FOODNET CANADA BIENNIAL REPORT **2011–2012**

PROTECTING CANADIANS FROM ILLNESS

Public Health Agency of Canada
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Canada

TO PROMOTE AND PROTECT THE HEALTH OF CANADIANS THROUGH LEADERSHIP, PARTNERSHIP, INNOVATION AND ACTION IN PUBLIC HEALTH.

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FOODNET CANADA
BIENNIAL REPORT **2011–2012**

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EXECUTIVE SUMMARY

FoodNet Canada (formerly known as C-EnterNet) is a preventive, multi-partner sentinel site surveillance system, facilitated by the Public Health Agency of Canada, that identifies what food and other sources are causing illness in Canada. FoodNet Canada collects samples at the community level on human illness cases (i.e. exposures and behaviours) and along the farm to fork continuum (i.e. retail food, farm animals, and local water) to identify risks. Information on the areas of greatest risk to human health helps to direct food and water safety actions, programming and public health interventions, and to evaluate their effectiveness. Specifically, its core objectives are to:

- Detect changes in trends in human enteric disease and in levels of pathogen exposure from food, farm animal, and water sources (untreated) in a defined population.
- Strengthen source attribution efforts in Canada by determining significant exposures and risk factors for enteric illness.
- Provide practical preventive information to prioritize risks, compare interventions and direct actions, and to assess the effectiveness of food safety programs and targeted public health interventions.

Each sentinel site is founded on a unique partnership with the local public health unit, private laboratories, and water and agri-food sectors, as well as the provincial and federal institutions responsible for public health, food safety, and water safety. The pilot sentinel site (ON site), comprised of the Region of Waterloo, Ontario, has approximately 525,000 residents, with a mix of urban and rural communities and innovation in public health and water conservation. A second site (BC site) was officially established in the Fraser Health Authority, British Columbia in April of 2010. This BC site includes the communities of Burnaby, Abbotsford, and Chilliwack and has approximately 450,000 residents.

In the ON site, enhanced surveillance of human cases of enteric disease in the community is performed, as well as active surveillance of enteric pathogens in water, food (retail meat and produce) and on farms. In the BC site in 2010, enhanced human disease surveillance began, as did active surveillance of enteric pathogens (for retail produce only).

The following key findings are based on the surveillance data from 2011–2012 in the ON and BC sites:

- A total of 1663 human cases of 11 bacterial, viral and parasitic diseases were reported within the ON and BC sites between 2011 and 2012. The three most frequently reported diseases (campylobacteriosis, salmonellosis and giardiasis) accounted for 82% of the cases.
- Campylobacteriosis remained the most commonly reported enteric disease in both sentinel sites, with *Campylobacter jejuni* being the most common species associated with human campylobacteriosis. The majority of raw chicken samples tested were also contaminated with *Campylobacter jejuni*. Possible exposure factors included living on a farm or country property, contacting on-farm poultry, contacting household pets, contacting animal manure and consuming spoiled food. Overall, as found in the past, retail chicken meat was considered to be the most important vehicle of transmission for *Campylobacter*.

- Distributions of patient age and gender among the human salmonellosis cases between 2011 and 2012 were similar to those observed historically in both the ON and BC sites. The most commonly reported serovars for human cases of salmonellosis were Enteritidis, Typhimurium, and Heidelberg. Phage type alignment continues to be observed among isolates from endemic human cases, chicken meat, and broiler chicken feces for both *Salmonella* Heidelberg and *Salmonella* Enteritidis. A slight decrease was observed in the rate in both sites (in 2011–2012 combined compared to 2010), which is comparable to the national trend observed during the same time period (2, 3, 7, 8). The prevalence of *Salmonella* on ground chicken was twice the level found on chicken breast. This may highlight the greater chance of product contamination during processing. Overall, possible salmonellosis exposure factors included contact with pet reptiles, retail poultry products, and broiler chicken manure (Table 4.6). The most important possible vehicle of transmission is considered to be retail poultry products.
- Verotoxigenic *E. coli* (O157:H7 and non-O157:H7 serotypes) infections continue to be primarily acquired domestically, as demonstrated by the low number of travel-related cases in 2011–2012. *E. coli* O157:H7 PFGE patterns in both human and non-human samples from 2011–2012 continued to show considerable diversity, as observed nationally and within the FoodNet Canada sites, in past years.
- As in previous years, the majority of *Yersinia* cases are domestically acquired. Among travel-related cases, the majority reported travel to Central or South America in 2011–2012. The incidence in domestically acquired cases was much higher in females than males. None of the swine manure samples in the ON site in 2011 were positive for pathogenic *Yersinia* (biotype 4, serotype O:3).
- As in previous years, pathogenic strains of *Listeria monocytogenes* were recovered in 2011–2012 from samples of skinless chicken breasts, ground beef, ground chicken and ground turkey, as well as uncooked chicken nuggets. The scientific literature suggests that abattoirs and meat processing environments rather than farm animals may be an important source of *L. monocytogenes* (21). The retail meat data from many historical surveillance years indicate that pathogenic serotypes of *L. monocytogenes* are present on raw chicken, beef, and pork meat sold at retail, as well as in bagged leafy greens. Although, based on one PFGE enzyme, there was a match between a human case and a sample of uncooked chicken nuggets in 2011–2012, there were no matches between sources and sentinel site cases of listeriosis in 2011–2012 when both PFGE enzyme patterns were compared. Also, based on one enzyme, a few matches were identified between meat isolates (chicken and beef) and four of the top five PFGE patterns reported at the national level in humans (according to PulseNet Canada data). In 2012, fresh herbs were tested for *L. monocytogenes* though the pathogen was not detected.
- The majority of *Shigella* infections were travel-related, with Asia being the most frequently reported travel destination.

- FoodNet Canada surveillance identified human pathogenic strains of norovirus on retail soft berries and fresh herbs in 2011–2012. Historically, pathogenic subtypes have also been found in food animal manure, as well as retail pork chops and leafy greens.
- *Cryptosporidium* was found in 2011–2012 on retail soft berries and in untreated surface water. *Giardia* was detected on retail soft berries and herbs, and water in the same period. Also, *Cyclospora* was found on soft berries. However, the viability of these pathogens was unable to be determined.
- Travel outside of Canada continued to add to the burden of enteric disease observed in Canada during 2011–2012, with 27% of the reported cases from both sites (combined) likely involving infections acquired abroad. Safe travel practices continue to be important considerations among Canadians.
- Enhanced, standardized laboratory testing across all FoodNet Canada surveillance components (human, retail, on-farm, and water) has allowed for the identification of patterns in subtype distributions among human cases and potential exposure sources over time. Continued surveillance and addition of more sentinel sites will help in refinement of the key findings and inform prevention and control measures for enteric diseases in Canada.

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1. INTRODUCTION

1.1 Objectives

FoodNet Canada (formerly known as C-EnterNet) is a preventive, multi-partner sentinel site surveillance system, facilitated by the Public Health Agency of Canada, that identifies foods and other sources causing enteric illness in Canada. FoodNet Canada collects samples at the community level on human illness cases (i.e. exposures and behaviours) and along the farm to fork continuum (i.e. retail food, farm animals, and local water) to identify risks. Information on the areas of greatest risk to human health helps to direct food and water safety actions and programming as well as public health interventions, and to evaluate their effectiveness. Specifically, its core objectives are to:

- Detect changes in trends in human enteric disease and in levels of pathogen exposure from food, farm animal, and water sources (untreated) in a defined population.
- Strengthen source attribution efforts in Canada by determining significant exposures and risk factors for enteric illness.
- Provide practical information on prevention to prioritize risks, compare interventions and direct actions, and to assess the effectiveness of food safety programs and targeted public health interventions.

FoodNet Canada conducts continuous and episodic surveillance activities in four components: human, retail (meat and produce), on-farm (farm animals), and water. For a complete list of the pathogen tests performed, see Appendix A. Continuous surveillance occurs throughout the year to identify trends in human disease occurrence, exposure sources, and source attribution for 11 enteric pathogens. Episodic surveillance activities are limited in duration and provide specific information to complement the continuous activities. Detailed descriptions of the FoodNet Canada study design and laboratory methods are available online (www.phac-aspc.gc.ca/FoodNet Canada/niedsp10-pnisme10/index-eng.php).

Each sentinel site relies on a unique partnership with the local public health unit, private laboratories, and water and agri-food sectors as well as the provincial and federal institutions responsible for public health, food safety, and water safety. The ON site, which was established as the pilot sentinel site (June 2005), includes the Region of Waterloo and has approximately 525,000 residents. A second site (BC site) was officially established in April 2010 in the Fraser Health Authority, British Columbia. The BC site includes the communities of Burnaby, Abbotsford, and Chilliwack and has approximately 450,000 residents. In the ON site, enhanced surveillance of human cases of enteric disease in the community is routinely performed as well as active surveillance of enteric pathogens in untreated surface water, in food, and on farms. In the BC site in April 2010, enhanced human disease surveillance began, as did active surveillance of enteric pathogens. However, active surveillance in the BC site was limited in 2010 to sampling of retail produce (i.e. bagged leafy greens). By using harmonized subtyping methods across components, FoodNet Canada can compare pathogens found in retail food, water and on farms with human infections to help identify what food and other sources are causing illness in Canadians.

The 2011–2012 combined annual report begins with a summary of the reported human cases of infectious enteric disease in the two sentinel sites described above, summarizing the outbreak- and travel-related cases separately from the endemic cases (Chapter 2). Chapters 3 through 11 provide information on human cases and exposure sources, as well as temporal trends, for 2011–2012 by pathogen, including the results of the episodic studies. A summary of FoodNet Canada's ongoing efforts to test and refine methodologies to estimate source attribution is presented in Chapter 12.

The surveillance data provided in this report only pertain to two sentinel sites. Therefore, readers need to consider that the accuracy of generalizing these results beyond these communities decreases with increasing distance from the specific geographical area. As additional sentinel sites are established, comprehensive information from laboratory and epidemiological analyses from all sites will provide more representative national trends in enteric disease incidence and exposure sources, to inform accurate source attribution estimates for all of Canada.

For this combined 2011–2012 Biennial Report, unless otherwise noted, all results have been combined for both years and for both sites. Where differences were significant (between years), these results are reported on separately.

1.2 Surveillance Strategy

Human surveillance

The enhanced human disease surveillance component of FoodNet Canada is fully implemented in two sentinel sites: the Region of Waterloo, Ontario (ON site) and the Fraser Health Authority, British Columbia (BC site).

Public health inspectors or environmental health officers in each site use FoodNet Canada's enhanced standardized questionnaire to interview reported enteric disease cases (or proxy respondents). Information on potential exposures collected from the questionnaires is used to determine case status (e.g. international travel versus endemic) and compare exposures between cases. In addition, advanced subtyping analyses on isolates from the human stool specimens are conducted.

Non-Human Surveillance

In 2011–2012, the non-human surveillance component of FoodNet Canada has been implemented for all components within the ON site, and in various stages of implementation for the BC site.

The non-human surveillance data collected by FoodNet Canada represent possible exposure sources for human enteric illnesses in the sentinel sites. The data are meant to be interpreted aggregately, as opposed to being used to directly attribute a specific human case reported to FoodNet Canada to a particular positive isolate from an exposure source. Rather, the non-human data are combined with the human data via source attribution models, with the aim of obtaining an overall refined estimate of the proportion of illnesses being caused by each of the various exposure sources.

Retail surveillance

The retail stage of food production represents a point at which consumers can be exposed to enteric pathogens through contaminated food. Both retail meat and produce samples are collected. Samples are collected on a weekly basis from randomly selected grocery stores within each site.

In the ON site, FoodNet Canada has been collecting samples of raw (unfrozen) skinless chicken breasts and ground beef on a weekly basis since mid-2005. Targeted meat samples, such as pork chops, ground chicken and turkey, and uncooked (frozen) chicken nuggets are collected on a rotating basis. At the beginning of 2011, retail meat sampling also began in the BC site, with the sampling methodology modeled after the ON site. Samples were then tested for a number of different bacterial pathogens (Appendix A).

In 2012, produce sampling continued in both sites (in the BC site, produce sampling began in April 2010). Prior to 2011, the produce type being sampled was leafy greens. In 2011, this changed in both sites to soft berries and in 2012 to fresh herbs. Samples were tested for a variety of different bacteria, parasites, and viruses (Appendix A).

On-farm surveillance

The presence of enteric pathogens on farms (in animal manure) is a potential source of environmental exposure to enteric pathogens, and also represents one of the main sources in the farm-to-fork transmission chain. In 2011 and 2012, the farm component was active only within the ON site. To estimate the pathogen burden on farms, samples of feces were collected from swine (2011 only), dairy, beef, and broiler chicken farms. Approximately 30 of each type of farms were visited each year. A short management survey, one stored fecal sample (i.e. from a manure pit), and three fresh, pooled manure samples were obtained at each farm visit. All samples were tested for *Campylobacter, E. coli* O157:H7/VTEC, *Listeria*, *Salmonella*, and *Yersinia* (2011 only).

Water surveillance

Another environmental source of pathogen exposure is water. Since 2005, regular, bi-weekly collection of untreated surface water samples has occurred at five points along the Grand River (located in the ON site) to determine the potential for human exposure to pathogens through untreated surface water. In 2011 and 2012, beach samples were also collected during the summer months in the ON site. In June 2011, water sampling began in the BC site with both untreated surface water and beach samples collected. Samples were tested for a number of different enteric bacteria, parasites, and viruses.

1.3 Definitions

Exposure factor: Possible demographic factor or exposure source in the transmission of infection, such as consumption of contaminated food or exposure to an animal.

Exposure source: Point along the waterborne, food-borne, animal-to-person, or person-to-person transmission route at which people were suspected to have been exposed to a given pathogen.

Outbreak-related case of disease: One of a number of affected individuals associated with a sudden increased occurrence of the same infectious disease, whose illness is confirmed through a public health partner (ON and BC sites) on the basis of laboratory or epidemiological evidence.

International travel-related case of disease: Affected individual who travelled outside of Canada prior to onset of illness, and the travel time overlapped with the expected disease incubation period (varies depending on the pathogen).

Endemic case of disease: Affected individual who had an infection that was considered sporadic and domestically acquired (i.e. within Canada).

Non-endemic: Includes immigration-related cases where illness was acquired outside of Canada.

Lost to follow-up: Includes cases that could not be followed up with an interview by public health.

Significant: The term "significant" in this report has been reserved for statistically significant findings (i.e. $p < 0.05$).

Verotoxigenic Escherichia coli (VTEC): *Escherichia coli* are normal intestinal inhabitants in humans and animals, and most strains do not cause enteric disease. However, the group of verotoxigenic *E. coli* includes certain toxin-producing strains that can cause severe diarrhea and, in some people (particularly young children), hemolytic uremic syndrome. In terms of nomenclature, verocytotoxin (VT) -producing *E. coli* can also be referred to as Shiga-toxin-producing *E. coli* (1).

1.4 Source Attribution

In the context of acute infectious gastrointestinal diseases, source attribution is the process of partitioning human cases of illness into specific sources, where the term source includes animal reservoirs and transmission pathways, such as specific foods or water. Source attribution is one of FoodNet Canada's core, long-term objectives. Source attribution is accomplished through various approaches, from basic methods to more complex ones.

Continuous surveillance for enteric pathogens in each component provides FoodNet Canada with the ability to compare pathogen profiles amongst components and contributes to our understanding of source attribution.

Firstly, in each of the following Chapters, potential exposures (e.g. swimming, contact with animals, attending a social event) among cases are analyzed using a case-case comparison approach to determine if any are statistically significant. Larger proportional differences between cases and other cases combined do not necessarily represent higher risk, but highlight areas where further research may help us to better understand disease sources at the community level.

In addition, within the Chapters, integrated tables containing results from testing of samples using various microbiological typing methodologies are compared among the human cases, retail, farm, and water components, to determine if any possible overlap or similarities in results exists. For example, the same serotype may have been identified among a number of human cases as well as having been found in samples from one or more of the other components. The comparison of results among the components, combined with the human data, allows for the highlighting of possible sources that could be causing illness in humans and which could be explored further.

In the Source Attribution chapter (Chapter 12), research activities are listed that use more refined and rigorous methodologies to generate source attribution estimates.

FoodNet Canada has made significant progress in developing a Canadian approach to source attribution and continues to make improvements and refinements to the methodology as the system expands to additional sites and builds on its data sources.

1.5 Changes to Methodologies for 2011–2012

Sample collection

In the retail component in 2011 and 2012, both skinless chicken breasts and ground beef continued to be sampled. Pork chop sampling was discontinued in 2011. For the targeted products, ground turkey was collected in 2011, frozen chicken nuggets were collected in 2012, and ground chicken was collected in both years.

For the produce component, soft berries were collected in both the ON and BC sites in 2011 and fresh herbs were collected in both sites in 2012.

Fresh and stored manure samples were collected for the farm component from dairy, beef, swine, and broiler chicken farms in the ON site in 2011, and dairy, beef, and broiler chicken farms in the ON site in 2012. No farm sampling occurred in the BC site during these years.

Untreated surface water and beach samples were collected in both the ON and BC sites in 2011 and 2012 (Appendix A).

Laboratory testing and pathogen detection

In the retail component, VTEC testing on chicken breast samples and *Campylobacter* and *Salmonella* testing on ground beef samples were stopped in 2011 due to low recovery rates, allowing allocation of resources to other testing. In addition, *Campylobacter*, *Salmonella*, and *Listeria* Most Probable Number (MPN) testing were stopped on all core (chicken breast and ground beef) retail meat samples as little variation was noted over the years. Serotyping of all positive VTEC ground beef samples from the BC site began in September 2011.

In the produce component, tests to determine the presence of *Cyclospora*, *Cryptosporidium*, *Giardia*, norovirus, and rotavirus continued to be conducted on soft berries in 2011 and fresh herbs in 2012. Fresh herbs were also tested for the presence of *Listeria* in 2012 for a short period from January 11 to May 2, generic *E. coli* from February 29 to April 25, and *Campylobacter* during the month of January.

In 2012, *Yersinia* testing was stopped in all commodities in the farm component as very low prevalence was noted over the previous years. Also in 2012, VTEC testing (as opposed to *E. coli* O157:H7 specifically) was started in all commodities (dairy, beef, and broiler chickens). This testing was performed in parallel with the traditional *E. coli* O157:H7 testing during this year.

In 2011, in the water component, testing for *Campylobacter*, *Salmonella*, VTEC, generic *E. coli*, *Cryptosporidium*, and *Giardia* was continued for water samples from the ON site. In BC, *Campylobacter*, *Cryptosporidium*, and *Giardia* testing was done on the water samples in 2011 and then in 2012, *Salmonella* and VTEC were also tested.

2. HUMAN CASE SUMMARY

2.1 Overview of Human Cases of Disease

The enhanced human disease surveillance component of FoodNet Canada has been fully implemented in both the ON and BC sentinel sites. Since expansion to the second sentinel site occurred in April 2010, the 2011 data for the BC site represents the first full year of surveillance data reported to FoodNet Canada.

A total of 1663 human cases of 11 bacterial, viral and parasitic enteric diseases were reported to FoodNet Canada within the ON and BC sites between 2011 and 2012 (Table 2.1).

The three most frequently reported diseases in the 2011–2012 time period (campylobacteriosis, salmonellosis and giardiasis) accounted for 82% of the cases (Figure 2.1).

Information on potential exposures was obtained from 88% (1464/1663) of reported cases in the ON and BC sites between 2011 and 2012.

TABLE 2.1: Number of cases and incidence rates per 100,000 person-years of laboratory-confirmed enteric diseases in both the ON and BC sites, 2011–2012

ON AND BC SITES 2011–2012									
		Number of Cases						Incidence Rate[a]	
Disease	Incubation Period[b]	Endemic	Outbreak	Travel	Non-Endemic	Lost to Follow-Up	Total	Endemic	Total
Amoebiasis[c]	2–4 weeks	21	0	13	21	6	**61**	1.05	**3.06**
Campylobacteriosis	1–10 days	426	0	143	0	88	**657**	21.38	**32.97**
Cryptosporidiosis	1–12 days	34	0	14	0	5	**53**	1.71	**2.66**
Cyclosporiasis	1–14 days	1	0	7	0	1	**9**	0.05	**0.45**
Giardiasis	3–25 days	96	0	76	28	38	**238**	4.82	**11.94**
Hepatitis A[c]	15–50 days	5	0	3	1	0	**9**	0.25	**0.45**
Listeriosis[d]	3–70 days	3	0	1	0	0	**4**	0.15	**0.20**
Salmonellosis	6–72 hours	254	14	150	4	47	**469**	12.80	**23.54**
Shigellosis	0.5–4 days	13	0	27	0	4	**44**	0.65	**2.21**
Verotoxigenic *E. coli* (VTEC)	2–10 days	46	10	5	0	0	**61**	2.31	**3.06**
Yersiniosis	3–10 days	36	0	12	0	10	**58**	1.81	**2.91**
Total		**935**	**24**	**451**	**54**	**199**	**1663**		

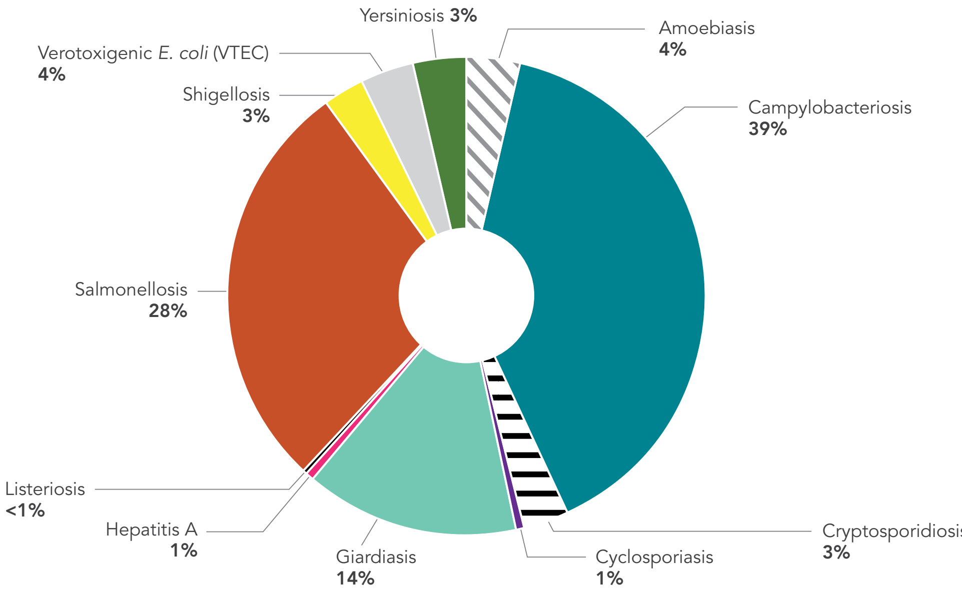
[a] Population estimates for the ON site obtained from the Ontario Ministry of Health and Long-Term Care, Population Projections 2011–2012, IntelliHEALTH Ontario, Extracted on: February 19, 2012. Population estimates for the BC site obtained from BC Ministry of Finance and Corporate Relations. BC Stats, P.E.O.P.L.E. 2011–2012 (Population Extrapolation for Organizational Planning with Less Error), Sep 2011 and Sep 2012.

[b] Provides range used by sites. There are differences across sites for *Shigella*, *Cyclospora* and *Yersinia*.

[c] Cases reported to the ON site only.

[d] Incubation period changed to 3–28 days in mid-2012 (BC site).

FIGURE 2.1: Relative proportion of enteric diseases reported in both the ON (11 enteric diseases) and BC (9 enteric diseases) sites combined, 2011–2012 (all cases)[a]



[a] Amoebiasis and Hepatitis A cases reported to the ON site only.

