vaccination can contribute to the development of needle fears, vaccine hesitancy and healthcare avoidance behaviours, including vaccination noncompliance (3,4). This is particularly important during childhood, when concerns about pain and fear of needles are high and attitudes towards healthcare providers are being shaped (2,5).

Vaccination is the most common reason, by far, why people receive needles. The World Health Organization has identified overcoming barriers to immunizations as a priority for global health (6). Addressing barriers to vaccination is even more relevant now, during the pandemic, to help with acceptance of COVID-19 vaccine(s) when they become available.

There are numerous negative consequences of unmanaged pain when receiving needles. Individuals are often subjected to longer procedure times and increased use of restraint, and can experience potentially serious adverse events such as fainting, nausea and other stress-related responses (2,7,8). Having to deal with long and complex patient interactions leads to additional stress for the healthcare providers administering vaccinations. Immunizers commonly report challenges with current vaccination delivery processes that may increase the risk of unwanted outcomes. These challenges include suboptimal physical spaces, lack of preparation and communication of important stakeholders, unclear roles, competing demands and excessive patient symptoms (fear, pain, dizziness), particularly in children (9–11). Recently, fear of acquiring COVID-19 infection while being immunized has only exacerbated these concerns.

There are numerous evidence-based and feasible interventions for improving the vaccination experience (1). Pain management needs to be recognized as a part of good vaccination practice and this knowledge needs to be systematically integrated into practice (12). Based on their clinical practice guideline (1), the national HELPinKids&Adults team recently developed a vaccine delivery framework called CARD™ that shows immunizers and program managers responsible for vaccination delivery how to integrate these interventions into vaccination planning and delivery processes. In addition, CARD teaches patients how to cope with their own vaccination experience (11). This article explains the framework and how to apply it in various settings.

What is CARD?

CARD stands for **C**omfort, **A**sk, **R**elax and **D**istract. Each of the four initial letters stands for an intervention category, and the four encompass activities that reduce pain, fear, fainting and related symptoms before, during and after vaccination. The CARD system can be used with children and adults, with participatory activities in all four intervention categories.

How was CARD developed?

CARD was originally designed to improve the vaccination experience at school, but it is a valuable tool for vaccination delivery in various settings, including healthcare providers' offices. In fact, one of its main strengths lies in its adaptability to many different settings. Most importantly, CARD was developed with input from different stakeholders involved in vaccinations at school. Immunizers, students, parents/guardians and school staff were involved in a stepwise approach that included identifying needs and preferences, developing tools and resources, and implementing and evaluating the impact of implementation (11).

CARD works

In a controlled cluster trial conducted in Niagara, Ontario, students in schools where CARD was implemented (versus control) reported less fear (odds ratio [OR] =0.47, 95% confidence interval [CI]: 0.27–0.82) and dizziness (OR=0.26, 95% CI: 0.07–0.91) during vaccination (13). Students educated about CARD had higher knowledge scores and more positive attitudes towards vaccination. Students wanted other students to learn about CARD as they had found it so helpful (13). Immunizers, parents/guardians and school staff also reported more positive attitudes about the vaccination experience when CARD was in use (14).

