Risk Factors and Surveillance Systems for Foodborne Illness Outbreaks in Canada

Annie Lukacsovics, Megan Hatcher, and Andrew Papadopoulos

Summary

- Risk factors for foodborne illness in Canada span along the “farm-to-fork continuum.”
- Human risk factors include personal hygiene, cross-contamination, temperature control and unsafe food sources.
- Surveillance and food safety systems at the regional (or local), provincial/territorial, and federal levels are designed to function collaboratively.
- The efficiency of surveillance systems to produce complete datasets with pathogen-specific risk factor information is challenged by inconsistent disease reporting and insufficient information sharing.
- Recommendations include standardizing reportable disease lists and procedures for reporting (case and outbreak-related) and encouraging participation of all jurisdictions in information sharing using electronic systems.

Introduction

A foodborne illness outbreak is defined as an incident in which two or more persons experience a similar illness from consuming a common food. A well-known example was the listeriosis outbreak in the summer of 2008. The consumption of contaminated deli meats sickened a total of 57 Canadians in seven provinces and claimed 23 lives. Procedures for reporting suspected cases and the routine surveillance of laboratory-confirmed cases are important mechanisms for detecting foodborne illness outbreaks and triggering outbreak investigations. Surveillance also elucidates risk factors that may contribute to foodborne illness cases in order to inform public health policies and interventions. In Canada, foodborne illness surveillance is a shared responsibility between the federal, provincial/territorial (P/T), and regional (or local) levels of government. The federal government sets food safety standards and policies, develops and maintains surveillance systems, initiates food recalls, and develops national strategies for managing food safety risks. Provincial and territorial governments each have a public health mandate that includes food safety surveillance, investigations, and compliance inspections.

This review aims to summarize pertinent literature about the risk factors for foodborne illness outbreaks in Canada. Outbreak investigation procedures, with an emphasis on the role of surveillance, will also be assessed in order to determine if any improvements can be made to help establish a more complete dataset for reporting risk factors specific to Canada. Appendix A describes relevant terms used in this document.

1 MPH Program, University of Guelph
2 MPH Program, University of Guelph
3 University of Guelph
Methodology

Multiple databases, including ProQuest LLC, PubMed, Web of Science and Google Scholar were used to search for relevant peer-reviewed articles. Key word searches for article titles and abstracts were conducted using the primary search terms: foodborne, outbreaks, and risk factors. Combinations of these primary search terms were combined with: food safety, food handling, food inspection, incidence, common, and prevalence. Specific etiological agents were also searched for including: Salmonella, Campylobacter, Escherichia coli (E. coli), Listeria, norovirus, rotavirus, Clostridium perfringens (C. perfringens), Staphylococcus aureus (S. aureus), Bacillus cereus (B. cereus), and Shigella spp. Grey literature, such as consumer reports, government reports, and government websites were also used, especially for information on surveillance systems (regulations and protocols). Documents on surveillance were searched for using Google, with the terms provincial, territorial, Canada, and province/territory names in combination with reportable diseases, communicable diseases, public health act, public health laboratories, health authorities, health regions, surveillance, outbreak response, foodborne illness, case follow-up forms and protocols. Appendix B provides further details on the literature search strategy.

Canadian Foodborne Illness Outbreaks and Microbial Causative Agents

In 2009, Ravel et al. published the most extensive study to date of 6,908 recorded foodborne illness outbreaks in Canada, spanning from 1976 to 2005. An analysis of 3,476 outbreaks with data on etiological agents indicated that the most frequent microorganisms identified were Salmonella (33%), S. aureus (15%), B. cereus (12%), C. perfringens (11%), and E. coli (10%). Although pathogens such as Salmonella, B. cereus, Campylobacter, E. coli, and S. aureus, were linked to all or almost all food categories, more frequent associations seemed to exist with the respective food categories of produce, poultry, and beef (Table 1). Among the 5,745 outbreaks with identified food vehicles, the most prevalent associated food vehicles were multi-ingredient foods (34%), meat (26%), and meals (22%). Food categories with a broad spectrum of pathogens include “produce,” “seafood,” and “multi-ingredient foods.” Other food categories such as “eggs,” “meat: wild game,” and “dairy: milk” were associated with a relatively narrow spectrum of pathogens.