For all enteric diseases, the majority of specimen submissions were stool. Isolations from non-fecal sources, including blood and urine, were reported for *Salmonella*, *Listeria*, and Hepatitis A infections. Isolation of an organism from extra-intestinal isolation sites (i.e. blood) may reflect more severe illness and an increased likelihood to seek medical treatment and be tested. Among all *Salmonella* cases, there were 30 cases where the pathogen was detected from blood and included the following serotypes: Typhimurium (1 case), Heidelberg (4 cases), Typhi (7 cases), Paratyphi A (9 cases) and Enteritidis (9 cases). The *Salmonella* cases where the pathogen was detected from urine included the following serotypes: Infantis (1 case), Bovismorbificans (1 case), I OR:i:1,2 (1 case), Paratyphi A (1 case), Albany (1 case), Agbeni (1 case), I,OR:-:- (1 case), I 4,5,12:-:- (1 case), and Enteritidis (3 cases). *Salmonella* also accounted for the majority of isolations from extra-intestinal sources reported to the National Enteric Surveillance Program (NESP) during the same time period. NESP reported top serotypes included Dublin (58%), Paratyphi A (42%) and Typhi (34%) having the highest proportion of submission from extra-intestinal sources. Approximately 9% of *S.* Heidelberg isolates were collected from non-fecal sites, whereas for *S.* Enteritidis and *S.* Typhimurium, less than 5% of isolates were collected from non-fecal sites (2, 3).

TABLE 2.2: Number of cases of laboratory-confirmed enteric diseases in both the ON and BC sites, 2011–2012, by type of specimen submitted

ON AND BC SITES					
2011–2012					
	Site of Isolation				
Disease	Blood	Stool	Urine	Other	Total
Amoebiasis[a]	0	61	0	0	**61**
Campylobacteriosis	2	655	0	0	**657**
Cryptosporidiosis	0	53	0	0	**53**
Cyclosporiasis	0	9	0	0	**9**
Giardiasis[a]	0	236	0	0	**236**
Hepatitis A[b]	9	0	0	0	**9**
Listeriosis	1	0	0	3	**4**
Salmonellosis	30	427	11	1	**469**
Shigellosis	0	44	0	0	**44**
Verotoxigenic *E. coli* (VTEC)	0	61	0	0	**61**
Yersiniosis	0	58	0	0	**58**
Total	**42**	**1604**	**11**	**4**	**1661**

[a] Site of isolation data not available for 2 cases.

[b] Cases reported to the ON site only.

2.2 Outbreak-related Cases

In the ON site, a total of ten outbreak-associated cases were reported between 2011 and 2012. Nine of these outbreak-associated cases were attributed to *E. coli* O157:H7 infection and one was attributed to *Salmonella*. Six of the *E. coli* cases were associated with a national investigation that occurred between July and September 2012. These six cases included two family clusters of three cases each. The source of these infections was not identified. The remaining three *E. coli* cases and the *Salmonella* case were identified as being part of local or regional outbreaks.

In the BC site, 14 outbreak-associated enteric disease cases were reported between 2011 and 2012. Twelve *Salmonella* cases were identified as being part of local or regional outbreaks. One additional *Salmonella* case was part of an international outbreak attributed to *S.* Braenderup infection associated with mango consumption. This outbreak occurred between July and August 2012 and resulted in 23 cases reported in Canada in both British Columbia and Alberta (4). The remaining outbreak-associated case was attributed to *E. coli* O157:H7 infection and linked to a nation-wide outbreak associated with the consumption of beef. This outbreak of *E. coli* O157:H7 occurred between September and October 2012 and resulted in 18 cases reported in multiple provinces including British Columbia, Alberta, Québec and Newfoundland and Labrador (5).

2.3 Travel-related Cases

In both the ON and BC sites, of the reported cases in 2011 and 2012, approximately 27% (451/1663) were classified as international travel-related. Salmonellosis, giardiasis and campylobacteriosis continue to be the three most common diseases, contributing to over 82% of the travel-related cases (Table 2.1). Most of the cases had visited South or Central America or Asia prior to acquiring their illness (Table 2.3); a trend that possibly reflects travel preferences of the sentinel site populations. As observed in previous years, over half of the travel-related *Salmonella* cases had been to Central or South America. There were very few travel-associated VTEC infections reported in both sites over two years.

TABLE 2.3: International travel-related cases in both the ON and BC sites, 2011–2012

ON AND BC SITES 2011–2012							
Disease	**Africa**	**South or Central America**	**Asia**	**Europe**	**USA**	**Multiple Destinations & Others**	**Total**
Amoebiasis[a]	0	2	10	0	1	0	**13**
Campylobacteriosis	9	39	47	26	20	2	**143**
Cryptosporidiosis	1	5	6	0	2	0	**14**
Cyclosporiasis	0	3	2	0	2	0	**7**
Giardiasis	8	17	38	1	10	2	**76**
Hepatitis A[a]	0	1	2	0	0	0	**3**
Listeriosis	0	0	0	0	1	0	**1**
Salmonellosis	5	86	41	5	11	2	**150**
Shigellosis	0	5	22	0	0	0	**27**
Verotoxigenic *E. coli*	0	4	0	0	1	0	**5**
Yersiniosis	1	9	0	0	2	0	**12**
Total	**24**	**171**	**168**	**32**	**50**	**6**	**451**

[a] Cases reported to the ON site only.

2.4 Endemic Cases

The analyses presented in the remainder of this report largely refer to the endemic cases. While domestic outbreak cases are also attributed to local sources of exposure, they are considered to be unusual events. By excluding outbreak and international travel cases in the long-term trend analyses (i.e. multiple years), more stable estimates of disease incidence can be provided and estimates will not be overly influenced by unusual events. However, for the purpose of comparison and comprehensiveness for the current reporting/surveillance year, domestic outbreak cases will be included in tables which include both human and non-human data. Note that reported national and provincial annual incidence rates for each pathogen include endemic, outbreak and travel cases.

In addition, in an ongoing effort to refine human endemic case data and ensure that only cases having acquired the infection domestically are included in total case counts, a new case classification has been created; non-endemic, to capture immigration-related cases. These cases represent a very small proportion of cases and have been excluded from the analyses for the 2011–2012 beinnial report.

2.5 Case-case Analysis

In each of the following Chapters, potential exposures (e.g. swimming, contact with animals, attending a social event) among cases are identified using univariate analysis where $p<0.05$ indicates significance. Multivariate analysis was conducted for *Campylobacter* only (controlling for age, site and season) where $p<0.20$ was used as the level of significance for inclusion of exposure factors in the model. Comparisons are made between cases of one disease and cases of all other diseases in the database, which serve as controls (Appendix B). There are at least two advantages of using ill individuals from the same database as the controls in a case-control analysis. First, the potential for information bias from differential recall between cases and controls is reduced. Second, the use of ill controls precludes the need to enrol non-ill persons as controls (6). Control enrolment is generally more difficult than case enrolment. Due to the small number of cases in both sentinel sites, exposure information is not stratified by age or gender. The exposures reported herein represent overall exposures for the general population in each site, and are not valid for age-specific subgroups (e.g. children).

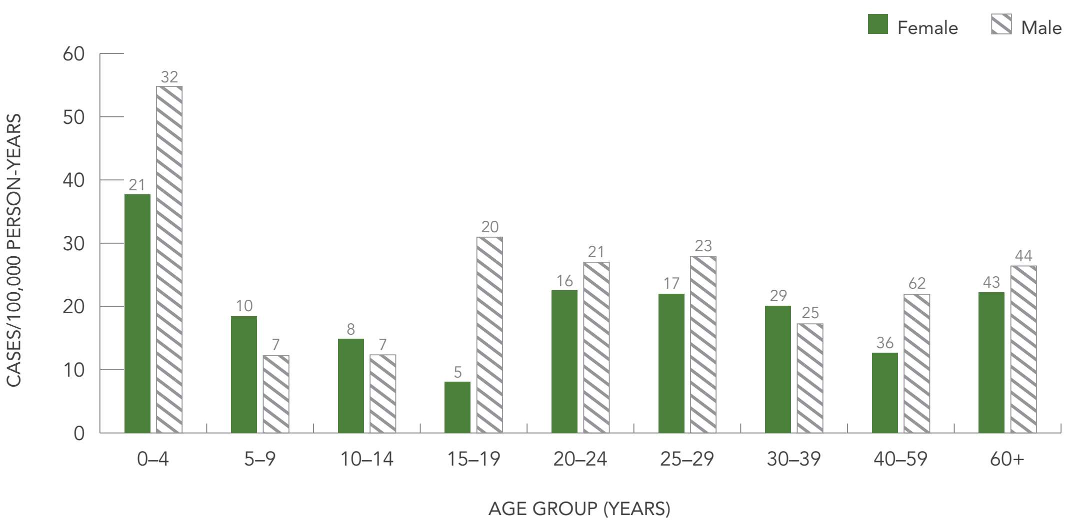
3. *CAMPYLOBACTER*

3.1 Human Cases

In both the ON and BC sites, a total of 657 cases of campylobacteriosis were reported between 2011 and 2012 (combined[1]), representing an incidence rate of 33.0 cases/100,000 person-years. Of these cases, 22% (143/657) were travel-related (7.2 cases/100,000 person-years) and 65% (426/657) were classified as endemic (21.4 cases/100,000 person-years). A total of 13% (88/657) of human campylobacteriosis cases were lost to follow-up. In comparison, the annual incidence rate for campylobacteriosis in 2011 and 2012 combined for all of Canada was 28.5 cases/100,000 person-years (7, 8).

Of the 426 endemic cases, 241 (24.3 cases/100,000 person-years) were male and 185 (18.5 cases/100,000 person-years) were female (Figure 3.1). Incidence rates were highest in males between the ages of 0–4 (54.8 cases/100,000 person-years). Of the 143 travel-related cases, 74 (7.5 cases/100,000 person-years) were males and 69 (6.9 cases/100,000 person-years) were females.

FIGURE 3.1: Incidence rates of sporadic, human endemic campylobacteriosis in the ON and BC sites in 2011 and 2012, by gender and age group



NOTE: The number of cases is indicated above each bar.

The majority (95%) of *Campylobacter* isolates subtyped from endemic campylobacteriosis cases in the ON and BC sites in 2011–2012 were *C. jejuni* (Table 3.1). Between 2011 and 2012, 3.3% (10/306) of endemic *Campylobacter* isolates were subtyped as *C. coli*.

[1] For this combined 2011–2012 Biennial Report, unless otherwise noted, all results have been combined for both years and for both sites. Where differences were significant (between years), these results are reported on separately.

3.1.1 Case Exposures

Information was collected for 87% (569/657) of all campylobacteriosis cases regarding exposure to potential sources of infection in the ten days prior to the onset of illness.

Case-case comparisons were conducted for endemic cases with exposure data combining both the ON and BC sites. Univariate comparisons identified a number of significant exposure factors among campylobacteriosis cases compared to other disease cases. Living on a farm or country property, contacting on-farm poultry, contacting household pets, contacting animal manure and consuming spoiled food were significantly ($p<0.05$) associated with an increased risk of campylobacteriosis (Appendix B).

Multivariate analysis results suggest on-farm poultry contact is associated with an increased risk of illness for campylobacteriosis when controlling for age, site and season. Gender was also significant, illustrating that males are at an increased risk of campylobacteriosis compared to females, as reported in the literature (9).

3.2 Surveillance of Potential Sources

Retail food

Previous FoodNet Canada reports (10), as well as international studies, have established that retail chicken has a higher prevalence of *Campylobacter* than beef or pork. For 2011–2012, the prevalence of *Campylobacter* on skinless chicken breast in both sentinel sites was 47% (Table 3.1). It was also detected on other poultry products—ground chicken (35%), and ground turkey (27%). Very little was detected on uncooked frozen chicken nuggets (1.0%). This low prevalence is most likely due to the freezing process, which results in die-off of *Campylobacter* (11, 12).

Though the prevalence of *Campylobacter* tends to be high for many of these products, the number of organisms detected tends to be low (Appendix D). In 2011, of skinless chicken breast samples that tested positive for *Campylobacter,* 73% (32/44) had organism counts below the detection limit, which is 0.3 most probable number (MPN) of organisms per gram.

Campylobacter jejuni was the most commonly detected species of *Campylobacter* on retail products (Table 3.1).

Farm animals

Campylobacter coli continued to be the most common species of *Campylobacter* detected in pooled manure samples on swine farms in 2011 (Table 3.1). Conversely, *C. jejuni* was the most common species on broiler chicken, dairy and beef cattle farms in 2011–2012. *Campylobacter* was not commonly detected on broiler chicken farms (9.2% of pooled manure samples were positive).

Water

About 22% of untreated surface water samples were found to be contaminated with *Campylobacter* in 2011–2012 (Table 3.1). More than half of the *Campylobacter* isolates recovered from water samples that were typed were identified as *C. jejuni*. The overall species distribution detected in water was similar to those species identified in the human cases.

TABLE 3.1: *Campylobacter* detection and subtyping, ON and BC sites, 2011–2012

METHOD	HUMAN	RETAIL FOOD				FARM ANIMAL MANURE[b]				WATER[c]
	ENDEMIC	SKINLESS CHICKEN BREASTS	GROUND CHICKEN	GROUND TURKEY[a]	UNCOOKED CHICKEN NUGGETS[a]	SWINE[a]	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
Detection										
No. of samples tested	…	695	513	251	306	120	240	240	240	301
No. positive	426	324	181	67	3	102	22	186	189	66
Percent positive	..	47%	35%	27%	1.0%	85%	9.2%	78%	79%	22%
Subtyping										
No. of isolates subtyped	306	319	179	67	3	102	22	186	187	41
Campylobacter coli	10	29	25	10	1	97	0	49	22	8
	(3.3%)	(9.1%)	(14%)	(15%)	(33%)	(95%)	(0%)	(26%)	(12%)	(20%)
Campylobacter jejuni	292	289	152	55	2	1	22	125	146	27
	(95%)	(91%)	(85%)	(82%)	(67%)	(1.0%)	(100%)	(67%)	(78%)	(66%)
Campylobacter jejuni/coli	1	.	.	.	.	.	.	.	.	1
	(0.3%)	..	..	..	..	..	..	..	..	(2.4%)
Campylobacter lari	0	1	2	2	0	.	.	.	.	3
	(0%)	(0.3%)	(1.1%)	(3.0%)	(0%)	..	..	..	..	(7.3%)
Campylobacter upsaliensis	2	.	.	.	.	.	.	.	.	.
	(0.7%)	..	..	..	..	..	..	..	..	..
Other species	0	0	0	0	0	4	0	12	19	2
	(0%)	(0%)	(0%)	(0%)	(0%)	(3.9%)	(0%)	(6.5%)	(10%)	(4.9%)
Untypeable	1	0	0	0	0	0	0	0	0	0
	(0.3%)	(0%)	(0%)	(0%)	(0%)	(0%)	(0%)	(0%)	(0%)	(0%)

NOTE: Retail food and water samples tested for *coli*, *jejuni* and *lari* species only, and manure samples tested for *coli* and *jejuni* species only.

… Not available, .. Not applicable, . Not tested

[a] 2011 only.

[b] ON site only.

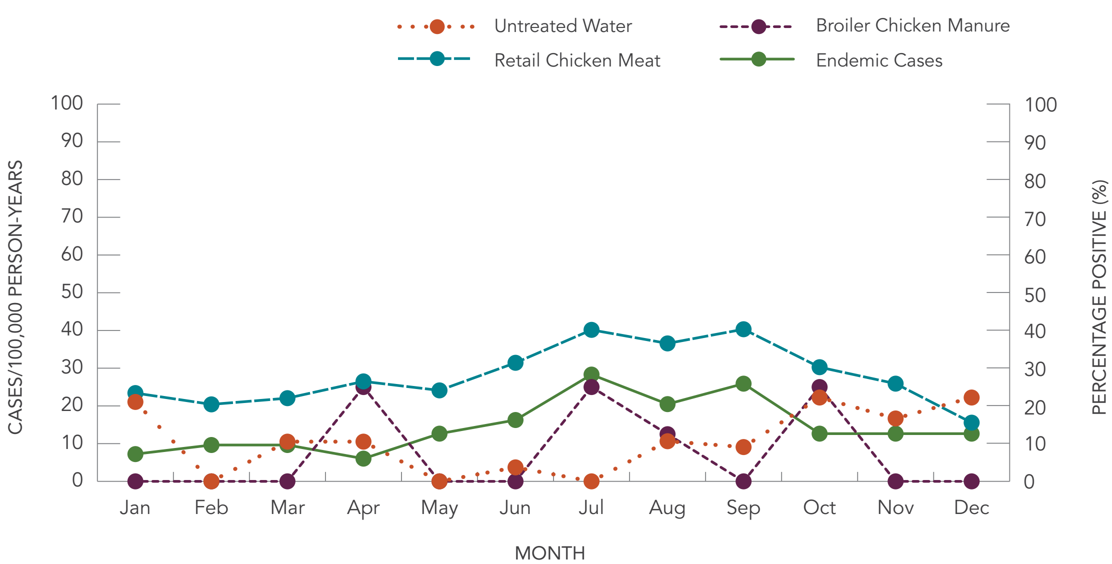
[c] Samples of untreated surface water were collected from five sites along the Grand River and three recreational beaches in the ON site in 2011/2012 as well as four beaches in the BC site in 2012.

3.3 Temporal Distribution

The seasonal pattern of campylobacteriosis has been well documented in many countries, as has the association of campylobacteriosis with weather conditions (e.g. precipitation, temperature). However, temporal trends in potential sources of contamination or exposure have been less studied, and their association with human disease trends is usually investigated one source at a time. Since *C. jejuni* is by far the most common species found in humans, it is the focus of this section.

In 2011–2012, the incidence rates of endemic cases of human campylobacteriosis from *Campylobacter jejuni* in both BC and ON combined were significantly higher during the summer months (June, July, and August) than in the Spring (March, April, and May) or Winter (December, January, and February) (Figure 3.2). The trends observed are in line with trends observed previously in the ON and BC sites.

FIGURE 3.2: Incidence rate of human endemic *Campylobacter jejuni* cases and prevalence of *Campylobacter jejuni* in potential non-human sources, by month, ON and BC sites, 2011–2012



NOTES:

1. Chicken meat includes skinless chicken breast, uncooked chicken nuggets, and ground chicken. Broiler manure is from ON only.
2. 'Month' refers to onset month for human cases and sample collection month for non-human data.
3. Sporadic endemic cases included in analysis.

Chicken meat is a known source of human *Campylobacter* infection, and in particular, *C. jejuni* (13, 14, 15). The prevalence of *C. jejuni* contamination in retail chicken (skinless chicken breast, ground chicken, and uncooked chicken nuggets) peaked in the summer and fall of 2011–2012. In comparison, *C. jejuni* was less likely to be recovered from untreated surface water samples during the summer months. Pooled manure samples from broiler chicken operations had a higher prevalence in the summer months, on average.

A clear seasonal relationship between human case incidence and exposure source contamination was not evident. However, broadly, similar seasonal trends were observed in retail chicken contamination and in human case incidence. FoodNet Canada has a number of studies underway to investigate this relationship in more detail.

Longer term trends in the ON site of human illness and possible sources of infection (broiler chicken, cattle manure, and skinless chicken breast) indicate that the seasonal variation seen earlier is often similar from year to year both for human campylobacteriosis from *C. jejuni* and some of the possible sources (Figure 3.3).

Trends in the seasonal human case counts tended to follow the same pattern in the Ontario site from 2006 to 2012. Counts increased from 2006 to 2008, then returned to typical values in 2009. Since then, they have continued to increase.

Seasonal patterns did change in 2009 for the percent of positive samples found with *C. jejuni* on retail chicken, and then again in 2012. Between 2007 to 2011, prevalence rates decreased, and then increased sharply in the summer of 2012.

Beef and dairy cattle manure have similar profiles of *C. jejuni*, so are grouped together. The prevalence of *C. jejuni* in cattle manure from beef and dairy farms tended to be higher in winter than the summer over the 2008 to 2012 period. There was no general increasing or decreasing trend from year-to-year.

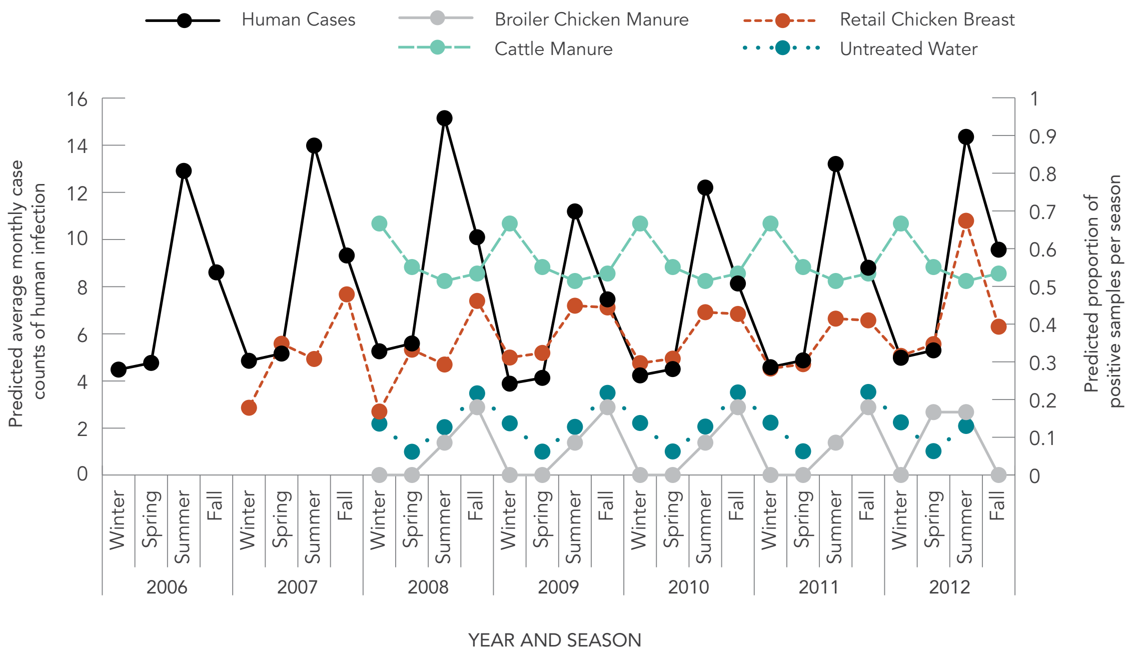
Untreated surface water samples had a stable pattern of fall peaks and spring-summer troughs from 2008 to 2012. A general increase or decrease from year to year was not found to be statistically significant. Note that the *Campylobacter* detection method was different in June to September, 2011 and June to October, 2012 and may impact the interpretation of trends.

Broiler chicken manure samples had a higher prevalence of *C. jejuni* in the fall versus the spring and summer from 2008 to 2012. This trend was stable from year to year with no general increase or decrease.

Pooled swine manure results were not included in the model as *C. jejuni* is rarely detected in this source.

No clear associations over these longer time periods were identified between the number of human cases and the possible exposure sources.

FIGURE 3.3: Predicted values of average monthly human endemic cases of campylobacteriosis (*C. jejuni* only) and *C. jejuni* prevalence on retail meats and pooled manure samples in the ON site, by season and year, 2005 to 2012



NOTE: Seasons are spring (March, April, May), summer (June, July August), fall (September, October, November), and winter (December, January, February). The December of a given year is included in the winter season of the following year. Human sporadic, endemic cases were modeled using a Poisson regression model and possible sources using a logistic regression model. Regressions modeled a seasonal dummy variable, a continuous time (in years) variable, a multi-year dummy variable, and interactions if significant.

3.4 Summary of *Campylobacter* Results

What is the same in 2011–2012 as in previous years?

- Campylobacteriosis was the most commonly reported enteric disease in both sentinel sites.
- *Campylobacter jejuni* is the most common species associated with human campylobacteriosis.
- Of the raw chicken samples tested, the majority were found to be contaminated with *Campylobacter jejuni.* As found in previous years, beef was rarely contaminated with this strain of the pathogen.

What is new?

- In addition to being detected on skinless chicken breast (47%), *Campylobacter* was also detected on other poultry products, namely ground chicken (35%) and ground turkey (27%).
- *Campylobacter jejuni* was detected in broiler chicken fecal samples at a higher rate in the spring of 2012 than was found in the past.

