FOODNET CANADA ANNUAL REPORT 2013

PROTECTING AND EMPOWERING CANADIANS TO IMPROVE THEIR HEALTH

Public Health Agency of Canada
Agence de la santé publique du Canada

Canada

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

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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 enteric illness in Canada. FoodNet Canada collects data at the community level on human illness cases (i.e. exposures and behaviours) and samples 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 authority/ 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. 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 both the ON and BC sites, enhanced surveillance of human cases of enteric disease in the community is performed through the collection of information on exposures and behaviours, as well as active surveillance of enteric pathogens in water, food (retail meat and produce) and on farms.

The following key findings are based on the surveillance data from 2013 in the ON and BC sites:

- A total of 803 human cases of 11 bacterial, viral and parasitic diseases were reported within the ON and BC sites in 2013. The three most frequently reported diseases (campylobacteriosis, salmonellosis and giardiasis) accounted for 81% 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.* Consumption of unpasteurized milk was identified as a possible exposure factor. As observed in previous years, retail chicken meat continues to be considered to be the most important vehicle of transmission for *Campylobacter*. However, other sources such as beef and dairy cattle, and their products, in particular unpasteurized milk, are also likely important.

- Distributions of patient age and gender among the human salmonellosis cases in 2013 were similar to those observed historically. The most commonly reported serovars from human cases of salmonellosis were Enteritidis, Heidelberg and Typhimurium. Phage type and pulsed-field gel electrophoresis (PFGE) pattern alignment continues to be observed among isolates from endemic human cases, retail chicken products, and broiler chicken manure for both *Salmonella* Heidelberg and *Salmonella* Enteritidis. The prevalence of *Salmonella* on ground chicken and broiler chicken manure continues to be high as reported in previous years. The most important possible vehicle of transmission identified were retail chicken products, especially uncooked chicken nuggets.
- Verotoxigenic *E. coli* (O157:H7 and non-O157:H7 serotypes) infections continue to be primarily domestically acquired, as demonstrated by the low number of travel-related cases in 2013. *E. coli* O157:H7 PFGE patterns in both human and non-human samples from 2013 continued to show considerable diversity and a lack of persistence over time, as observed nationally and within the FoodNet Canada sites.
- As in previous years, pathogenic strains of *Listeria monocytogenes* were detected in 2013 from samples of skinless chicken breasts, ground beef, ground chicken and 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* (**11**). FoodNet Canada retail data from past surveillance years indicate that pathogenic serotypes of *L. monocytogenes* have been present on raw chicken, beef, and pork meat sold at retail, as well as less commonly, in bagged leafy greens. *L. monocytogenes* was also detected in 2013 on samples of bagged leafy greens. FoodNet Canada is contributing towards the development of new typing methods for *L. monocytogenes* based on whole genome sequencing.
- Findings are consistent with previous years showing that the majority of *Yersinia* cases were domestically acquired. Among travel-related cases, the majority reported travel to Central or South America in 2013. As in the past, the majority of *Shigella* infections were travel-related, with Central or South America also being the most frequently reported travel destination.
- *Giardia*, *Cryptosporidium* and *Cyclospora* were all detected, though infrequently, on retail leafy greens in 2013. Additionally, *Giardia* and *Cryptosporidium* were more commonly found in untreated surface water and recreational water (beaches) in 2013.
- FoodNet Canada surveillance found both pathogenic norovirus and rotavirus on leafy greens. Historically, norovirus and rotavirus have been identified in many of the tested sources, including fresh produce, retail meats, and food animal manure. However, the potential risk to consumers is unknown given the uncertain viability of these viruses.

- Travel outside of Canada continued to add to the burden of enteric disease observed in Canada in 2013, 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.
- The collection of information across all of FoodNet Canada surveillance components (human, retail, on-farm, and water) in an enhanced and standardized way, has allowed for the integration of these data leading to 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 refining key findings and informing prevention and control measures for enteric diseases in Canada.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Objectives

FoodNet Canada 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 data at the community level on human illness cases and samples along the farm to fork continuum (i.e. retail food, farm animals, and local water) to identify risks. Information on the sources 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:

- Determine what food and other sources are making Canadians ill;
- Determine significant risk factors for enteric illness;
- Accurately track disease rates and risks over time; and
- Provide practical prevention information to:
  - Prioritize risks;
  - Compare interventions, direct actions and advance policy; and
  - Assess effectiveness of food safety activities and public health interventions and measure performance

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/foodnetcanada/niedsp10-pnisme10/index-eng.php).

Efforts have also been made to better integrate FoodNet Canada and the Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS). This has included the streamlining and sharing of sampling and sampling sites, retrospective and prospective testing of antimicrobial resistance in selected bacteria isolated from FoodNet Canada samples, and improving data management mechanisms to maximize data linkages. CIPARS monitors trends and the relationship between antimicrobial use and antimicrobial resistance in selected bacterial organisms from human, animal, and food sources across Canada to inform evidence- based policy decision making to contain the emergence and spread of resistant bacteria. For further information about CIPARS, please refer to the program’s website (www.phac-aspc.gc.ca/cipars-picra/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 Ontario (ON) site, which was established as the pilot sentinel site (June 2005), includes the Region of Waterloo and has approximately 525,000 residents. In this 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. 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. FoodNet Canada surveillance in the BC site in 2010 was limited to the enhanced human disease surveillance component as well as active surveillance of enteric pathogens in retail produce, with the expanded retail meat, water, and farm sampling components being initiated in subsequent years. By using harmonized subtyping methods across components and sites, 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.

About the Report:

The 2013 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 10 provide information on human cases and exposure sources, as well as temporal trends for 2013 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 11.

The surveillance data presented in this 2013 Annual Report pertains only to the ON and BC sentinel sites. Unless otherwise noted, all results for these two sites have been combined. 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.

1.2 Surveillance Strategy

Human surveillance

The enhanced human disease surveillance component of FoodNet Canada is fully implemented in the two sentinel sites: the ON site and the 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 case specimens (e.g. stool samples) are conducted.

Non-Human Surveillance

In 2013, all components (retail, farm, and water) were fully implemented in both the ON and BC sites.

The non-human surveillance data collected by FoodNet Canada represent possible exposure sources for human enteric illnesses within each sentinel site. 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. The non-human and human data are integrated via source attribution methodology, with the aim of obtaining an overall refined estimate on the proportion of illnesses being caused by each of the various exposure sources.

Retail surveillance

The retail stage of food production represents the point closest to consumers through which they 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 began in the BC site, with the sampling methodology modeled after the ON site. Samples from both sentinel sites were tested for selected bacterial pathogens on each commodity (Appendix A).

Produce sampling has occurred in the ON site since 2009 and in the BC site since 2010. To date, produce samples have included bagged leafy greens, soft berries, and fresh herbs.

On-farm surveillance

The presence of enteric pathogens on farms (in animal manure) is a potential source of environmental exposure of enteric pathogens, and also represents one of the main sources in the farm-to-fork transmission chain. In 2013, the farm component was active within both the ON and BC sites, although commodities varied by site. Manure samples were collected from beef cattle, broiler chicken, dairy cattle, layer chicken, and turkey farms in order to estimate the pathogen burden on farms. Approximately 30 of each type of farm were visited each year in each site. A short management survey, and up to four manure samples (usually fresh pooled samples) were obtained at each farm visit. All samples were tested for *Campylobacter* and *Salmonella* with the beef and dairy samples additionally being tested for *E. coli* O157/VTEC.

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. Since 2011, beach sampling has taken place within the Grand River Watershed in and/or near the ON site and also in the BC site and since 2013 irrigation canal sampling has taken place in the BC site. Samples were tested for a list of selected enteric bacteria, parasites, and viruses (Appendix A).

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 and/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**).

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 to more complex modelling approaches.

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.

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.

Chapter 12 focuses on Source Attribution and includes a listing of FoodNet Canada research activities that include the use of 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 Methodologies for 2013

Sample collection

In the retail component in 2013, sampling of both skinless chicken breasts and ground beef continued in both the ON and BC sites. In addition, frozen chicken nuggets and ground chicken samples were targeted in both sites.

In 2013, bagged leafy greens were collected for the produce component in both the ON and BC sites.

For the farm component, in 2013 in the ON site, beef, broiler chicken, dairy, and layer chicken farms were visited. From each farm in the ON site, three fresh pooled manure samples and one stored manure sample were collected. In the BC site in 2013, broiler chickens, layer chickens, and turkey farms were sampled. All of the sampling in the BC site was done in conjunction with the CIPARS program. For the broiler chickens in BC, both placement and pre-harvest fresh pooled manure samples were collected, but only the pre-harvest samples (collected within one week of slaughter) were used for the FNC analysis. For the layer chickens in BC, environmental samples were collected and for the turkey, four fresh pooled manure samples were collected at each farm visit.

Both untreated surface water and beach samples were collected throughout the year within the Grand River Watershed in and/or near the ON site in 2013 and irrigation canal samples were collected throughout the year in the BC site in 2013.

Laboratory testing and pathogen detection

In the retail component, in March 2012 *Campylobacter* testing was discontinued on the frozen chicken nuggets due to the very low recovery rates. Testing continued as in previous years with *Campylobacter* and *Salmonella* being tested for among all chicken products, *Listeria* for all retail meat products, and VTEC for ground beef samples (Appendix A). In addition, bagged leafy greens were tested for the presence of *Listeria*, *Cyclospora*, *Cryptosporidium*, *Giardia*, Norovirus, and Rotavirus.

In 2012, a method change was implemented in the farm component for detecting pathogenic *E. coli*. Therefore, in 2013, for the beef and dairy samples, an isolation test was done for VTEC as well as *E. coli* O157 (versus *E. coli* O157:H7 as in previous years). Serotyping was then completed on all positives. *E. coli* O157:H7 is therefore now identified using serotyping versus isolation results which was found to be more accurate. *Campylobacter* and *Salmonella* continued to be tested for in all farm commodities.

In 2013 in the water component, testing for *Campylobacter*, *Salmonella*, VTEC, *Cryptosporidium*, and *Giardia* was continued for water samples from the ON site. In the BC site, samples were only tested for *Campylobacter*, *Salmonella,* and VTEC.

Molecular subtyping results of *Campylobacter* positive samples have also been added to the 2013 Annual Report including results from previous years. Comparative Genomic Fingerprinting (CGF) was the method used. It tests for the presence/absence of the 40 genes in the bacterial genome. The CGF 100% nomenclature requires that all 40 genes match which results in little clustering. The 90% nomenclature clusters the fingerprints together into groups that may differ by up to four genes.

2. HUMAN CASE SUMMARY

2.1 Overview of Human Cases of Disease

A total of 803 human cases of 11 bacterial, viral and parasitic enteric diseases were reported to FoodNet Canada within the ON and BC sites in 2013 (Table 2.1).

The three most frequently reported diseases in the 2013 time period (campylobacteriosis, salmonellosis and giardiasis) accounted for 81% of the cases (Figure 2.1).

Information on potential exposures was obtained from 88% (709/803) of reported cases in the ON and BC sites in 2013.

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, 2013.

ON AND BC SITES

2013

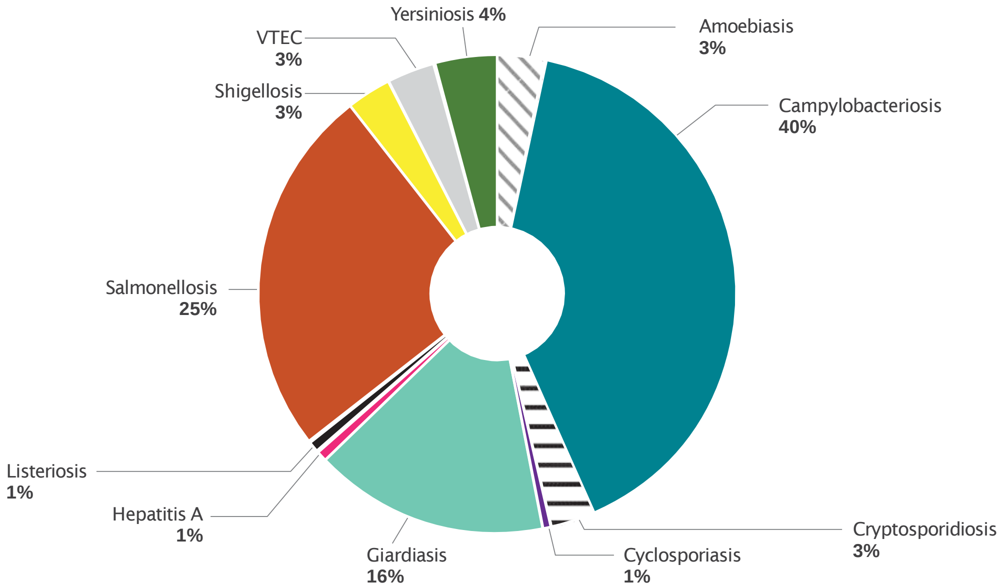
Disease	Incubation Period[b]	Number of Cases						Incidence Rate[a]	
		Endemic	Outbreak	Travel	Non-Endemic	Lost to Follow-Up	Total	Endemic	Total
Amoebiasis[c]	2–4 weeks	6	0	4	9	8	**27**	1.10	**4.96**
Campylobacteriosis	1–10 days	228	0	61	2	31	**322**	22.56	**31.86**
Cryptosporidiosis	1–12 days	12	0	11	0	2	**25**	1.19	**2.47**
Cyclosporiasis	1–14 days	2	0	2	0	0	**4**	0.20	**0.40**
Giardiasis	3–25 days	45	0	45	15	22	**127**	4.45	**12.56**
Hepatitis A[c]	15–50 days	2	0	5	0	0	**7**	0.37	**1.29**
Listeriosis[d]	3–70 days	5	1	0	0	1	**7**	0.49	**0.69**
Salmonellosis	6–72 hours	99	11	65	2	24	**201**	9.79	**19.89**
Shigellosis	0.5–4 days	7	0	17	0	1	**25**	0.69	**2.47**
Verotoxigenic *E. coli* (VTEC)	2–10 days	21	2	3	0	0	**26**	2.08	**2.57**
Yersiniosis	3–10 days	20	0	7	0	5	**32**	1.98	**3.17**
Total		**447**	**14**	**220**	**28**	**94**	**803**		

[a] Population estimates for the ON site obtained from the Ontario Ministry of Health and Long-Term Care, Population Projections 2013, IntelliHEALTH Ontario, Extracted on: November 21, 2013. Population estimates for the BC site obtained from BC Ministry of Finance and Corporate Relations. BC Stats, P.E.O.P.L.E. 2013 (Population Extrapolation for Organizational Planning with Less Error), Sep 2013.

[b] Combined range used by sites. There are different incubation periods across the sites for *Shigella*, *Cyclospora* and *Yersinia*.

[c] Cases reported to the ON site only.

FIGURE 2.1: Relative proportion of enteric diseases reported in both the ON (11 enteric diseases) and BC (9 enteric diseases) sites combined, 2013 (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 *Campylobacter* (1 blood), *Salmonella* (17 blood and 9 urine), *Listeria* (6 blood), and Hepatitis A (7 blood, no stool) 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 17 cases where the pathogen was detected from blood and included the following serotypes: Heidelberg (5 cases), Typhi (5 cases), Paratyphi A (4 cases), Hadar (1 case), Bonariensis (1 case) and Enteritidis (1 case). The *Salmonella* cases where the pathogen was detected from urine included the following serotypes: Enteritidis (3 cases), Alachua (1 case), Agona (1 case), Muenchen (1 case), Paratyphi B var Java (1 case), Rubislaw (1 case) and I Rough-O:-:- (1 case). *Salmonella* accounted for the majority of isolations from extra-intestinal sources as reported to the National Enteric Surveillance Program in 2013 (**2**). Among the more frequently reported serovars, *S.* Typhi (44%) and *S.* Paratyphi A (36%) had the highest proportion of submissions from extra-intestinal sources. Within the three most commonly reported serovars, approximately 12% of *S.* Heidelberg isolates were identified from non-fecal specimens, whereas non-fecal sources accounted for only 5% and 4% of cases of *S.* Enteritidis and *S.* Typhimurium, respectively (**2**).

2. Outbreak-related Cases

In the ON site, a total of ten outbreak-associated cases were reported in 2013. Nine of these outbreak-associated cases were attributed to *Salmonella* and one was attributed to *Listeria*. Five of the nine *Salmonella* cases were identified as being part of a travel-related cluster, three cases were part of a cluster at a long term care residence and one case was part of a provincial outbreak. The *Listeria* outbreak-associated case was part of a cluster of cases associated with a general increase in listeriosis during this time period.