Outbreaks associated with the food category “produce” have been increasing in occurrence in Canada. Kozak et al.’s review of produce-related outbreaks reported 27 outbreaks including an estimated 1,549 cases of illness from 2001 through 2009. Fifty percent of these outbreaks were linked to Salmonella as the causative agent, followed by E. coli (33%) and Shigella (17%). Outbreaks due to bacterial infection represented 66% of the total, seven outbreaks were parasite-associated, and foodborne viruses were implicated in two outbreaks.

Potential Risk Factors Contributing to Outbreaks in Canada’s Food System

Foodborne illness outbreaks are a result of an error or series of errors along the “farm-to-fork” continuum where pathogens are introduced, efforts to eliminate pathogens fail, or improper handling allows pathogens to multiply. An outbreak could be attributed to activities at the primary production (or farm level) due to pre-harvest sources or from post-harvest contamination. Food manufacturers and processors can also introduce hazards into the food supply by inadequately addressing the risks of contaminants. Retailers and wholesalers are gatekeepers to the food supply for most Canadians: their storage, packaging, and handling practices are significant determinants of food safety outcomes.

Risk factors associated with foodborne illness outbreaks found in the later stages of the farm-to-fork continuum can be divided into non-human and human risk factors. Non-human risk factors are related to the physical environment and are present when there is poor design or maintenance of facilities. Human risk factors are the most critical variables that food handlers have control over such as various food preparation techniques and ethnic or cultural preferences. Food safety knowledge and behaviour influence the likelihood of introduction and/or growth of pathogens. The following sections are based mostly on United States (US) and international research, as there are relatively few relevant Canadian studies.

Poor personal hygiene

Poor hygiene and handling food while infected with an enteric pathogen have been significant risk factors for foodborne illness. In numerous instances, investigators
attributed the failure of properly washing hands to the lack of adequate hand hygiene supplies or facilities.

Maintaining personal hygiene is the first and most pervasive risk factor for foodborne outbreaks. The estimated annual incidence of infections from pathogens associated with personal hygiene control factors is about 9.3 million cases in the US at a cost of $8.2 billion (USD). Infections from bacteria such as *Salmonella* spp. and *Shigella flexneri*, viruses such as Hepatitis A and norovirus, and parasites such as *Giardia lamblia* have been documented to be transmitted via food due to poor personal hygiene.

**Cross-contamination**

Inadequate food preparation practices, including cooking and cross-contamination factors, are associated with approximately 3.5 million cases at a cost of 4.3 billion USD, annually. Pathogenic and nonpathogenic organisms are continually introduced into the home by people, and the persistence of microorganisms and the potential spread of microbial contaminants from contaminated foods in the home have also been reported. A study found significant bacterial contamination of domestic kitchens with fecal coliforms, *E. coli*, *Campylobacter*, and *Salmonella*.

Dufrene et al. found that the most likely mode of *Salmonella* or *Campylobacter* infection was cross-contamination of ready-to-eat products directly with raw poultry, or indirectly via contaminated surfaces or niches in the household kitchen. Additionally, earlier studies indicated that cross-contamination of foods not subjected to further cooking from raw products via hands, cleaning cloths or sponges, and utensils contributed to the occurrence of outbreaks of foodborne salmonellosis in the US.

**Improper time / temperature control**

Inadequate cooking or holding temperatures for foods was a contributing factor in 19% of outbreaks analyzed by Todd et al. After contamination by food handlers, temperature abuse by undercooking, or improper cooling or storage was seen to enhance growth and multiplication of bacteria in the implicated products. Temperature abuse was a common factor in all outbreaks caused by bacterial pathogens, but not those caused by viruses or protozoan parasites.