Integration of results

Findings suggesting the possible sources of *Campylobacter* infection are summarized in the following table. Possible exposures identified through univariate analysis included living on a farm or country property, contacting on-farm poultry, contacting household pets, contacting animal manure and consuming spoiled food.

Overall, as found in the past, retail chicken meat was considered to be the most important vehicle of transmission for *Campylobacter*, based on FoodNet Canada surveillance data. FoodNet Canada initiated *Campylobacter* testing of raw skinless chicken breasts in 2005 and broiler chicken operations in 2007. *Campylobacter* prevalence has been consistently lower at the farm level when compared to the retail level. Despite multiple investigations to improve recovery rates at the farm level, the recovery rate has remained low. These results suggest that the frequent *Campylobacter* contamination of chicken at the retail level may be a result of cross contamination at the abattoir processing level (16, 17). Mitigation strategies therefore should be focused at the abattoir level to decrease retail *Campylobacter* levels on raw chicken.

In comparison, *Campylobacter* isolation rates have been consistently high at the farm level on beef and swine operations while remaining low at the retail raw meat level. This finding based on FoodNet Canada results suggests that for beef and swine, interventions at the abattoir processing level are effective at preventing the contamination of raw meat at the retail level.

TABLE 3.2: Possible sources of campylobacteriosis in 2011–2012

FOODNET CANADA DATA SOURCE	METHODOLOGY	POSSIBLE SOURCES
Human exposure data from case questionnaires	Descriptive	Living on a farm or country property, contacting on-farm poultry, contacting household pets, contacting animal manure and consuming spoiled food
Agricultural manure surveillance	Descriptive	Primarily bovine manure, lesser extent: chicken and swine manure
Retail grocery store samples	Descriptive	Retail chicken meats (skinless chicken breast, ground chicken and uncooked frozen nuggets)
Water surveillance	Descriptive	Contact with natural waters
Most commonly found source of *Campylobacter* infection based on current FoodNet Canada data	Descriptive	Retail chicken meat

FoodNet Canada is currently collecting molecular typing data so that more detailed analyses can be performed in the future to determine the most important reservoirs and vehicles for *Campylobacter* infection.

What impact do these findings have on public health?

These findings reinforce the continued efforts being made to control *Campylobacter* in the farm to fork and source to tap continuums in Canada.

4. *SALMONELLA*

4.1 Human Cases

In both the ON and BC sites, a total of 469 cases of salmonellosis were reported between 2011 and 2012 (combined[2]), representing an incidence rate of 23.5 cases/100,000 person-years. Of these cases, 32% (150/469) were travel-related (7.5 cases/100,000 person-years), 3% (14/469) were domestic outbreak-related (0.70 cases/100,000 person-years), 54% (254/469) were classified as endemic (12.7 cases/100,000 person-years) and 1% (4/469) were classified as non-endemic cases related to recent immigration. A total of 10% (47/469) of human salmonellosis cases were lost to follow-up. In comparison, the annual incidence rate for salmonellosis in 2011 and 2012 combined for all of Canada was 19.9 cases/100,000 person-years (7, 8).

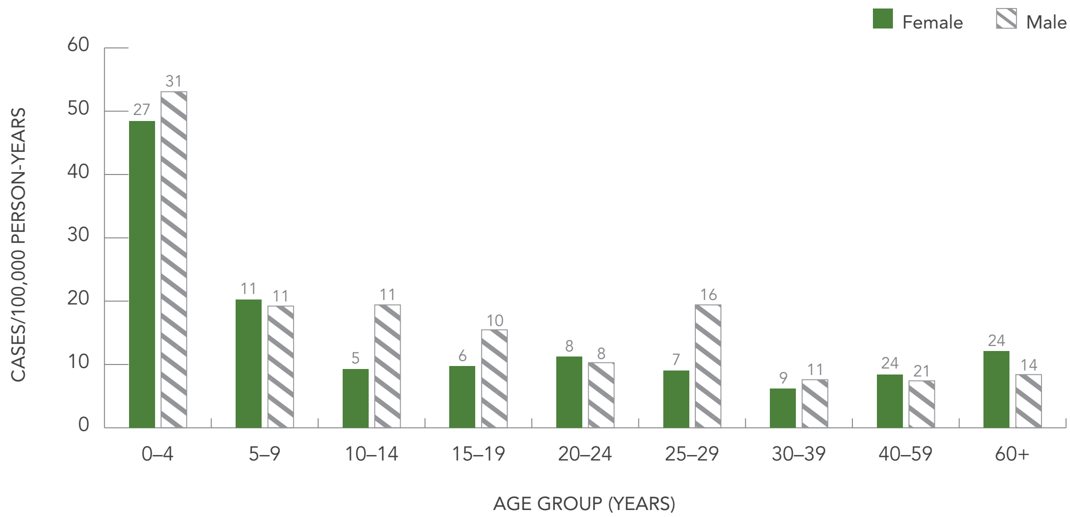
The most commonly reported serovars of *Salmonella* were Enteritidis (45%; 210/469), Typhimurium (32%; 45/469) and Heidelberg (9%; 41/469). Of the 254 endemic cases, the most commonly reported serovars of *Salmonella* were Enteritidis (42%; 106/254), Heidelberg 13%; 33/254) and Typhimurium (13%; 32/254). These serovars were also the same top three reported to the NESP in 2011 and 2012 (2, 3). Of the 210 cases attributed to *S.* Enteritidis, 56% (106 endemic and 11 outbreak cases) were classified as domestically acquired. Of those attributed to *S.* Typhimurium, 71% (32 endemic) were domestically acquired, as were 83% (33 endemic and 1 outbreak) of cases attributed to *S.* Heidelberg infection.

Distributions of age and gender among the salmonellosis cases between 2011 and 2012 were similar to those observed historically in both the ON and BC sites (Figure 4.1). The highest rates of salmonellosis were reported among children less than five years of age.

Among the 254 endemic cases in both the ON and BC sites, 47 serovars were identified. The top three *Salmonella* serovars were Enteritidis, Heidelberg, and Typhimurium, which comprised 67% (171/254) of serotyped isolates (Table 4.1).

[2] For this combined 2011–2012 Biennial Report, unless otherwise noted, all results have been combined for both years and for both sites. Where differences were significant (between years), these results are reported on separately.

FIGURE 4.1: Incidence rates of sporadic, human endemic salmonellosis in the ON and BC sites in 2011 and 2012, by gender and age group



NOTE: The number of cases is indicated above each bar.

4.2 Travel-Related Cases

The most commonly isolated *Salmonella* serovars for travel-related cases in both the ON and BC sites were Enteritidis (46%; 68/149), Typhi (9%; 13/149), Typhimurium (7%; 10/149) and Paratyphi A (7%; 10/149).

In total, in both sites, 57% (86/150) of people with travel-related salmonellosis reported travel to the Americas (South or Central locations), whereas 27% (41/150) reported travelling to Asia and 7% (11/150) to the United States. In the BC site, the predominant travel destination for salmonellosis cases was Asia (45%; 32/71), with the most common serovars including Paratyphi A (8/32) and Typhi (8/32), whereas in the ON site, the predominant travel destination for salmonellosis cases were the Americas (South and Central locations) (74%; 58/78), with Enteritidis reported as the most common serovar, representing over half of the cases (34/58).

4.3 Case Exposures

Information was collected for 90% (422/469) of all salmonellosis cases regarding exposure to potential sources of infection in the three days prior to the onset of illness.

Case-case comparisons were conducted for endemic cases with exposure data combining both the ON and BC sites. Univariate comparisons identified contact with household reptiles to be significantly ($p<0.05$) associated with an increased risk of salmonellosis (Appendix B).

4.4 Surveillance of Potential Sources

Retail food

Salmonella was detected in 29% (201/700) of skinless chicken breast samples collected in 2011–2012 from retail establishments in both sentinel sites (Table 4.1). This prevalence of contamination is identical to the prevalence observed in 2010 in the ON site. Also consistent with findings in previous years is the observation that overall counts of *Salmonella* organisms on *Salmonella*-positive samples were consistently low (Appendix C).

The three most common *Salmonella* serovars detected in skinless chicken breast samples (Table 4.1) were Kentucky (98/201), Heidelberg (35/201), and Enteritidis (23/201). The same top three serovars were isolated from uncooked chicken nuggets, ground chicken and ground turkey, though they ranked differently.

Farm animals

The prevalence of *Salmonella* in pooled manure samples from swine in the ON site was 34% (Table 4.1). Top serovars found were Worthington (13/41) and Typhimurium (6/41). The prevalence of *Salmonella* in samples of broiler chicken feces in the ON site was 59% in 2011–2012, similar to the finding in 2010, 63%. Top serovars for broiler chickens were Kentucky (71/142), Heidelberg (49/142), Enteritidis (8/142) and I:OR:i:z6 (8/142).

Water

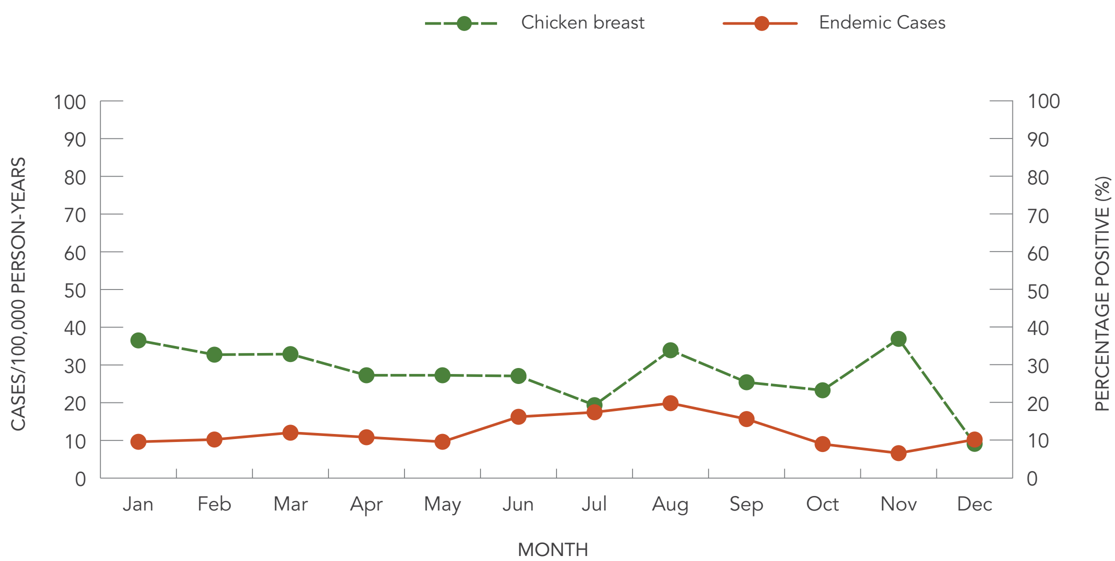
Salmonella was detected in 27% of untreated surface water samples in 2011–2012. The top serovars found in 2011–2012 were Thompson (10/71), Typhimurium (7/71) and Newport (6/71).

The *Salmonella* positive samples originated from both sentinel sites. Historically, levels observed at each monitoring site within the sentinel sites, have been similar over time.

4.5 Temporal Distribution

In 2011–2012, the incidence rate of endemic salmonellosis was higher in June, July, August and September (Figure 4.2). The prevalence of *Salmonella* on skinless chicken breast meat tended to fall from January to July, though it followed an erratic pattern for the rest of the year.

FIGURE 4.2: Incidence rate of human endemic cases of salmonellosis, and the prevalence of *Salmonella* in potential non-human sources, by month, ON and BC sites, 2011–2012



NOTES:

1. 'Month' refers to onset month for human cases and sample collection month for non-human data.
2. Sporadic endemic cases included in analysis.

4.6 Subtype Comparison

One of the benefits of the FoodNet Canada surveillance program is the application of laboratory subtyping methodologies to identify patterns in subtype distributions among both the human cases and potential sources over time (Table 4.1). In this section, data on the top three serovars associated with human *Salmonella* infection for all of Canada and in the ON and BC sites are more thoroughly presented, by phage type or PFGE pattern, and key trends are identified.

Salmonella Typhimurium

Typhimurium was one of the top three serovars associated with reported human cases of salmonellosis in the ON and BC sites and in all of Canada in 2011–2012 (2, 3). Certain phage types were found in both cases and exposure sources (Table 4.2). Phage type 108 was the most common phage type found in human endemic cases (6/24) in 2011–2012 and was also found in low levels in skinless chicken breasts (1/6), retail ground chicken (1/4), and untreated surface water (2/7). The U302 phage type was also found in three endemic cases, as well as in swine manure (3/6) and dairy cattle manure (1/4).

Salmonella Enteritidis

Although the incidence of human cases of *Salmonella* Enteritidis infection increased in Canada from mid-2008 to 2010, the rate decreased in 2011–2012 (2, 3). The serovar is common among travel- and non-travel-related cases (including endemic and outbreak-related cases), yet particular phage types are more common among endemic cases, including type 8, 13, and 13A (Table 4.3). In contrast, type 1 and 5B are more likely to be the cause of travel-related cases. One of the main sources of endemic *S.* Enteritidis infection is believed to be poultry products, including eggs and chicken meat (18). The FoodNet Canada surveillance data support this: 8, 13A, and 13 were detected in retail chicken meat, as well as other sources.

Phage type 8 was found in 42 of 85 endemic cases and in all retail meats sampled—skinless chicken breasts (12/23), uncooked chicken nuggets (49/76), ground chicken (28/65) and ground turkey (3/13)—as well as beef cattle manure (1/2). Phage type 13A was found in 16 of 85 cases and was also found in all retail meats. Six out of 85 salmonellosis cases were phage type 13, which was not detected on skinless chicken breasts or ground turkey but was detected in uncooked chicken nuggets and ground chicken samples (in both sites). Within each of the most common phagetypes, the most prominent PFGE pattern in the endemic cases was also the most prominent pattern seen in other sources tested.

Salmonella Heidelberg

Data on *Salmonella* Heidelberg are presented by phage type and by PFGE pattern for the two most common phage types (Table 4.4). *S.* Heidelberg is the second most common serovar in samples of skinless chicken breasts and on broiler chicken farms. Most *S.* Heidelberg cases were phage type 19 and 29. Three phage type patterns (19, 29 and 18) accounted for most (22/26) of the human endemic cases and most of the Heidelberg isolates from all retail food products, farm commodities and water samples. Within phage types 19 and 29, the most prominent PFGE pattern in the endemic cases was also the most prominent pattern seen in other sources tested.

Other Serovars

Salmonella Kentucky was commonly recovered from samples of retail chicken meats, 31% (242/774), and broiler chicken feces, 50% (71/142), (Table 4.1). The serovar was rarely detected in untreated surface water samples and was not found among human cases of salmonellosis in 2011–2012 in either site. A similar trend has been observed in the ON site since 2005 when the surveillance began. The epidemiology of *S.* Kentucky is important to understand, since surveillance data suggest the organism is prevalent in several potential exposure sources, yet its contribution to the human burden of salmonellosis is limited.

S. Cerro was most commonly detected in dairy cattle pooled manure samples, 22% (5/23), as observed in previous years, yet was only associated with one endemic human case during 2011–2012. This particular serovar is uncommon nationally. Ground chicken and ground turkey are new products undergoing testing in 2011–2012. In addition to Heidelberg and Enteritidis, serovars Infantis, Thompson, Hadar and Schwarzengrund were found on ground chicken samples. Eight ground turkey samples were positive for Hadar. These serovars were detected in manure and water, though not commonly in human cases.

TABLE 4.1: Number of *Salmonella* detected and serotyped (culture-based methods), ON and BC sites, 2011–2012

METHOD	HUMAN			RETAIL FOOD				FARM ANIMAL MANURE[a]				WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
Detection												
Number of samples tested	…	…	…	700	567	515	251	120	240	240	240	261
Number positive	254	14	150	201	247	326	60	41	142	21	23	71
Percent postive	..	..	..	29%	44%	63%	24%	34%	59%	8.8%	9.6%	28%
Serotyping												
Number of samples serotyped	254	14	149	201	247	326	60	41	142	21	23	69
Enteritidis	106	11	68	23	76	65	13	0	8	2	1	1
Heidelberg	33	1	3	35	79	61	11	0	49	3	2	3
Typhimurium	32	0	10	6	2	4	1	6	0	0	4	7
Oranienburg	6	0	0	1	0	1	0	0	0	2	0	1
Newport	5	0	4	0	0	4	1	0	0	0	0	6
I 4,5,12:i:-	5	0	4	1	5	3	0	0	0	0	0	1
Infantis	4	0	4	4	6	15	0	4	1	0	1	5
I 4,5,12:b:-	4	0	1	0	0	0	0	0	0	0	1	4
Mbandaka	4	0	0	2	3	2	0	0	0	0	0	0
Javiana	3	0	4	0	0	0	0	0	0	0	0	0
Panama	3	0	1	0	0	0	0	0	0	0	0	0
Tennessee	3	0	0	0	0	0	0	0	0	0	0	1
Thompson	3	0	0	4	5	14	1	0	0	0	1	10
Anatum	2	0	1	1	0	0	3	0	0	0	0	0
Muenchen	2	0	1	0	0	0	0	0	0	0	0	0

METHOD	HUMAN			RETAIL FOOD				FARM ANIMAL MANURE[a]				WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
Albany	2	0	0	1	1	1	0	0	0	0	0	0
Bareilly	2	0	0	0	0	0	0	0	0	0	0	0
Berta	2	0	0	0	0	6	0	0	0	0	0	1
Bovismorbificans	2	0	0	0	0	0	0	0	0	0	0	1
Kiambu	2	0	0	5	0	5	0	0	0	0	0	0
Ssp Diarizonae	2	0	0	0	0	0	0	0	0	0	0	1
Weltevreden	2	0	0	0	0	0	0	0	0	0	0	0
Braenderup	1	1	3	0	2	0	0	0	0	0	0	0
Paratyphi A	1	0	10	0	0	0	0	0	0	0	0	0
Hartford	1	0	2	0	0	0	0	0	0	0	0	4
Mississippi	1	0	2	0	0	0	0	0	0	0	0	1
Saintpaul	1	0	2	0	0	0	2	0	0	0	0	1
Cerro	1	0	1	0	0	1	0	1	0	3	5	1
Montevideo	1	0	1	0	0	1	0	0	0	0	0	1
Brandenburg	1	0	0	0	0	0	0	1	0	0	0	0
Hadar	1	0	0	7	6	23	8	0	0	1	0	3
Schwarzengrund	1	0	0	1	2	10	3	2	0	0	0	4
Typhi	0	0	13	0	0	0	0	0	0	0	0	0
Kentucky	0	0	2	98	46	98	9	0	71	1	2	1
Sandiego	0	0	2	0	0	0	0	0	0	0	0	0
Blockley	0	0	1	0	0	0	0	0	0	0	0	1
Derby	0	0	1	0	0	0	0	4	0	1	0	2
Manhattan	0	0	1	0	0	0	0	0	0	0	0	1
Stanley	0	0	1	0	0	0	0	0	0	0	0	1

	HUMAN			RETAIL FOOD				FARM ANIMAL MANURE[a]				WATER[b]
METHOD	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
Uganda	0	0	1	0	0	0	1	1	0	1	1	0
Agona	0	0	0	1	2	0	2	4	1	0	0	1
Indiana	0	0	0	0	6	0	0	0	0	0	0	0
Litchfield	0	0	0	2	0	1	0	0	0	0	0	0
Livingstone	0	0	0	0	0	0	0	0	3	0	0	0
London	0	0	0	0	0	0	0	1	0	1	0	1
Mbandaka Var.14+	0	0	0	0	0	1	0	1	0	0	0	0
Ohio	0	0	0	1	1	1	0	1	0	1	0	0
Orion Var.15+34+	0	0	0	0	1	1	0	0	0	1	0	0
Senftenberg	0	0	0	0	0	1	0	0	0	0	0	1
Worthington	0	0	0	0	0	1	1	13	0	0	0	0
I 4,12:-:1,7	0	0	0	0	1	0	1	0	0	0	0	0
I 4,12:i:-	0	0	0	3	0	1	1	0	0	0	0	0
I 6,-,18:-:-	0	0	0	0	0	0	0	0	0	0	3	0
I 6,14,18:-:-	0	0	0	0	0	0	0	0	0	4	2	0
I 8,20:-:-	0	0	0	2	0	0	0	0	0	0	0	0
I OR:i:z6	0	0	0	2	0	1	1	0	8	0	0	0
I OR:r:1,5	0	0	0	0	1	1	0	0	0	0	0	0
Other[c]	15	1	5	1	2	3	1	2	1	0	0	3

NOTE: Ground turkey and swine manure samples are for 2011 only. One untreated surface water sample that tested positive for Saintpaul also tested positive for London. Typhimurium var, Copenhagen are grouped with Typhimurium because they are indistinguishable in the human results.

[a] ON site only.

[b] Samples of untreated surface water were collected from five sites along the Grand River and three recreational beaches in the ON site in 2011/2012 as well as four beaches in the BC site in 2012.

[c] Serovars that were identified once in a single component are listed here rather than in the table. Human endemic: Anecho; Ealing; Eastbourne; Elizabethville; Irumu; Monschaui; Norwich; Paratyphi B var Java; Pomona; Poona; Singapore; Ssp Arizonae; I OR:-:-; I 4,12:b:- ; I 4,5,12:h:-; I OR:i:1,2. Human domestic outbreak: Agbeni. Human travel: Corvallis; Essen; Rissen; Virchow; I 6,7:r:-. Chicken breast: I 6,7:k:-. Uncooked chicken nuggets: Reading; Widemarsh. Ground chicken: I 8,20:-:z6; I 8,20:i:-; I OR:r:1,2. Ground turkey: Muenster. Swine: Havana; Livingstone var.14+. Broiler chicken: I 6,7:-:-. Untreated surface water: Holcomb; I 18:-:-; I 6,7:z10:-.

TABLE 4.2: Integrated comparison of *Salmonella* Typhimurium phage types, ON and BC sites, 2011–2012 compared to 2008 to 2010

PHAGE TYPE	HUMAN		RETAIL FOOD				FARM ANIMAL MANURE[a]				WATER[b]
	ENDEMIC	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY[c]	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. OF SAMPLES FOR 2011–2012 (No. FOR 2008–2010)										
Number of samples typed	**24 (49)**	**6 (5)**	**6 (12)**	**2 (.)**	**4 (1)**	**1 (.)**	**6 (33)**	**0 (11)**	**0 (3)**	**4 (4)**	**7 (9)**
108	6 (7)	0 (1)	1 (6)	0 (.)	1 (1)	0 (.)	0 (1)	0 (3)	0 (0)	0 (0)	2 (5)
Atypical	4 (3)	0 (0)	0 (0)	0 (.)	1 (0)	0 (.)	0 (1)	0 (1)	0 (0)	0 (0)	2 (1)
U302	3 (6)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	3 (1)	0 (0)	0 (0)	1 (0)	0 (0)
104	2 (3)	2 (0)	0 (3)	0 (.)	2 (0)	0 (.)	1 (4)	0 (5)	0 (1)	0 (3)	1 (1)
10	2 (2)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
104B	1 (3)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (9)	0 (0)	0 (1)	1 (1)	0 (1)
2	1 (1)	1 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)
UT1	1 (1)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)
208	1 (1)	0 (0)	0 (1)	0 (.)	0 (0)	0 (.)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)
135	1 (0)	0 (0)	0 (2)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
170	0 (6)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)
15A	0 (2)	1 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
104A	0 (2)	0 (1)	0 (0)	0 (.)	0 (0)	0 (.)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)
193	0 (2)	0 (1)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	0 (2)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (2)	0 (1)	0 (0)	0 (0)	1 (0)
22	0 (1)	1 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
U311	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	1 (2)	0 (0)	0 (0)	0 (0)	0 (1)
Other	2 (7)	1 (2)	4 (0)	0 (.)	0 (0)	1 (.)	1 (0)	0 (0)	0 (1)	1 (0)	1 (0)
Untypable	0 (0)	0 (0)	1 (0)	2 (.)	0 (0)	0 (.)	0 (4)	0 (0)	0 (0)	1 (0)	0 (0)

NOTE: No outbreak cases were reported in 2011 or 2012.