In the BC site, four outbreak-associated enteric disease cases were reported in 2013. Two *Salmonella* cases were part of a local outbreak associated with consumption of undercooked, low quality eggs. Two verotoxigenic *E. coli* (VTEC) cases were part of a national outbreak investigation associated with the consumption of unpasteurized cheese products. This outbreak occurred between July and September 2013 with 28 cases reported in multiple provinces including British Columbia, Alberta, Saskatchewan, Manitoba and Quebec (**3**).

3. Travel-related Cases

Of the cases reported in both the ON and BC sites in 2013, approximately 27% (220/803) were classified as international travel-related. Salmonellosis, campylobacteriosis and giardiasis continue to be the three most common travel-related diseases, contributing to 78% of the travel-related cases (Table 2.1). Most of the cases had visited Asia or South or Central America (including the Caribbean) prior to acquiring their illness (Table 2.3); a trend that possibly reflects travel preferences of the sentinel site populations.

TABLE 2.2: International travel-related cases in both the ON and BC sites, 2013.

ON AND BC SITES 2013							
Disease	**Africa**	**South or Central America[a]**	**Asia**	**Europe**	**USA**	**Multiple Destinations & Others**	**Total**
Amoebiasis[b]	1	2	0	0	0	1	**4**
Campylobacteriosis	1	23	20	9	6	2	**61**
Cryptosporidiosis	3	2	5	0	1	0	**11**
Cyclosporiasis	0	1	1	0	0	0	**2**
Giardiasis	4	10	26	0	4	1	**45**
Hepatitis A[a]	0	0	4	0	0	1	**5**
Listeriosis	0	0	0	0	0	0	**0**
Salmonellosis	2	28	26	2	7	0	**65**
Shigellosis	1	8	7	0	1	0	**17**
Verotoxigenic *E. coli*	0	2	0	0	1	0	**3**
Yersiniosis	0	4	0	1	2	0	**7**
Total	**12**	**80**	**89**	**12**	**22**	**5**	**220**

[a] Includes the Caribbean

[b] Cases reported to the ON site only.

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 analyses, more stable estimates of disease incidence can be provided and estimates will not be overly influenced by unusual events. However, for the purpose of integrated comparison and comprehensiveness for the current reporting/surveillance year, domestic outbreak and international travel cases will be identified in integrated tables (include both human and non-human data).

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. 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 (**4**). 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).

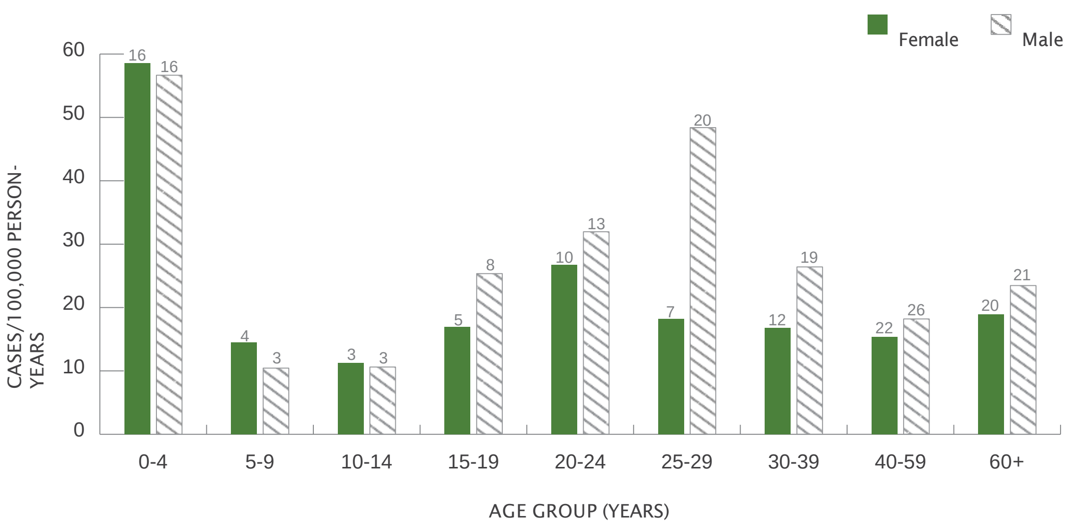
3. CAMPYLOBACTER

3.1 Human Cases

In both the ON and BC sites, a total of 322 cases of campylobacteriosis were reported in 2013, representing an incidence rate of 31.9 cases/100,000 person-years. Of these cases, 19% (61/322) were travel-related (6.0 cases/100,000 person-years), 71% (228/322) were classified as endemic (22.6 cases/100,000 person-years) and 0.6% (2/322) were classified as non-endemic cases related to recent immigration. A total of 10% (31/322) of human campylobacteriosis cases were lost to follow-up. In comparison, the annual incidence rate for campylobacteriosis in 2013 for all of Canada was 29.13 cases/100,000 person-years (**5**).

Of the 228 endemic cases, 129 (25.6 cases/100,000 person-years) were male and 99 (19.5 cases/100,000 person-years) were female (Figure 3.1). Incidence rates were highest in males (56.7 cases/100,000 person-years) and females (58.5 cases/100,000 person-years) between the ages of 0–4 and males between the ages of 25–29 (48.4 cases/100,000 person-years). Of the 61 travel-related cases, 28 (5.6 cases/100,000 person-years) were males and 33 (6.5 cases/100,000 person-years) were females.

FIGURE 3.1: Incidence rates of sporadic, human endemic campylobacteriosis identified in the ON and BC sites in 2013, by gender and age group.



NOTE: The total number of cases is included on top of each bar.

The majority (89%; 152/170) of *Campylobacter* isolates subtyped from endemic campylobacteriosis cases in the ON and BC sites in 2013 were *C. jejuni* (Table 3.1). In 2013, 4.1% (7/170) of endemic *Campylobacter* isolates were subtyped as *C. coli*.

3.1.1 Case Exposures

Information was collected for 90% (291/322) 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 by combining both the ON and BC sites. Univariate comparisons identified consumption of unpasteurized milk to be significantly ($p<0.05$) associated with an increased risk of campylobacteriosis (Appendix B).

3.2 Surveillance of Potential Sources

Retail food

In 2013, the retail products tested for *Campylobacter* included skinless chicken breast and ground chicken. The testing of chicken nuggets for *Campylobacter* was discontinued in 2013 due to the low recovery observed in previous years, likely due to this being a frozen product. The prevalence of *Campylobacter* on skinless chicken breast in both sentinel sites in 2013 was 46% (117/257) (Table 3.1). The prevalence on ground chicken was 31% (58/189).

Though the prevalence of *Campylobacter* tends to be high for poultry products, the number of organisms detected tends to be low. In 2013, *Campylobacter* enumeration was only performed for ground chicken, but 70% of these samples (39/56) had organism counts below the detection limit of 0.3 most probable number (MPN) of organisms per gram (Appendix C).

Campylobacter jejuni was the most commonly detected species of *Campylobacter* on both skinless chicken breasts and ground chicken in 2013, as in previous years (Table 3.1).

CGF 100% cluster 83.1.2 was the most commonly found among chicken breasts and ground chicken out of all clusters that contained at least one human case in 2013 (Table 3.2); it was also the second most commonly found in cases. In addition, cluster 957.1.1 was the second most common among chicken meats. There were two human cases with cluster 957.1.1. Cluster 173.10.2 was the most common among human cases and third most common among chicken breast cuts.

Farm animals

In 2013, *Campylobacter* was found at relatively high prevalences in manure from turkey (79%; 88/112), beef cattle (75%; 90/120), and dairy cattle (75%; 90/120) (Table 3.1). It was also found in layer and broiler chickens, although less commonly.

Campylobacter jejuni was the most common species from the farm commodities sampled in 2013. It was the only species found in the broiler chickens and the most frequent species detected in the other commodities as well. The only exception being layer chickens in which *Campylobacter coli* was the predominant subtype (Table 3.1).

CGF cluster 173.10.2 was common on broiler chicken manure (Table 3.2) in 2013. Cluster 898.4.2 was the most common in beef and dairy cattle manure and was found in one human case.

Water

In 2013, 25% of untreated surface water samples were found to be contaminated with *Campylobacter* (Table 3.1). *Campylobacter jejuni* was the most common species found in water as well, with more than half of the *Campylobacter* isolates positive for this subtype. CGF clusters 238.2.2 and 532.2.1 were the only types found in water samples and also found in at least one human case (Table 3.2).

TABLE 3.1: *Campylobacter* detection and subtyping, ON and BC sites, 2013.

METHOD	HUMAN			RETAIL		FARM ANIMAL MANURE					WATER [a]
	ENDEMIC SPORADIC	OUTBREAK	TRAVEL	CHICKEN BREAST	GROUND CHICKEN	BROILER CHICKEN	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKEN	TURKEY	
Detection											
No. of samples tested	…	…	…	257	189	216	120	120	61	112	167
No. positive	227	1	61	117	58	51	90	90	34	88	42
Percent positive	..	..	..	46%	31%	24%	75%	75%	56%	79%	25%
Subtyping											
No. of isolates subtyped	169	1	49	116	57	51	90	90	34	88	39
Campylobacter jejuni	151	1	36	99	47	51	59	74	14	81	25
	89%	100%	73%	85%	82%	100%	66%	82%	41%	92%	64%
Campylobacter jejuni/coli [b]	10	0	4	..	..	..	..	..	..	..	..
	5.9%	0%	8.2%								
Campylobacter coli	7	0	7	17	9	0	29	9	20	7	6
	4.1%	0%	14%	15%	16%	0%	32%	10%	59%	8.0%	15%
Campylobacter fetus	1	0	0	..	..	..	..	..	..	..	..
	0.6%	0%	0%								
Campylobacter lari	0	0	0	0	1	..	..	..	..	..	9
	0%	0%	0%	0%	1.8%	23%					
Campylobacter upsaliensis	0	0	2	..	..	..	..	..	..	..	..
	0%	0%	4.1%								
Other species	0	0	0	0	0	0	2	7	0	0	0
	0%	0%	0%	0%	0%	0%	2.2%	7.8%	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. Turkey was only sampled in BC.

… Not available

.. Not applicable

[a] Multiple isolates were subtyped for water samples, all identified species are reported in the table.

[b] Samples have not been differentiated between *C. jejuni* or *C. coli.*

TABLE 3.2: Number of isolates in Comparative Genomic Fingerprint 100% clusters in all sources with at least one human case, in BC and ON sites, in 2013, and from samples collected from 2006 to 2012.

SELECT 100% CGF CLUSTER	HUMAN	RETAIL FOOD					FARM ANIMAL MANURE					WATER
	ENDEMIC	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKENS	
		No. TYPED IN 2013 (2006–2012)										
Number	**86**	**111 (529)**	**0 (3)**	**0 (3)**	**57 (184)**	**. (68)**	**. (345)**	**25 (29)**	**34 (317)**	**33 (319)**	**11 (.)**	**10 (61)**
173.10.2	10	7 (10)	0 (0)	0 (0)	4 (2)	. (1)	. (0)	11 (0)	0 (0)	0 (0)	0 (.)	0 (0)
83.1.2	8	9 (27)	0 (0)	0 (0)	7 (12)	. (4)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
882.5.1	5	1 (20)	0 (0)	0 (0)	1 (6)	. (3)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
169.1.2	4	0 (13)	0 (0)	0 (0)	1 (9)	. (1)	. (0)	0 (3)	0 (10)	2 (10)	0 (.)	0 (0)
82.1.1	3	2 (1)	0 (0)	0 (0)	0 (1)	. (1)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
982.1.2	3	0 (3)	0 (0)	0 (0)	1 (0)	. (2)	. (0)	0 (0)	1 (12)	1 (15)	0 (.)	0 (0)
957.1.1	2	8 (34)	0 (0)	0 (2)	5 (11)	. (5)	. (0)	0 (0)	1 (1)	0 (0)	0 (.)	0 (2)
18.1.2	2	4 (4)	0 (0)	0 (0)	2 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
926.2.1	2	3 (31)	0 (0)	0 (0)	1 (5)	. (3)	. (0)	0 (1)	1 (0)	0 (7)	0 (.)	0 (1)
103.1.2	2	1 (8)	0 (0)	0 (0)	0 (2)	. (1)	. (0)	1 (0)	0 (1)	0 (0)	0 (.)	0 (0)
120.1.2	2	1 (1)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
44.3.1	2	1 (2)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (17)	0 (13)	0 (.)	0 (0)
695.6.1	2	1 (1)	0 (0)	0 (0)	0 (2)	. (0)	. (0)	0 (0)	3 (41)	0 (20)	0 (.)	0 (0)
238.2.2	2	0 (1)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (4)	0 (2)	3 (.)	1 (0)
83.3.2	2	0 (2)	0 (0)	0 (0)	0 (1)	. (2)	. (0)	2 (0)	0 (0)	0 (0)	0 (.)	0 (0)
123.2.1	1	3 (1)	0 (0)	0 (0)	1 (3)	. (1)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
173.2.4	1	3 (8)	0 (0)	0 (0)	0 (2)	. (0)	. (1)	0 (0)	0 (3)	0 (1)	0 (.)	0 (0)
923.2.1	1	3 (7)	0 (0)	0 (0)	1 (7)	. (0)	. (0)	0 (0)	0 (6)	0 (10)	0 (.)	0 (1)
12.1.2	1	2 (7)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
933.4.2	1	2 (16)	0 (0)	0 (0)	1 (1)	. (1)	. (0)	0 (0)	0 (2)	0 (2)	0 (.)	0 (0)
893.1.1	1	1 (17)	0 (0)	0 (0)	0 (10)	. (0)	. (0)	0 (3)	0 (0)	0 (2)	0 (.)	0 (0)

SELECT 100% CGF CLUSTER	HUMAN	RETAIL FOOD					FARM ANIMAL MANURE					WATER
	ENDEMIC	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	GROUND TURKEY	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKENS	
11.3.13	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
114.1.3	1	0 (1)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
117.1.1	1	0 (9)	0 (0)	0 (0)	0 (4)	. (1)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
119.1.1	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
121.2.4	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
14.1.5	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
169.11.2	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
169.6.5	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
238.7.2	1	0 (0)	0 (0)	0 (0)	0 (1)	. (1)	. (0)	0 (0)	1 (1)	0 (4)	0 (.)	0 (0)
44.3.13	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
524.1.2	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
524.4.5	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
532.2.1	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	1 (0)
54.4.5	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
54.4.6	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
61.1.2	1	0 (1)	0 (0)	0 (0)	1 (0)	. (0)	. (0)	0 (0)	0 (3)	0 (1)	0 (.)	0 (0)
731.1.5	1	0 (3)	0 (1)	0 (0)	0 (1)	. (0)	. (0)	0 (0)	3 (26)	5 (20)	0 (.)	0 (0)
731.1.6	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
735.1.2	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (2)	0 (1)	0 (.)	0 (0)
782.1.3	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
82.1.9	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
83.1.14	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
83.1.9	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
891.1.1	1	0 (6)	0 (0)	0 (0)	0 (3)	. (0)	. (0)	0 (0)	0 (6)	2 (1)	0 (.)	0 (1)
894.1.2	1	0 (2)	0 (0)	0 (0)	3 (2)	. (0)	. (0)	1 (0)	0 (0)	0 (0)	0 (.)	0 (0)
898.4.2	1	0 (2)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	3 (11)	6 (12)	0 (.)	0 (0)
933.8.1	1	0 (5)	0 (0)	0 (0)	3 (6)	. (2)	. (0)	0 (0)	0 (1)	0 (0)	0 (.)	0 (0)
949.3.6	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)
952.3.2	1	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (0)

3.3 Temporal Distribution

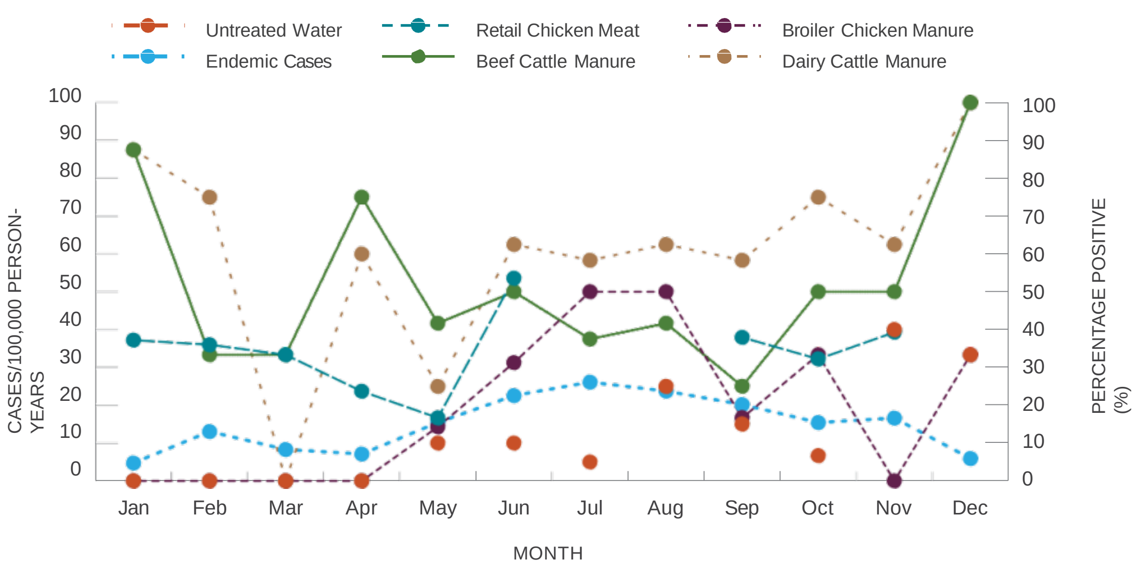
It is well known that campylobacteriosis tends to vary with season; however, little is known about temporal trends in potential sources of *Campylobacter*. As *C. jejuni* is the most common *Campylobacter* species found in human cases and is also found in many potential sources of exposure, the following temporal analysis is focused only on this subtype.