*Campylobacter jejuni* has a minimum growth temperature of about 31°C and therefore does not normally grow in foods, but it has a low infectious dose, highlighting the importance of microbial survival, not only growth, as a risk factor. Additionally, microorganisms cannot grow in dried foods and frozen foods, but they can survive in these foods for long periods with only a slight decrease in numbers still sufficient to cause illness, or may proliferate when conditions become suitable (i.e., pH, temperature, and moisture). The pathogens primarily associated with inadequate control of refrigeration and hot holding—*S. aureus*, *C. perfringens*, and *B. cereus*—cause relatively mild foodborne illness, and it is estimated that in the US there are almost 500,000 illnesses per year from these three pathogens with a cost of 142 million USD.

**Unsafe food sources**

Unsafe food sources, such as raw (unpasteurized) milk and raw-milk cheeses, have been associated with outbreaks caused by numerous etiological agents such as *Salmonella* spp., *Campylobacter* spp., *E. coli*, *Listeria monocytogenes* (*L. monocytogenes*), and *S. aureus*. Improperly made home-canned foods have long constituted a major source of botulism, while ready-to-eat meats are most commonly linked to outbreaks of *Listeria*. The estimated annual incidence of illness associated with the consumption of foods from unsafe sources in the US is only 10,000 cases but with a substantial cost of 30 million USD since the pathogens can cause severe illness.

**Current Federal Surveillance Systems**

Regional authorities, P/T governments, the Public Health Agency of Canada (PHAC), and other federal government organizations, including the Canadian Food Inspection Agency (CFIA) and Health Canada, are all involved in the overall food safety system that works to prevent foodborne illness in Canada. The food safety system includes foodborne illness surveillance and outbreak investigations involving disease reporting, laboratory testing (case specimens), case follow-up, and information sharing between various agencies and affected jurisdictions.

**Provincial/territorial surveillance**

Provincial Reportable Disease Surveillance Systems (PRDSS) collect the number of laboratory-confirmed illnesses reported to regional and provincial public health authorities. Each province and territory has its own list of reportable diseases which include important foodborne pathogens (Table 2). Reporting is
mandated by P/T public health laws that specify the requirements of communicable disease control (Figure 1 and Table 3).25,29,37,39-52

Regional health officials, with assistance from other departments such as Agriculture, lead investigations of outbreaks that are detected through the PRDSS and are within provincial or territorial boundaries.4 Case follow-up forms and Foodborne Illness Outbreak Response Protocols (FIORP) are standardized within provinces and territories (Table 3).4,31,53-62 Jurisdictions use electronic platforms (such as the integrated Public Health Information System or iPHIS) to report information on reportable disease case follow-up to P/T health authorities and PHAC (Table 3).63

**National surveillance and coordinated response**

Regional and affiliated P/T authorities voluntarily report nationally notifiable diseases, data which supports the PHAC-coordinated Canadian Notifiable Disease Surveillance System.64,65 Select foodborne pathogens are also reportable to PulseNet Canada, the National Enteric Surveillance Program (NESP), and FoodNet Canada (Table 2).66-69

The National Microbiology Laboratory (NML) coordinates laboratory (national and participating P/T) and epidemiological surveillance (national) to inform PulseNet Canada and NESP.3 The NML and Centre for Food-borne, Environmental and Zoonotic Infectious Diseases (CFEZID) jointly compile and analyze data from PulseNet Canada and NESP to identify foodborne illness outbreaks as efficiently as possible for investigation and public health intervention (Figure 2).3,4,70-72 Additionally, CFEZID houses FoodNet Canada which works to identify the risk factors for enteric illness (including foodborne illness) through integrated surveillance.73 The program uses enhanced questionnaires at their sentinel sites to collect the level of detail they need to study the risk factors of enteric illness in Canada.