[a] ON site only.

[b] Samples of untreated surface water were collected from five sites along the Grand River and three recreational beaches in the ON site in 2011/2012 as well as four beaches in the BC site in 2012.

[c] 2011 only.

TABLE 4.3: Integrated comparison of *Salmonella* Enteritidis phage types, ON and BC sites, 2011–2012 compared to 2008 to 2010

PHAGE TYPE	HUMAN			RETAIL FOOD				FARM ANIMAL MANURE[a]				WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY[c]	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. OF SAMPLES FOR 2011–2012 (No. FOR 2008–2010)											
Number of samples typed	**85 (82)**	**10 (3)**	**62 (55)**	**23 (22)**	**76 (.)**	**65 (3)**	**13 (.)**	**0 (0)**	**8 (13)**	**2 (4)**	**1 (0)**	**1 (3)**
8 (total)	**42 (37)**	**5 (3)**	**5 (6)**	**12 (13)**	**49 (.)**	**28 (0)**	**3 (.)**	**0 (0)**	**0 (2)**	**1 (1)**	**0 (0)**	**0 (0)**
SENXAI.0003	38 (33)	5 (3)	5 (6)	11 (11)	46 (.)	25 (0)	3 (.)	0 (0)	0 (2)	0 (1)	0 (0)	0 (0)
SENXAI.0007	3 (2)	0 (0)	0 (0)	1 (1)	3 (.)	3 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other	1 (0)	0 (0)	0 (0)	0 (1)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)
Not done	0 (2)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13A (total)	**16 (28)**	**4 (0)**	**5 (8)**	**5 (6)**	**11 (.)**	**12 (0)**	**5 (.)**	**0 (0)**	**0 (6)**	**0 (0)**	**0 (0)**	**1 (0)**
SENXAI.0006	10 (20)	4 (0)	3 (4)	5 (6)	10 (.)	9 (0)	3 (.)	0 (0)	0 (4)	0 (0)	0 (0)	1 (0)
SENXAI.0003	3 (4)	0 (0)	1 (3)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)
SENXAI.0068	1 (1)	0 (0)	1 (0)	0 (0)	1 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SENXAI.0007	0 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)
SENXAI.0038	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	3 (0)	2 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other	2 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Not done	0 (2)	0 (0)	0 (1)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Atypical (total)	**9 (4)**	**0 (0)**	**12 (3)**	**3 (0)**	**3 (.)**	**13 (3)**	**3 (.)**	**0 (0)**	**0 (1)**	**0 (1)**	**0 (0)**	**0 (0)**
SENXAI.0038	7 (0)	0 (0)	0 (0)	3 (0)	1 (.)	8 (1)	2 (.)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)
SENXAI.0001	1 (2)	0 (0)	3 (0)	0 (0)	0 (.)	4 (2)	1 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SENXAI.0003	1 (0)	0 (0)	0 (0)	0 (0)	2 (.)	0 (0)	0 (.)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)
SENXAI.0008	0 (1)	0 (0)	4 (1)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SENXAI.0002	0 (0)	0 (0)	1 (0)	0 (0)	0 (.)	1 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SENXAI.0004	0 (0)	0 (0)	1 (1)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SENXAI.0155	0 (0)	0 (0)	2 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other	0 (1)	0 (0)	1 (1)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

PHAGE TYPE	HUMAN			RETAIL FOOD				FARM ANIMAL MANURE[a]				WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY[c]	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. OF SAMPLES FOR 2011–2012 (No. FOR 2008–2010)											
Number of samples typed	**85 (82)**	**10 (3)**	**62 (55)**	**23 (22)**	**76 (.)**	**65 (3)**	**13 (.)**	**0 (0)**	**8 (13)**	**2 (4)**	**1 (0)**	**1 (3)**
13 (total)	**6 (3)**	**1 (0)**	**0 (2)**	**0 (1)**	**7 (.)**	**6 (0)**	**0 (.)**	**0 (0)**	**8 (1)**	**1 (2)**	**1 (0)**	**0 (2)**
SENXAI.0038	5 (2)	1 (0)	0 (2)	0 (1)	6 (.)	6 (0)	0 (.)	0 (0)	8 (1)	1 (2)	1 (0)	0 (2)
SENXAI.0003	1 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other	0 (0)	0 (0)	0 (0)	0 (0)	1 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
51	5 (4)	0 (0)	1 (0)	1 (0)	2 (.)	2 (0)	1 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5B	2 (1)	0 (0)	11 (9)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	1 (3)	0 (0)	3 (0)	0 (0)	1 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)
1	1 (0)	0 (0)	12 (9)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2	1 (0)	0 (0)	0 (0)	0 (1)	0 (.)	1 (0)	0 (.)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)
21C	1 (0)	0 (0)	1 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4B	1 (0)	0 (0)	0 (0)	0 (0)	1 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	0 (2)	0 (0)	1 (4)	0 (0)	0 (.)	1 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
1B	0 (0)	0 (0)	2 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (2)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	2 (0)	2 (.)	1 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6A	0 (0)	0 (0)	6 (4)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7A	0 (0)	0 (0)	1 (1)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
911	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	1 (0)	1 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other	0 (0)	0 (0)	1 (4)	0 (1)	0 (.)	0 (0)	0 (.)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)
Untypable	0 (0)	0 (0)	1 (3)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

NOTE: PFGE patterns may occur in more than one phage type.

[a] ON site only.

[b] Samples of untreated surface water were collected from five sites along the Grand River and three recreational beaches in the ON site in 2011/2012 as well as four beaches in the BC site in 2012.

[c] 2011 only.

TABLE 4.4: Integrated comparison of *Salmonella* Heidelberg phage types, ON and BC sites, 2011–2012 compared to 2008 to 2010

PHAGE TYPE	HUMAN			RETAIL FOOD				FARM ANIMAL MANURE[a]				WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY[c]	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. OF SAMPLES FOR 2011–2012 (No. FOR 2008–2010)											
Number of samples typed	**26 (21)**	**1 (2)**	**3 (1)**	**35 (41)**	**80 (.)**	**61 (2)**	**11 (.)**	**0 (0)**	**49 (9)**	**3 (3)**	**2 (3)**	**3 (0)**
19 (total)	**15 (13)**	**1 (2)**	**0 (0)**	**11 (15)**	**27 (.)**	**23 (0)**	**6 (.)**	**0 (0)**	**9 (1)**	**0 (1)**	**0 (0)**	**2 (0)**
SHEXAI.0001	9 (7)	1 (2)	0 (0)	11 (9)	26 (.)	23 (0)	6 (.)	0 (0)	8 (1)	0 (1)	0 (0)	2 (0)
SHEXAI.0009	3 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0126	2 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0007	0 (5)	0 (0)	0 (0)	0 (1)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0020	0 (0)	0 (0)	0 (0)	0 (5)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other	0 (0)	0 (0)	0 (0)	0 (0)	1 (.)	0 (0)	0 (.)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)
Not done	1 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
29 (total)	**5 (2)**	**0 (0)**	**0 (0)**	**18 (4)**	**21 (.)**	**22 (1)**	**3 (.)**	**0 (0)**	**11 (3)**	**2 (0)**	**0 (0)**	**0 (0)**
SHEXAI.0001	5 (0)	0 (0)	0 (0)	16 (3)	17 (.)	16 (1)	2 (.)	0 (0)	8 (3)	2 (0)	0 (0)	0 (0)
SHEXAI.0007	0 (1)	0 (0)	0 (0)	0 (0)	2 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0009	0 (0)	0 (0)	0 (0)	2 (0)	0 (.)	3 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0020	0 (0)	0 (0)	0 (0)	0 (1)	1 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other	0 (0)	0 (0)	0 (0)	0 (0)	1 (.)	3 (0)	1 (.)	0 (0)	3 (0)	0 (0)	0 (0)	0 (0)
Not done	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	2 (1)	0 (0)	0 (0)	2 (1)	3 (.)	7 (0)	0 (.)	0 (0)	20 (0)	1 (0)	2 (3)	0 (0)
2	1 (2)	0 (0)	0 (0)	0 (3)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
54	1 (0)	0 (0)	0 (0)	0 (0)	1 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Atypical	1 (0)	0 (0)	0 (0)	2 (0)	7 (.)	1 (0)	2 (.)	0 (0)	5 (3)	0 (1)	0 (0)	0 (0)

PHAGE TYPE	HUMAN			RETAIL FOOD				FARM ANIMAL MANURE[a]				WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY[c]	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. OF SAMPLES FOR 2011–2012 (No. FOR 2008–2010)											
Number of samples typed	**26 (21)**	**1 (2)**	**3 (1)**	**35 (41)**	**80 (.)**	**61 (2)**	**11 (.)**	**0 (0)**	**49 (9)**	**3 (3)**	**2 (3)**	**3 (0)**
22	0 (1)	0 (0)	2 (1)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
29A	0 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (.)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)
41	0 (1)	0 (0)	0 (0)	0 (2)	7 (.)	1 (0)	0 (.)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)
10	0 (0)	0 (0)	0 (0)	0 (1)	1 (.)	1 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	1 (3)	5 (.)	1 (0)	0 (.)	0 (0)	2 (1)	0 (0)	0 (0)	0 (0)
19A	0 (0)	0 (0)	0 (0)	1 (2)	2 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
26	0 (0)	0 (0)	0 (0)	0 (3)	1 (.)	1 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	0 (0)	0 (0)	0 (0)	0 (5)	1 (.)	0 (0)	0 (.)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)
52	0 (0)	0 (0)	1 (0)	0 (0)	2 (.)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
58	0 (0)	0 (0)	0 (0)	0 (0)	1 (.)	1 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other	1 (0)	0 (0)	0 (0)	0 (2)	1 (.)	3 (1)	0 (.)	0 (0)	0 (0)	0 (1)	0 (0)	1 (0)

NOTE: PFGE patterns may occur in more than one phage type.

[a] ON site only.

[b] Samples of untreated surface water were collected from five sites along the Grand River and three recreational beaches in the ON site in 2011/2012 as well as four beaches in the BC site in 2012.

[c] 2011 only.

TABLE 4.5: Integrated comparison of *Salmonella* Heidelberg PFGE patterns, ON and BC sites, 2011–2012 versus in 2008 through 2010

PATTERN	HUMAN			RETAIL FOOD				FARM ANIMAL MANURE[a]				WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY[c]	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. OF SAMPLES FOR 2011–2012 (No. FOR 2008–2010)											
Number of samples typed	32 (21)	1 (2)	3 (1)	35 (41)	80 (1)	61 (2)	11 (.)	0 (0)	49 (9)	3 (3)	2 (3)	3 (0)
SHEXAI.0001 (total)	**21 (9)**	**1 (2)**	**0 (0)**	**32 (20)**	**60 (1)**	**46 (1)**	**8 (.)**	**0 (0)**	**43 (7)**	**3 (2)**	**2 (3)**	**2 (0)**
SHEBNI.0001	17 (8)	1 (2)	0 (0)	26 (18)	53 (1)	37 (1)	8 (.)	0 (0)	41 (7)	3 (2)	2 (3)	2 (0)
SHEBNI.0014	1 (0)	0 (0)	0 (0)	0 (0)	2 (0)	2 (0)	0 (.)	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)
SHEBNI.0002	0 (0)	0 (0)	0 (0)	5 (0)	0 (0)	1 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEBNI.0009	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEBNI.0012	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEBNI.0203	0 (0)	0 (0)	0 (0)	1 (0)	1 (0)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other	1 (0)	0 (0)	0 (0)	0 (2)	2 (0)	1 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Not done	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0002	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	1 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0006	1 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (1)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0007	0 (9)	0 (0)	0 (0)	0 (3)	2 (0)	1 (0)	0 (.)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)
SHEXAI.0009 (total)	**8 (1)**	**0 (0)**	**1 (0)**	**2 (1)**	**2 (0)**	**10 (0)**	**0 (.)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**
SHEBNI.0001	6 (1)	0 (0)	0 (0)	2 (0)	0 (0)	7 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEBNI.0025	0 (0)	0 (0)	1 (0)	0 (1)	2 (0)	3 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Not done	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0011	0 (0)	0 (0)	0 (0)	0 (6)	7 (0)	0 (0)	0 (.)	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)
SHEXAI.0020	0 (0)	0 (0)	0 (0)	0 (9)	4 (0)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

PATTERN	HUMAN			RETAIL FOOD				FARM ANIMAL MANURE[a]				WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY[c]	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. OF SAMPLES FOR 2011–2012 (No. FOR 2008–2010)											
Number of samples typed	**32 (21)**	**1 (2)**	**3 (1)**	**35 (41)**	**80 (1)**	**61 (2)**	**11 (.)**	**0 (0)**	**49 (9)**	**3 (3)**	**2 (3)**	**3 (0)**
SHEXAI.0111	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	3 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0126	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0158	0 (0)	0 (0)	0 (0)	1 (0)	1 (0)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0201	0 (1)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0251	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)
Other	0 (1)	0 (0)	1 (1)	0 (2)	2 (0)	2 (0)	0 (.)	0 (0)	2 (0)	0 (0)	0 (0)	1 (0)

NOTE: Only first enzyme patterns SHEXAI.0001 and SHEXAI.0009 have a further tabulation by the second enzyme pattern to improve discrimination.

[a] ON site only.

[b] Samples of untreated surface water were collected from five sites along the Grand River and three recreational beaches in the ON site in 2011/2012 as well as four beaches in the BC site in 2012.

[c] 2011 only.

4.7 Summary of *Salmonella* Results

What is the same in 2011–2012 as in previous years?

- A slight decrease was observed in the rate in both sites (in 2011–2012 combined compared to 2010), which is comparable to the national trend (2, 3, 7, 8)
- Distributions of human salmonellosis cases by age, gender, and season, in 2011 and 2012, were similar to those observed historically in both the ON and BC sites.
- The most commonly reported serovars for human salmonellosis were Enteritidis, Typhimurium, and Heidelberg.
- Phage type alignment continues to be observed among isolates from endemic human cases, chicken meat, and broiler chicken feces for both *S.* Heidelberg and *S.* Enteritidis.
- Of the broiler chicken feces samples tested in 2011–2012, 59% were positive for *Salmonella*, which is close to the 2010 value of 63%, though it is almost double the 39% detected in 2009. No changes in laboratory methodology occurred during this time period.

What is new?

- The prevalence of *Salmonella* on ground chicken—a new product under surveillance—was twice the level found on chicken breast. This may highlight the greater chance of product contamination during the grinding step, and also highlights the importance of cooking ground chicken thoroughly.

Integration of results

Possible salmonellosis infection sources are: contact with pet reptiles, retail poultry products, and broiler chicken manure (Table 4.6). The most important vehicle of transmission is considered to be retail poultry products, based on FoodNet Canada retail surveillance data. The much larger contamination rate for ground chicken suggests cross-contamination during processing.

The historical recovery of *Salmonella* from beef, dairy cattle, and swine sources is lower than that on poultry products, suggesting the possibility that they may be less important contributors to human *Salmonella* infection as compared to poultry products.

TABLE 4.6: Possible sources of salmonellosis, ON and BC sites, 2011–2012

FOODNET CANADA DATA SOURCE	METHODOLOGY	POSSIBLE SOURCES
Human exposure data from case questionnaires	Descriptive	Contact with pet reptiles
Agricultural manure surveillance	Descriptive	Broiler chickens primarily
Retail grocery store samples	Descriptive	Chicken and turkey meat products
Water surveillance	Descriptive	Limited impact
Most commonly found source of *Salmonella* infection based on current FoodNet Canada data	Descriptive	Retail poultry products

What impact does this have on public health?

- The data on retail food contamination with *Salmonella* has been used to inform:
  - A Canadian Food Inspection Agency (CFIA) 'iRisk' pathogen food product risk ranking tool,
  - The design of a CFIA baseline survey study of retail chicken contamination,
  - A multi-departmental initiative within the Health Portfolio to support a pathogen reduction strategy in Canadian foods.

- The results for pooled manure samples from farms and results from water samples are being used to inform the development of source tracking studies and a national attribution model for *Salmonella* transmission, as well as to understand the environmental prevalence of this pathogen.

5. PATHOGENIC *E.COLI*

5.1 Human Cases

In both the ON and BC sites, a total of 61 cases of verotoxigenic *E. coli* (VTEC) infections were reported between 2011 and 2012 (combined[3]) representing an incidence rate of 3.1 cases/100,000 person-years. Of these cases, 75% (46/61) were endemic, 16% (10/61) were outbreak-related (all domestically-acquired), and 8% (5/61) were travel-related. In comparison, the annual combined incidence rate for verotoxigenic *E. coli* infection in Canada for both years was 1.9 cases/100,000 person-years (7, 8).

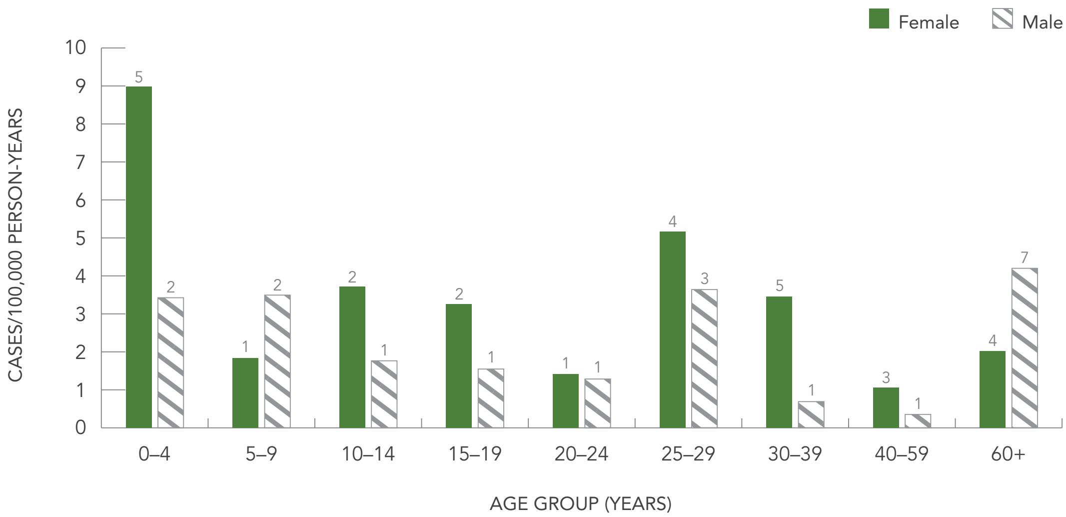
Of the total VTEC cases reported, 69% (42/61) were *E. coli* O157:H7 infections. The combined incidence rate within the sites over the two year period for *E. coli* O157:H7 was 2.1/100,000 person-years. In comparison, the combined incidence rate for *E. coli* O157:H7 in Canada for both years was 1.4 cases/100,000 person-years (2, 3).

In the ON site, the remaining VTEC cases included three *E. coli* O157:non-motile, and one *E. coli* O49:non-motile. In the BC site, the remaining VTEC cases included nine *E. coli* Shiga toxin/verotoxin positive only, one *E .coli* O157: (H antigen not specified), one *E. coli* O111: non-motile, one *E. coli* O48:H45, one *E. coli* O121:H19 and two were untypable. It is important to note that reporting differs between the two sites as testing procedures differ. In both sites, the O157 serotype is routinely tested for, however in British Columbia, more Shiga-toxin testing is done on *E. coli* isolates than in Ontario.

The age- and gender-specific incidence rates among the 46 endemic cases from both sites combined show that females less than five years of age had the highest rate overall (9.0 cases/100,000 person-years) (Figure 5.1). Also, more female cases than male cases were reported over the two year period (27 female cases, 19 male cases).

[3] For this combined 2011–2012 Biennial Report, unless otherwise noted, all results have been combined for both years and for both sites. Where differences were significant (between years), these results are reported on separately.

FIGURE 5.1: Incidence rates of sporadic, human endemic verotoxigenic *E. coli* infection in both the ON and BC sites in 2011 and 2012, by gender and age group



NOTE: The number of cases is indicated above each bar.

5.1.1 Case Exposures

Information was collected for 100% (61/61) of all VTEC infection cases regarding exposure to potential sources of infection in the ten days prior to the onset of illness.

Case-case comparisons were conducted for endemic cases with exposure data by combining both the ON and BC sites. Univariate comparisons identified swimming in a lake, attending a social gathering and going canoeing, kayaking, hiking or camping, to be significantly ($p<0.05$) associated with an increased risk of VTEC infection (Appendix B).

Of the five international travel-related cases, four cases travelled to Central or South America (2 O157:H7, 2 verotoxin-positive only) and one case travelled to the USA (O121:H19).

5.2 Surveillance of Potential Sources

Retail Food

VTEC was detected on 2.8% (19/688) of retail ground beef samples in 2011–2012 in both sentinel sites (Table 5.1). Only one of the ten samples serotyped was O157:H7 positive. The positive sample was included in a national recall (XL Foods Inc.) that was initiated for *E. coli* O157:H7 in beef products.

TABLE 5.1: Verotoxigenic *E. coli* detection data from the integrated surveillance activities in the ON and BC sites in 2011–2012

METHOD	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]				WATER
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE[b]	BROILER CHICKENS[b]	BEEF CATTLE	DAIRY CATTLE	
Detection									
No. of samples tested	…	…	…	688	120	120	240	240	248
No. positive	46	10	5	19	3	0	41	53	76
Percentage positive	..	..	..	2.8%	2.5%	0%	17%	22%	31%
Serotyping									
No. typed	39	10	3	10	3	0	40	51	69
Top 7 pathogenic types[c]									
O157:H7	30	10	2	1	0	0	21	28	6
O111	1	0	0	0	0	0	0	0	2
O103	0	0	0	0	0	0	0	0	9
O121	0	0	1	0	0	0	0	0	2
O145	0	0	0	0	0	0	0	0	1
O26	0	0	0	0	0	0	1	0	4
Other human to non-human matching subtypes[d]									
O157:NM	3	0	0	0	0	0	1	0	0
Other VTEC[e]	3	0	0	9	3	0	17	23	45
Untypable	2	0	0	0	0	0	0	0	0

NOTE: Three water samples contained multiple top 7 pathogenic subtypes.

[a] ON site only. Testing in 2011 was only for the presence of *E. coli* O157 and O157:H7 subtypes.

[b] 2011 only.

[c] Pathogenic VTECs (O157:H7, O26, O45, O103, O111, O121, O145) are listed explicitly if there is at least one positive to report. O45 was not found in 2011–2012.

[d] Additional subtypes found in both human and non-human samples (not in the top 7 list).

[e] "Other VTEC" includes subtypes not falling into either of the previous two lists. The three endemic cases were composed of one O49:NM, one O157, and one O48:H45.

… Not available

.. Not applicable

Farm

Roughly half of all VTEC manure samples on both dairy and beef farms were positive for *E. coli* O157:H7. Of pooled fresh manure samples positive for VTEC collected from beef operations, 53% (21/40) were *E. coli* O157:H7 positive, while on dairy farms, *E. coli* O157:H7 was detected in 55% (28/51) of VTEC-positive samples (Table 5.1).

None of the broiler chicken manure samples tested positive for *E. coli* O157:H7 in 2011, consistent with previous surveillance years. VTEC was also isolated from 2.5% (3/120) of swine manure samples in 2011, but none were positive for O157:H7.

Water

VTEC was detected in 31% (76/248) of water samples collected from beaches in both sentinel sites as well as along the Grand River in the ON site in 2011–2012 (multiple subtypes were detected in some samples). Since transitioning to a new detection method in 2010, the prevalence of VTEC and *E. coli* O157:H7 in water, has increased. A full description of the new method and surveillance results is provided in Johnson et al. (19).