In 2013, the incidence rates of endemic cases of human campylobacteriosis caused by *C. jejuni* in both the ON and BC sites combined were significantly higher during the summer months (June, July, and August) compared to the Spring (March, April, and May) or Winter (December, January, and February) months (Figure 3.2). These trends reflect those observed previously in the ON and BC sites.

Chicken meat is a known source of human *Campylobacter* infection, and in particular, *C. jejuni*. Historically, the prevalence of *C. jejuni* on retail chicken meat has increased during the summer months, similar to the human cases. In 2013, however, retail chicken was not sampled during July and August resulting in June having the highest observed prevalence. Fecal samples from broiler chicken operations within the sentinel sites also had a higher prevalence in the summer and fall months in 2013 similar to previous years.

A clear seasonal relationship between the number of human cases and the exposure sources was not evident in 2013. Though broadly the same movements between retail chicken and human cases are seen, as in the past, further investigation is warranted. FoodNet Canada has a number of studies underway to probe this relationship in more detail.

FIGURE 3.2: *Campylobacter jejuni* detection from endemic human cases and selected non-human sources, by month, ON and BC sites, 2013.



NOTE: For human cases, month is determined by onset date. Also, no sampling of retail chicken occurred between June 18, 2013 and September 15, 2013.

3.4 Summary of Campylobacter Results

What is the same in 2013 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.
- A high proportion of raw chicken samples were contaminated with *Campylobacter jejuni.*
- All broiler chicken manure samples positive for *Campylobacter* were *C. jejuni*.
- *Campylobacter* continues to be found at a relatively high prevalence in both beef and dairy cattle, although with a lower proportion of *C. jejuni* than in the broiler chickens.

What is new?

- 2013 was the first year that both layer chicken and turkey farms were sampled. The prevalence of *Campylobacter* in both layer chicken and turkey manure was found to be significantly higher than in broiler manure in 2013. Both *C. jejuni* and *C. coli* were found in the layer chickens and turkey.
- CGF data has been included in this 2013 Annual Report (for current and past years), which supports the association of chicken meat products with human cases through subtype comparisons.

Integration of results

Possible sources of *Campylobacter* infection based on analysis of the enhanced case questionnaire information as well as surveillance data are summarized in the following table. The only possible exposure identified through univariate analysis was the consumption of unpasteurized milk. Among the manure collected from dairy cattle farms, cluster 731 was the most commonly identified, in addition to one human case also identified with the same cluster number. The subtyping information supports the possibility of unpasteurized milk being a source of *Campylobacter* for the population in these sentinel sites.

FoodNet Canada surveillance data continues to suggest retail chicken meat as the most important possible source of *Campylobacter* for humans. This is further supported by the most common CGF clusters identified among retail chicken products representing the most common clusters identified among human infections. However, other sources, such as beef and dairy cattle and their products, in particular unpasteurized milk as noted above, are also likely important. For the retail chicken meat, the lower prevalence of *C. jejuni* on farm compared to the meat continues to suggest a focus on decreasing cross contamination at the processing level is necessary.

TABLE 3.3: Possible sources of campylobacteriosis identified in BC and ON sites in 2013

FOODNET CANADA DATA SOURCE	METHODOLOGY	POSSIBLE SOURCES
Human exposure data from case questionnaires	Descriptive	Consumption of unpasteurized milk
Agricultural manure surveillance	Descriptive	Beef and dairy cattle, turkey, and layer and broiler chickens
Retail grocery store samples	Descriptive	Skinless chicken breast and ground chicken
Water surveillance	Descriptive	Contact with natural waters

FoodNet Canada has been and is continuing to collect molecular subtyping data (Table 3.2) so that more detailed analyses can be performed in the future to determine the most important reservoirs and vehicles for *Campylobacter* infection.

FoodNet Canada surveillance in action

FoodNet Canada's human, retail, farm, and water *Campylobacter* data has recently been used to inform:

- A *Campylobacter* source attribution analysis
- A *Campylobacter* cluster analysis using CGF in collaboration with BC
- A *Campylobacter* case-control study
- A *Campylobacter* comparative exposure assessment analysis

4. SALMONELLA

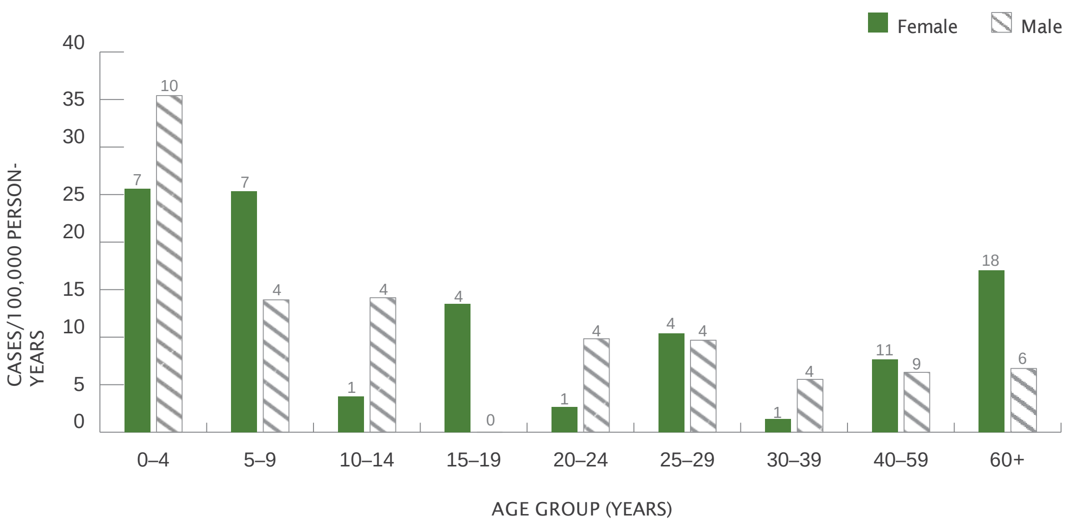
4.1 Human Cases

A total of 201 cases of salmonellosis were reported in 2013 in both ON and BC sites, representing an incidence rate of 19.9 cases/100,000 person-years. Of these cases, 32% (65/201) were travel-related (6.4 cases/100,000 person-years), 5% (11/201) were outbreak-related (1.1 cases/100,000 person-years), 49% (99/201) were classified as endemic (9.8 cases/100,000 person-years) and 1% (2/201) were classified as non-endemic cases related to recent immigration. Five outbreak cases were associated with international travel. A total of 12% (24/201) of human salmonellosis cases were lost to follow-up. In comparison, the annual incidence rate for salmonellosis in 2013 for all of Canada was 17.6 cases/100,000 person-years (**5**).

The most commonly reported *Salmonella* serovars were Enteritidis (36%; 72/201), Heidelberg (13%; 27/201) and Typhimurium (10%; 20/201). Of the 99 endemic cases, the most commonly reported *Salmonella* serovars were Enteritidis (36%; 36/99; 3.6/100,000 person-years), Heidelberg 23% (23/99; 2.3/100,000 person-years) and Typhimurium (12%; 12/99; 1.2/100,000 person-years). These serovars were also the top three serovars reported to the NESP in 2013 (**2**).

Distributions of age and gender among the salmonellosis cases in 2013 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.

FIGURE 4.1: Incidence rates of sporadic, human endemic salmonellosis in the ON and BC sites in 2013, by gender and age group.



NOTE: The total number of cases is included on top of each bar.

1. Travel-Related Cases

The most commonly isolated *Salmonella* serovars for travel-related cases in both the ON and BC sites were Enteritidis (34%; 22/65), Typhi (9%; 6/65) and Paratyphi A (8%; 5/65).

In total, 43% (28/65) of people with travel-related salmonellosis within both sites reported travelling to South or Central America (including the Caribbean), 40% (26/65) reported travelling to Asia, 11% (7/65) to the United States, 3% (2/65) to Africa and 3% (2/65) to Europe. In the BC site, the predominant travel destination for salmonellosis cases was Asia (58%; 15/26), whereas in the ON site, the predominant travel destination for salmonellosis cases was to South or Central America (including the Caribbean) (54%; 21/39).

2. Case Exposures

Information was collected for 88% (177/201) 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. Based on univariate analysis, cases who were a student, unemployed or retired or age 60 or older (referent 30–59), were more likely to acquire *Salmonella* infection (Appendix B). Historically, contact with household reptiles has been found to be significantly associated with an increased risk of salmonellosis.

4.2 Surveillance of Potential Sources

Food

Salmonella was detected in 21% of skinless chicken breast samples collected in 2013 from retail establishments in both sentinel sites (Table 4.1). This prevalence is significantly lower than that observed in both sites in 2011–12 (29%). *Salmonella* was found at a higher prevalence in the other retail chicken products with 60% of ground chicken samples and 35% of chicken nugget samples testing positive. Overall counts of *Salmonella* organisms on chicken nuggets were low, as in previous years, while two ground chicken samples had counts of >100/g (Appendix C).

The three most common *Salmonella* serovars detected in chicken meat samples were Kentucky (60 isolates), Enteritidis (54 isolates), and Heidelberg (47 isolates) (Table 4.1). Of note, *Salmonella* Heidelberg was significantly higher in chicken nuggets, (11%, 21/189) and ground chicken (11%, 20/189) than in chicken breasts (2%, 6/257). Similarly, *S.* Enteritidis was significantly higher in chicken nuggets (11%, 21/189) and ground chicken (13%, 24/189) than in chicken breasts (4%, 9/257).

Farm animals

The prevalence of *Salmonella* in pooled fecal samples from broiler chickens in both sites combined was 64% (Table 4.1). This prevalence is similar to that found in 2011–12 in broiler chickens in the ON site (59%). The top three serovars identified were Kentucky (21%, 45/215), Enteritidis (15%, 32/215), and Heidelberg (11%, 23/215), the same as in the chicken retail products.

Salmonella was found at a lower prevalence in turkey (35%), layer chickens (20%), beef (11%), and dairy cattle (9%). The most common serovars identified in the beef and dairy cattle farms were Oranienburg (3%) and Give (2%), respectively.

Water

Overall, *Salmonella* was detected in 34% of water samples in 2013. The top three serovars found were Give (4%, 7/167), Typhimurium (3%, 5/167), and Heidelberg (2%, 4/167).

TABLE 4.1: Number of *Salmonella* isolates recovered and serotyped (culture-based methods) across all FoodNet Canada surveillance components, ON and BC sites, 2013.

METHOD	HUMAN			RETAIL FOOD			FARM ANIMAL MANURE					WATER
	ENDEMIC SPORADIC	OUTBREAK[a]	TRAVEL	CHICKEN BREAST	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKENS	TURKEY	
Detection												
Number of samples tested	…	…	…	257	189	189	215	120	120	61	112	167
Number positive	99	11	65	54	66	114	137	13	11	12	39	56
Percent positive	..	..	..	21%	35%	60%	64%	11%	9%	20%	35%	34%
Serotyping												
Number of isolates serotyped	97	11	64	54	66	113	137	13	11	12	39	47
Enteritidis	36	7	22	9	21	24	32	0	0	0	0	1
Heidelberg	23	0	0	6	21	20	23	2	0	1	0	4
Typhimurium	12	1	2	4	2	5	0	0	1	0	0	5
Schwarzengrun	3	0	0	0	0	5	0	0	0	0	0	0
d Agona	2	0	1	0	1	1	0	1	0	0	4	3
Brandenburg	2	0	0	0	1	0	0	0	0	0	0	0
Paratyphi B Var.	2	0	1	0	0	0	0	0	0	0	0	0
Java Derby	1	0	0	0	0	0	0	0	0	0	0	1
Hartford	1	0	1	0	0	0	0	0	0	0	0	0
Manhattan	1	0	1	0	0	0	0	1	0	0	0	0
Newport	1	0	2	1	0	0	0	0	0	0	3	2
Oranienburg	1	0	0	0	0	0	0	3	0	0	0	0
Rissen	1	0	1	0	0	0	0	0	0	0	0	0
Rubislaw	1	0	0	0	0	1	0	0	0	0	0	2

METHOD	HUMAN			RETAIL FOOD			FARM ANIMAL MANURE					WATER
	ENDEMIC SPORADIC	OUTBREAK[a]	TRAVEL	CHICKEN BREAST	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKENS	TURKEY	
i:4,12:i:-	1	0	0	0	0	2	0	0	0	0	0	0
i:4,5,12:i:-	1	0	4	0	0	2	7	0	0	0	0	0
Aberdeen	0	0	2	0	0	0	0	0	0	0	0	0
Albany	0	0	0	0	0	0	0	0	0	0	4	0
Anatum	0	0	0	0	0	0	2	0	0	0	0	1
Braenderup	0	0	2	0	0	0	1	0	0	3	0	1
Bredeney	0	0	0	0	0	0	0	1	0	0	0	1
Cerro	0	0	0	0	0	0	0	0	3	0	0	2
Corvallis	0	0	2	0	0	0	0	0	0	0	0	0
Cubana	0	0	0	0	0	1	13	0	0	0	4	0
Give	0	0	0	0	0	0	0	1	4	0	0	7
Hadar	0	0	0	2	5	5	0	0	0	0	3	1
Infantis	0	0	0	1	2	1	2	0	0	0	0	2
Javiana	0	0	2	0	0	0	0	0	0	0	0	0
Kentucky	0	0	0	19	11	30	45	1	0	5	0	1
Kiambu	0	0	0	1	0	4	0	0	0	0	0	1
Liverpool	0	0	0	0	0	1	3	0	0	0	17	0
Livingstone	0	0	0	1	0	2	4	0	0	0	0	0
Mbandaka	0	0	0	3	2	3	0	0	0	0	0	2
Montevideo	0	0	1	0	0	1	0	0	2	0	0	0
Muenchen	0	3	1	0	0	0	0	0	0	0	0	0
Ohio Var. 14+	0	0	0	0	0	0	0	0	0	2	0	0
Paratyphi A	0	0	5	0	0	0	0	0	0	0	0	0
Poona	0	0	0	0	0	0	2	0	0	0	0	0

METHOD	HUMAN			RETAIL FOOD			FARM ANIMAL MANURE					WATER
	ENDEMIC SPORADIC	OUTBREAK[a]	TRAVEL	CHICKEN BREAST	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKENS	TURKEY	
Senftenberg	0	0	0	0	0	0	0	0	0	0	3	1
Tennessee	0	0	0	0	0	1	0	0	0	0	0	1
Thompson	0	0	0	3	0	4	0	0	0	0	0	1
Typhi	0	0	6	0	0	0	0	0	0	0	0	0
Uganda	0	0	0	0	0	0	0	3	0	0	0	0
i:4,5,12:b:-	0	0	0	0	0	0	0	0	0	0	0	3
i:8,20:-:z6	0	0	0	2	0	0	0	0	0	0	0	0
i:8,20:i:-	0	0	0	0	0	0	3	0	0	0	0	1
Other[b]	8	0	8	2	0	0	0	0	1	1	1	3

[a] Five of these outbreak cases were also related to international travel.