Provinces and territories all have access to the Canadian Network of Public Health Intelligence’s forum known as Public Health Alerts: Enteric Alerts, which facilitates the early notification of outbreaks, thereby encouraging a collaborative response to multi-jurisdictional enteric outbreaks.74 For multi-provincial or international cases, PHAC (i.e., CFEZID) usually leads the response to such incidences using Canada’s FIORP (Table 3).4,75 Outbreak investigations are also accomplished through the activities of CFIA, which include food safety investigations, testing and recall activities, and regulatory compliance and enforcement activities.4 P/T departments usually lead responses to cases within P/T boundaries or if the majority of cases reside in a single P/T. The risk factor information collected for multi-jurisdictional outbreak investigations is similar to what is collected by the US Centers for Disease Control and Prevention, and is housed in an online repository called Outbreak Summaries.76-78 Regional, P/T, and national public health authorities are also able to publish their outbreak summaries here.78

**Gaps in the Literature and Surveillance Systems**

Assessment of risk factors in relation to consumers remains the least studied in the farm-to-fork continuum. A considerable amount of food preparation and handling occurs in the domestic environment; therefore, research regarding the risk of unsafe food-handling practices is an essential element towards prevention of foodborne disease.

Foodborne illness is vastly underreported in Canada, a trend consistent in other countries.79 The role of transmission via food is additionally obscured by the fact that many foodborne pathogens are also spread through water or from person-to-person. A recent study by Thomas et al. estimated that approximately 1.6 million annual cases of domestically acquired foodborne illnesses are attributable to “known pathogens” in Canada, while 2.4 million are attributable to “unspecified agents.”67 The inability to specify organisms is another hindrance for establishing accurate source attribution values. These challenges put further pressure on Canadian foodborne illness surveillance systems and outbreak detection and response mechanisms to be efficient. Greater efficiency allows for the timely collection of important human risk factor information by increasing the opportunities to collect food samples and reducing case-recall bias for information on risk behaviour and food consumption (risk factors).

There are approximately 30 specified pathogens known to cause foodborne illness.67 Many of these pathogens are tracked by public health systems that monitor cases of illness. However, reportable disease lists and disease definitions are not consistent between the various public health authorities in Canada, which could make the task of amalgamating the data more challenging (Table 2). Additionally, it is not mandatory for regional authorities within provinces and territories to report disease cases to
agencies beyond the P/T level.\textsuperscript{64}

The process of reporting within provinces/territories is fairly consistent (with the exception of pathogen reporting urgency; refer to Table 2). On the other hand, case follow-up forms for surveillance are not consistent between P/T authorities: some jurisdictions use pathogen-specific forms while others use general enteric illness forms.

Public health authorities at all levels do not use the same electronic platforms for information sharing (Table 3). For example, not all jurisdictions use the same systems to upload case follow-up forms for routine surveillance. In terms of outbreak detection and investigations, participation in programs like PulseNet Canada, and uploading outbreak alerts to Public Health Alerts: Enteric Alerts and investigation summaries to Outbreak Summaries, does not necessarily occur across the board.

Better communication is needed at federal, provincial, and municipal levels to apply the data from the food safety system to inform programs and educational activities involving food service employers and employees as well as everyday consumers.

**Conclusion**

Despite gaps apparent in the surveillance of foodborne illness in Canada, there have been notable improvements in the system. For example, norovirus outbreaks became notifiable to NESP in 2009, and *L. monocytogenes* was added to the list of organisms included in NESP in 2012 and was adopted by all provinces/territories.\textsuperscript{80,81} An impressive network of agencies coordinates the movement of large amounts of data at both provincial/territorial and federal levels on an ongoing basis. Some refinements in the system are still required, however, to improve foodborne illness surveillance and outbreak detection and response. International foodborne illness surveillance data, especially from the US, continue to be used to draw parallels to the Canadian situation. However, generating and analyzing a comprehensive dataset of foodborne outbreaks in Canada would assist in accurately identifying contributing factors for foodborne illness in the context of Canada’s food safety systems, agencies, and programs. Suggested enhancements to food safety systems in Canada at the regional, P/T, and national levels include:

- adopting consistent reportable disease lists and procedures for reporting to facilitate the efficient collection of all available data at the national level;
- using consistent methods to gather information in the event of a foodborne outbreak to enhance reporting and learning from past outbreaks;
- using databases (such as iPHIS) that can be shared across jurisdictions to document case interviews of foodborne illness to facilitate information access and sharing;
- participating in uploading investigation summaries in Outbreak Summaries to build a single database on Canadian outbreaks;
- using Public Health Alerts: Enteric Alerts to notify other jurisdictions of outbreaks to encourage collaboration;
- streamlining the reporting process to avoid duplication of services.

An enriched data set could reflect the importance of certain sources and modes of contamination, pathogen survival, and pathogen proliferation in association with specified etiological agents and can be used identify priority areas in food safety. Comparative analysis of consistent data sets would help determine trends in foodborne illness and provide information on the progression of food safety initiatives.

**Acknowledgements**

We would like to thank Daniel Fong, Helen Ward, Nelson Fok, and Michael Duncan for their valuable input and review of the draft document.
Figures

Figure 1. Model of reporting foodborne illness cases and outbreaks at the provincial level

CFEZID: Centre for Food-borne, Environmental and Zoonotic Infectious Diseases; CPHLN: Canadian Public Health Laboratory Network; CIPARS: Canadian Integrated Program for Antimicrobial Resistance Surveillance; HC: Health Canada; LFZ: Laboratory for Foodborne Zoonoses; NESP: National Enteric Surveillance Program; NSAGI: National Studies on Acute Gastrointestinal Illness; NML: National Microbiology Laboratory; PHAC: Public Health Agency of Canada
Figure 2. Federal surveillance of foodborne illness cases and outbreak detection

- Sentinel Sites
- LFZ (PHAC)
- Bureau of Microbial Hazards (HC)
- PulseNet Canada
- NML
- PulseNet USA
- Outbreak Detection/Investigations
- CIPARS
- CFEZID
- NESP
- Enhanced National Listeriosis Surveillance
- Provincial-Territorial Laboratories*
- FoodNet Canada
- NSAGI

Connections:
- case matching for follow-up
- sub-typing
- 10 participate in informing
- coordinates
- communicate
- comprises
- part of
- informs
- inform
- part of

Note: *Provincial-Territorial Laboratories include participating laboratories in each province and territory.
Table 1. Foodborne illness outbreaks in Canada from 1996 to 2005, by etiological agent and vehicle of transmission (highest attributions)

<table>
<thead>
<tr>
<th>Pathogen (total number of outbreaks)</th>
<th>Transmission Vehicle</th>
<th>Percentage of outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Salmonella enterica</em>(^a)</td>
<td>Produce</td>
<td>29%</td>
</tr>
<tr>
<td></td>
<td>Poultry</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Meat other than poultry, pork, and beef</td>
<td>15%</td>
</tr>
<tr>
<td><em>Campylobacter</em>(^{32})</td>
<td>Poultry</td>
<td>56%</td>
</tr>
<tr>
<td></td>
<td>Dairy products other than fluid milk</td>
<td>22%</td>
</tr>
<tr>
<td><em>Escherichia coli</em>(^{4})</td>
<td>Beef</td>
<td>37%</td>
</tr>
<tr>
<td></td>
<td>Cooked multi-ingredient dishes</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Meat other than beef, poultry, and pork</td>
<td>11%</td>
</tr>
</tbody>
</table>

Adapted from Ravel et al.\(^7\)
Table 2. Summary of reportable foodborne illnesses for federal surveillance programs and P/T surveillance systems