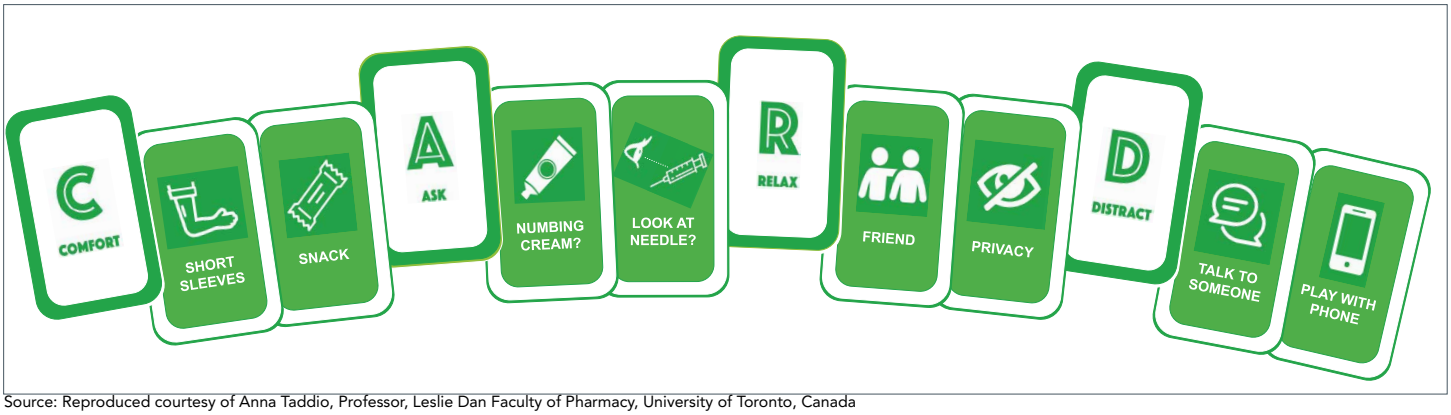
Tailoring CARD to your setting

CARD can be tailored to work in a variety of settings, including private offices, hospitals, schools and pharmacies. Key elements of CARD include education of immunizers and patients, setting up the vaccination site to be supportive, and ensuring that immunizer and patient interactions embrace the patients' preferences (i.e. CARD choices). Patients can learn about CARD from online resources, for example, videos and pamphlets (11). While the majority of resources are primarily focused on adolescents, new resources are currently being developed for the adult vaccination context (https://immunize.ca/card-adults). **Figure 1** shows sample interventions that patients can "play" to make the procedure a more positive experience.

Immunizers also receive simple training in the importance of the components of CARD and how to support the choices patients make. The immunizer and patient form a team to make the experience as positive as possible. From the planning stages to actual injection, and across different vaccination settings, the immunizer can review current vaccination procedures against the CARD framework, looking for opportunities to incorporate ways to optimize the vaccination experience.

Table 1 summarizes some of the activities normally associated with planning and delivery of vaccinations and how to incorporate CARD into those activities. All stakeholders involved in the vaccination process, including immunizers and patients, can "play their CARDs" to facilitate a more positive vaccination experience. For instance, immunizers can make sure there is comfortable seating for the patient (**C**omfort) and invite patients to ask questions before, during and after the procedure (**A**sk). Doing this helps patients feel comfortable, informed and involved, which helps them feel calm. It also builds trust in healthcare providers because they demonstrate that they are caring and attentive to patient needs. Immunizers can also ask patients questions (e.g. How afraid are you? Do you prefer to look away?) to help them assess the patient's status as well as to engage patients as active participants. Patients can bring a favourite item (**C**omfort) or an electronic device (**D**istract) for use

Figure 1: Sample interventions from the CARD system



Source: Reproduced courtesy of Anna Taddio, Professor, Leslie Dan Faculty of Pharmacy, University of Toronto, Canada