[b] Serovars that were identified once in a single component are listed here rather than in the table. Human endemic sporadic: Bonariensis; Chester; Haifa; Litchfield; I [6,14],18:-:-; Stanley; i:4,5,12:-:1,2; i:rough-o:-:-. Human travel: Dublin; Eastbourne; Hvittingfoss; Richmond; Tokoin; Weltevreden; I 3,{10}{15}{15–34}:b:-; i:9,12:-:-. Chicken breast: i:rough-o:i:z6; i:rough-o:k:1,5. Dairy cattle: Worthington. Layer chickens: Mbandaka Var.14+. Turkey: i:rough-o:d:e,n,z15. Water: Orion; Paratyphi B Var. L+; i:rough-o:r:1,5.

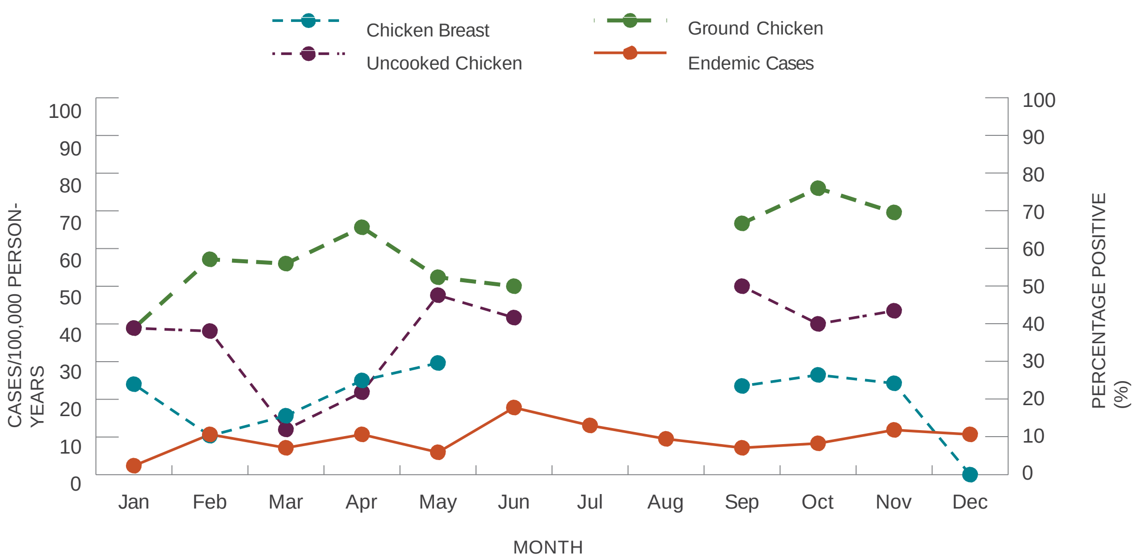
… Not available

.. Not applicable

4.3 Temporal Distribution

In 2013, retail chicken samples were not collected from mid-June to mid-September (Figure 4.2). This lack of sampling makes it difficult to interpret the distribution of *Salmonella* by month for these products.

FIGURE 4.2: Distribution of reported human endemic sporadic cases of salmonellosis and the prevalence of *Salmonella* found on retail chicken meat (chicken breast, uncooked chicken nuggets, and ground chicken) in the ON and BC sites in 2013, by month.



NOTE: For human cases, month was determined by onset date. Also, sampling of retail chicken meat did not occur from June 18 to September 15, 2013.

4.4 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. 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 presented, by phage type or PFGE pattern, and key trends are identified.

Salmonella Enteritidis

In 2013, *S.* Enteritidis was the most common serovar reported among human cases, chicken breasts, uncooked chicken nuggets, ground chicken and manure from broiler chicken farms (Table 4.1). Phage types 8, 13A, and 2 were the top three phage types associated with human endemic sporadic cases of *S.* Enteritidis in 2013 and were also observed among the retail and farm samples (Table 4.2). It should be noted that no *S.* Enteritidis was isolated from beef cattle, dairy cattle, layer chicken and turkey farm manure samples.

In 2013, phage type 8 was found in nine of 35 human endemic sporadic cases and was the most common phage type found in chicken nuggets (16/21 isolates) as well as chicken breasts (4/9 isolates) (Table 4.2). Phage type 8 was also found in ground chicken and broiler chicken manure. All of the human cases with this phage type had PFGE pattern SENXAI.0003. This PFGE pattern was also the most common PFGE pattern in all of the sources with this phage type. This information suggests that poultry and poultry products, especially uncooked chicken nuggets, are a very likely source of *S.* Enteritidis for humans. Phage type 13A was also found in nine of 35 human endemic sporadic cases, was found in all of the retail meat sources tested, and was the most common phage type found in the broiler chicken manure samples (17/32 isolates). The most common PFGE pattern associated with this phage type for the human cases as well as all of the sources was SENXAI.0006. This finding again suggests that poultry are very likely sources of *S.* Enteritidis for humans. Phage type 2 was found in 5/35 human endemic cases and in the possible sources it was only found in chicken breasts. All phage type 2 positive samples had the PFGE pattern SENXAI.0003.

TABLE 4.2: Integrated comparison of *Salmonella* Enteritidis phage types and PFGE patterns, ON and BC sites, 2013 compared to 2008 to 2012.

PHAGE TYPE AND PFGE PATTERN FOR SELECT PHAGE TYPES	HUMAN			RETAIL FOOD			FARM ANIMAL MANURE					WATER
	ENDEMIC SPORADIC	OUTBREAK[a]	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKENS	TURKEY	
	No. TYPED IN 2013 (2008–2012)											
Number of isolates	**35 (172)**	**6 (14)**	**21 (118)**	**9 (45)**	**21 (78)**	**24 (68)**	**32 (21)**	**0 (6)**	**0 (1)**	**0 (.)**	**0 (.)**	**1 (4)**
typed	**9 (78)**	**0 (8)**	**4 (11)**	**4 (25)**	**16 (50)**	**7 (28)**	**5 (2)**	**0 (2)**	**0 (0)**	**0 (.)**	**0 (.)**	**0 (0)**
8 (total)	9 (69)	0 (8)	3 (11)	3 (22)	15 (47)	5 (25)	5 (2)	0 (1)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.000	0 (5)	0 (0)	1 (0)	1 (2)	1 (3)	2 (3)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
3	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.000	0 (2)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (.)	0 (.)	0 (0)
7	**9 (48)**	**2 (4)**	**2 (13)**	**3 (11)**	**2 (12)**	**8 (12)**	**17 (6)**	**0 (0)**	**0 (0)**	**0 (.)**	**0 (.)**	**0 (1)**
SENXAI.004	8 (35)	2 (4)	2 (8)	2 (11)	2 (11)	8 (9)	12 (4)	0 (0)	0 (0)	0 (.)	0 (.)	0 (1)
1	1 (2)	0 (0)	0 (1)	1 (0)	0 (1)	0 (0)	2 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
Other	0 (8)	0 (0)	0 (4)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
13A (total)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.000	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (3)	1 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
6	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.006	**5 (1)**	**0 (0)**	**0 (0)**	**1 (1)**	**0 (0)**	**0 (1)**	**0 (2)**	**0 (0)**	**0 (0)**	**0 (.)**	**0 (.)**	**0 (0)**
8	5 (1)	0 (0)	0 (0)	1 (1)	0 (0)	0 (1)	0 (2)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.000	**3 (9)**	**0 (2)**	**1 (2)**	**0 (1)**	**1 (7)**	**5 (6)**	**3 (9)**	**0 (3)**	**0 (1)**	**0 (.)**	**0 (.)**	**0 (2)**
3	2 (7)	0 (2)	1 (2)	0 (1)	0 (6)	5 (6)	3 (9)	0 (3)	0 (1)	0 (.)	0 (.)	0 (2)
SENXAI.000	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
7	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.003	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
8	**2 (5)**	**0 (0)**	**1 (3)**	**0 (0)**	**2 (1)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (.)**	**0 (.)**	**1 (1)**
Other	**2 (14)**	**0 (0)**	**6 (15)**	**0 (3)**	**0 (3)**	**2 (16)**	**6 (1)**	**0 (1)**	**0 (0)**	**0 (.)**	**0 (.)**	**0 (0)**
2 (total)	2 (1)	0 (0)	3 (5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.0003												
13 (total)												
SENXAI.003												
8												
SENXAI.000												

PHAGE TYPE AND PFGE PATTERN FOR SELECT PHAGE TYPES	HUMAN			RETAIL FOOD			FARM ANIMAL MANURE					WATER
	ENDEMIC SPORADIC	OUTBREAK[a]	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKENS	TURKEY	
	No. TYPED IN 2013 (2008–2012)											
Number of typed	**35 (172)**	**6 (14)**	**21 (118)**	**9 (45)**	**21 (78)**	**24 (68)**	**32 (21)**	**0 (6)**	**0 (1)**	**0 (.)**	**0 (.)**	**1 (4)**
SENXAI.0001	0 (3)	0 (0)	0 (3)	0 (0)	0 (0)	0 (6)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.0002	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.0003	0 (2)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (1)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.0004	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.0038	0 (7)	0 (0)	0 (0)	0 (3)	0 (1)	1 (9)	6 (0)	0 (1)	0 (0)	0 (.)	0 (.)	0 (0)
SENXAI.0155	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
Other	0 (1)	0 (0)	3 (2)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
21	1 (0)	0 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
23	1 (0)	0 (0)	0 (0)	0 (2)	0 (2)	0 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
4	1 (2)	0 (0)	2 (5)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
51	1 (9)	0 (0)	0 (2)	1 (1)	0 (2)	2 (2)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
5B	1 (3)	0 (0)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
1	0 (1)	4 (0)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
1B	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
21C	0 (1)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
41	0 (0)	0 (0)	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
4B	0 (1)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
6A	0 (0)	0 (0)	0 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
7A	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
2B	**0 (0)**	**0 (0)**	**1 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (.)**	**0 (.)**	**0 (0)**
8A	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**1 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**
911	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
2B	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
8A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other[b]	0 (0)	0 (0)	1 (4)	0 (1)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)

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

[a] Includes outbreak cases that are also related to international travel.

[b] Phage types that were identified only once in a single component in 2013 are listed here rather than in the table. Human travel: 2b. Broiler chickens: 8a.

Salmonella Heidelberg

S. Heidelberg is the second most common serovar among the human endemic sporadic cases and was also commonly found in the retail chicken meat and on broiler chicken farms (Table 4.1). Data on *S.* Heidelberg are presented by phage type with associated PFGE patterns (Table 4.3) to illustrate the different configurations observed with these available subtyping methods. As in previous years, most *S.* Heidelberg cases were phage type 19 and 29, which together are very closely aligned with the results for PFGE pattern SHEXAI.0001. These phage types and this PFGE pattern accounted for most of the human endemic cases and were common in all retail food products and on broiler chicken farms. Phage type 19 was also found in one beef cattle isolate and in water and phage type 29 was also found in one water isolate.

TABLE 4.3: Integrated comparison of *Salmonella* Heidelberg phage types and PFGE patterns, ON and BC sites, 2013 compared to 2008 to 2012.

PHAGE TYPE AND PFGE PATTERN FOR SELECT PHAGE TYPES	HUMAN			RETAIL FOOD			FARM ANIMAL MANURE					WATER
	ENDEMIC SPORADIC	OUTBREAK[a]	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKENS	TURKEY	
	No. TYPED IN 2013 (2008–2012)											
Number of isolates typed	**22 (48)**	**0 (3)**	**0 (4)**	**6 (76)**	**21 (80)**	**20 (63)**	**23 (58)**	**2 (6)**	**0 (5)**	**1 (.)**	**0 (.)**	**4 (3)**
19 (total)	**14 (29)**	**0 (3)**	**0 (0)**	**1 (26)**	**6 (27)**	**4 (23)**	**7 (10)**	**1 (1)**	**0 (0)**	**0 (.)**	**0 (.)**	**3 (2)**
SHEXAI.0001	13 (18)	0 (3)	0 (0)	1 (20)	6 (26)	3 (23)	7 (9)	1 (1)	0 (0)	0 (.)	0 (.)	3 (2)
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.0009	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	1 (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)
SHEXAI.0126	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
Other	1 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (1)	0 (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)
29 (total)	**5 (8)**	**0 (0)**	**0 (0)**	**2 (22)**	**5 (21)**	**4 (23)**	**2 (14)**	**0 (2)**	**0 (0)**	**0 (.)**	**0 (.)**	**1 (0)**
SHEXAI.0001	4 (5)	0 (0)	0 (0)	2 (19)	5 (17)	2 (17)	2 (11)	0 (2)	0 (0)	0 (.)	0 (.)	0 (0)
SHEXAI.0009	1 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SHEXAI.0007	0 (2)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
SHEXAI.0020	0 (1)	0 (0)	0 (0)	0 (1)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
Other	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	2 (3)	0 (3)	0 (0)	0 (0)	0 (.)	0 (.)	1 (0)
Atypical	1 (1)	0 (0)	0 (0)	0 (2)	3 (7)	3 (1)	3 (8)	0 (1)	0 (0)	0 (.)	0 (.)	0 (0)
5	1 (0)	0 (0)	0 (0)	0 (5)	1 (1)	0 (0)	0 (1)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
	1 (3)	0 (0)	0 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
	0 (1)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
	0 (0)	0 (0)	0 (0)	0 (3)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)

PHAGE TYPE AND PFGE PATTERN FOR SELECT PHAGE TYPES	HUMAN			RETAIL FOOD			FARM ANIMAL MANURE					WATER
	ENDEMIC SPORADIC	OUTBREAK[a]	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKENS	TURKEY	
	No. TYPED IN 2013 (2008–2012)											
Number of typed	**22 (48)**	**0 (3)**	**0 (4)**	**6 (76)**	**21 (80)**	**20 (63)**	**23 (58)**	**2 (6)**	**0 (5)**	**1 (.)**	**0 (.)**	**4 (3)**
58	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	2 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
54	0 (1)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
53	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
52	0 (0)	0 (0)	0 (1)	0 (0)	0 (2)	0 (0)	1 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
41	0 (1)	0 (0)	0 (0)	0 (2)	0 (7)	0 (1)	1 (1)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
36	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (1)
26	0 (0)	0 (0)	0 (0)	0 (3)	1 (1)	0 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
22	0 (1)	0 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	1 (0)	0 (0)	0 (0)	1 (.)	0 (.)	0 (0)
18	0 (3)	0 (0)	0 (0)	1 (3)	0 (3)	0 (7)	7 (20)	0 (1)	0 (5)	0 (.)	0 (.)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (4)	1 (6)	2 (1)	1 (3)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
10	0 (0)	0 (0)	0 (0)	0 (1)	1 (1)	3 (1)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
4	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (.)	0 (.)	0 (0)
Other	0 (1)	0 (0)	0 (0)	0 (2)	0 (0)	0 (4)	0 (0)	1 (0)	0 (0)	0 (.)	0 (.)	0 (0)

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

Salmonella Typhimurium

S. Typhimurium was the third most common serovar in the human endemic sporadic cases in 2013 (Table 4.1). The most common phage type in the human cases, phage type 10, was not found in any of the sources tested (Table 4.4). In general, there did not appear to be good alignment between the phage types in the human cases and in the possible sources in 2013.

TABLE 4.4: Integrated comparison of *Salmonella* Typhimurium phage types, ON and BC sites, 2013 compared to 2008 to 2012.