<table>
<thead>
<tr>
<th>Reportable Diseases</th>
<th>Federal Surveillance Programs</th>
<th>Provincial Surveillance Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NESP (67,68)</td>
<td>CNDSS (65)</td>
</tr>
<tr>
<td></td>
<td>FoodNet Canada (69)</td>
<td>PulseNet Canada (66)</td>
</tr>
<tr>
<td></td>
<td>AB (26)</td>
<td>BC (27)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MB (28)</td>
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<tr>
<td></td>
<td></td>
<td>NB (29)</td>
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<tr>
<td></td>
<td></td>
<td>NL (30)</td>
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<tr>
<td></td>
<td></td>
<td>NT (31)</td>
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<td></td>
<td></td>
<td>NS (32)</td>
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<td></td>
<td></td>
<td>NU (33)</td>
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<td>ON (34)</td>
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<tr>
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<td>PE (35)</td>
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<td></td>
<td></td>
<td>QC (36)</td>
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<tr>
<td></td>
<td></td>
<td>SK (37)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>YT (38)</td>
</tr>
<tr>
<td>Adenovirus</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Astrovirus</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><em>Bacillus cereus</em></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Botulism</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Brucellosis</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Calicivirus</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Campylobacteriosis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cholera</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><em>Clostridium perfringens</em></td>
<td></td>
<td></td>
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<tr>
<td>Cryptosporidiosis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cyclosporiasis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><em>Escherichia coli, pathogenic</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foodborne illness, all causes</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Gastroenteritis epidemic (bacterial, parasitic, viral)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Giardiasis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Listeriosis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Norovirus</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Paralytic Shellfish Poisoning</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Paratyphoid</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Rotavirus</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Note: X indicates the surveillance program monitors the disease.
| Condition                        | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Salmonellosis                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Sapovirus                       | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Shigellosis                     | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Staphylococcus aureus intoxication | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Toxoplasmosis                   | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Trichinosis                     | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Typhoid                         | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Vibrio parahaemolyticus         | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Vibrio spp.                     | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Vibrio vulnificus               | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| VTEC O157                       | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| VTEC, non-O157                  | X |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| VTEC, all                       | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Yersiniosis                     | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

X = immediate notification
Table 3. Provincial regulations for communicable disease reporting and available Foodborne Illness Outbreak Response Protocols at the federal and provincial/territorial level