TABLE 5.2: PFGE patterns for pathogenic *E. coli* O157:H7 in both sentinel sites in 2011–2012 compared to results for 2008–2010

PFGE	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]				WATER
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. TYPED IN 2011–2012 (2008–2010)								
No. of samples typed	**30 (27)**	**10 (1)**	**2 (0)**	**1 (0)**	**0 (6)**	**0 (0)**	**21 (40)**	**25 (18)**	**7 (3)**
ECXAI.0008	2 (1)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)
ECXAI.2012	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.0001	1 (1)	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	5 (3)	0 (1)	0 (0)
ECXAI.1845	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)
ECXAI.2607	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (3)	0 (1)	1 (0)
ECXAI.0221	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.1694	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.2353	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.1898	0 (1)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.1182	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)
ECXAI.1301	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	0 (0)	0 (0)
ECXAI.2303	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)
ECXAI.0339	0 (0)	6 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)
ECXAI.1581	0 (0)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)
ECXAI.0014	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)
ECXAI.0266	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)
ECXAI.0407	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)
ECXAI.0821	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)
ECXAI.0825	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (3)	0 (0)	0 (0)
ECXAI.1164	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (1)	0 (0)

PFGE	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]				WATER
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. TYPED IN 2011–2012 (2008–2010)								
No. of samples typed	**30 (27)**	**10 (1)**	**2 (0)**	**1 (0)**	**0 (6)**	**0 (0)**	**21 (40)**	**25 (18)**	**7 (3)**
ECXAI.1288	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (3)	0 (0)	0 (0)
ECXAI.1687	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (0)	2 (0)	0 (0)
ECXAI.2110	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)
ECXAI.2330	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)
ECXAI.2464	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)
ECXAI.2678	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)
ECXAI.2781	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (0)	0 (0)
ECXAI.2897	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)
Other[b]	23 (15)	0 (0)	1 (0)	0 (0)	0 (6)	0 (0)	6 (14)	14 (11)	4 (3)

NOTE: Some samples had multiple PFGE patterns (one dairy sample also contained ECXAI.2903, and one beef sample also contained ECXAI.0702).

[a] ON site only.

[b] Only PFGE patterns with more than one occurrence are listed; the remaining are combined in the “Other” category.

Two endemic cases with PFGE pattern ECXAI.0008 were detected, which is the fifth most common pattern in the PulseNet Canada database (associated with 28 human cases in Canada in 2011–2012).

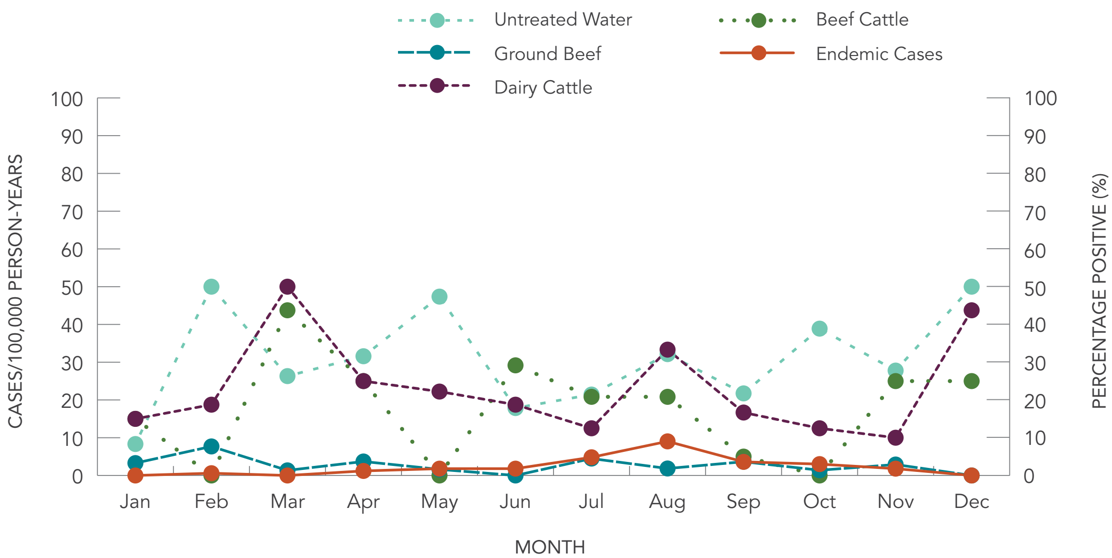
There were also two endemic cases with the same PFGE pattern (ECXAI.0001 and ECXAI.2607) that had been detected in fresh beef cattle manure in 2011–2012 (Table 5.2).

There were two cases of *E. coli* O157:H7 with PFGE pattern ECXAI.0001—one endemic and one outbreak—reported from the sentinel sites in 2011–2012 (Table 5.2). The outbreak case was part of a multi-provincial outbreak in 2012. Collaborative investigation with local, provincial and federal health authorities and food regulatory partners confirmed the source of this outbreak to be beef from XL Foods Inc. One FoodNet Canada ground beef sample that tested positive for *E. coli* O157:H7 during the outbreak period was from a lot number included in the recall by the Canadian Food Inspection Agency. As part of the investigation, additional testing revealed that the *E. coli* O157 found in the ground beef sample had the same PFGE pattern (ECXAI.0001/ECBNI.0012) as defined in the outbreak. Of note, the PFGE pattern ECXAI.0001/ECBNI.0012 was also the most commonly identified *E. coli* O157:H7 PFGE pattern in humans in Canada as reported by PulseNet Canada for 2011–2012.

When comparing the years 2011–2012 to 2008–2010 of surveillance data, few PFGE patterns recurred from the first period to the next. Past results have shown considerable diversity in *E. coli* O157:H7 PFGE patterns, observed both nationally (PulseNet Canada) and within the FoodNet Canada sites.

5.3 Temporal Distribution

FIGURE 5.2: Incidence rate of human endemic cases of verotoxigenic *E. coli* infections, and the prevalence of verotoxigenic *E. coli* in potential non-human sources, by month, ON and BC sites, 2011–2012



NOTES:

1. Pooled manure samples from dairy and beef cattle are for the ON site only, and in 2011, they were only tested for O157 VTEC.
2. 'Month' refers to onset month for human cases and sample collection month for non-human data.
3. Sporadic endemic cases included in analysis.

In 2011–2012, human cases of VTEC in the sentinel sites were higher in the summer, with the highest rate reported in August. Retail ground beef VTEC prevalence rates were low throughout the year. The prevalence of VTEC in the ON site in dairy manure was highest in March.

5.4 Summary of Pathogenic *E. coli* Results

- Verotoxigenic *E. coli* (O157:H7 and non-O157:H7 serotypes) infections continue to be domestically-acquired, as demonstrated by the low number of travel-related cases in 2011–2012. Of the 61 reported cases in the two sites, five were found to be associated with international travel (four with travel to South and Central America, and one with travel to the USA).
- *E. coli* O157:H7 PFGE patterns in both human and non-human samples from 2011–2012 continued to show considerable diversity, as observed nationally and within the FoodNet Canada sites, in past years.

What impact does this have on public health?

- Though a decreasing trend in VTEC infections and VTEC isolated from meats has been observed, a need to remain vigilant exists, including continued efforts to ensure that rates remain low and that food safety messaging continues to highlight the importance of prevention measures when handling and cooking meat.

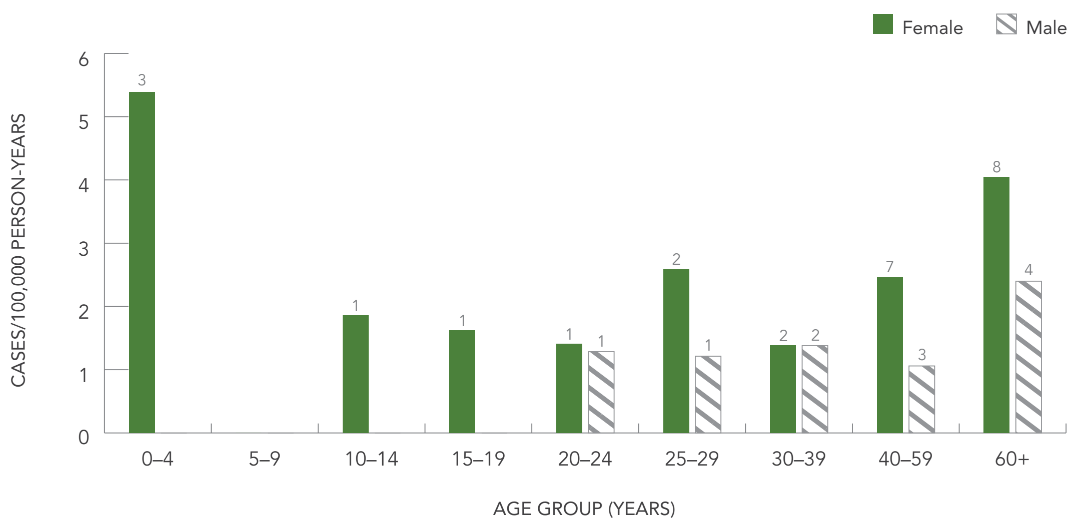
6. *YERSINIA*

6.1 Human Cases

In both the ON and BC sites, a total of 58 cases of human *Yersinia* infection were reported between 2011 and 2012 (combined[4]), representing an incidence rate of 2.9 cases/100,000 person-years. Of these cases, 62% (36/58) were endemic and 21% (12/58) were travel-related. The majority of travel-related cases (9/12) reported travel to Central or South America. A total of 17% (10/58) of human yersiniosis cases were lost to follow-up. Currently, *Yersinia* is not a nationally-notifiable disease, and so the annual national incidence rates are not available for comparison.

Of the 36 endemic cases, 25 (2.5 cases/100,000 person-years) were females and 11 (1.1 cases/100,000 person-years) were males. Incidence rates were highest in females less than 5 years of age (5.4 cases/100,000 person-years) and in females older than 60 years (4.0 cases/100,000 person-years)(Figure 6.1). Of the 12 travel-related cases, 7 (0.7 cases/100,000 person-years) were females and 5 (0.5 cases/100,000 person-years) were males.

FIGURE 6.1: Incidence rates of sporadic, human endemic yersiniosis in both the ON and BC sites in 2011 and 2012, by gender and age group



NOTE: The number of cases is indicated above each bar.

The majority of *Yersinia* isolates subtyped from endemic yersiniosis cases were *Y. enterocolitica*. Of the human *Yersinia* isolates that were subtyped, the majority were *Y. enterocolitica* biotype 4, serotype O:3, considered to be a pathogenic strain.

[4] For this combined 2011–2012 Biennial Report, unless otherwise noted, all results have been combined for both years and for both sites. Where differences were significant (between years), these results are reported on separately.

6.2 Case Exposures

Information was collected for 83% (48/58) of all yersiniosis cases regarding exposure to potential sources of infection in the seven days prior to the onset of illness.

Case-case comparisons were conducted for endemic cases with exposure data combining both the ON and BC sites. No significant risk factors were identified from the univariate comparisons (Appendix B).

6.3 Surveillance of Potential Sources

Farm animals

Yersinia enterocolitica was not found on any of the pooled manure samples collected on 30 farms (Table 6.1). Historically, pathogenic *Y. enterocolitica* (biotype 4, serotype O:3) was found on about 3% (25/832) of farm samples (swine). Only two retail pork chop samples were positive for the pathogenic strain of the 891 samples collected between 2005 and 2010. Historically, pathogenic *Yersinia* has not been found in water samples and thus was discontinued in FoodNet Canada surveillance in 2011.

TABLE 6.1: Number of *Yersinia* isolates detected and subtyped through integrated surveillance activities in 2011–2012

	HUMAN		
METHOD	ENDEMIC	DOMESTIC OUTBREAK	FARM ANIMAL MANURE[a] (SWINE)
Detection			
No. of samples tested	…	…	120
No. of positive samples	36	12	0
Subtyping			
No. of isolates subtyped	36	12	0
Pathogenic *Yersinia enterocolitica*	32	11	0
Yersinia frederiksenii	1	1	0
Yersinia intermedia	2	0	0
Yersinia kristensenii	1	0	0

[a] ON site in 2011.

… Not available

6.4 Summary of *Yersinia* Results

- Findings are consistent with previous years with the majority of *Yersinia* cases being domestically acquired. Among travel-related cases, the majority reported travel to Central or South America between 2011 and 2012.
- The incidence of yersiniosis was higher for females than males for domestically acquired cases.
- None of the swine manure samples in the ON site in 2011 were positive for pathogenic *Yersinia* (biotype 4, serotype O:3). Historically, the prevalence has been around 3% for this subtype.

7. *LISTERIA*

7.1 Human Cases

Human listeriosis is rare and is typically identified in immune-compromised individuals who develop severe disease requiring hospitalization. In both the ON and BC sites, a total of four listeriosis cases (all female) were reported between 2011 and 2012 (combined[5]), three of which were endemic cases, and one of which was travel-related. The combined incidence rate for listeriosis in the two sites was 0.2 cases/100,000 person-years. The annual national incidence rate for listeriosis in 2011–2012 (combined) in all of Canada was 0.4 cases/100,000 person-years.

7.2 Surveillance of Potential Sources

Retail food

In 2011–2012, in the ON and BC sites, *Listeria monocytogenes* was found on all retail meat types (chicken breasts, ground beef, uncooked frozen chicken nuggets, ground chicken, and ground turkey). Fresh herbs were tested in 2012, though no positives (0/229) were detected (Table 7.1). Historically, *L. monocytogenes* has been found on leafy greens and pork chops.

Of the raw meat samples positive for *Listeria monocytogenes* that were further tested to determine MPN/g, 67% (8/12) ground beef, 59% (16/27) chicken breast, 83% (95/114) uncooked frozen chicken nuggets, 67% (139/2017) ground chicken, and 67% (60/89) ground turkey, contained amounts that were below the detection limit (0.3 MPN/g) of the testing method used for bacterial quantification (Appendix C).

TABLE 7.1: Case counts and prevalence of *Listeria monocytogenes*, ON and BC sites, 2011 to 2012

	HUMAN		RETAIL FOOD					
SEROTYPE	ENDEMIC	TRAVEL	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	FRESH HERBS
No. of samples tested	…	…	700	699	567	515	251	229
No. positive	3	1	220	122	116	211	89	0
Percentage positive	..	..	31%	17%	20%	41%	35%	0%

.. Not applicable
… Not available

[5] For this combined 2011–2012 Biennial Report, unless otherwise noted, all results have been combined for both years and for both sites. Where differences were significant (between years), these results are reported on separately.

7.3 Subtype Comparison

Listeria monocytogenes serotypes 1/2a, 1/2b, and 1/2c were the three most common serotypes found in the retail food sources tested (Table 7.2) of which 1/2a and 1/2b are two (of the three) most predominant serotypes in Canada causing human illness (3, 20).

TABLE 7.2: Serotypes of *Listeria monocytogenes*, ON and BC sites, 2011–2012 compared with 2005–2010

SEROTYPE	HUMAN			RETAIL FOOD						FARM ANIMAL (MANURE)			
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
	No. TYPED 2011–2012 (No. TYPED 2005–2010)												
Total	**3 (3)**	**0 (3)**	**1 (0)**	**. (73)**	**219 (204)**	**120 (149)**	**114 (6)**	**209 (7)**	**89 (3)**	**. (4)**	**. (8)**	**. (74)**	**. (15)**
1/2a	2 (2)	0 (3)	0 (0)	. (30)	191 (136)	70 (68)	79 (5)	165 (4)	62 (2)	. (1)	. (5)	. (33)	. (2)
1/2b	1 (0)	0 (0)	0 (0)	. (21)	11 (40)	38 (72)	14 (0)	27 (1)	14 (0)	. (3)	. (3)	. (12)	. (4)
4b	0 (1)	0 (0)	1 (0)	. (1)	10 (8)	2 (2)	3 (1)	1 (0)	8 (1)	. (0)	. (0)	. (21)	. (5)
1/2c	0 (0)	0 (0)	0 (0)	. (20)	3 (12)	7 (6)	6 (0)	12 (2)	2 (0)	. (0)	. (0)	. (0)	. (0)
3a	0 (0)	0 (0)	0 (0)	. (1)	4 (2)	1 (1)	3 (0)	0 (0)	1 (0)	. (0)	. (0)	. (0)	. (0)
3b	0 (0)	0 (0)	0 (0)	. (0)	0 (6)	2 (0)	7 (0)	3 (0)	1 (0)	. (0)	. (0)	. (0)	. (0)
4a	0 (0)	0 (0)	0 (0)	. (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	. (0)	. (0)	. (4)	. (0)
4c	0 (0)	0 (0)	0 (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	. (4)	. (4)
4d	0 (0)	0 (0)	0 (0)	. (0)	0 (0)	0 (0)	1 (0)	0 (0)	1 (0)	. (0)	. (0)	. (0)	. (0)
Untypable	0 (0)	0 (0)	0 (0)	. (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	. (0)	. (0)	. (0)	. (0)

. Not tested

One human case identified in 2011–2012 had PFGE pattern LMAAI.0499, which was also detected in a sample of uncooked chicken nuggets (Table 7.3). However, the PFGE pattern for the AscI enzyme in these two samples did not match and therefore was not likely related to the case.

PulseNet Canada provides information on the most common human PFGE patterns detected at a national level, and these patterns were compared with those detected in the FoodNet Canada sentinel sites in 2011–2012. PFGE patterns LMAAI.0001, LMAAI.0015, LMAAI.0126 and LMAAI.0204 were found in retail meat sources and were also the 2nd, 5th, 4th and 3rd ranked patterns found in humans. A complete list of PFGE patterns identified in the ON and BC sites in 2011–2012, as well as historical PFGE pattern data, can be found in Appendix E.

TABLE 7.3: Select PFGE patterns among *Listeria monocytogenes* cases and samples, ON and BC sites, 2011–2012 compared with 2005 through 2010

PATTERN	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE[b]				HUMAN TOP 5 RANKING[a]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. OF SAMPLES FOR 2011–2012 (No. FOR 2005–2010)														
No. subtyped	3 (4)	0 (3)	1 (0)	. (73)	218 (204)	120 (149)	114 (6)	210 (7)	89 (3)	. (12)	. (4)	. (8)	. (74)	. (15)	
LMAAI.0182	1 (0)	0 (0)	0 (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (1)	. (0)	. (0)	. (0)	
LMAAI.0499	1 (0)	0 (0)	0 (0)	. (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	. (0)	. (0)	. (0)	. (0)	. (0)	
LMAAI.0563	1 (0)	0 (0)	0 (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	. (0)	. (0)	. (0)	
LMAAI.0003	0 (1)	0 (0)	0 (0)	. (1)	0 (1)	0 (1)	1 (0)	0 (0)	0 (0)	. (0)	. (0)	. (0)	. (0)	. (0)	
LMAAI.0093	0 (1)	0 (0)	0 (0)	. (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	. (1)	. (11)	. (0)	
LMAAI.0265	0 (1)	0 (0)	0 (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	. (0)	. (0)	. (0)	
LMAAI.0423	0 (1)	0 (0)	0 (0)	. (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	. (0)	. (1)	. (0)	
LMAAI.0001	0 (0)	0 (3)	0 (0)	. (3)	2 (19)	1 (6)	26 (2)	7 (0)	6 (1)	. (0)	. (0)	. (0)	. (0)	. (0)	2
LMAAI.1069	0 (0)	0 (0)	1 (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	. (0)	. (0)	. (0)	
LMAAI.0015	0 (0)	0 (0)	0 (0)	. (0)	4 (5)	0 (0)	2 (0)	1 (1)	0 (0)	. (0)	. (0)	. (0)	. (0)	. (0)	5
LMAAI.0126	0 (0)	0 (0)	0 (0)	. (3)	2 (5)	3 (6)	2 (0)	1 (0)	0 (0)	. (0)	. (0)	. (0)	. (5)	. (0)	4
LMAAI.0204	0 (0)	0 (0)	0 (0)	. (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	. (1)	. (0)	. (0)	. (9)	. (5)	3
LMAAI.0234	0 (0)	0 (0)	0 (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	. (1)	. (0)	. (0)	. (0)	. (0)	1

NOTE: Patterns listed are only those in the top five PulseNet Canada ranking of most common patterns and those that were found in FoodNet Canada human cases.

. Not tested

[a] Most common national patterns, PulseNet Canada, 2011, 2012.

[b] ON site only.

7.4 Summary of *Listeria monocytogenes* Results

- In 2012, fresh herbs were tested for *L. monocytogenes* though the pathogen was not detected. As in previous years, pathogenic strains of *L. monocytogenes* were recovered in 2011–2012 from samples of retail skinless chicken breasts and ground beef, and were also found on uncooked chicken nuggets, ground chicken and ground turkey.
- The scientific literature suggests that abattoirs and meat processing environments rather than farm animals may be an important source of *L. monocytogenes* (21). Although testing of farms for the pathogen was discontinued in 2008, the retail meat data from many historical surveillance years indicate that pathogenic serotypes of *L. monocytogenes* are present on raw chicken, beef, and pork meat sold at retail, as well as in bagged leafy greens.
- Although, based on one PFGE enzyme, there was a match between a human case and a sample of uncooked chicken nuggets in 2011–2012, there were no matches between sources and sentinel site cases of listeriosis in 2011–2012 when both PFGE enzyme patterns were compared. Also, based on one enzyme, a few matches were identified between meat isolates (chicken and beef) and four of the top five PFGE patterns reported at the national level in humans (according to PulseNet Canada data).

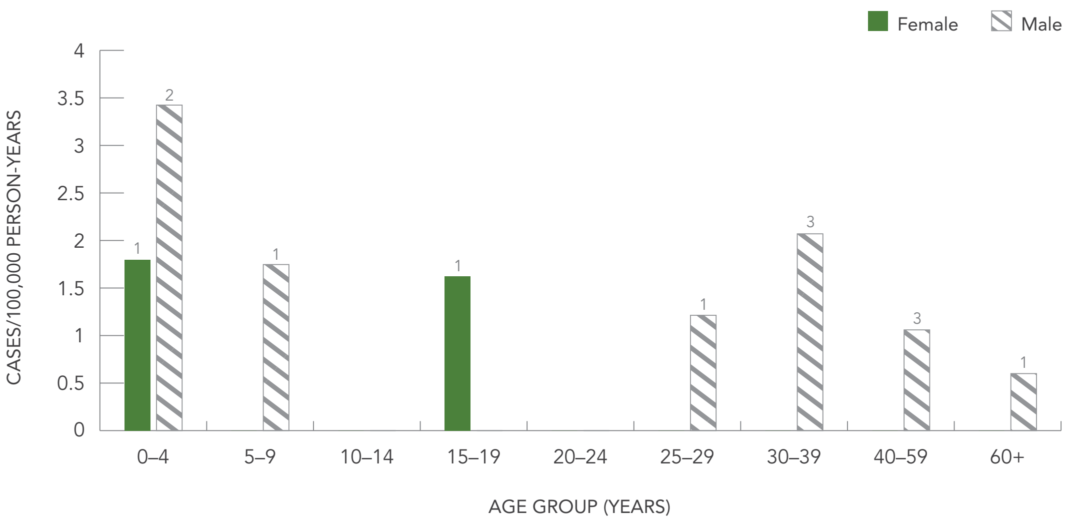
8. *SHIGELLA*

8.1 Human Cases

In both the ON and BC sites, a total of 44 cases of human *Shigella* infection were reported between 2011 and 2012 (combined[6]), representing an incidence rate of 2.2 cases/100,000 person-years. Of these cases, 30% (13/44) were endemic and 61% (27/44) were travel-related. The majority of travel-related cases reported travel to Asia (22/27). A total of 9% (4/44) of human shigellosis cases were lost to follow-up. In comparison, the annual combined incidence rate for shigellosis in Canada for both years was 3.1 cases/100,000 person-years (7, 8).

Of the 13 endemic cases, 11 (1.1 cases/100,000 person-years) were males and 2 (0.2 cases/100,000 person-years) were females. Incidence rates were highest in males less than 5 years of age (3.4 cases/100,000 person-years) and in males between the ages of 30 to 39 (2.1 cases/100,000 person-years); Figure 8.1). Of the 27 travel-related cases, 13 (1.3 cases/100,000 person-years) were males and 14 (1.4 cases/100,000 person-years) were females.