PHAGE TYPE	HUMAN			RETAIL FOOD			FARM ANIMAL MANURE					WATER
	ENDEMIC SPORADIC	OUTBREAK[a]	TRAVEL	CHICKEN BREASTS	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE	LAYER CHICKENS	TURKEY	
	No. TYPED IN 2013 (2008–2012)											
Number of typed	**12 (75)**	**1 (0)**	**2 (12)**	**4 (18)**	**2 (2)**	**5 (5)**	**0 (11)**	**0 (3)**	**1 (8)**	**0 (.)**	**0 (.)**	**5 (16)**
10	4 (4)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
108	3 (13)	0 (0)	0 (1)	0 (7)	0 (0)	0 (2)	0 (3)	0 (0)	1 (0)	0 (.)	0 (.)	0 (7)
22	1 (1)	0 (0)	0 (1)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
41	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	1 (0)
Atypical	1 (7)	0 (0)	1 (0)	0 (0)	0 (0)	0 (1)	0 (1)	0 (0)	0 (0)	0 (.)	0 (.)	0 (3)
UT1	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
104	0 (6)	0 (0)	0 (2)	0 (3)	0 (0)	5 (2)	0 (5)	0 (1)	0 (3)	0 (.)	0 (.)	0 (2)
104a	0 (2)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
104b	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (2)	0 (.)	0 (.)	2 (1)
110b	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (1)
12	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (.)	0 (.)	0 (1)
135	0 (1)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
15a	0 (2)	0 (0)	0 (1)	0 (0)	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 (.)	0 (0)
193	0 (2)	0 (0)	0 (2)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
2	0 (2)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
208	0 (2)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (0)
U302	0 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (.)	0 (.)	0 (0)
U311	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (.)	0 (.)	0 (1)
Other	1 (7)	0 (0)	1 (3)	0 (4)	0 (0)	0 (0)	0 (0)	0 (1)	0 (1)	0 (.)	0 (.)	2 (0)
Untypable	0 (0)	0 (0)	0 (0)	2 (1)	1 (2)	0 (0)	0 (0)	0 (0)	0 (1)	0 (.)	0 (.)	0 (0)

Other Serovars

In 2013, *S.* Kentucky was the most common serovar found in broiler chickens, ground chicken, and chicken breasts, and the second most common in chicken nuggets (Table 4.1). Although this serovar is not usually associated with human disease, considering its prevalence in poultry and poultry products, it may be important to monitor in case of any future increases due to potential changes in virulence.

4.5 Summary of Salmonella Results

What is the same in 2013 as in previous years?

- Distributions of human salmonellosis cases by age and gender were similar to historical distributions in the ON and BC sites.
- The most commonly reported serovars for human cases of salmonellosis were Enteritidis, Heidelberg, and Typhimurium.
- *Salmonella* continues to have a relatively high prevalence in both ground chicken (60%) and broiler chicken manure (64%), as it has in the past few years.
- Phage type and PFGE pattern alignment continues to be observed among *S.* Heidelberg and *S.* Enteritidis isolates from endemic human cases, retail chicken products, and broiler chicken manure.

What is new?

- Of the retail chicken products sampled, chicken nuggets appear to be the most important source of both *S.* Heidelberg and *S.* Enteritidis with significantly higher levels of these serovars.
- 2013 was the first year that both layer chickens and turkey were sampled. These poultry commodities also appear to be potential sources of *Salmonella*, although to a lesser extent than broiler chickens based on their lower *Salmonella* prevalences.

Integration of results

In previous years, survey data has identified the most likely sources of salmonellosis in humans to be retail poultry products, pet reptiles, and broiler chicken manure. In 2013, results from FoodNet Canada surveillance of possible sources continue to suggest retail poultry products as the most important source of *Salmonella* for humans. In particular, chicken nuggets appear to be a very important source of the top serovars causing human salmonellosis: *S.* Heidelberg and *S.* Enteritidis. This finding is consistent with previous outbreak investigations which found chicken nuggets to be the source of *S.* Heidelberg infections in humans (**9**). Additionally, the higher prevalence of *Salmonella* in ground chicken and chicken nuggets suggests that processing likely plays a role in the contamination of retail chicken products with *Salmonella*.

FoodNet Canada surveillance in action

- FoodNet Canada's human, retail, farm, and water *Salmonella* data has recently been used to inform:
  - A multi-departmental initiative within the Health Portfolio to support a pathogen reduction strategy in Canadian foods.
  - Health Canada's National Strategy for the Control of Poultry-Related Human *Salmonella* Enteritidis Illness in Canada.
  - Numerous foodborne disease outbreak investigations, both provincial and national.
  - A *Salmonella* source attribution analysis.
  - A *Salmonella* exposure assessment analysis.

5. PATHOGENIC E. COLI

5.1 Human Cases

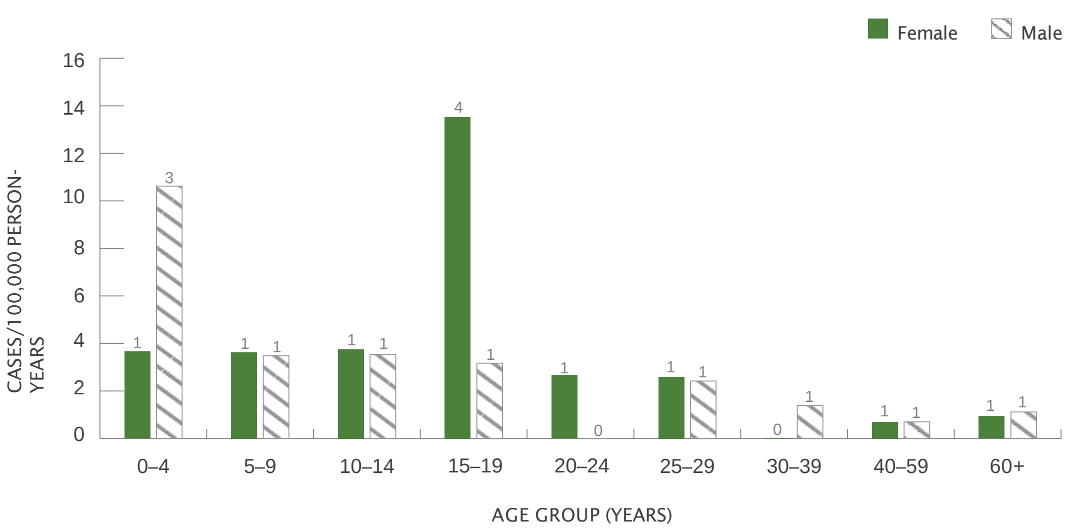
In both the ON and BC sites, a total of 26 cases of VTEC infections were reported in 2013 representing an incidence rate of 2.6 cases/100,000 person-years. Of these cases, 80.8% (21/26) were endemic, 7.7% (2/26) were outbreak-related (all domestically-acquired), and 11.5% (3/26) were travel-related. In comparison, the annual incidence rate for verotoxigenic *E. coli* infection in Canada in 2013 was 1.8 cases/100,000 person-years (**5**).

Of the total VTEC cases reported, 76.9% (20/26) were *E. coli* O157 infections, of which 19 were *E. coli* O157:H7/NM. The incidence rate within the sites in 2013 for *E. coli* O157 was 2.0 cases/100,000 person-years. In comparison, the incidence rate for *E. coli* O157 in Canada in 2013 was 1.3 cases/100,000 person-years (**2**).

In the ON site, of the six VTEC cases, all were O157:H7. In the BC site, of the 20 VTEC cases, 12 were O157:H7, while the remaining cases included three cases of VTEC – not further specified, two cases of O26:H11, one case of O157:H antigen untypable, one case of O103:H2, and one case of O157: non-motile. 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 BC, more Shiga-toxin testing is done on stool samples than in Ontario.

There is no clear pattern with age- and gender-specific incidence rates among the 21 endemic cases from both sites combined due to the small numbers. (Figure 5.1).

FIGURE 5.1: Incidence rates of sporadic, human endemic verotoxigenic *E. coli* infection in both the ON and BC sites in 2013, by gender and age group.



NOTE: The number of cases is indicated on top of each bar.

5.1.1 Case Exposures

Information was collected for 100% (26/26) 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 any water and swimming in a pool as well as being five to 19 years of age (referent 30 to 59 years of age) to be significantly ($p<0.05$) associated with an increased risk of VTEC infection (Appendix B). Based on past risk factors identified for VTEC infection, this is suggestive that (seasonal) recreational exposure/activity could contribute to an increased risk of infection, and/or, that the activity itself could be indicative of other behaviours/risk factors, that could themselves lead to an increased risk of infection.

Of the three international travel-related VTEC cases, two cases travelled to Central or South America (including the Caribbean) (1 O157:H7, 1 O103:H2) and one case travelled to the USA (O157:H7).

5.2 Surveillance of Potential Sources

Retail Food

VTEC was detected on 1.7% (6/343) of retail ground beef samples in 2013 in both sentinel sites (Table 5.1). Of the top seven human subtypes historically, only one each of the subtypes O103 and O26, were detected.

TABLE 5.1: Verotoxigenic *E. coli* detection data from the integrated surveillance activities in the ON and BC sites in 2013.

METHOD	HUMAN			RETAIL FOOD	FOOD ANIMALS (MANURE)[a]		WATE R
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	BEEF CATTLE	DAIRY CATTLE	
Detection							
No. of samples tested	…	…	…	343	120	120	167
No. positive	21	2	3	6	68	75	75
Percentage positive	..	..	..	1.7%	57%	63%	45%
Serotyping							
No. typed	21	2	3	6	67	72	69
Top 7 pathogenic types[b]							
O157:H7	14	2	2	0	17	12	3
O157:NM	1	0	0	0	5	0	0
O157	1	0	0	0	0	0	0
O26	2	0	0	1	0	0	1
O103	0	0	1	1	2	2	6
O111	0	0	0	0	1	1	0
O45	0	0	0	0	0	0	3
Other VTEC[c]	3	0	0	5	43	58	57

NOTE: Serotype counts do not match the total number typed because one water sample contained O157:H7 and O103 and one ground beef sample contained O103 and O26.

[a] Ontario site only.

[b] The top ranked human VTECs (O157:H7, O26, O45, O103, O111, O121, O145) are listed explicitly if there is at least one positive to report. O145 and O121 were not found in 2013.

[c] The three endemic cases were composed of three cases positive for shiga toxins (no other subtype information available).

… Not available

.. Not applicable

Farm

VTEC was detected on 57% (68/120) and 63% (75/120) of pooled fresh manure beef and dairy cattle samples, respectively, in 2013 in the ON site (Table 5.1). The prevalence of subtype O157:H7/NM was 18% (22/120) and 10% (12/120) from beef and dairy cattle, respectively. (Table 5.1).

Water

VTEC was detected in 45% (75/167) of water samples collected from beaches and along the Grand River in the ON site, and from irrigation ditches in the BC site, in 2013. The total number of subtypes is greater than the total samples subtyped as one sample contained both O103 and O157:H7

TABLE 5.2: PFGE patterns for pathogenic *E. coli* O157:H7/NM in both sentinel sites in 2013 compared to results for 2008–2012.

PFGE	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]				WATER	PULSENET RANKING
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE		
	No. TYPED IN 2013 (2008–2012)									
No. of samples typed	**16 (63)**	**2 (11)**	**2 (2)**	**0 (0)**	**. (6)**	**. (0)**	**21 (62)**	**11 (43)**	**3 (10)**	
ECXAI.0001	1 (2)	0 (1)	0 (0)	0 (0)	. (0)	. (0)	0 (8)	1 (1)	0 (0)	1
ECXAI.1182	1 (1)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (1)	0 (0)	
ECXAI.1845	1 (1)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (1)	0 (0)	
ECXAI.1936	1 (1)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	
ECXAI.2607	1 (1)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (5)	0 (1)	0 (1)	4
ECXAI.0008	0 (3)	0 (0)	0 (1)	0 (0)	. (0)	. (0)	1 (2)	0 (0)	0 (0)	3
ECXAI.0221	0 (2)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	5 (0)	0 (0)	0 (0)	5
ECXAI.1694	0 (2)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (0)	
ECXAI.2012	0 (2)	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)	
ECXAI.2483	0 (2)	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)	
ECXAI.1301	0 (1)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (3)	0 (0)	0 (0)	
ECXAI.2303	0 (1)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (1)	0 (0)	
ECXAI.1398	0 (0)	2 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (1)	2
ECXAI.0339	0 (0)	0 (6)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (0)	0 (1)	
ECXAI.1581	0 (0)	0 (3)	0 (0)	0 (0)	. (0)	. (0)	1 (0)	0 (0)	0 (1)	
ECXAI.0014	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 (2)	0 (0)	0 (0)	
ECXAI.0407	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 (3)	0 (0)	0 (0)	

PFGE	HUMAN			RETAIL FOOD	FARM ANIMAL MANURE[a]				WATER	PULSENET RANKING
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	GROUND BEEF	SWINE	BROILER CHICKENS	BEEF CATTLE	DAIRY CATTLE		
	No. TYPED IN 2013 (2008–2012)									
No. of samples typed	**16 (63)**	**2 (11)**	**2 (2)**	**0 (0)**	**. (6)**	**. (0)**	**21 (62)**	**11 (43)**	**3 (10)**	
ECXAI.0825	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 (1)	0 (1)	0 (0)	
ECXAI.1251	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	2 (0)	0 (0)	
ECXAI.1288	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 (3)	0 (2)	0 (0)	
ECXAI.2110	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 (2)	0 (0)	0 (0)	
ECXAI.2464	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 (2)	0 (0)	
ECXAI.2781	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (4)	0 (0)	
ECXAI.2897	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	0 (2)	0 (0)	
ECXAI.2915	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	2 (0)	1 (0)	
ECXAI.2916	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	3 (0)	0 (0)	0 (0)	
ECXAI.2943	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	0 (0)	2 (0)	0 (0)	
ECXAI.3008	0 (0)	0 (0)	0 (0)	0 (0)	. (0)	. (0)	3 (0)	0 (0)	0 (0)	
Other[b]	11 (41)	0 (0)	2 (1)	0 (0)	. (6)	. (0)	8 (21)	4 (25)	2 (6)	

NOTE: Some O157 samples contained multiple PFGE patterns.

[a] ON site only.

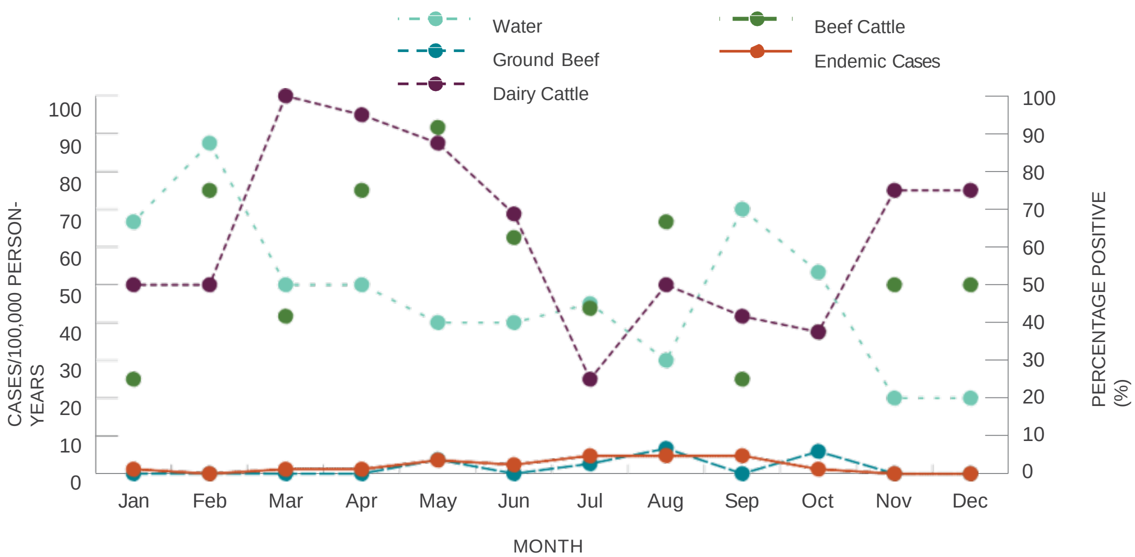
[b] Only PFGE patterns with more at least one human case or more than one occurrence are listed; the remaining are combined in the “Other” category.

There was one endemic case with the same PFGE pattern (ECXAI.0001) as found in a sample of fresh dairy cattle manure in 2013 (Table 5.2). This pattern has also been found in the past in human cases and dairy and beef cattle manure samples. *E. coli* O157 PFGE pattern ECXAI.0001 is the 1st ranked pattern in humans according to PulseNet Canada data.

When comparing the years 2013 to 2008–2012 of surveillance data, few PFGE patterns recurred from the first period to the next. Past results have shown considerable diversity and this lack of persistence over time in *E. coli* O157 PFGE patterns, both nationally (PulseNet Canada) and within the FoodNet Canada sites. Notable exceptions were patterns ECXAI.0001, ECXAI.1182, ECXAI.1845, ECXAI.1936 and ECXAI.2607 for human cases and ECXAI.0008 for beef cattle which occurred in 2008–2012 and in 2013.

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, 2013.