<table>
<thead>
<tr>
<th>Province/Territory</th>
<th>Public Health Acts for communicable disease regulation (39)</th>
<th>Citation for Public Health Acts</th>
<th>Examples of foodborne illness outbreak response protocols and/or case follow-up forms</th>
<th>Case follow-up recording (63)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>Communicable Diseases Regulation, Alberta Regulation 238/1985 – Public Health Act, P-37 RSA 2000.</td>
<td>(40)</td>
<td>Alberta Foodborne Illness and Risk Investigation Protocol (53); Notifiable disease guidelines and related documents (54)</td>
<td>iPHIS</td>
</tr>
<tr>
<td>MB</td>
<td>Part 4, Disease Control – The Public Health Act, CCSM, c P210.</td>
<td>(42)</td>
<td>Enteric Illness Protocol (57)</td>
<td>iPHIS*</td>
</tr>
<tr>
<td>NL</td>
<td>Communicable Diseases Act, RSNL 1990, C-26.</td>
<td>(43)</td>
<td>Newfoundland and Labrador Disease Control Manual (58)</td>
<td>iPHIS</td>
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<tr>
<td>NT</td>
<td>Reportable Disease Control Regulations, NWT Reg 128-2009 – Public Health Act, SNWT 2007, c 17; Disease Surveillance Regulations, NWT REG 096-2009 – Public Health Act, SNWT 2007, c 17.</td>
<td>(44); (45)</td>
<td>Government of the Northwest Territories Communicable Disease Manual (31)</td>
<td>iPHIS</td>
</tr>
<tr>
<td>Province</td>
<td>Description</td>
<td>Notes</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>NU</td>
<td>Communicable Diseases Regulations, RRNWT (Nu) 1990 c P-13 – Public Health Act, RSNWT 1988, c P-12; Communicable Diseases Regulations, RRNWT (Nu) 1990 c P-13 – Disease Registries Act, RSNWT (Nu) 1988, c 7 (Supp).</td>
<td>(49)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ontario’s Foodborne Illness Outbreak Response Protocol (ON-FIORP) (60); Annexes to Ontario’s Foodborne Illness Outbreak Response Protocol (ON-FIORP) (61)</td>
<td>iPHIS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE</td>
<td>Notifiable Diseases and Conditions and Communicable Diseases Regulations, PEI Reg EC560/13 – Public Health Act, RSPEI 1988, c P-30.1.</td>
<td>(50)</td>
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<td></td>
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<tr>
<td>QC</td>
<td>Chapter VIII, Reportable Intoxicants, Infections and Diseases - Public Health Act, RSQ, c S-2.2.</td>
<td>(51)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SK</td>
<td>Disease Control Regulations, RRS c P-37.1 Reg 11 – The Public Health Act, 1994, SS 1994, c P-37.1.</td>
<td>(37)</td>
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<td>Communicable Disease Control Manual – Section 3: Enteric Illness (62)</td>
<td>iPHIS</td>
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<td>Canada’s Food-borne Illness Outbreak Response Protocol (FIORP) 2010: To guide a multi-jurisdictional response (4)</td>
<td>iPHIS</td>
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<td>Federal/ Provincial/ Territorial Collaboration</td>
<td>Canada’s Food-borne Illness Outbreak Response Protocol (FIORP) 2010: To guide a multi-jurisdictional response (4); Outbreak Summaries (78)<strong>; Public Health Alerts: Enteric Alerts (74)</strong></td>
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*Not entire province
**Participation not mandatory

Appendix A

Relevant Terms:

a. **Surveillance** is the systematic process of collecting, analyzing, interpreting, and communicating health-related data to reduce disease rates and mortality.

b. The **study conducted by Ravel et al.** used the most comprehensive sets of Canadian outbreak data, spanning from 1976 to 2005, generating the most up-to-date Canadian food attribution values for microbial causative agents and temporal trends.

c. **Multi-ingredient foods** include pasta dishes, baked goods, salad, sandwiches, sauces, etc.

d. **Meals** include multiple/various foods, buffets, etc.

e. The “**farm-to-fork**” continuum describes the series of opportunities for contamination and pathogen multiplication from growing animals and plants for food, to processing agricultural products, manufacturing and transporting foods, preparing foods for consumption, and eating foods.

f. **Pre-harvest sources** include soil, feces, irrigation water, reconstituted pesticides, dust, pests, inadequately composted manure, wild or domestic animals, and human handling.

g. **Post-harvest contamination** can be contributed by human handling along with harvesting equipment, transport containers, pests, dust, rinse water, ice, transport vehicles, and processing equipment.

h. **Unsafe food sources** can have a wide variety of meanings, depending upon where the focus is in the farm-to-fork continuum. However, with respect to the important risk factors that occur at the final stages of the farm-to-fork continuum, unsafe sources can be ready-to-eat foods that are produced or processed in a way that does not kill pathogens, and therefore leave consumers unknowingly at risk.

i. **Case follow-up forms** are used by public health investigators to interview laboratory confirmed cases of foodborne illness (those that are reportable to the province or territory), and are also used to inform foodborne illness outbreak investigations through the collection of risk factor information.

j. The **integrated Public Health Information System (iPHIS)** is an electronic database which houses case follow-up information for provincial/territorial and national reportable diseases, and is managed by the Canadian Integrated Public Health Surveillance Collaborative. It facilitates rapid information sharing between public health jurisdictions.