FIGURE 8.1: Incidence rates of sporadic, endemic shigellosis in both the ON and BC sites in 2011 and 2012, by gender and age group



NOTE: The number of cases is indicated above each bar.

The majority of *Shigella* isolates subtyped from endemic shigellosis cases were *S. flexneri*. Between 2011 and 2012, only one endemic *Shigella* isolate was subtyped as *S. sonnei*.

6 For this combined 2011–2012 Biennial Report, unless otherwise noted, all results have been combined for both years and for both sites. Where differences were significant (between years), these results are reported on separately.

8.2 Surveillance of Potential Sources

Shigella testing of bagged leafy greens was last performed in the ON site in 2009–2010. Of the 474 samples tested in this period, 1 (0.21%) *Shigella* positive sample was identified using PCR methods. The one PCR positive was also tested by culture methods and was negative, therefore viability could not be determined.

8.3 Summary of *Shigella* Results

- The majority of *Shigella* infections were travel-related. Asia was the most frequently reported travel destination. Historically, FoodNet Canada found *Shigella* bacteria on one sample of bagged leafy greens using PCR methods.

9. VIRUSES

9.1 Human Cases

Although norovirus outbreaks are nationally reportable (as of 2009), individual cases are not, and human infections of norovirus or rotavirus are not reported to FoodNet Canada from the sentinel sites.

9.2 Exposure Surveillance

In 2012, fresh herbs were tested for the presence of norovirus and rotavirus. Norovirus was found on 1.3% (8/597) of samples by PCR. In 2011, 0.5% (3/597) of samples of soft berries were positive for norovirus. Rotavirus was not found on fresh herbs and only 0.2% (1/595) of soft berries were positive by PCR.

TABLE 9.1: Norovirus and Rotavirus subtyping in potential sources, ON and BC sites, 2011–2012 with comparison to 2005–2010

PATTERN	RETAIL FOOD						FARM ANIMAL MANURE				TOTAL
	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	SOFT BERRIES	LEAFY GREENS	HERBS	SWINE[c]	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	No. OF SAMPLES FOR 2011–2012 (No. FOR 2005–2010)										
Norovirus											
No. genotyped	. (1)	. (0)	. (0)	3 (.)	. (22)	8 (.)	. (27)	. (11)	. (7)	. (3)	82
GII											
non-4	. (0)	. (0)	. (0)	3 (.)	. (0)	3 (.)	. (23)	. (1)	. (1)	. (0)	31
4[a]	. (1)	. (0)	. (0)	0 (.)	. (6)	5 (.)	. (3)	. (6)	. (5)	. (2)	28
GI	. (0)	. (0)	. (0)	0 (.)	. (16)	0 (.)	. (0)	. (4)	. (1)	. (0)	21
GIII	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (1)	1
NLV[b]	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (1)	. (0)	. (0)	. (0)	1
Rotavirus											
No. genotyped	. (5)	. (10)	. (13)	1 (.)	. (1)	0 (.)	. (19)	. (0)	. (0)	. (7)	56
Species A	. (5)	. (10)	. (13)	1 (.)	. (1)	0 (.)	. (19)	. (0)	. (0)	. (7)	56

NOTE: Herb and leafy greens results are for both sentinel sites; all other data are from the ON site only.

. Not tested

[a] Two herb samples with GII.4 also contained GI.

[b] Norwalk-like virus.

[c] Five swine samples from 2005 had porcine sapovirus GIII and two had porcine enterovirus type 10 group 3.

Norovirus genogroups GI, GII and GIV are pathogenic to humans (22); genotype GII.4 is associated with person-to-person outbreaks and GI is associated with foodborne and waterborne outbreaks (23). In 2011–2012, fresh herbs and soft berries sampled in both sentinel sites were found to have pathogenic norovirus genogroup GII (Table 9.1). Historically, fresh leafy greens have been found to be contaminated with GII.4 and GI. Other historical results from the ON site found GII on all manure samples, GI on broiler and beef cattle manure and GIII on dairy cattle. On fresh retail meats in the ON site, GII.4 was found on one sample of pork chops.

Rotavirus species A was the only species found in the potential sources that FoodNet Canada has monitored. It can be both a human and animal pathogen. In 2011, during sampling in both sentinel sites, one soft berry sample was found to be positive for species A. Historically, it has also been found in the ON site on retail ground beef, chicken breast, pork chops and leafy greens, as well as in pooled swine and dairy cattle manure.

9.3 Summary of Norovirus and Rotavirus Results

- FoodNet Canada surveillance found pathogenic norovirus on retail soft berries and fresh herbs in 2011–2012. Historically, pathogenic subtypes have also been found in food animal manure, as well as retail pork chops and leafy greens.

10. PARASITES

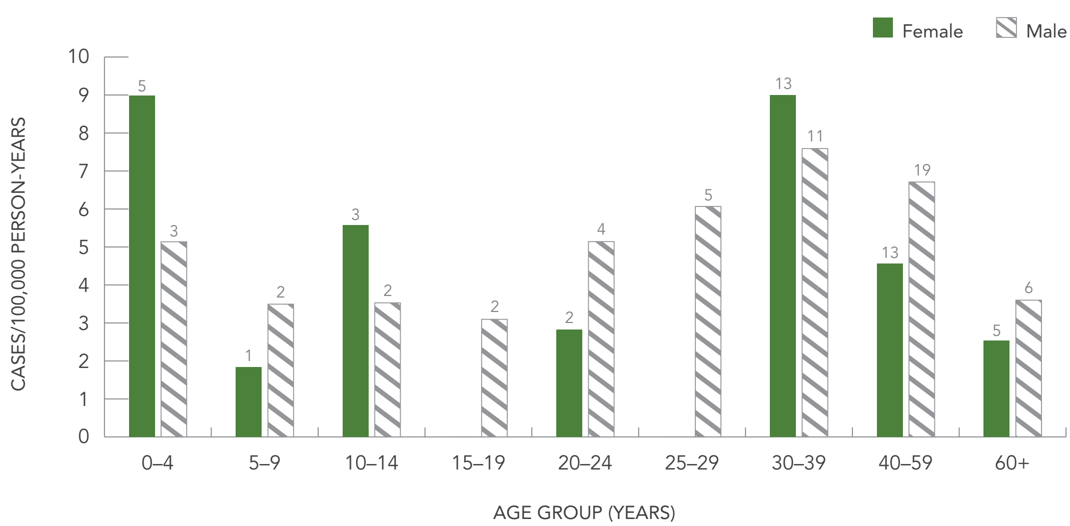
10.1 *Giardia*

10.1.1 Human Cases

In both the ON and BC sites, a total of 238 human cases of giardiasis were reported between 2011 and 2012 (combined[7]), representing an incidence rate of 11.9 cases/100,000 person-years. Of these cases, 40% (96/238) were endemic (4.8 cases/100,000 person-years), 12% (28/238) were non-endemic (1.4 cases/100,000 person-years) and 32% (76/238) were travel-related (3.8 cases/100,000 person-years). A total of 16% (38/238) of human giardiasis cases were lost to follow-up. In comparison, the annual combined incidence rate for giardiasis in Canada for both years was 11.1 cases/100,000 person-years (7, 8).

Of the 96 endemic cases, 54 (5.4 cases/100,000 person-years) were males and 42 (4.2 cases/100,000 person-years) were females (Figure 10.1). Incidence rates were highest in females between the ages of 0–4 (9.0 cases/100,000 person-years) and 30–39 (9.0 cases/100,000 person-years). Of the 76 travel-related cases, 44 (4.4cases/100,000 person-years) were males and 32 (3.2 cases/100,000 person-years) were females.

FIGURE 10.1: Incidence rates of sporadic, human endemic giardiasis in both the ON and BC sites in 2011 and 2012, by gender and age group



NOTE: The number of cases is indicated above each bar.

[7] For this combined 2011–2012 Biennial Report, unless otherwise noted, all results have been combined for both years and for both sites. Where differences were significant (between years), these results are reported on separately.

10.1.2 Case Exposures

Information was collected for 84% (200/238) of all giardiasis cases regarding exposure to potential sources of infection in the 25 days prior to the onset of illness.

Case-case comparisons were conducted for endemic cases with exposure data combining both the ON and BC sites. Univariate comparisons identified swimming in a river to be significantly ($p<0.05$) associated with an increased risk of giardiasis (Appendix B).

10.1.3 Surveillance of Potential Sources

Retail food

In 2011–2012, of the 599 soft berry samples collected in the sentinel sites (Table 10.1), *Giardia* contamination was confirmed by molecular methods in 54 (9.0%) of the samples. Testing by microscopy led to the identification of 14 (2.3%) positives. Six in 598 (1.0%) of fresh herbs were found to be contaminated with *Giardia*, according to PCR testing. Of the six PCR positive samples, four were then tested by microscopy, resulting in three positives (3/598; 0.5%).

TABLE 10.1: *Giardia* detection, ON and BC sites, 2011 to 2012

METHOD	HUMAN	RETAIL FOOD		WATER[a]
	ENDEMIC CASES	SOFT BERRIES	HERBS	
	2011–2012			
Microscopy				
No. of samples tested	...	599	4[b]	62
No. of positive samples	96	14	3	39
Percentage of samples positive	..	2.3%	75%	63%
Polymerase chain reaction (PCR) assay				
No. of samples tested	...	599	598	.
No. of positive samples	...	54	6	.
Percentage of samples positive	..	9.0%	1.0%	..

[a] Samples of untreated surface water were collected from five sites along the Grand River and three recreational beaches in the ON site in 2011/2012 as well as four beaches in the BC site in 2012.

[b] Only PCR positives are tested

. Not tested

.. Not applicable

... Not available

Farm animals

Testing of pooled manure samples collected from farm animals for the presence of *Giardia* stopped in 2009. Historical subtyping data can be found in Table 10.2.

Water

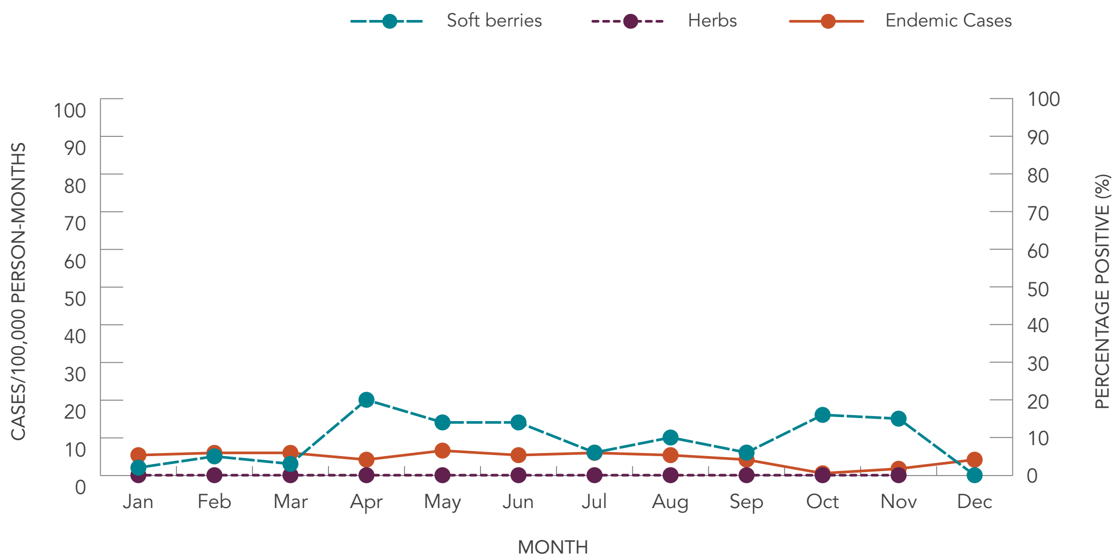
Giardia was found in 39 of 62 (63%) water samples taken from both sentinel sites (Table 10.1).

Mean concentrations of *Giardia* cysts were lowest in the summer (June to August) for the 2011 to 2012 period, due to sampling being limited to beaches in the summer months.

10.1.4 Temporal Distribution

The monthly incidence rate of reported cases varied from 0.6 to 6.6/100,000, with the highest number in May in the 2011–2012 period (Figure 10.2). *Giardia* was found on soft berries and was also detected, though rarely, on fresh herbs.

FIGURE 10.2: Incidence rate of human endemic cases of giardiasis, and the prevalence of *Giardia* in potential non-human sources, by month, ON and BC sites, 2011–2012



NOTES:

1. 'Month' refers to onset month for human cases and sample collection month for non-human data.
2. Sporadic endemic cases included in analysis.

10.1.5 Subtype Comparison

TABLE 10.2: *Giardia* subtyping, ON and BC sites, 2011 to 2012 compared with 2005 to 2010

METHOD	RETAIL FOOD						FARM ANIMAL MANURE[c]				WATER
	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	SOFT BERRIES	LEAFY GREENS	HERBS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	
	2011–2012 (2005–2010)										
DNA sequencing											
No. of samples sequenced	. (18)	. (10)	. (10)	54 (.)	. (23)	6 (.)	. (63)	. (7)	. (73)	. (43)	3 (7)
Genotype											
Assemblage A	. (0)	. (0)	. (0)	0 (.)	. (1)	0 (.)	. (0)	. (1)	. (0)	. (3)	.
Assemblage B	. (18)	. (10)	. (9)	54 (.)	. (22)	6 (.)	. (58)	. (4)	. (0)	. (18)	.
Assemblage E	. (0)	. (0)	. (1)	0 (.)	. (0)	0 (.)	. (5)	. (2)	. (73)	. (22)	.
Speciation											
Microti	.	.	.	.	.	.	.	.	.	.	2[a] (7[b])
Lamblia	.	.	.	.	.	.	.	.	.	.	0 (0)
Mixed	.	.	.	.	.	.	.	.	.	.	1[b] (0)

[a] One drinking water intake location on the Grand River, ON; one beach site, ON.

[b] Drinking water intake location on the Grand River, ON.

[c] ON site only.

. Not tested

Assemblages A and B are pathogenic to humans. Assemblage B was detected in soft berries and fresh herbs in 2011–2012. Historically, it has also been found in the other sources listed in Table 10.2, with the exception of beef cattle manure and water. *Giardia microti*, a non-pathogenic species, was found in water samples, although these results should be interpreted with caution since the method provides insufficient discrimination. Very few of the water samples were submitted for sub-typing, given the development stage of the typing method for water. Subtyping was discontinued after 2012 for *Giardia* in water.

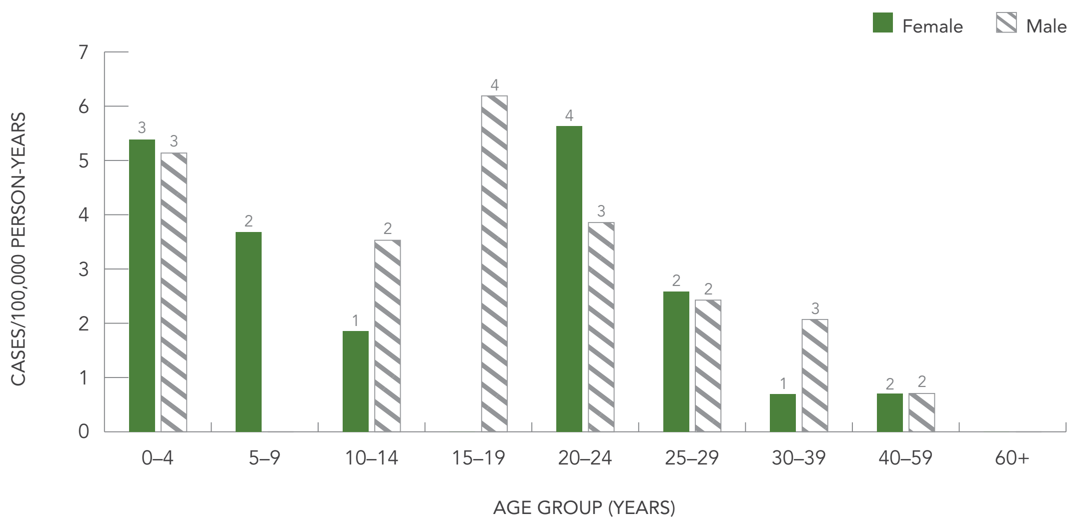
10.2 *Cryptosporidium*

10.2.1 Human Cases

In both the ON and BC sites, a total of 53 cases of human cryptosporidiosis were reported between 2011 and 2012 (combined), representing an incidence rate of 2.7 cases/100,000 person years. Of these cases, 64% (34/53) were endemic and 26% (14/53) were travel-related. A total of 9% (5/53) of human cryptosporidiosis cases were lost to follow-up. In comparison, the annual combined incidence rate for cryptosporidiosis in Canada for both years was 1.6 cases/100,000 person-years (7, 8).

Of the 34 endemic cases, 19 (1.9 cases/100,000 person-years) were males and 15 (1.5 cases/100,000 person-years) were females (Figure 10.1). Incidence rates were highest in males between the ages of 15–19 (6.2 cases/100,000 person-years).

FIGURE 10.3: Incidence rates of sporadic human endemic cryptosporidiosis in both the ON and BC sites in 2011 and 2012, by gender and age group



NOTE: The number of cases is indicated above each bar.

10.2.2 Case Exposures

Information was collected for 91% (48/53) of all cryptosporidiosis cases regarding exposure to potential sources of infection in the 12 days prior to the onset of illness.

Case-case comparisons were conducted for endemic cases with exposure data combining both the ON and BC sites. Univariate comparisons identified a number of significant exposure factors among cryptosporidiosis cases compared to other disease cases. Working in agriculture/food handling, swimming in a pool, consuming unpasteurized milk, and visiting a farm, petting zoo or fair were significantly ($p<0.05$) associated with an increased risk of cryptosporidiosis (Appendix B).

10.2.3 Surveillance of Potential Sources

Retail food

In 2011–2012, *Cryptosporidium* was detected via PCR in two of 599 (0.3%) soft berry samples (Table 10.3). Using microscopy, 12 out of 599 (2.0%) samples were positive. Fresh herbs were also tested; PCR methods did not detect any *Cryptosporidium* on the 598 herb samples collected by FoodNet Canada. PCR-positive soft berries were subtyped as *C. parvum*, which is pathogenic to humans.

TABLE 10.3: *Cryptosporidium* detection, ON and BC sites, 2011 to 2012

METHOD	HUMAN	RETAIL FOOD		WATER
	ENDEMIC CASES	SOFT BERRIES	HERBS	
	2011–2012			
Microscopy				
No. of samples tested	…	599	.	62
No. of positive samples	34	12	.	35
Percentage of samples positive	..	2.0%	..	56%
Polymerase chain reaction (PCR) assay				
No. of samples tested	.	599	598	.
No. of positive samples	.	2	0	.
Percentage of samples positive	..	0.3%	0.0%	..

. Not tested

.. Not applicable

… Not available

Farm animals

Pathogenic strains of *Cryptosporidium* have been found in manure samples (on farms) historically (Table 10.4).

Water

In 2011–2012, *Cryptosporidium* was detected in 35 of 62 (56%) samples of untreated surface water in the ON and BC sites (Table 10.3). *C. andersoni* was the most common genotype (Table 10.4). It should be noted that *C. andersoni*, although not commonly associated with human infections, has been implicated in some cases of cryptosporidiosis in immunocompetent individuals (24, 25), suggesting that it might be mildly infectious. The two most common human pathogenic strains, *C. hominis and C. parvum* (26), were detected in two and six of the 28 samples, respectively, that underwent DNA sequencing.

TABLE 10.4: *Cryptosporidium* subtyping, ON and BC sites, 2011 to 2012 compared with 2005–2010

METHOD	RETAIL FOOD						FARM ANIMAL MANURE				WATER	TOTAL
	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	SOFT BERRIES	LEAFY GREENS	HERBS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE		
	2011–2012 (2005–2010)											
DNA sequencing												
No. of isolates sequenced	. (1)	. (2)	. (4)	2 (.)	. (28)	0 (.)	. (55)	. (8)	. (28)	. (24)	28 (127)	307
Genotype												
Andersoni	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (1)	. (27)	. (9)	7 (65)	109
Parvum[a]	. (1)	. (2)	. (4)	2 (.)	. (28)	0 (.)	. (31)	. (6)	. (1)	. (11)	6 (4)	96
Pig II	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (20)	. (0)	. (0)	. (0)	0 (0)	20
Hominis[ab]	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	2 (10)	12
Ubiquitum[c]	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	4 (8)	12
Baileyi	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	4 (5)	9
Muris	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (3)	. (1)	. (0)	. (0)	0 (1)	5
Muskrat I	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	0 (5)	5
Skunk	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	0 (5)	5
Deer Mouse III	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	1 (2)	3
Muskrat II	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	1 (2)	3
W25	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	1 (2)	3
Bovis	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (2)	0 (0)	2
Deer-Like	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (2)	0 (0)	2
Suis	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (1)	. (0)	. (0)	. (0)	0 (1)	2
W12	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	0 (2)	2
Other	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	2 (12)	14
Unknown	. (0)	. (0)	. (0)	0 (.)	. (0)	0 (.)	. (0)	. (0)	. (0)	. (0)	0 (3)	3

NOTES: 1) Historical samples from 2005–2010 are from the ON site. Not all positive samples were sequenced. However, some samples have more than one sequencing result; consequently, the column total may exceed the total number sequenced; 2) Subtyping of human samples is not conducted and thus is not reported.

[a] Known to be pathogenic to humans, while other strains (e.g. *Andersoni*, *Suis* and Pig II) have been detected in humans less frequently (26).

[b] Only found in humans.

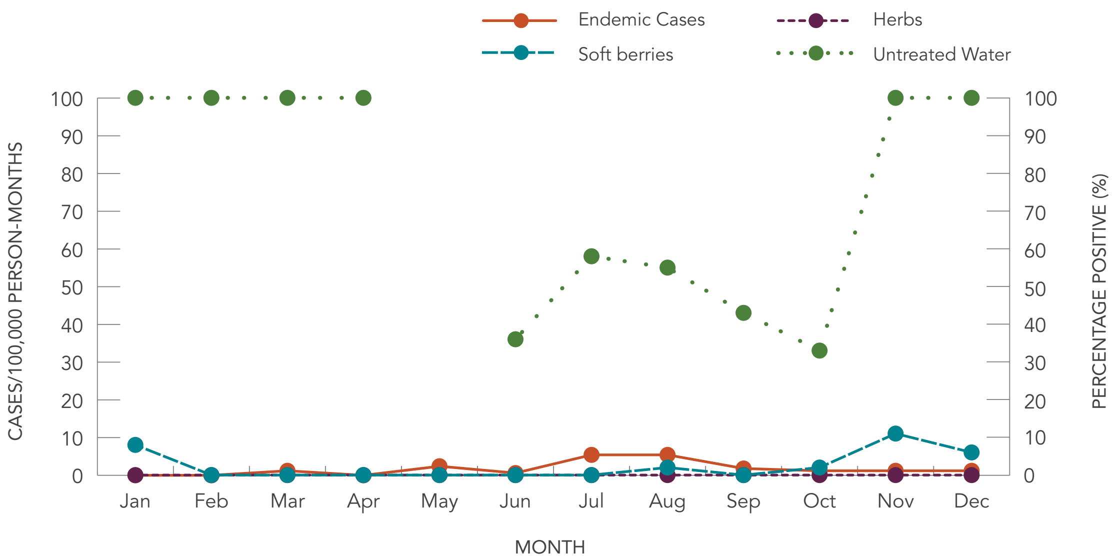
[c] Previously named *Cryptosporidium* cervine.

. Not tested

10.2.4 Temporal Distribution

Endemic cases of cryptosporidiosis occurred mostly in the summer months (Figure 10.4). The prevalence of *Cryptosporidium* in water was lower in the summer months. The detection of *Cryptosporidium* was low on soft berries except in the months of November, December and January.