NOTES:

1. Pooled manure samples from dairy and beef cattle, 120 each, are for the ON site only.
2. ‘Month’ refers to onset month for human cases and sample collection month for non-human data.
3. Endemic cases are sporadic cases only.

In 2013, human cases of VTEC in the sentinel sites were higher in the summer. Retail ground beef VTEC prevalence rates were low throughout the year. Beef and dairy cattle manure tended to be higher in the spring.

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 2013. Of the 26 reported cases in the two sites, three were found to be associated with international travel.
- *E. coli* O157 PFGE patterns in both human and non-human samples in 2013 continued to show considerable diversity and a lack of persistence over time, as observed nationally and within the FoodNet Canada sites.

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.
- Ongoing work using FoodNet Canada results are showing that VTEC in ground beef and human illness are remaining low following a large decrease from 2000 to 2012.

6. LISTERIA

6.1 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 seven listeriosis cases (57% (4/7) female) were reported in 2013, five of which were endemic cases, one which was outbreak-related, and one which was lost to follow-up. The combined incidence rate for listeriosis in the two sites was 0.7 cases/100,000 person-years. The annual national incidence rate for listeriosis in 2013 in all of Canada was 0.4 cases/100,000 person- years (**5**).

6.2 Surveillance of Potential Sources

Retail food

In 2013, in the ON and BC sites, *Listeria monocytogenes* was found on all retail meat types (chicken breasts, ground beef, uncooked frozen chicken nuggets, and ground chicken). Leafy greens were tested in 2013 and of the 590 tested, four were positive (Table 6.1). Although historically *L. monocytogenes* has been found on pork chops, it was not identified in 2013.

Raw meat samples positive for *L. monocytogenes* contained amounts that were below the detection limit (0.3 MPN/g) of the testing method used for bacterial quantification in the following quantities: 81% (26/32) of uncooked frozen chicken nuggets and 80% (56/70) of ground chicken samples (Appendix C).

TABLE 6.1: Case counts and prevalence of *Listeria monocytogenes*, ON and BC sites, 2013.

SEROTYPE	HUMAN			RETAIL FOOD				
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	LEAFY GREENS
	No. TYPED IN 2013 (2008–2012)							
No. of samples tested	**…**	**…**	**…**	**258**	**258**	**189**	**189**	**590**
No. positive	5	1	0	55	28	32	70	4
Percentage positive	..	..	..	21%	11%	17%	37%	0.7%

.. Not applicable

… Not available

6.3 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 6.2). Of these three, 1/2a and 1/2b are the most predominant serotypes in Canada causing human illness (**2, 10**). The most common serotypes found in human endemic cases from FoodNet Canada were 1/2a, 1/2b and 4b.

TABLE 6.2: Serotypes of *Listeria monocytogenes*, ON and BC sites, 2013 compared with 2008–2012.

SEROTYPE	HUMAN			RETAIL FOOD				
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	LEAFY GREENS
	No. TYPED 2013 (2008–2012)							
Total	**5 (5)**	**1 (3)**	**0 (1)**	**51 (282)**	**27 (173)**	**31 (120)**	**69 (216)**	**4 (12)**
1/2a	2 (3)	0 (3)	0 (0)	39 (231)	15 (97)	28 (84)	51 (169)	2 (7)
4b	2 (1)	1 (0)	0 (1)	1 (14)	0 (4)	1 (4)	0 (1)	2 (4)
1/2b	1 (1)	0 (0)	0 (0)	4 (22)	11 (58)	1 (14)	9 (28)	0 (1)
1/2c	0 (0)	0 (0)	0 (0)	3 (10)	1 (10)	0 (6)	4 (14)	0 (0)
3a	0 (0)	0 (0)	0 (0)	4 (4)	0 (2)	0 (3)	4 (0)	0 (0)
3b	0 (0)	0 (0)	0 (0)	0 (1)	0 (2)	0 (7)	1 (3)	0 (0)
4a	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)
4c	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4d	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)
Untypable	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)

One human case identified in 2013 had PFGE pattern LMAAI.0234, which was also detected in a sample of leafy greens (Table 6.3). The PFGE pattern (LMACI.0009) for the AscI enzyme in these two samples also matched. However, it is important to note that the data are meant to be interpreted aggregately and cannot be used to directly attribute a specific human case reported to FoodNet Canada to a particular positive isolate from an exposure source. Rather, the goal of the integrated approach is to obtain an overall refined estimate on the proportion of illnesses being caused by each of the various exposure sources.

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 2013. PFGE patterns LMAAI.0234, LMAAI.0126 and LMAAI.0001 were found in retail meat sources or leafy greens (LMAAI.0234 only) and were also the 1st, 4th and 5th ranked patterns, respectively, found in humans according to PulseNet Canada 2013 data (of the patterns identified in FoodNet Canada human cases in 2013).

TABLE 6.3: Select PFGE patterns among *Listeria monocytogenes* cases and samples, ON and BC sites, 2013 compared with 2008 through 2012.

PATTERN	HUMAN			RETAIL FOOD					NATIONAL HUMAN TOP 5 RANKING[a]
	ENDEMIC	DOMESTIC OUTBREAK	TRAVEL	CHICKEN BREASTS	GROUND BEEF	UNCOOKED CHICKEN NUGGETS	GROUND CHICKEN	LEAFY GREENS	
	No. OF SAMPLES FOR 2013 (2008 – 2012)								
No. subtyped	**5 (6)**	**1 (3)**	**0 (1)**	**51 (281)**	**27 (173)**	**31 (120)**	**69 (217)**	**4 (12)**	
LMAAI.0048	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3
LMAAI.0204	1 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (1)	2
LMAAI.1012	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
LMAAI.1118	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
LMAAI.1150	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
LMAAI.0003	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	
LMAAI.0182	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)	
LMAAI.0265	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
LMAAI.0423	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5
LMAAI.0499	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	
LMAAI.0563	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
LMAAI.0234	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1
LMAAI.0001	0 (0)	0 (3)	0 (0)	0 (4)	0 (3)	7 (28)	1 (7)	0 (0)	5
LMAAI.1069	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
LMAAI.0015	0 (0)	0 (0)	0 (0)	0 (6)	0 (0)	0 (2)	0 (2)	0 (0)	4
LMAAI.0126	0 (0)	0 (0)	0 (0)	1 (4)	1 (6)	0 (2)	0 (1)	0 (0)	4

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.

[a] Most common national patterns, PulseNet Canada, 2013.

6.4 Summary of Listeria monocytogenes Results

- In 2013, *L. monocytogenes* was detected on 0.7% (4/590) of leafy greens samples. As in previous years, pathogenic strains of *L. monocytogenes* were recovered in 2013 from samples of retail skinless chicken breasts and ground beef, and were also found on uncooked chicken nuggets and ground chicken.
- The scientific literature suggests that abattoirs and meat processing environments rather than farm animals may be an important source of *L. monocytogenes* (**11**). 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* have been present on raw chicken, beef, and pork meat sold at retail, as well as in bagged leafy greens.
- There was a match between a human outbreak case and a sample of leafy greens in 2013 based on both PFGE enzyme patterns. Also, based on one enzyme, a few matches were identified between meat isolates (chicken and beef) and two of the top five-ranked PFGE patterns reported at the national level in humans in 2013 (according to PulseNet Canada data) of the patterns identified in FoodNet Canada cases.

FoodNet Canada surveillance in action

- FoodNet Canada data is playing a role in the development of new typing methods for *L. monocytogenes* based on whole genome sequencing.
- FoodNet Canada's data has been used to inform numerous foodborne disease outbreak investigations, both provincial and national.

7. OTHER BACTERIA (YERSINIA, SHIGELLA)

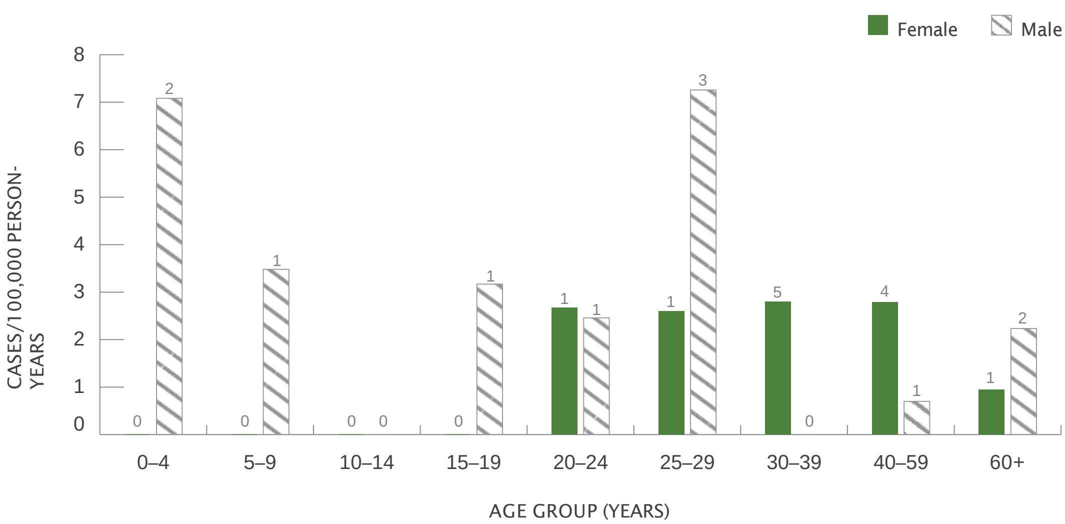
7.1 Yersinia

7.1.1 Human Cases

In both the ON and BC sites, a total of 32 cases of human *Yersinia* infection were reported in 2013, representing an incidence rate of 2.0 cases/100,000 person-years. Of these cases, 63% (20/32) were endemic and 21.9% (7/32) were travel-related. The majority of travel-related cases (57.1%; 4/7) reported travel to Central or South America. A total of 15.6% (5/32) of human yersiniosis cases were lost to follow-up. Currently, *Yersinia* is not a nationally-notifiable disease; therefore the annual national incidence rates are not available for comparison.

Of the 20 endemic cases, 11 (2.2 cases/100,000 person-years) were males and nine (1.8 cases/100,000 person-years) were females. Incidence rates were highest in males between 25–29 years of age (7.3 cases/100, 000 population) and less than five years of age (7.1 cases/100,000 person-years) (Figure 7.1). Of the seven travel-related cases, five (1.0 cases/100,000 person-years) were females and two (0.4 cases/100,000 person-years) were males.

FIGURE 7.1: Incidence rates of sporadic, human endemic yersiniosis in both the ON and BC sites in 2013, by gender and age group.



NOTE: The number of cases is indicated on top of each bar.

All of the *Yersinia* isolates subtyped from endemic yersiniosis cases were *Y. enterocolitica*.

2. Case Exposures

Information was collected for 62.5% (20/32) 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).

3. Surveillance of Potential Sources

In 2013, testing of potential sources for *Yersinia* was not conducted due to low prevalences historically.

Pathogenic *Y. enterocolitica* (biotype 4, serotype O:3) has been previously identified on approximately 3% (25/832) of farm samples (swine manure). Only two retail pork chop samples were positive for the pathogenic strain of the 891 samples collected between 2005 and 2010. Historically, pathogenic *Y. enterocolitica* has not been found in water samples and thus testing for this organism in water was discontinued in FoodNet Canada surveillance as of 2011.

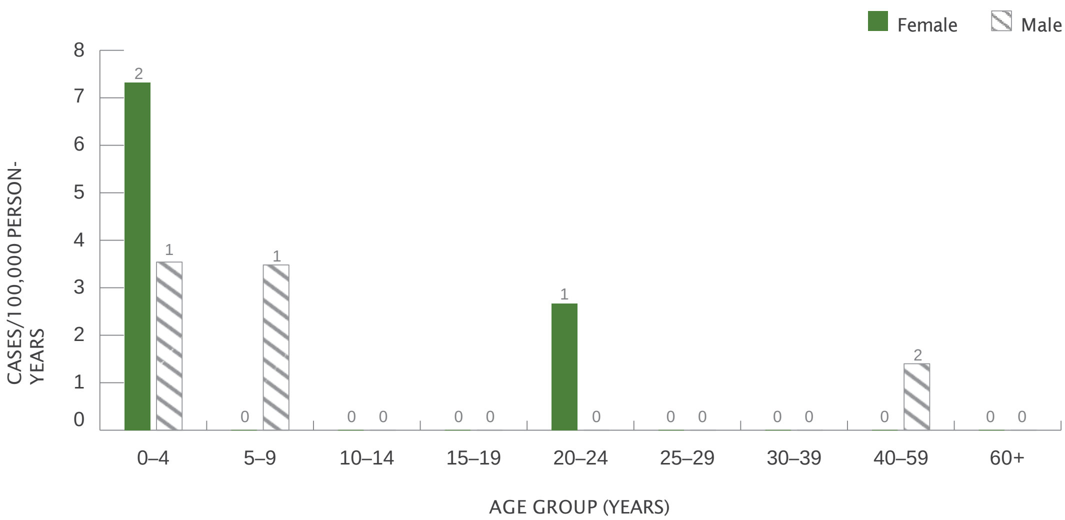
7.2 Shigella

7.2.1 Human Cases

In both the ON and BC sites, a total of 25 cases of human *Shigella* infection were reported in 2013, representing an incidence rate of 2.5 cases/100,000 person-years. Of these cases, 28% (7/25) were endemic and 68% (17/25) were travel-related. The majority of travel-related cases reported travel to Central or South America (32%; 8/25). A total of 4% (1/25) of human shigellosis cases were lost to follow-up. In comparison, the annual incidence rate for shigellosis in Canada in 2013 was 1.9 cases/100,000 person-years (**5**).

Of the seven endemic cases, four (0.8 cases/100,000 person-years) were males and three (0.6 cases/100,000 person-years) were females. Incidence rates were highest in females less than five years of age (7.3 cases/100,000 person-years) (Figure 8.1). Of the 17 travel-related cases, nine (1.8 cases/100,000 person-years) were female and eight (1.6 cases/100,000 person-years) were male.

FIGURE 7.2: Incidence rates of sporadic, human endemic shigellosis in both the ON and BC sites in 2013, by gender and age group.



NOTE: The number of cases is indicated on top of each bar.

The majority of *Shigella* isolates subtyped from endemic shigellosis cases were *S. flexneri* (71.4%; 5/7). The remaining two endemic Shigella isolates were subtyped as *S. sonnei*.

7.2.2 Surveillance of Potential Sources

In 2013, testing of potential sources for *Shigella* was not conducted as it is a human specific pathogen and very low levels were found in previous assessments.

Shigella testing of bagged leafy greens was last performed in the ON site in 2009–2010. Of the 474 samples tested in this period, one (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.

7.3 Summary of Other Bacteria (Yersinia and Shigella) Results

- Findings are consistent with previous years showing the majority of *Yersinia* cases are domestically acquired. Among travel-related cases, the majority reported travel to Central or South America in 2013.
- As in the past, the majority of *Shigella* infections were travel-related. Central or South America was the most frequently reported travel destination.
- The incidence of yersiniosis was higher for males than females for domestically acquired cases.
- No testing of potential sources was conducted for *Yersinia* or *Shigella* in 2013. In 2011, none of the swine manure samples tested in the ON site were positive for pathogenic *Yersinia* (biotype 4, serotype O:3). Previously, the prevalence has been around 3% for this subtype. Also, historically, FoodNet Canada has found *Shigella* bacteria on one sample of bagged leafy greens using PCR methods.