Table 1: CARD system framework for vaccination delivery

Phase of vaccination	Immunizer activity
Preparation/planning	
Ensure adequate clinic space	• Esthetic room, free of hazards • Temperature control • Accommodates equipment and supplies • Comfortable seating for patient with ability to lie down • Allows for privacy • Allows for no interruptions • Allows for ability to accommodate a support person with seating
Educate patients and other stakeholders (e.g. parents/ guardians, teachers)	• CARD education (e.g. discussion, tools)[a] • Answer patient questions • Book vaccination appointment
Vaccination day reminders	• Patients ask questions they have about vaccination or coping interventions • Patients plan how they will play their selected coping strategies (e.g. bring cell phone to use as a distraction item, wear short-sleeved shirt to allow for easy access to arm and to increase comfort)
Vaccination day	
Vaccination clinic set-up	• Use separate areas for waiting, vaccination and post-vaccination with chairs • Allow for privacy (e.g. use window coverings, physical barriers) • Ensure safety measures are in place to prevent transmission of infectious diseases (e.g. sanitization items, face coverings) • Make sure patients have comfortable seating and are able to be in a reclining position • Allow patients to use distraction aids or comfort items • Allow patients to bring a support person • Arrange seating at clinic tables so that patients do not face each other or equipment, and obscure frightening equipment from site (e.g. use towel, table-top poster)
Vaccination administration	• Foster a calm environment and be positive • Review patients' medical history, including fainting and level of fear or worry about vaccination • Answer patients' questions • Communicate using neutral language. Do not use words that elicit fear (e.g. the needle "stings") and do not use repetitive reassurance (i.e. don't worry, it's ok, you'll be fine) • Provide balanced information. Do not suggest that vaccination will not hurt; instead, describe sensations (e.g. "pressure" and "pinch") and duration (e.g. "about 1 second") and invite patients to report on how they feel • Ask patients about their preferences. Do not impose coping interventions such as verbal distraction, taking deep breaths, looking away during injection (these interventions are counter to preferred coping strategies of many individuals and lead to increased levels of fear or distress) • Ask patients what CARDs they are playing and accommodate requests (e.g. topical anesthetic, support person, private room, injection of two vaccines in same arm)

Table 1: CARD system framework for vaccination delivery (*continued*)

Phase of vaccination	Immunizer activity
Vaccination day (*continued*)	
Vaccination administration (*continued*)	• Provide distraction agents for patients that do not have them but would like to be distracted (in keeping with infection control and prevention guidelines) • Ask patients about their preference with respect to the arm to vaccinate. If there is no preference, inject the non-dominant arm • Ask patients about their preference with respect to injecting two vaccines in the same arm • Encourage patients to relax their arm so that it is loose and jiggly • Consider not using alcohol to cleanse the skin as this step is unnecessary, adds time and can increase anticipatory stress[b] • Inject patients sitting upright (on a parent's/ guardian's lap if patient is a young child) • Inject vaccines quickly, without aspiration • If there are multiple injections, administer the most painful vaccine last • Monitor patient symptoms after vaccination. Suggest muscle tension to patients who are dizzy or prone to fainting (this can be achieved by squeezing legs together or lying down in a reclining chair or on a gym mat) • Counsel patient regarding post-injection reactions and use of acetaminophen • Document symptoms and feedback to inform future vaccination[c]

[a] Resources/tools available online (11)
[b] See World Health Organization. WHO best practices for injections and related procedures toolkit. Geneva (Switzerland): WHO Document Production Services; 2010 (15)
[c] See Appendix 5, page 2 of Taddio *et al.* (1)
Source: Reproduced courtesy of Anna Taddio, Professor, Leslie Dan Faculty of Pharmacy, University of Toronto, Canada

during vaccination to help cope. While each stakeholder (needle givers and receivers) has their own CARDs to play, the full potential of the CARD framework is realized when all play their own CARDs with the shared goal of improving the vaccination experience.

Playing CARD is teamwork

In many settings, vaccination delivery is complex, and immunizers are unable to make the necessary changes to adopt CARD on their own. It is crucial to involve organizational leaders who can facilitate adoption by making changes to relevant policies and procedures. These changes could include staff roles, training, ongoing communication and evaluation (e.g. staff meetings, summaries, audit and feedback) and ongoing support (e.g. educational resources) (11). This also includes promoting awareness and understanding of overarching models of healthcare delivery and professional standards that promote person-centred care and evidence-based practice, and actively practising continuous quality improvement and reflective practice.

Immunizers and their organizational leaders can also identify opportunities to leverage current activities to facilitate activities

specific to CARD. For instance, immunizers typically notify teachers and parents/guardians of upcoming school-based vaccinations. These stakeholders can learn about CARD and reinforce teaching the CARD system to the children. Engaging stakeholders, including teachers and parents/guardians, has multiple benefits, including improving fidelity of implementation, creating a "social norm" that recognizes and respects individuals' participation in their healthcare, their preferences for information and coping, and it minimizes the need for additional resources. In turn, parents/guardians and teachers feel more at ease knowing that children are being cared for, and this creates a more welcoming environment for everyone.