k. The **Canadian Notifiable Disease Surveillance System (CNDSS)** collects the number of laboratory confirmed illnesses that are reported to local public health units/regions, provincial public health authorities, and national level authorities.

l. **PulseNet Canada** is a national laboratory outbreak investigation network of federal, provincial, and territorial laboratories coordinated by the NML. It allows for information on pathogens to be exchanged in real time, and is linked to the US PulseNet system, allowing information sharing across North America.

m. **National Enteric Surveillance Program (NESP)** collects aggregate counts of laboratory isolates of select enteric pathogens (species and subtype) reported through the provincial laboratories on a weekly basis.

n. **FoodNet Canada** collaborates with local public health units (sentinel sites) to conduct enhanced, integrated surveillance of enteric pathogens within regionally representative communities as a way of informing the source attribution of enteric illness in Canada. It currently has three sentinel sites in Alberta, British Columbia, and Ontario.

o. **National Microbiology Laboratory (NML)** provides federal level laboratory-based surveillance through reference services that allow for strain identification and characterization. This information can then be disseminated to Canada’s foodborne surveillance programs, PulseNet Canada, and NESP.

p. The **Centre for Food-borne, Environmental and Zoonotic Infectious Disease (CFEZID)** conducts national surveillance and targeted studies of enteric illness, cases, and outbreaks. It houses various programs including Pharmacy Syndromic Surveillance, FoodNet Canada, and the Canadian Integrated Program for Antimicrobial Resistance Surveillance, and facilitates burden of illness work. PHAC’s enteric illness Outbreak Management Division also exists under the umbrella of CFEZID.

q. **Public Health Alerts: Enteric Alerts** is a secure, web-based application developed by the Canadian Network for Public Health Intelligence (CNPHI), and is used to improve the identification of multi-jurisdictional outbreaks. Information is posted by regional health authorities, provinces/territories, and PHAC about current and potential enteric outbreaks in their jurisdiction, allowing various other public health authorities to view the information.

r. **Outbreak Summaries** is a portal where public health authorities, of all jurisdictions in Canada, can document enteric disease investigations in a standard and systematic way. It is managed by CNPHI. Participating members can access any of the outbreak information in the system to identify trends, create annual reports, and inform policy development and planning. Outbreak Summaries went live in 2008 and its membership is still growing.
Appendix B

Literature Search Strategy: Foodborne illness outbreaks and microbial causative agents

Search Tools

The literature search employed the following search tools (databases/indices): ProQuest LLC, PubMed, Web of Science, Google Scholar.

Search Terms

Utilizing the proposed databases, key word searches for article titles and abstracts were conducted using the primary search terms: foodborne, outbreaks, and risk factors. Combinations of these primary search terms were combined with: food safety, food handling, food inspection, incidence, common, and prevalence. Specific etiological agents were also searched for including: Salmonella, Campylobacter, E. coli, Listeria, norovirus, rotavirus, Clostridium perfringens, Staphylococcus aureus, Bacillus cereus, Shigella spp.

Inclusion Criteria

All papers, identified by the search, were screened for relevance using the title and/or abstract. The United States of America, the United Kingdom, and Australia engage in similar food safety practices and standards as Canada, and so were included due to scarce literature specific to Canada.

Exclusion Criteria

Literature was restricted to only those written in the English language, and literature published prior to 1970 was excluded.

Current surveillance systems

Search Tools

The document search employed the following search engines: Google

Search Terms

Grey literature, primarily government documents, was searched for using a combination of the terms: national, federal, provincial, territorial, Canada, province/territory names; and reportable diseases, communicable diseases, notifiable diseases, public health act, public health laboratories, health authorities, health regions, surveillance, outbreak response, foodborne illness, case follow-up forms, and protocols.

Literature Management:

Bibliographic data for the electronic literature obtained through the above methods was entered and stored in RefWorks, an online reference manager (www.refworks.com).
References