8. PARASITES

8.1 Giardia

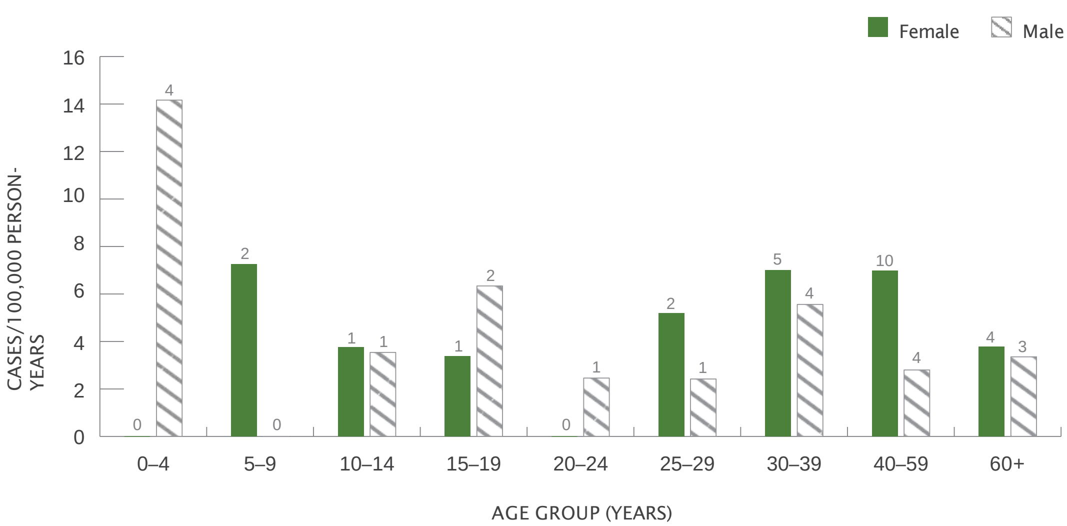
8.1.1 Human Cases

In both the ON and BC sites, a total of 127 human cases of giardiasis were reported in 2013, representing an incidence rate of 12.6 cases/100,000 person-years. Of these cases, 35% (45/127) were endemic (4.5 cases/100,000 person-years), 12% (15/127) were non-endemic (1.5 cases/100,000 person-years) and 35% (45/127) were travel-related (4.5 cases/100,000 person-years). A total of 17% (22/127) of human giardiasis cases were lost to follow-up. In comparison, the annual incidence rate for giardiasis in Canada in 2013 was 10.8 cases/100,000 person-years (**5**).

Of the 45 endemic cases, 20 (4.0 cases/100,000 person-years) were male and 25 (4.9 cases/100,000 person-years) were female (Figure 8.1). Incidence rates were highest between the ages of 0 and 4 in males (14.2 cases/100,000 person-years) and in females between the ages of 5 and 9 (7.2 cases/100,000 person-years). Of the 45 travel-related cases, 21 (4.2 cases/100,000 person-years) were males and 24 (4.7 cases/100,000 person-years) were females.

The monthly incidence rate of reported endemic giardiasis cases did not have a clear seasonal trend. This may be due to low case counts each month. The highest rates of endemic giardiasis were in July (7.1 cases/100,000) and August (8.3 cases/100,000).

FIGURE 8.1: Incidence rates of human endemic giardiasis in both the ON and BC sites in 2013, by gender and age group



NOTE: The number of cases is indicated on top of each bar.

2. Case Exposures

Information was collected for 83% (105/127) of all giardiasis cases regarding exposure to potential sources of infection in the 25 days prior to the onset of illness (Appendix B.1).

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 river or pool, drinking untreated water and going canoeing, kayaking, hiking or camping to be significantly ($p<0.05$) associated with an increased risk of giardiasis.

3. Surveillance of Potential Sources

Food

In 2013, of the 590 leafy greens samples collected in the sentinel sites (Table 8.1), *Giardia* contamination was confirmed by molecular methods in 41 (6.9%) samples. Of the 41 positive samples, 13 were also positive by microscopy. In past years, *Giardia* has also been found in retail meat as well as soft berries and herbs.

Farm animals

Testing of fecal samples collected from farm animals for the presence of *Giardia* stopped in 2009. Historically, *Giardia* has been found in all farm commodities tested (swine, broiler chickens, beef cattle, and dairy cattle).

Water

Giardia was found in 16 of 23 (70%) untreated surface water and recreational water (beaches) samples taken from the ON sentinel site (Table 8.1). Mean concentrations of *Giardia* cysts appeared to be lower in the summer (June to August) for 2013 but this was not significant.

TABLE 8.1: *Giardia* detection across human, retail and water components of FoodNet Canada, ON and BC sites, 2013

METHOD	HUMAN	RETAIL	WATER
	ENDEMIC CASES	LEAFY GREENS	
Polymerase chain reaction (PCR) assay			
No. of samples tested	.	590	.
No. of positive samples	.	41	.
Percentage of samples positive	..	6.9%	..
Microscopy			
No. of samples tested	…	41	23
No. of positive samples	45	13	16
Percentage of samples positive	..	32%	70%

… Not available
.. Not applicable
. Not tested

The monthly prevalence of *Giardia* on leafy greens and water in 2013 did not have a clear trend. This may be due to the low number of samples in each month.

8.1.4 Subtype Comparison

Giardia can be separated into seven different assemblages referred to as A to G, of which only assemblages A and B are pathogenic to humans. In 2013, assemblage A was detected in two water samples from the sampling site located near the Grand River waste water treatment plant outflow in the ON site. Assemblage B was detected in leafy greens in 2013 and was the only genotype detected in this product. Historically, assemblage B has been found in a number of other retail as well as farm sources.

TABLE 8.2: *Giardia* subtyping, ON site, 2013 compared with 2008 to 2012

METHOD	RETAIL LEAFY GREENS	WATER
DNA sequencing		
No. of samples sequenced	41 (23)	2 (10)
Genotype		
Assemblage A	0 (1)	2 (0)
Assemblage B	41 (22)	0 (0)
Assemblage E	0 (0)	0 (0)
Speciation		
Microti	.	0 (9)
Lamblia	.	0 (0)
Mixed	.	0 (1)

. Not tested

8.2 Cryptosporidium

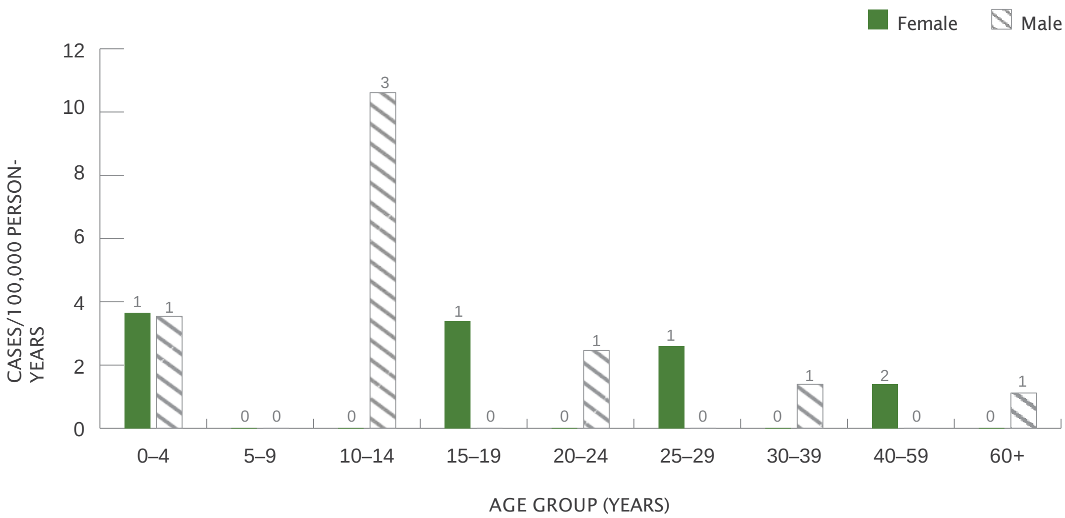
8.2.1 Human Cases

In both the ON and BC sites, a total of 25 cases of human cryptosporidiosis were reported in 2013 representing an incidence rate of 2.5 cases/100,000 person-years. Of these cases, 48% (12/25) were endemic and 44% (11/25) were travel-related. A total of 8% (2/25) of human cryptosporidiosis cases were lost to follow-up. In comparison, the annual incidence rate for cryptosporidiosis in Canada in 2013 was 2.4 cases/100,000 person-years (**5**).

Of the 12 endemic cases, seven (1.4 cases/100,000 person-years) were male and five (1.0 cases/100,000 person-years) were female (Figure 8.3). Incidence rates were highest in males between the ages of 10–14 (10.6 cases/100,000 person-years).

The monthly incidence rate of reported endemic cryptosporidiosis cases did not have a clear seasonal trend. This may be due to low case counts each month. There were a total of 12 endemic cryptosporidiosis cases in 2013.

FIGURE 8.2: Incidence rates of human endemic cryptosporidiosis in both the ON and BC sites in 2013, by gender and age group



NOTE: The number of cases is indicated on top of each bar.

2. Case Exposures

Information was collected for 68% (17/25) of all cryptosporidiosis cases regarding exposure to potential sources of infection in the 12 days prior to the onset of illness (Appendix B.1).

Case-case comparisons were conducted for endemic cases with exposure data by combining both the ON and BC sites. Univariate comparisons identified a number of significant exposure factors among cryptosporidiosis cases compared to other disease cases. Visiting a farm, petting zoo or fair and contact with cattle while visiting a farm, petting zoo or fair were significantly ($p<0.05$) associated with an increased risk of cryptosporidiosis.

3. Surveillance of Potential Sources

Food

In 2013, *Cryptosporidium* was detected via PCR in 21 of 589 (3.6%) leafy greens samples (Table 8.3). Five out of 19 PCR positive samples were also positive by microscopy. Of the 21 PCR positive leafy greens samples, 15 were identified as *C. parvum* and two as *C. hominis* (Table 8.4), both of which are known to be pathogenic to humans. However, only four *C. parvum* positive samples and one *C. hominis* positive sample were confirmed by microscopy. Four samples were not typed further. For those samples identified as positive only by PCR, their viability and therefore their infectiousness to humans remains unknown.

Historically, pathogenic *Cryptosporidium* has been found in retail meat samples as well as soft berries.

TABLE 8.3: *Cryptosporidium* detection in samples collected through the human, retail and water components of FoodNet Canada, ON and BC sites, 2013.

METHOD	HUMAN	RETAIL	WATER
	ENDEMIC CASES	LEAFY GREENS	
Polymerase chain reaction (PCR) assay			
No. of samples tested	.	589	.
No. of positive samples	.	21	.
Percentage of samples positive	..	3.6%	..
Microscopy			
No. of samples tested	.	19	23
No. of positive samples	12	5	15
Percentage of samples positive	..	26%	65%

... Not available

.. Not applicable

. Not tested

Farm animals

Pathogenic strains of *Cryptosporidium* have been found in swine, broiler chicken, beef cattle, and dairy cattle manure historically.

Water

In 2013, *Cryptosporidium* was detected in 15 of 23 (65%) samples of untreated surface water and recreational water (beaches) in the ON site (Table 8.3). *C. andersoni* was the most common genotype (Table 8.4). 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 (**12, 13**), suggesting that it might indeed be mildly infectious. *C. parvum* was detected in two of the 38 samples that underwent DNA sequencing.

TABLE 8.4: *Cryptosporidium* subtyping from retail and water samples collected by FoodNet Canada, ON and BC sites, 2013 compared with 2008–2012.

METHOD	RETAIL	WATER
	LEAFY GREENS	
DNA sequencing		
No. of isolates sequenced	26 (28)	38 (79)
Genotype		
Andersoni[a]	0 (0)	14 (30)
Baileyi	0 (0)	7 (4)
Deer Mouse III	0 (0)	0 (3)
Hominis[ab]	3 (0)	0 (5)
Muris	0 (0)	0 (1)
Muskrat I	0 (0)	2 (3)
Parvum[a]	15 (28)	2 (6)
Skunk	0 (0)	1 (4)
Ubiquitum	0 (0)	10 (7)
Vole	0 (0)	2 (1)
W12	0 (0)	0 (2)
W25	0 (0)	0 (3)
Other	0 (0)	0 (10)
Unknown	5 (0)	0 (0)

NOTE: 1) Three leafy greens samples collected in 2013 were found not to be cryptosporidium when typed. 2) More than one isolate may be typed per sample.

[a] Known to be pathogenic to humans.

[b] Only found in humans.

The monthly prevalence of *Cryptosporidium* on leafy greens and water in 2013 did not have a clear trend. This may be due to the low number of samples in each month.

8.3 Cyclospora

In both the ON and BC sites, a total of four cases of human cyclosporiasis were reported in 2013, representing an incidence rate of 0.4 cases/100,000 person-years. Of these four cases, 50% (2/4) were travel-related and 50% (2/4) were endemic. In comparison, the annual incidence rate for cyclosporiasis in Canada in 2013 was also 0.4 cases/100,000 person-years (**5**).

Travel-related cyclosporiasis cases reported travel to South or Central America (including the Caribbean) and Asia.

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, imported and domestic leafy greens were tested for the parasite. Initial pre-screening by molecular methods identified *Cyclospora* on two of 590 (0.3%) leafy greens samples (Table 8.4). Of these two samples, 1 (50%) was also confirmed positive by microscopy. Historically, *Cyclospora cayetanensis* infection has been found in human cases and the pathogen has been found on bagged leafy greens and soft berries.

TABLE 8.5: *Cyclospora* detection and subtyping within human cases and leafy green samples collected at retail, FoodNet Canada, ON and BC, 2013.

METHOD	HUMAN	RETAIL
	ENDEMIC CASES	LEAFY GREENS
DNA sequencing		
No. of samples tested	.	590
No. of positive samples	.	2
Percentage of samples positive	..	0.3%
Microscopy		
No. of samples tested	…	2
No. of positive samples	2	1
Percentage of samples positive	..	50%
DNA sequencing	**2013 (2008–2012)**	
C. cayetanensis	2 (4)	2 (6)

… Not available

.. Not applicable

. Not tested

4. Entamoeba

Amoebiasis cases are reported to the ON site as *Entamoeba histolytica/dispar* which does not distinguish if the isolate is pathogenic or not. In 2013, in the ON site, 27 human cases of amoebiasis were reported, representing an incidence rate of 2.7 cases/100,000 person-years. Of these cases, 15% (4/27) were travel-related, 22% (6/27) were classified as endemic and 33% (9/27) were non-endemic cases related to recent immigration. A total of 30% (8/27) of human amoebiasis cases were lost to follow-up. Of the endemic cases, four (0.8 cases/100,000 person-years) were female and two (0.4 cases/100,000 person-years) were male.

Amoebiasis was removed from the Canadian Notifiable Disease Surveillance System as of January 2000 (**14**); 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 (**15**). FoodNet Canada does not test for the organism in exposure sources (food, farm animals, and water).

5. Integrated Overview

- *Giardia, Cryptosporidium,* and *Cyclospora* were all found on retail leafy greens in 2013. Additionally, *Giardia* and *Cryptosporidium* were also found in untreated surface water and recreational water (beaches) in 2013.

FoodNet Canada surveillance in action

- The 2013 FoodNet Canada parasite data was used to inform:
  - An issue identification process in Health Canada for *Cyclospora* in leafy greens and fresh herbs.
  - Several outbreak investigations.

9. VIRUSES

9.1 Human Cases

Although norovirus outbreaks have been nationally reportable since 2009, individual cases are not. As such, human infections of norovirus and rotavirus identified within the sentinel sites are not reported to FoodNet Canada.

9.2 Exposure Surveillance

In 2013, in addition to parasites and *Listeria*, leafy greens were also tested for norovirus and rotavirus. Norovirus was found on 0.7% (4/590) of leafy greens samples by PCR. Rotavirus was found on 0.2% (1/590) of leafy greens samples by PCR. Leafy greens were previously tested for norovirus and rotavirus by FoodNet Canada in 2009 and 2010. In 2010, 0.5% (3/574) of samples were positive for norovirus and no samples were positive for rotavirus.

TABLE 9.1: Norovirus and rotavirus subtyping in potential leafy greens available at retail, FoodNet Canada, ON and BC, 2013 compared to 2008-2012

GENOTYPE	RETAIL
	LEAFY GREENS
Norovirus	
No. genotyped	4 (22)
GII	
non-4	1 (0)
4	2 (6)
GI	1 (18)
Rotavirus	
No. genotyped	1 (1)
Species A	1 (1)

NOTE: Two leafy greens samples with GII.4 also contained GI.

Norovirus genogroups GI, GII and GIV are pathogenic to humans (**16**); genotype GII.4 is associated with person-to-person outbreaks and GI is associated with food and waterborne outbreaks (**17**). In 2013, norovirus genogroups GI and GII were found in leafy greens samples from both sites (Table 9.1). GI and GII.4 have been found on leafy greens in the past. Other historical results found GII on soft berries and fresh herbs, GII.4 on pork chops, GII in all manure samples, GI in broiler and beef cattle manure, and GIII in dairy cattle manure.

Rotavirus species A can be both a human and animal pathogen. In 2013, one leafy green sample from the BC site was found to be positive for rotavirus species A. Historically, it has also been found on leafy greens, soft berries, retail ground beef, chicken breast, and pork chops, as well as in swine and dairy cattle manure.

It is important to note that since both norovirus and rotavirus were tested by PCR, the infectivity of these viruses, and therefore the potential risk to consumers, is unknown.