FIGURE 10.4: Incidence of human endemic cases of cryptosporidiosis and the prevalence of *Cryptosporidium* in potential non-human sources, by month, ON and BC sites, 2011–2012



NOTES:

1. 'Month' refers to onset month for human cases and sample collection month for non-human data.
2. Sporadic endemic cases included in analysis.

10.3 *Cyclospora*

In both the ON and BC sites, a total of nine cases of human cyclosporiasis were reported between 2011 and 2012 (combined), representing an incidence rate of 0.5 cases/100,000 person-years. Of these nine cases, 78% (7/9) were travel-related and 11% (1/9) was endemic. One case (11%) was lost to follow-up. In comparison, the annual incidence rate for cyclosporiasis in Canada for both years was 0.36 cases/100,000 person-years (7, 8).

In total, in both sites, 43% (3/7) of people with travel-related cyclosporiasis reported travel to the Americas (South or Central locations), whereas 29% (2/7) reported travelling to Asia and another 29% (2/7) to the United States.

Cyclosporiasis is not considered to be endemic to Canada. Therefore, active surveillance for *Cyclospora* was not performed for the on-farm and water surveillance components of the FoodNet Canada program. However, soft berries and herbs were tested for the parasite. Initial pre-screening by molecular methods identified *Cyclospora* on six of 599 (1.0%) soft berry samples (Table 10.4). However, it could not be determined whether the oocysts were infectious. None were found on herb samples. Historically, *Cyclospora cayetanensis* infection was found in human cases as well as bagged leafy greens in 2005–2010.

TABLE 10.5: *Cyclospora* detection and subtyping, ON and BC sites, 2011–2012

	HUMAN	RETAIL FOOD		
METHOD	ENDEMIC CASES	SOFT BERRIES	LEAFY GREENS	HERBS
Microscopy				
No. of samples tested	…	599	.	.
No. of positive samples	1	4	.	.
Percentage of samples positive	..	0.7%	..	..
Polymerase chain reaction (PCR) assay				
No. of samples tested	.	599	.	598
No. of positive samples	.	6	.	0
Percentage of samples positive	..	1.0%	..	0.0%
DNA sequencing	**2011–2012 (2005–2010)**			
C. cayetanensis	0 (4)	4 (.)	. (6)	0 (.)

. Not tested
.. Not applicable
… Not available

10.4 *Entamoeba*

Amoebiasis cases were reported to the ON site as *Entamoeba histolytica/dispar* which does not distinguish if the isolate is pathogenic or not. Between 2011 and 2012, in the ON site, 61 human cases of amoebiasis were reported, representing an incidence rate of 3.1 cases/100,000 person-years. Of these cases, 21% (13/61) were travel-related, 34% (21/61) were classified as endemic and 34% (21/61) were non-endemic cases related to recent immigration. A total of 10% (6/61) of human amoebiasis cases were lost to follow-up. Of the endemic cases, six (0.6 cases/100,000 person-years) were females and 15 (1.5 cases/100,000 person-years) were males. Amoebiasis cases were not reported to the BC site in 2011/2012.

Amoebiasis was removed from the Canadian Notifiable Disease Surveillance System as of January 2000 (27); therefore, comparative incidence data cannot be provided for Canada.

Entamoeba is a human intestinal pathogen. Although not considered a zoonotic agent, *Entamoeba* has been known to infect dogs (28). FoodNet Canada does not test for the organism in exposure sources (food, farm animals, and water).

10.5 Integrated Overview

Cryptosporidium was found in 2011–2012 on soft berries and in untreated surface water. *Giardia* was detected on soft berries and herbs, and water in the same period. Also, *Cyclospora* was found on soft berries. However, the viability of these pathogens was unable to be determined.

11. *EPISODIC STUDIES*

While continuous surveillance in the sentinel sites provides the core data for FoodNet Canada's analyses and reporting activities, intermittent surveillance activities are conducted to inform specific hypotheses or research questions in order to complement results obtained from the continuous activities.

Testing for parasites and viruses in soft berries and herbs

In 2011, soft berries were sampled in both sites for parasites and viruses and in 2012, fresh herbs were sampled. Prevalence and subtyping results for these retail products can be found in the Parasites and Viruses chapters. This section will focus on the country that produced the food and provide a descriptive look at the contamination rates for products from particular countries.

SOFT BERRIES

In 2011, 599 samples of soft berries were tested for enteric pathogens. Of these, 134 were blackberries, 173 were blueberries, 123 were raspberries and 169 were strawberries.

Giardia was detected by polymerase chain reaction (PCR) in 12% (7/58) of soft berries sold at retail in both sentinel sites that were grown in Canada, and at varying rates above and below this value for products grown in other countries [8.4% (25/298) United States, 8.8% (13/147) Mexico, 5.3% (4/76) Chile, 23% (3/13) Argentina, 67% (2/3) Uruguay, 0% (0/2) in Guatemala and 0% (0/2) New Zealand]. All samples regardless of country of origin were Assemblage B genotype, which can be pathogenic to humans.

There were some seasonal variations in the *Giardia* results. Positive results found on Canadian sourced products were collected in the summer and fall. For internationally sourced products, the results were: Argentina, fall; Chile, spring; Mexico, all seasons; United States, spring, summer, fall; and Uruguay, fall. Much of this variation is from the samples being much smaller and often zero in certain seasons, likely due to lack of available products in the stores from which to select. This may reflect differences in the growing seasons of the source countries and industry dynamics in the source country and in Canada. Some exemptions include Chile, with 0% (0/42) positive in winter and 12% (4/34) positive in spring (no samples for the remaining seasons). Also, the United States had 0% (0/31) positive in winter and 14% (10/72) in spring, 8.4% (9/107) in summer and 6.8% (6/88) in fall.

Cryptosporidium was detected on 0.7% (2/298) of samples from the United States, both of which were *C. parvum*. None were detected in 58 Canadian samples.

Cyclospora was found at low levels in Canadian samples [1.7% (1/58)], the United States [1.0% (3/298)], and Mexico [0.7% (1/147)]. Of the two samples imported from Guatemala, one was positive (50%).

Norovirus was detected in samples from Mexico [1.4% (2/147)] and the United States [0.3% (1/297)]. All positives were genotype II.3. One sample of 296 of United States origin was positive for rotavirus, species A.

FRESH HERBS

In 2012, a variety of fresh herbs (598 in total) were tested for enteric pathogens. This study sample comprised 1 arugula, 69 basil, 6 bay, 47 chives, 59 cilantro, 1 coriander, 62 dill, 1 fenugreek, 1 lemon grass, 7 marjoram, 52 mint, 45 oregano, 93 parsley, 36 rosemary, 42 sage, 16 savoury, 3 sorrel, 21 tarragon, 34 thyme and 2 unclassified herbs, hereafter referred to as "other".

In 2012, *Giardia* was detected on 3.6% (1/28) of samples originating from the Dominican Republic, 2.4% (1/41) from Columbia, 2.0% (3/151) from the United States, and 1.5% (1/68) from Israel. All genotypes were assemblage B.

Norovirus was found on 5.9% (4/68) of samples that originated from Israel, 2.4% (1/41) from Columbia, and 2.0% (3/150) from the United States. The positive isolate from Columbia was GII.3 genotype, from Israel, three positive isolates were GII.4 and one was GII.2, and from the United States, two isolates were GII.4 and one was GII.3.

Cryptosporidium, *Cyclospora* and rotavirus were not detected on fresh herbs.

TABLE 11.1: Parasite and virus detection via polymerase chain reaction (PCR) assay in the ON and BC sites in 2011–2012

	CANADA (n=58)	UNITED STATES (n=298)	MEXICO (n=147)	CHILE (n=76)	ARGENTINA (n=13)	URUGUAY (n=3)	GUATEMALA (n=2)	NEW ZEALAND (n=2)	TOTAL (n=599)
Soft berries									
Giardia	12%	8.4%	8.8%	5.3%	23%	67%	0%	0%	9.0%
Cryptosporidium	0%	0.7%	0%	0%	0%	0%	0%	0%	0.3%
Cyclospora	1.7%	1.0%	0.7%	0%	0%	0%	50%	0%	1.0%
Norovirus[a]	0%	0.3%	1.4%	0%	0%	0%	0%	0%	0.5%
Rotavirus[a]	0%	0.3%	0%	0%	0%	0%	0%	0%	0.2%

[a] The sample sizes were 57 for Canada, and 297 for the United States.

	CANADA (n=133)	UNITED STATES (n=151)	MEXICO (n=162)	ISRAEL (n=68)	COLOMBIA (n=41)	DOMINICAN REPUBLIC (n=28)	UNITED STATES AND MEXICO (n=3)	UNKNOWN (n=12)	TOTAL (n=598)
Fresh Herbs									
Giardia	0%	2.0%	0%	1.5%	2.4%	3.6%	0%	0%	1.0%
Cryptosporidium	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cyclospora	0%	0%	0%	0%	0%	0%	0%	0%	0%
Norovirus[a]	0%	2.0%	0%	5.9%	2.4%	0%	0%	0%	1.3%
Rotavirus[a]	0%	0%	0%	0%	0%	0%	0%	0%	0%

[a] The sample size was 150 for the United States.

12. SOURCE ATTRIBUTION

FoodNet Canada analyses the sources of gastrointestinal illness using a multi-pronged approach. Using multiple methodologies provides a more complete picture of the sources of illness. These methodologies include microbial subtyping approaches, comparative exposure assessments, epidemiological studies (case-control, case-case, cohort, outbreak), intervention studies and expert elicitation methods. These methodologies have been applied to a number of pathogens to date (Table 12.1). Work is underway to combine the results from the various methods, on a pathogen by pathogen basis, to provide an overall narrative on the contribution of food and water sources to enteric illness.

TABLE 12.1: FoodNet Canada source attribution activities

PATHOGEN	CASE-CASE STUDIES	CASE-CONTROL STUDIES	COMPARATIVE EXPOSURE ASSESSMENT	MICROBIAL SUBTYPING APPROACH	OUTBREAK DATA ANALYSIS	EXPERT ELICITATION	MOST LIKELY SOURCE ANALYSIS
Campylobacter	X	X	X	X	X	X	X
Salmonella	X	X		X	X	X	X
Cryptosporidium	X	X		No human subtyping	X	X	X
Giardia	X	X		Insufficient discrimination	X	X	X
VTEC	X				X	X	X
Other pathogens					X	X	X

SOURCE ATTRIBUTION STUDIES PUBLISHED:

- Butler A, Pintar K, Thomas K. "Expert elicitation as a means to attribute 28 enteric pathogens to foodborne, waterborne, animal contact and person-to-person transmission routes." Foodborne Pathogens and Disease. Accepted Sept 2014.
- David JM, Ravel A, Nesbitt A, Pintar K, Pollari F. "Assessing multiple foodborne, waterborne and environmental exposures of healthy people to potential enteric pathogen sources: effect of age, gender, season, and recall period." Epidemiology & Infection. 2014, 142(1):28–39. Epub 2013 Apr 26.
- Davidson V, Ravel A, Nguyen T, Fazil A, Ruzante J. "Food-Specific Attribution of Selected Gastrointestinal Illnesses: Estimates from a Canadian Expert Elicitation Survey". Foodborne Pathogens and Disease. (May 2011, ahead of print) September 2011, 8(9): 983–995.
- Dumoulin D, Nesbitt A, Marshall B, Sittler N, Pollari F. "Informing source attribution of enteric disease: An analysis of public health inspectors' opinions on the 'Most Likely Source of Infection' ". Environmental Health Review. 2012, 55(1): 27–36.
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APPENDIX A: 2011/2012 LABORATORY TESTS PERFORMED ON FOODNET CANADA SAMPLES

Component	Sample Type	Isolation or Microscopic ID	Molecular ID	Enumeration (MPN or Oocyst,cyst/ 100L)	Serotyping/ Biotyping	Phagetyping	Ribotyping	AMR	PFGE	Genotyping
RETAIL MEAT	Skin-off chicken breasts Ground beef Ground turkey (2011) Ground chicken Frozen chicken nuggets (2012)	*Salmonella* (chicken/ turkey only) *Campylobacter* (chicken/ turkey only) VTEC (beef only) *Listeria*		*Salmonella* *Campylobacter* *Listeria*	*Salmonella* *Campylobacter* VTEC *Listeria*	*Salmonella* (specific serovars)	*Listeria*		*Salmonella* VTEC *Listeria*	
RETAIL PRODUCE	Soft berries (2011) Fresh herbs (2012)	*Campylobacter* (2012 only) Generic *E. coli* (2012 only) *Listeria monocytogenes* (2012 only) *Cryptosporidium* *Giardia* *Cyclospora*	*Cryptosporidium* *Giardia* *Cyclospora* Norovirus Rotavirus		*Campylobacter* *Listeria*		*Listeria*		*Listeria*	*Cryptosporidium* *Giardia* (small number of samples) *Cyclospora* Norovirus Rotavirus
ON-FARM (manure)	Dairy Beef Swine (2011) Broiler chickens	*Salmonella* *Campylobacter* *Yersinia* *E. coli* O157:H7 (2011)/VTEC (2012)			*Salmonella* *Campylobacter* VTEC	*Salmonella* (specific serovars)			*Salmonella* *E. coli* O157:H7/ VTEC	
WATER	Raw surface water Beaches	*Salmonella* *Campylobacter* VTEC Generic *E. coli* *Giardia* *Cryptosporidium*	Norovirus Rotavirus	*Campylobacter* *Cryptosporidium* *Giardia*	*Salmonella* *Campylobacter*	*Salmonella* (specific serovars)			*Salmonella* VTEC	*Cryptosporidium* *Giardia*
HUMAN	Human specimens[a]	*Salmonella* *Campylobacter* *Yersinia* VTEC *Cryptosporidium* *Giardia* *Shigella* *Listeria*			*Salmonella* *Listeria* *Yersinia*	*Salmonella*		*Salmonella* *Campylobacter*	*Salmonella* VTEC *Listeria*	

[a] Chaper 2, Table 2.2.

APPENDIX B: HUMAN QUESTIONNAIRE RESULTS, BOTH SITES COMBINED, 2011–2012

EXPOSURE	CAMPYLOBACTERIOSIS		SALMONELLOSIS		VEROTOXIGENIC *E. COLI* INFECTION		YERSINIOSIS		GIARDIASIS		CRYPTOSPORIDIOSIS		ALL
	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases
Total endemic cases with exposure data	**426**	**466**	**254**	**638**	**46**	**846**	**36**	**856**	**96**	**796**	**34**	**858**	**892**
	%	%	%	%	%	%	%	%	%	%	%	%	%
Age (years)													
0 to 4	12	18	**23***	12	15	15	8	15	8	16	18	15	15
5 to 19	13	18	**21***	14	20	16	6	16	10	16	26	15	16
20 to 29	18	16	15	18	20	17	14	17	11	18	**32***	16	17
30 to 59 (ref)	36	33	26	38	22	35	39	34	58	31	24	35	34
>60	20	15	15	19	24	17	33	17	11	19	0	19	18
Gender													
Male	57	51	52	54	41	54	31	54	56	53	56	53	53
Female (ref)	43	49	48	46	59	46	69	46	44	47	44	47	47
Season													
Summer	36	37	32	38	**54***	35	36	36	35	37	53	36	36
Fall, Winter, Spring (ref)	64	63	68	62	46	65	64	64	65	63	47	64	64

EXPOSURE	CAMPYLOBACTERIOSIS		SALMONELLOSIS		VEROTOXIGENIC *E. COLI* INFECTION		YERSINIOSIS		GIARDIASIS		CRYPTOSPORIDIOSIS		ALL
	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases
Total endemic cases with exposure data	**426**	**466**	**254**	**638**	**46**	**846**	**36**	**856**	**96**	**796**	**34**	**858**	**892**
	%	%	%	%	%	%	%	%	%	%	%	%	%
Occupation													
Agriculture/ Food handler	10	7	4	10	13	8	6	9	6	9	**24***	8	8
Health care	3	3	3	3	2	3	3	3	3	3	3	3	3
Day care	5	6	6	5	9	5	3	5	2	6	12	5	5
Other	39	34	29	40	30	37	31	37	**53***	34	29	37	36
Student, unemployed, retired	43	50	**58***	43	46	47	58	46	35	48	32	47	47
Travelled within Canada	11	10	8	11	15	10	8	11	11	10	18	10	11
Drank untreated water	4	6	3	6	10	5	3	5	10	4	13	5	5
Swam	21	22	16	24	30	21	19	22	25	21	**47***	20	21
In a lake	6	7	3	8	**17***	6	6	6	9	6	12	6	6
In a river	<1	1	<1	1	0	1	0	1	**4***	<1	0	1	1
In a pool	12	14	11	14	17	13	14	13	11	13	**32***	12	13
In a hottub	3	5	4	4	4	4	9	4	4	4	9	4	4

EXPOSURE	CAMPYLOBACTERIOSIS		SALMONELLOSIS		VEROTOXIGENIC *E. COLI* INFECTION		YERSINIOSIS		GIARDIASIS		CRYPTOSPORIDIOSIS		ALL
	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases
Total endemic cases with exposure data	**426**	**466**	**254**	**638**	**46**	**846**	**36**	**856**	**96**	**796**	**34**	**858**	**892**
	%	%	%	%	%	%	%	%	%	%	%	%	%
Went canoeing, kayaking, hiking or camping	7	8	5	9	**17***	7	3	8	10	7	18	7	8
Drank unpasteurized milk	4	2	2	4	2	3	0	3	2	3	**13***	3	3
Ate undercooked food	8	7	8	8	7	8	6	8	7	8	10	8	8
Ate spoiled food	**10***	6	5	8	14	7	0	8	5	8	3	8	7
Attended a barbecue	24	18	15	23	31	20	6	22	21	21	33	20	21
Attended a social gathering	15	16	11	17	**31***	14	12	15	17	15	29	15	15
Ate food prepared outside the home	63	57	51	64	70	59	62	60	65	59	60	60	60
Ate meat from hunting	3	2	3	2	0	3	3	2	2	3	0	3	2
Ate meat from a butcher shop	9	10	7	10	19	9	12	9	12	9	9	9	9
Ate meat from a private kill	3	2	1	3	2	2	3	2	0	3	6	2	2

EXPOSURE	CAMPYLOBACTERIOSIS		SALMONELLOSIS		VEROTOXIGENIC *E. COLI* INFECTION		YERSINIOSIS		GIARDIASIS		CRYPTOSPORIDIOSIS		ALL
	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases
Total endemic cases with exposure data	**426**	**466**	**254**	**638**	**46**	**846**	**36**	**856**	**96**	**796**	**34**	**858**	**892**
	%	%	%	%	%	%	%	%	%	%	%	%	%
Contact with household pet	**63***	56	54	61	69	59	47	60	49	61	76	59	59
Birds	3	2	2	3	2	2	3	2	3	2	3	2	2
Cats	29	24	24	27	24	26	18	27	18	27	42	26	26
Dogs	48	42	38	48	49	45	38	45	43	45	61	45	45
Reptiles	2	4	**5***	2	0	3	0	3	3	3	3	3	3
Rodents	2	2	3	2	4	2	0	2	1	2	3	2	2
Visited farm, petting zoo or fair	12	9	5	12	18	10	6	11	6	11	**39***	9	10
Animal Exposure													
Cats	<1	1	0	1	2	1	0	1	1	1	**9***	<1	1
Dogs	<1	<1	0	<1	0	<1	0	<1	0	<1	3	<1	<1
Horses	1	1	0	1	4	1	0	1	0	1	6	1	1
Cattle	5	4	1	5	9	4	3	4	1	4	**24***	3	4
Pigs	1	<1	<1	<1	0	<1	0	<1	0	1	0	<1	<1
Poultry	3	2	1	3	4	2	0	3	2	3	**12***	2	3
Sheep	1	1	1	1	2	1	3	1	0	1	6	1	1
Lived on a farm/ rural site	**13***	9	7	9	18	10	0	11	8	11	18	11	11

EXPOSURE	CAMPYLOBACTERIOSIS		SALMONELLOSIS		VEROTOXIGENIC *E. COLI* INFECTION		YERSINIOSIS		GIARDIASIS		CRYPTOSPORIDIOSIS		ALL
	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases	Non-cases[a]	Cases
Total endemic cases with exposure data	**426**	**466**	**254**	**638**	**46**	**846**	**36**	**856**	**96**	**796**	**34**	**858**	**892**
	%	%	%	%	%	%	%	%	%	%	%	%	%
Animal Exposure													
Cats	1	<1	<1	1	2	1	0	1	0	1	0	1	1
Dogs	2	1	<1	2	2	2	0	2	1	2	6	1	2
Horses	2	1	1	2	2	2	0	2	1	2	3	2	2
Cattle	3	2	1	3	2	2	0	2	1	3	6	2	2
Pigs	<1	1	<1	1	2	<1	0	1	1	1	0	1	1
Poultry	**5***	1	2	4	0	3	0	3	0	4	6	3	3
Sheep	<1	<1	0	1	0	<1	0	<1	0	1	**6***	<1	<1
Contact with animal manure	**15***	9	5	15	14	12	6	12	12	12	21	12	12

[a] Cases of enteric disease other than the disease indicated.

* Significant risk factors with $p < 0.05$ identified from univariate analysis. Significant protective factors are not indicated.

APPENDIX C: ENUMERATION RESULTS (ORGANISM COUNTS) FOR RETAIL FOOD SAMPLES, BOTH SITES COMBINED, 2011–2012

PATHOGEN BY COMMODITY	No. OF SAMPLES TESTED	No. OF POSITIVE RESULTS	No. TESTED FOR MPN	MOST PROBABLE NUMBER OF ORGANISMS/G OF SAMPLE				
				< 0.3[a]	0.3–10	11–100	101–1,000	> 1,000
Campylobacter								
Chicken breast[b]	695	324	44	32	12	0	0	0
Uncooked chicken nuggets[b]	359	3	3	3	0	0	0	0
Ground chicken	513	181	177	111	66	0	0	0
Ground turkey[b]	251	67	67	57	10	0	0	0
Listeria								
Chicken breast[b]	700	220	27	16	11	0	0	0
Ground beef[b]	699	122	12	8	3	0	1	0
Uncooked chicken nuggets	567	116	114	95	16	1	2	0
Ground chicken	515	211	207	139	58	3	3	4
Ground turkey[b]	251	89	89	60	26	2	0	1
Salmonella								
Chicken breast[b]	700	201	40	31	7	0	0	2
Uncooked chicken nuggets	567	247	247	214	29	1	0	3
Ground chicken	515	326	324	267	46	6	1	4
Ground turkey[b]	251	60	60	53	7	0	0	0

[a] Below the assay detection limit.

[b] 2011 only.