Our experience with using CARD in a school-based vaccination program in Niagara, Ontario, was that, after training and support during initial implementation, the system could be incorporated into usual activities in a cost-neutral manner (12). Immunizers will need some additional time to prepare for vaccinations because of the planning steps, such as educating all stakeholders. However, the required time will lessen as everyone becomes familiar with CARD.

Conclusion

Addressing pain and associated stress-related reactions are proven to improve the vaccination experience for patients and immunizers alike. The long-term benefits of the CARD framework are numerous and include the potential for improved health outcomes due to improved acceptance of healthcare interventions, including vaccination. CARD allows immunizers to "play their best hand" with respect to setting up and running clinics or individual vaccination appointments. The CARD system is a valuable tool for optimizing the vaccination experience and addressing one of the long-recognized yet neglected harms of vaccination, the needle.

Authors' statement

AT — Conceptualization, writing–original draft, review and editing
AI — Conceptualization, writing–review and editing
CMM — Conceptualization, writing–review and editing
LMB — Writing–review and editing
NM — Writing–review and editing
All authors take responsibility for the content of this article.

Competing interests

AT reports a Section 9 Trademark No. 924835 for CARD. LMB reports that Immunize Canada received grants from Pfizer Canada, Merck Canada, GSK Canada, Seqirus Canada and Sanofi Pasteur outside the submitted work. There are no other disclosures.

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How many people intend to get the COVID-19 vaccine?

Source: Emerging Science Group of the Public Health Agency of Canada. Evergreen Rapid Review on COVID-19 Vaccine: Knowledge, Attitudes and Behaviors, November 2020. Full report available from: phac.emergingsciencesecretariat-secretariatdessciencesemergentes.aspc@canada.ca

Background: When coronavirus disease 2019 (COVID-19) vaccines become available, the challenge of vaccinating entire populations will begin. Understanding the knowledge, attitudes and behaviors of the general public, healthcare workers (HCWs) and high-risk groups in Canada and around the world will be crucial in encouraging uptake of the vaccine.

Methods: Twenty databases and key websites were searched up to October 16, 2020 and a grey literature search for additional Canadian research was conducted November 5–6, 2020. Articles were screened, and relevant citations examined. Data from 67 articles (including 29 pre-prints) were extracted into evidence tables.

Results: Two global surveys with over 10,000 participants each, found over 70% of participants intended to receive the COVID-19 vaccine. The most common reasons for vaccine refusal were concerns about vaccine safety and effectiveness, the newness of the vaccine and the belief that it was unnecessary. In 45 studies on knowledge, attitudes and behaviors of the general public, the most common factors positively associated with intention to vaccinate were male gender, older age, higher socioeconomic status and concern about COVID-19. In the United States and United Kingdom, the intention to vaccinate was higher among White ethnic groups than Black, Asian and Hispanic ethnic groups. There were 11 studies of HCWs that found doctors were more likely to accept the vaccine than nurses or other HCWs. Two studies of high-risk populations found intention to receive a COVID-19 vaccine was positively associated with perceived severity of the disease, personal health consequences and health consequences to others.

Six studies were specific to Canada. The Atlantic provinces had the highest intent to vaccinate and Saskatchewan/Manitoba the lowest. There was a 4% decrease in intent to vaccinate between May and August 2020. Overall, 24% of Canadians were neutral or undecided about whether to get vaccinated.

Most studies were online surveys, which were at moderate/high risk of bias as many survey tools did not undergo validity testing or pre-testing, and there may have been a selection bias. A key knowledge gap is the evolution of vaccine knowledge, attitudes and behaviors over time, especially in HCWs and high-risk populations.

Conclusion: Early online surveys suggest about 70% of the world's population have reported an intention to vaccinate, although this appears to have decreased slightly since the start of the pandemic. In Canada, almost a quarter of the population remain neutral or undecided about whether to get vaccinated: their biggest concern is safety and effectiveness of the vaccine.

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