APPENDIX D: SUPPLEMENTAL TABLES

TABLE E.1: PFGE patterns identified in isolates of *Escherichia coli* O157:H7 obtained through FoodNet Canada surveillance between 2005 and 2012

	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]			WATER[b]
PATTERN	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BEEF CATTLE	DAIRY CATTLE	
Total	**100**	**22**	**5**	**1**	**6**	**69**	**66**	**13**
ECXAI.0001	8	1	0	1	0	8	1	0
ECXAI.0002	1	0	0	0	0	0	0	0
ECXAI.0007	2	0	0	0	0	0	0	0
ECXAI.0008	5	0	1	0	0	2	1	1
ECXAI.0012	0	0	0	0	0	1	0	0
ECXAI.0014	0	0	0	0	0	2	0	0
ECXAI.0017	3	0	0	0	0	0	0	0
ECXAI.0021	0	0	0	0	0	1	0	0
ECXAI.0023	0	0	0	0	0	0	1	0
ECXAI.0052	2	1	1	0	0	0	0	0
ECXAI.0055	1	0	0	0	0	0	0	0
ECXAI.0063	1	0	0	0	0	0	0	0
ECXAI.0073	0	0	0	0	0	1	0	0
ECXAI.0096	1	0	0	0	0	0	0	0
ECXAI.0221	2	0	0	0	0	0	0	0
ECXAI.0247	1	0	0	0	0	0	0	0
ECXAI.0262	9	0	0	0	0	0	0	0
ECXAI.0266	0	0	0	0	0	2	0	0
ECXAI.0309	1	0	0	0	0	0	0	0
ECXAI.0313	1	0	0	0	0	0	0	0
ECXAI.0317	0	0	0	0	0	0	1	0

PATTERN	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]			WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BEEF CATTLE	DAIRY CATTLE	
ECXAI.0339	0	6	0	0	0	0	0	1
ECXAI.0346	0	0	0	0	0	0	0	1
ECXAI.0378	0	0	0	0	0	0	1	0
ECXAI.0407	0	0	0	0	0	2	0	0
ECXAI.0478	1	0	0	0	0	0	0	0
ECXAI.0702	0	0	0	0	0	1	0	0
ECXAI.0776	0	0	0	0	0	1	0	0
ECXAI.0816	1	0	0	0	0	0	0	0
ECXAI.0821	0	0	0	0	0	3	0	0
ECXAI.0825	0	0	0	0	0	3	0	0
ECXAI.0841	0	1	0	0	0	0	0	0
ECXAI.1164	1	0	0	0	0	1	1	0
ECXAI.1175	1	0	0	0	0	0	0	0
ECXAI.1182	1	0	0	0	0	0	1	0
ECXAI.1186	1	0	0	0	0	0	0	0
ECXAI.1193	1	0	0	0	0	0	0	0
ECXAI.1206	1	0	0	0	0	0	0	0
ECXAI.1214	0	0	0	0	0	0	1	0
ECXAI.1216	0	0	0	0	1	0	0	0
ECXAI.1221	0	6	0	0	0	0	0	0
ECXAI.1239	1	0	0	0	0	0	0	0
ECXAI.1242	0	1	0	0	0	0	0	0
ECXAI.1246	0	0	0	0	0	0	1	0
ECXAI.1248	2	0	0	0	0	0	0	0
ECXAI.1267	0	0	0	0	0	1	1	0
ECXAI.1288	0	0	0	0	0	3	0	0
ECXAI.1301	1	0	0	0	0	4	0	0

PATTERN	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]			WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BEEF CATTLE	DAIRY CATTLE	
ECXAI.1304	0	0	0	0	0	0	1	0
ECXAI.1310	0	0	0	0	0	1	0	0
ECXAI.1318	1	0	0	0	0	0	0	0
ECXAI.1325	0	0	0	0	0	0	1	0
ECXAI.1328	1	0	0	0	0	0	0	0
ECXAI.1359	1	0	0	0	0	0	0	0
ECXAI.1398	0	0	0	0	0	0	0	1
ECXAI.1456	1	0	0	0	0	0	0	0
ECXAI.1477	1	0	0	0	0	0	0	0
ECXAI.1478	1	0	0	0	0	0	0	0
ECXAI.1495	1	0	0	0	0	0	0	0
ECXAI.1501	1	0	0	0	0	0	0	0
ECXAI.1503	1	0	0	0	0	0	0	0
ECXAI.1526	1	0	0	0	0	0	0	0
ECXAI.1527	1	0	0	0	0	0	0	0
ECXAI.1537	1	0	0	0	0	0	0	0
ECXAI.1538	0	0	0	0	0	1	0	0
ECXAI.1556	0	0	0	0	0	0	0	1
ECXAI.1557	0	0	0	0	0	0	0	1
ECXAI.1577	0	2	0	0	0	0	0	0
ECXAI.1578	1	0	0	0	0	0	0	0
ECXAI.1581	0	3	0	0	0	0	0	1
ECXAI.1599	0	0	0	0	0	0	1	0
ECXAI.1610	1	0	0	0	0	0	0	0
ECXAI.1611	0	0	0	0	0	0	1	0
ECXAI.1612	0	0	0	0	0	0	2	0
ECXAI.1613	0	0	0	0	0	0	1	0

PATTERN	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]			WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BEEF CATTLE	DAIRY CATTLE	
ECXAI.1614	0	0	0	0	0	0	1	0
ECXAI.1687	0	0	0	0	0	3	4	0
ECXAI.1688	0	0	0	0	0	0	1	0
ECXAI.1689	0	0	0	0	0	0	1	0
ECXAI.1690	0	0	0	0	0	0	1	0
ECXAI.1691	0	0	0	0	0	0	1	0
ECXAI.1692	1	0	0	0	0	0	1	0
ECXAI.1694	3	0	0	0	0	0	0	0
ECXAI.1704	1	0	0	0	0	0	0	0
ECXAI.1714	0	0	1	0	0	0	0	0
ECXAI.1737	2	0	0	0	0	0	0	0
ECXAI.1777	0	0	1	0	0	0	0	0
ECXAI.1844	0	0	0	0	0	0	0	1
ECXAI.1845	1	0	0	0	0	0	1	0
ECXAI.1855	0	0	0	0	0	0	1	0
ECXAI.1857	0	0	0	0	0	0	1	0
ECXAI.1858	0	0	0	0	0	1	0	0
ECXAI.1859	0	0	0	0	0	1	0	0
ECXAI.1860	0	0	0	0	0	1	0	0
ECXAI.1898	1	1	0	0	0	0	0	0
ECXAI.1901	1	0	0	0	0	0	0	0
ECXAI.1917	0	0	0	0	0	1	0	0
ECXAI.1936	1	0	0	0	0	0	0	0
ECXAI.1940	1	0	0	0	0	0	0	0
ECXAI.1971	1	0	0	0	0	0	0	0
ECXAI.1972	1	0	0	0	0	0	0	0
ECXAI.2003	0	0	0	0	0	0	1	0

PATTERN	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]			WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BEEF CATTLE	DAIRY CATTLE	
ECXAI.2012	2	0	0	0	0	0	0	0
ECXAI.2043	0	0	0	0	0	0	1	0
ECXAI.2108	0	0	0	0	0	1	0	0
ECXAI.2109	0	0	0	0	0	0	1	0
ECXAI.2110	0	0	0	0	0	2	0	0
ECXAI.2111	0	0	0	0	1	0	0	0
ECXAI.2112	0	0	0	0	0	0	1	0
ECXAI.2172	0	0	0	0	0	1	0	0
ECXAI.2202	1	0	0	0	0	0	0	0
ECXAI.2239	1	0	0	0	0	0	0	0
ECXAI.2303	1	0	0	0	0	0	1	0
ECXAI.2324	0	0	0	0	1	0	0	0
ECXAI.2325	0	0	0	0	1	0	0	0
ECXAI.2327	0	0	0	0	0	1	0	0
ECXAI.2328	0	0	0	0	0	0	1	0
ECXAI.2329	0	0	0	0	0	0	1	0
ECXAI.2330	0	0	0	0	0	2	0	0
ECXAI.2353	2	0	0	0	0	0	0	0
ECXAI.2378	0	0	0	0	0	0	1	0
ECXAI.2379	0	0	0	0	0	1	0	0
ECXAI.2380	0	0	0	0	0	1	0	0
ECXAI.2381	0	0	0	0	1	0	0	0
ECXAI.2382	0	0	0	0	0	1	0	0
ECXAI.2396	0	0	0	0	0	1	0	0
ECXAI.2411	1	0	0	0	0	0	0	0
ECXAI.2426	1	0	0	0	0	0	0	0
ECXAI.2440	1	0	0	0	0	0	0	0

PATTERN	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]			WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BEEF CATTLE	DAIRY CATTLE	
ECXAI.2464	0	0	0	0	0	0	2	0
ECXAI.2481	0	0	0	0	0	0	1	0
ECXAI.2483	1	0	0	0	0	0	0	0
ECXAI.2484	1	0	0	0	0	0	0	0
ECXAI.2532	0	0	0	0	0	0	0	1
ECXAI.2547	0	0	0	0	0	1	0	0
ECXAI.2550	0	0	0	0	0	1	0	0
ECXAI.2551	0	0	0	0	1	0	0	0
ECXAI.2552	0	0	0	0	0	0	1	0
ECXAI.2553	0	0	0	0	0	1	0	0
ECXAI.2554	0	0	0	0	0	1	0	0
ECXAI.2555	0	0	0	0	0	1	0	0
ECXAI.2556	0	0	0	0	0	0	1	0
ECXAI.2589	0	0	1	0	0	0	0	0
ECXAI.2607	1	0	0	0	0	5	3	1
ECXAI.2648	1	0	0	0	0	0	0	0
ECXAI.2663	1	0	0	0	0	0	0	0
ECXAI.2678	0	0	0	0	0	0	2	0
ECXAI.2687	1	0	0	0	0	0	0	0
ECXAI.2697	1	0	0	0	0	0	0	0
ECXAI.2731	0	0	0	0	0	0	1	0
ECXAI.2737	0	0	0	0	0	0	1	0
ECXAI.2739	0	0	0	0	0	1	0	0
ECXAI.2778	0	0	0	0	0	0	0	1
ECXAI.2781	0	0	0	0	0	0	4	0
ECXAI.2784	0	0	0	0	0	0	0	1
ECXAI.2823	0	0	0	0	0	0	0	1

PATTERN	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]			WATER[b]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BEEF CATTLE	DAIRY CATTLE	
ECXAI.2830	1	0	0	0	0	0	0	0
ECXAI.2832	1	0	0	0	0	0	0	0
ECXAI.2833	1	0	0	0	0	0	0	0
ECXAI.2834	1	0	0	0	0	0	0	0
ECXAI.2874	1	0	0	0	0	0	0	0
ECXAI.2879	0	0	0	0	0	0	1	0
ECXAI.2881	0	0	0	0	0	1	0	0
ECXAI.2882	0	0	0	0	0	1	0	0
ECXAI.2897	0	0	0	0	0	0	2	0
ECXAI.2898	0	0	0	0	0	0	1	0
ECXAI.2900	0	0	0	0	0	0	1	0
ECXAI.2903	0	0	0	0	0	0	2	0
ECXAI.2912	0	0	0	0	0	0	1	0
ECXAI.2913	0	0	0	0	0	0	1	0
ECXAI.2914	0	0	0	0	0	0	1	0
ECXAI.3022	0	0	0	0	0	0	1	0
ECXAI.3023	0	0	0	0	0	0	1	0

[a] Pooled manure samples collected from 30 farms in the ON site for each type of food animal.

[b] Five water sampling sites in the Grand River Watershed in the ON site were used: Canagagigue Creek, Conestogo River, Upper Grand River, Grand River near a drinking water intake, and a wastewater treatment plant effluent in the community.

TABLE E.2: PFGE patterns identified in isolates of *Listeria monocytogenes* obtained through FoodNet Canada surveillance between 2005 and 2012

	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE			
PATTERN	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	BAGGED LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
Number typed	**7**	**3**	**1**	**73**	**422**	**269**	**120**	**217**	**92**	**12**	**4**	**8**	**74**	**15**
LMAAI.0001	0	3	0	3	21	7	28	7	7	0	0	0	0	0
LMAAI.0003	1	0	0	1	1	1	1	0	0	0	0	0	0	0
LMAAI.0007	0	0	0	0	0	0	0	0	0	0	0	0	3	0
LMAAI.0013	0	0	0	13	56	64	14	14	3	0	0	0	0	0
LMAAI.0014	0	0	0	1	77	0	2	19	1	0	0	0	0	0
LMAAI.0015	0	0	0	0	9	0	2	2	0	0	0	0	0	0
LMAAI.0017	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0019	0	0	0	0	1	0	0	0	6	0	0	0	0	0
LMAAI.0024	0	0	0	4	4	22	2	7	0	0	0	0	0	0
LMAAI.0026	0	0	0	1	0	0	0	0	0	0	0	0	0	0
LMAAI.0028	0	0	0	2	5	2	0	0	0	0	0	0	0	0
LMAAI.0030	0	0	0	0	0	0	0	2	4	0	0	0	0	0
LMAAI.0032	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0035	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0042	0	0	0	0	2	0	0	0	0	0	0	0	0	0
LMAAI.0043	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0047	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0049	0	0	0	0	2	1	0	0	0	0	0	0	2	0
LMAAI.0054	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0061	0	0	0	0	1	0	0	0	0	0	0	0	0	0

	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE			
PATTERN	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	BAGGED LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
LMAAI.0067	0	0	0	0	1	1	0	0	0	0	0	0	0	0
LMAAI.0069	0	0	0	0	0	2	0	0	0	0	0	0	0	0
LMAAI.0074	0	0	0	0	5	0	0	0	0	0	0	0	2	1
LMAAI.0077	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0080	0	0	0	0	3	0	0	0	0	0	0	0	0	0
LMAAI.0086	0	0	0	0	0	0	0	3	0	0	0	0	0	0
LMAAI.0087	0	0	0	1	62	3	0	9	2	0	0	0	0	0
LMAAI.0090	0	0	0	0	0	0	0	0	0	0	0	0	1	1
LMAAI.0093	1	0	0	0	0	1	0	0	0	0	0	1	11	0
LMAAI.0095	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0096	0	0	0	0	0	0	0	0	0	6	0	0	0	0
LMAAI.0097	0	0	0	0	13	0	0	24	0	0	0	0	0	0
LMAAI.0101	0	0	0	0	0	2	0	0	0	0	0	0	0	0
LMAAI.0113	0	0	0	0	0	0	0	1	0	0	0	0	0	1
LMAAI.0118	0	0	0	0	2	4	0	1	12	0	0	0	0	0
LMAAI.0122	0	0	0	0	2	0	0	3	26	0	0	0	0	0
LMAAI.0123	0	0	0	0	0	0	0	14	0	0	0	0	0	0
LMAAI.0126	0	0	0	3	7	9	2	1	0	0	0	0	5	0
LMAAI.0128	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0130	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0147	0	0	0	7	0	0	0	0	0	0	0	0	0	0
LMAAI.0160	0	0	0	0	1	0	4	7	0	0	0	0	0	0
LMAAI.0165	0	0	0	2	0	0	0	0	0	0	0	0	1	0

PATTERN	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE			
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	BAGGED LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
LMAAI.0182	1	0	0	0	0	0	0	0	0	0	1	0	0	0
LMAAI.0193	0	0	0	0	10	0	1	1	0	0	0	0	1	0
LMAAI.0204	0	0	0	0	0	1	0	0	0	1	0	0	9	5
LMAAI.0207	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0213	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0214	0	0	0	0	2	0	0	0	0	0	0	0	0	0
LMAAI.0217	0	0	0	0	0	1	1	0	1	0	0	0	0	0
LMAAI.0219	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0223	0	0	0	9	2	45	0	0	0	0	0	0	0	0
LMAAI.0234	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LMAAI.0256	0	0	0	1	0	1	0	0	0	0	0	0	0	0
LMAAI.0259	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0265	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LMAAI.0266	0	0	0	0	0	0	0	0	0	0	0	0	5	0
LMAAI.0269	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0276	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0287	0	0	0	0	5	1	1	4	1	0	0	0	0	0
LMAAI.0317	0	0	0	0	0	1	0	0	0	0	0	0	1	0
LMAAI.0333	0	0	0	0	0	0	0	0	0	0	0	0	1	1
LMAAI.0345	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0352	0	0	0	0	1	0	0	0	0	1	0	0	0	0
LMAAI.0354	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LMAAI.0360	0	0	0	0	2	1	0	0	0	0	0	0	0	0
LMAAI.0364	0	0	0	0	3	1	0	0	0	0	0	0	0	0

PATTERN	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE			
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	BAGGED LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
LMAAI.0365	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LMAAI.0368	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0371	0	0	0	0	1	1	0	0	0	0	0	0	0	0
LMAAI.0375	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0377	0	0	0	0	3	3	1	0	0	0	0	0	0	0
LMAAI.0378	0	0	0	5	0	2	0	1	0	0	0	0	0	0
LMAAI.0379	0	0	0	1	0	0	0	0	0	0	0	0	0	0
LMAAI.0380	0	0	0	1	0	0	0	0	0	0	0	0	0	0
LMAAI.0381	0	0	0	0	2	0	0	0	0	0	0	0	0	0
LMAAI.0382	0	0	0	0	0	3	0	0	0	0	0	0	0	0
LMAAI.0383	0	0	0	0	13	0	0	0	0	0	0	0	0	0
LMAAI.0384	0	0	0	5	0	3	0	0	0	0	0	0	0	0
LMAAI.0392	0	0	0	0	1	0	0	0	0	0	0	1	0	0
LMAAI.0394	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LMAAI.0396	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LMAAI.0399	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0401	0	0	0	0	0	0	0	9	0	0	0	0	0	0
LMAAI.0402	0	0	0	0	13	0	2	0	0	0	0	0	0	0
LMAAI.0403	0	0	0	0	0	0	0	1	0	0	0	1	0	0
LMAAI.0404	0	0	0	0	0	0	0	0	0	0	0	1	0	0
LMAAI.0407	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0409	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0411	0	0	0	1	1	0	1	0	0	0	0	0	1	0
LMAAI.0413	0	0	0	0	0	0	0	0	0	0	0	0	1	0

	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE			
PATTERN	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	BAGGED LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
LMAAI.0414	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0415	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0418	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0420	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0421	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0423	1	0	0	1	0	0	0	0	0	0	0	0	1	0
LMAAI.0424	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0425	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0427	0	0	0	0	0	0	0	0	0	0	0	1	0	0
LMAAI.0428	0	0	0	0	0	0	0	0	0	0	0	1	0	0
LMAAI.0429	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0430	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0431	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0432	0	0	0	0	0	0	0	0	0	0	2	0	0	0
LMAAI.0433	0	0	0	0	1	1	0	2	0	0	0	1	0	0
LMAAI.0438	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LMAAI.0440	0	0	0	0	2	0	0	0	0	0	0	0	0	0
LMAAI.0442	0	0	0	0	1	0	1	1	0	0	0	0	0	0
LMAAI.0451	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0453	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0454	0	0	0	0	3	0	0	0	0	0	0	0	0	0
LMAAI.0455	0	0	0	0	3	0	2	0	0	0	0	0	0	0
LMAAI.0458	0	0	0	0	0	0	0	0	0	0	1	0	0	0
LMAAI.0459	0	0	0	0	1	0	0	0	0	0	0	0	0	0

PATTERN	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE			
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	BAGGED LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
LMAAI.0460	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0461	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0463	0	0	0	1	0	0	0	0	0	0	0	0	0	0
LMAAI.0464	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0465	0	0	0	0	7	0	0	0	0	0	0	0	0	0
LMAAI.0466	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0467	0	0	0	0	3	1	0	0	0	0	0	0	0	0
LMAAI.0468	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0469	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0472	0	0	0	0	2	0	1	0	0	0	0	0	0	0
LMAAI.0474	0	0	0	1	0	0	0	0	0	0	0	0	0	0
LMAAI.0477	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LMAAI.0482	0	0	0	1	1	0	0	0	0	0	0	0	0	0
LMAAI.0483	0	0	0	0	4	0	0	0	0	0	0	0	0	0
LMAAI.0486	0	0	0	0	1	0	1	0	0	0	0	0	0	0
LMAAI.0487	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0488	0	0	0	1	0	6	0	0	0	0	0	0	0	0
LMAAI.0492	0	0	0	0	0	1	0	0	0	0	0	0	1	0
LMAAI.0493	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0494	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LMAAI.0496	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0497	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0498	0	0	0	0	2	0	0	0	0	0	0	0	0	0
LMAAI.0499	1	0	0	0	0	0	1	0	0	0	0	0	0	0

PATTERN	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE			
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	BAGGED LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
LMAAI.0500	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LMAAI.0501	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LMAAI.0502	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0503	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0505	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0509	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0511	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0512	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0513	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0515	0	0	0	0	0	1	0	2	0	0	0	0	0	0
LMAAI.0519	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LMAAI.0520	0	0	0	0	0	0	6	2	0	0	0	0	0	0
LMAAI.0524	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0525	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0528	0	0	0	0	2	0	1	0	0	0	0	0	0	0
LMAAI.0531	0	0	0	0	2	0	0	0	0	0	0	0	0	0
LMAAI.0532	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0534	0	0	0	1	0	0	0	0	0	0	0	0	0	0
LMAAI.0559	0	0	0	0	0	0	1	0	4	0	0	0	0	0
LMAAI.0563	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LMAAI.0564	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0565	0	0	0	3	1	41	1	3	0	0	0	0	0	0
LMAAI.0572	0	0	0	0	0	0	0	0	5	0	0	0	0	0
LMAAI.0584	0	0	0	0	5	1	1	5	0	0	0	0	0	0

PATTERN	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE			
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	BAGGED LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
LMAAI.0608	0	0	0	1	0	0	0	0	0	0	0	0	0	0
LMAAI.0609	0	0	0	1	2	2	1	1	0	0	0	0	0	0
LMAAI.0611	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0624	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0626	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0636	0	0	0	0	1	0	1	8	0	0	0	0	0	0
LMAAI.0650	0	0	0	0	1	0	2	0	0	0	0	0	0	0
LMAAI.0654	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0663	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0671	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0689	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0695	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0702	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0707	0	0	0	0	0	1	1	12	2	0	0	0	0	0
LMAAI.0751	0	0	0	0	1	0	0	3	0	0	0	0	0	0
LMAAI.0762	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0796	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0808	0	0	0	0	0	2	0	0	0	0	0	0	0	0
LMAAI.0828	0	0	0	0	3	0	5	0	0	0	0	0	0	0
LMAAI.0851	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0852	0	0	0	1	0	0	0	0	0	0	0	0	0	0
LMAAI.0855	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0857	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LMAAI.0864	0	0	0	0	1	0	0	0	0	0	0	0	0	0

PATTERN	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE			
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	BAGGED LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
LMAAI.0878	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LMAAI.0880	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0881	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0883	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.0890	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.0922	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LMAAI.0924	0	0	0	0	0	0	3	22	1	0	0	0	0	0
LMAAI.0982	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0983	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0984	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0985	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0986	0	0	0	0	0	2	0	0	0	0	0	0	0	0
LMAAI.0987	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.0988	0	0	0	0	0	0	2	0	0	0	0	0	0	0
LMAAI.0990	0	0	0	0	0	0	2	1	0	0	0	0	0	0
LMAAI.0992	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.1000	0	0	0	0	0	0	0	2	0	0	0	0	0	0
LMAAI.1042	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.1043	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.1045	0	0	0	0	1	0	0	0	13	0	0	0	0	0
LMAAI.1046	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.1047	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.1048	0	0	0	0	0	0	0	12	0	0	0	0	0	0
LMAAI.1049	0	0	0	0	0	0	1	0	0	0	0	0	0	0

PATTERN	HUMAN			RETAIL FOOD							FARM ANIMAL MANURE			
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	PORK CHOPS	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	BAGGED LEAFY GREENS	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE
LMAAI.1050	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.1053	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.1054	0	0	0	0	0	4	0	0	0	0	0	0	0	0
LMAAI.1055	0	0	0	0	0	0	0	0	2	0	0	0	0	0
LMAAI.1056	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LMAAI.1058	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.1059	0	0	0	0	1	0	1	0	0	0	0	0	0	0
LMAAI.1062	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.1069	0	0	1	0	0	0	0	0	0	0	0	0	0	0
LMAAI.1078	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.1079	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.1109	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LMAAI.1110	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.1111	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LMAAI.1112	0	0	0	0	0	0	0	2	0	0	0	0	0	0
LMAAI.1114	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.1115	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LMAAI.1116	0	0	0	0	0	1	0	0	0	0	0	0	0	0
LMAAI.1162	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LMAAI.1163	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LMACI.0722	0	0	0	0	0	0	0	0	1	0	0	0	0	0
No match	0	0	0	0	7	0	0	0	0	0	0	1	6	3
Untypable	0	0	0	0	3	0	0	0	0	0	0	0	0	0

APPENDIX E: ABBREVIATIONS AND REFERENCES

Abbreviations

BC	British Columbia
CFIA	Canadian Food Inspection Agency
LFZ	Laboratory for Foodborne Zoonoses
MPN	Most probable number of organisms
NA	Not applicable
ND	Not done
ON	Ontario
PCR	Polymerase chain reaction
PFGE	Pulsed-field gel electrophoresis
PT	Phage type
VTEC	Verotoxigenic *Escherichia coli*

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