9.3 Summary of Norovirus and Rotavirus Results

- In 2013, FoodNet Canada found both pathogenic norovirus and rotavirus on leafy greens. However, as these were tested using PCR, the potential risk to consumers is unknown given the uncertain viability of these viruses.

10. 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 leafy greens

In 2013, fresh leafy greens were sampled in both sites for parasites and viruses. Prevalence and subtyping results for these retail products can be found in the Parasites and Viruses chapters (Chapter 8 and 9). 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 (Table 10.1). The country of origin is taken from information on the food packaging; in some cases, more than one country is listed on the package.

Leafy Greens

In 2013, a variety of fresh leafy greens (590 in total) were tested for enteric pathogens. This study sample comprised 273 mixed salad/mixed greens, 132 spinach, 99 romaine lettuce, 58 arugula, 14 iceberg lettuce, 7 kale, six green leaf lettuce, and one mâche (an edible leafy green).

In 2013, *Giardia* was detected on 7.9% (3/28) of samples originating in Canada, 6.8% (32/473) originating from the United States, 20% (3/15) from the United States and Canada, and 6.0% (3/50) from the United States and Mexico. All genotypes were assemblage B.

Cryptosporidium testing found 5.3% (2/38) positive samples from Canada. It was also found on samples from other countries: 3.0% (14/473) United States, 13% (2/15) United States and Canada, and 2.0% (1/50) United States and Mexico. All were either *C. hominis* or *C. parvum* genotypes.

Cyclospora was found on 0.42% (2/473) of the samples from the United States; all were identified as *C. cayetanensis*.

In 2013, norovirus was detected on 0.85% (4/473) of the samples originating from the United States: one was GI.3 genotype, two were GII.4, and the remaining one was GII.3. Rotavirus was found on one of the 473 samples tested from the United States and was genotype A.

Listeria monocytogenes was found on 7.9% (3/38) of samples with a Canadian origin and 0.21% (1/473) from the United States. Of these four samples positive, two were serotype 1/2a and two were 4b.

TABLE 10.1: Parasite, virus and *Listeria* detection on leafy greens, by country of origin, ON and BC sites, 2013.

	CANADA (N=38)	MEXICO (N=6)	UNITED STATES (N=473)	UNITED STATES AND CANADA[a] (N=15)	UNITED STATES AND MEXICO[a] (N=50)	UNKNOWN (N=8)	TOTAL (N=590)
	percent (number positive)						
Giardia	7.9% (3)	0% (0)	6.8% (32)	20% (3)	6% (3)	0% (0)	6.9% (41)
Cryptosporidium	5.3% (2)	0% (0)	3% (14)	13% (2)	2% (1)	25% (2)	3.6% (21)
Cyclospora	0% (0)	0% (0)	0.42% (2)	0% (0)	0% (0)	0% (0)	0.34% (2)
Listeria monocytogenes	7.9% (3)	0% (0)	0.21% (1)	0% (0)	0% (0)	0% (0)	0.68% (4)
Norovirus	0% (0)	0% (0)	0.85% (4)	0% (0)	0% (0)	0% (0)	0.68% (4)
Rotavirus	0% (0)	0% (0)	0.21% (1)	0% (0)	0% (0)	0% (0)	0.17% (1)

NOTE: viruses and parasite detection methods use polymerase chain reaction (PCR) assay.

[a] Both identified as country of origin on the package.

Organically grown foods, as specified by product labelling, had roughly equal levels of pathogens compared with those foods not labelled as organic (Table 11.2). One exception was *Giardia*, in which organic-labelled foods had a lower prevalence, 3.6% (6/169), versus those without organic labels, 8.5% (35/410).

TABLE 10.2: Parasite, virus and *Listeria* detection on leafy greens, by organic labelling, ON and BC sites, 2013.

	ORGANIC (N=169)	NOT ORGANIC (N=410)	UNKNOWN (N=11)	TOTAL (N=590)
	percent (number positive)			
Giardia	3.6% (6)	8.5% (35)*	0% (0)	6.9% (41)
Cryptosporidium	3.6% (6)	3.4% (14)	9.1% (1)	3.6% (21)
Cyclospora	0.59% (1)	0.24% (1)	0% (0)	0.34% (2)
Listeria monocytogenes	0% (0)	0.98% (4)	0% (0)	0.68% (4)
Norovirus	0.59% (1)	0.73% (3)	0% (0)	0.68% (4)
Rotavirus	0% (0)	0.24% (1)	0% (0)	0.17% (1)

* Statistically significant difference between not organic and organic, $P < 0.05$, Fisher's exact test.

11. SOURCE ATTRIBUTION

FoodNet Canada analyses the sources of gastrointestinal illness using a multi-pronged approach. The use of 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 investigations), intervention studies and expert elicitation methods. To date, one or more of these methodologies have been applied to a number of pathogens (Table 12.1). Work is underway to distil the results from the various methods, on a pathogen by pathogen basis, to inform the overall narrative on the contribution of food and environmental sources to enteric illness.

TABLE 11.1: FoodNet Canada source attribution activities, by methodology.

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	U	U	X	X	X
Salmonella	X		U	U	X	X	X
Cryptosporidium	X	U		No human subtyping	X	X	X
Giardia	X	U		Insufficient discrimination	X	X	X
VTEC	X	U			X	X	X
Other pathogens					X	X	X

NOTE: Other pathogens category represents a different series of pathogens depending on the method and focus of each study.

X: studies complete

U: studies underway

Articles 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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- Ravel A, Davidson VJ, Ruzante JM, Fazil A. “Foodborne proportion of gastrointestinal illness: Estimates from a Canadian expert elicitation survey.” Foodborne Pathogens and Disease. December 2010, 7(12): 1463–1472.
- Ravel A, Grieg J, Tinga C, Todd E, Campbell G, Cassidy M, Marshall B, Pollari F. “Exploring Historical Canadian Foodborne Outbreak Data Sets for Human Illness Attribution”. Journal of Food Protection. 2009, 72(9):1963–1976.

Campylobacter

Possible sources for campylobacteriosis based on FoodNet Canada data sources in previous years include retail chicken and ground turkey meats, contact with bovine, chicken and swine manures, as well as contact with natural waters, based on samples tested from these sources (**18**). Prevalence results from this 2013 report were similar to those previously presented. However, new information was obtained through the addition of sampling of layer hen manure, which provided prevalence data for *Campylobacter* in this sector. Risk factor analyses from case questionnaires based on case-case descriptive methods from the previous 2011-2012 annual report indicated a long list of possible sources of exposure: living on a farm or country property, consuming spoiled food, contact with on-farm poultry, household pets, and animal manure (**18**). Multivariate case-case analysis indicated that on-farm poultry contact is important. In this 2013 report, descriptive case-case methods identified consumption of unpasteurized milk as a possible source.

Analysis of public health inspector opinion on the most likely source of infection, taken from the FoodNet Canada case questionnaires for the BC sentinel site from April 2010 to 2012, indicated a number of possible sources of *Campylobacter* infection. These included food (23.7%), food safety practices (15.6%), unpasteurized milk, juice or cheese (4.3%), animal (13.2%), occupation (12.1%), other (12.1%), environment (8.6%), water (5.8%), domestic travel (3.1%), and person-to-person (1.6%) (**19**). This further supported earlier findings from work based on 2006 to 2010 data from the ON sentinel site which found that the most likely source of infection is food (23.3%), food safety practices (10.3%), unpasteurized milk, juice or cheese (7.5%), animal (17.9%), water (15.2%), person-to-person (11.3%), environment (7.9%), occupation (5.1%), and other (1.5%) (**20**).

Expert elicitation methods that summarise expert opinion on the source of enteric illness found that *Campylobacter* infections in Canada may come primarily from foodborne routes (62.3%), and to a less extent from animal contact (15.9%), waterborne (9.3%), person-to-person (7.7%) and other routes (4.8%) (**21**). A previous expert elicitation study found a similar proportion for the foodborne route (**22**). Within the foodborne route, additional work on this data found that infections were considered to be primarily from poultry (59%), and to a lesser extent, dairy (9.1%), beef (7.4%), produce (6.1%), eggs (4.7%), pork (4.6%), game (1.8%), luncheon meat (1.4%), seafood (0.9%), beverage (0.5%), and other food products (1.1%)(**23**).

Canadian data on published outbreaks from the Microbial Food Safety Database provides another source of information on foodborne illness. Data for 2000-2012 suggests that all two of the reported foodborne outbreaks with *Campylobacter* as the causative agent had milk implicated as the transmission vehicle (**24**). Previous work by FoodNet Canada using this dataset and others for the years 1996 to 2005 found that poultry (56.2%) and dairy products (25%) were the largest sources, and seafood (6.3%), cooked dishes of multi-ingredient foods (3.1%), meats other—other than ready-to-eat, beef, pork, poultry, sausage, and wild game—(3.1%), pork (3.1%), and wild game (3.1%), were sources with a much smaller share (**25**).

Case-control analysis using FoodNet Canada ON site data examined the role of waterborne, environmental and food purchasing behaviours, excluding the poultry or other food consumption routes, indicating that the waterborne route was the most important (**26**).

A comparative exposure assessment using data from the same site that estimated the number of organisms ingested from various routes (including food consumption, animal, and water exposure), found that the most important to least important exposures were: pets, consumption of chicken meat, living on a farm, drinking raw milk, visiting a farm, contact with recreational water, consumption of beef meat, drinking water, pork meat, vegetables, seafood, petting zoo attendance, and fruit (**27**).

A study also using Ontario data and the microbial subtyping approach using comparative genomic fingerprinting as the subtyping method, and results from the comparative exposure assessment study as weighting factors, found chicken meats to be the dominant cause by a large factor of *Campylobacter* compared to other possible sources examined (ground beef, turkey meat, chicken manure, swine manure, beef cattle manure and water sources) (**28**).

Together, point estimates from the outbreak investigations, most likely source of infection and expert elicitation methods suggest the foodborne route for *Campylobacter* infection is the most important, with values roughly ranging between 40% and 60%. The top food product by a large margin within the foodborne route is poultry, and to a lesser extent, dairy, beef, seafood, eggs, and pork. Results from quantitative methods suggest that chicken meat, household pets and living on a farm are important sources of infection. This is a descriptive summary; FoodNet Canada is looking into ways to better combine results from various methods.

Salmonella

Possible sources for salmonellosis, based on previous FoodNet Canada surveillance results, include retail chicken and ground turkey meats, contact with broiler chicken, swine and bovine manures, as well as contact with natural waters, based on samples tested from these sources (**18**). Risk factor analysis from case questionnaires based on case-case descriptive methods in previous FoodNet Canada reports indicate that potential sources could be contact with household pet reptiles (**18**).

The most likely source of infection question, based on public health inspector opinion, from the FoodNet Canada case questionnaires for the BC sentinel site from April 2010 to 2012 was analyzed. Results suggest that the most likely source of *Salmonella* infection was food (40.7%), food safety practices (8.3%), unpasteurized milk, juice or cheese (0.7%), other (18.6%), animal (9.7%), environment (8.3%), person-to-person (7.6%), occupation (2.8%), water (2.1%), and domestic travel (1.4%) (**19**). Earlier work from 2006 to 2010 data from the ON sentinel site found that the most likely source of infection was food (36.3%), food safety practices (15.6%), unpasteurized milk, juice or cheese (1.9%), animal (18.8%), person-to-person (10.6%), environment (7.5%), water (3.8%), other (3.8%), and occupation (1.9%) (**20**).

Expert elicitation methods found that *Salmonella* infections in Canada may come primarily from foodborne routes (62.9%), and to a less extent from animal contact (12.7%), waterborne (8.0%), person-to-person (10.0%) and other routes (6.4%) (**21**). A previous expert elicitation study found a similarly high proportion (54%) for the foodborne route (**22**). Within the foodborne route, additional work on data from this study found that infections were considered to be primarily from poultry (34.5%), eggs (20%) and produce (17.8%), and to a lesser extent, dairy (7.0%), pork (7.2%), beef (5.7%), luncheon meat (4.8%), seafood (1.7%), game (1.6%), beverage (0.9%), and other food products (2.0%) (**23**).

Canadian data on published outbreaks from the Microbial Food Safety Database for 2000-2012 suggests that the foodborne outbreaks with *Salmonella* as the causative agent had a wide variety of implicated transmission vehicles: produce (20%), meats from beef (18%) and poultry (14%), eggs (10%), dairy products (8.0%), cooked dishes with multi-food ingredients (4.0%), bakery items (4.0%), nuts (4.0%), ready-to-eat meats (2.0%), sausage meats (4.0%), pork meats (2.0%), wild game meats (2.0%), other meats (2.0%), seafood (2.0%), beverages (2.0%) and chocolate (2.0%) (**24**). Previous work involving FoodNet Canada on this dataset for the years 1996 to 2005 found a different ordering of sources: produce (29%), poultry meats (14%), other meats (14%), dairy products (9.2%), cooked dishes with multi-food ingredients (7.9%), seafood (6.6%), eggs (5.3%), other multi-ingredient foods (5.3%), beef meats (2.6%), wild game meats (2.6%), ready-to-eat meats (1.3%), and sausage meats (1.3%) (**25**).

Together, point estimates from the outbreak investigations, most likely source of infection and expert elicitation methods suggest the foodborne route for *Salmonella* infection is the most important, with values roughly ranging between 50% and 60%. The top ranked foods within the foodborne route are poultry, eggs, dairy foods, beef meats and produce. Though produce is ranked high in expert elicitation and outbreak analysis, historically, it has been found on these products in very low numbers. Work done on leafy greens by the Canadian Food Inspection Agency is one example (**29**). Because of this, produce is not ranked highly as an important source of salmonellosis. This is a descriptive summary; FoodNet Canada is looking into ways to better combine results from various methods.

Verotoxigenic *E. coli*

Possible sources for VTEC infection, based on FoodNet Canada data sources in previous years, include retail ground beef, beef cuts, contact with bovine, swine and chicken manures, as well as contact with natural waters, based on samples tested from these sources (**18, 30, 31, 32**). Results from this 2013 report are in line with these sources. Risk factor analysis from case questionnaires in the previous FoodNet Canada report for 2011-2012 based on case-case descriptive methods indicate several possible sources, including swimming in a lake, attending a social gathering, and going canoeing, kayaking, hiking or camping (**18, 30, 31, 32**).

Analysis of the most likely source of infection question, based on the opinion of public health inspectors, from the FoodNet Canada case questionnaires for the BC sentinel site from April 2010 to 2012 found that the most likely source of VTEC infection was food (32.0%), food safety practices (8.0%), unpasteurized milk, juice or cheese (4.0%), other (20.0%), animal (16.0%), water (4.0%), environment (4.0%), person-to-person (4.0%), occupation (4.0%), and domestic travel (4.0%) (**19**). Earlier work from the ON sentinel site on 2006 to 2010 data found that the most likely source of infection was food (36.3%), food safety practices (5.6%), unpasteurized milk, juice or cheese (11.1%), water (16.7%), person-to-person (13.9%), environment (11.1%), animal (8.3%), and occupation (5.6%) (**20**).

Summarised expert opinion on the source of enteric illness via expert elicitation methods found that VTEC infections in Canada may come primarily from foodborne routes (60.6%), and to a lesser extent from waterborne sources (12.4%), person-to-person (11.8%), animal contact (11.0%), and other routes (4.4%) (**21**). A previous expert elicitation study found a proportion of 40% for the foodborne route, though this value is specific to O157:H7 (**22**). Within the foodborne route, additional work on data from this study found that infections of *E.coli* O157:H7 were considered to be primarily from beef (54%) and produce (29%), and to a lesser extent, dairy (5.6%), beverage (4.1%), game (2.6%), luncheon meat (2.4%), pork (1.5%), eggs (0.5%), poultry (0.3%), seafood (0.3%), and other (2.7%) (**23**).

Data from the Microbial Food Safety Database provides another source of information on Canadian foodborne illness. Data for 2000-2012 suggested that foodborne outbreaks with VTEC as the causative agent had beef meats (60.9%) as the primary transmission vehicle implicated, and to a lesser degree produce (12.5%), dairy products (9.4%), other meats (7.8%), poultry meats (1.6%), cooked dishes with multi-food ingredients (1.6%), other multi-food ingredients (1.6%), nuts (1.6%), pork meats (1.6%), and beverages (1.6%) (**24**). Previous FoodNet Canada work using this dataset for the years 1996 to 2005 for *E. coli* found that beef meats (36.5%) and cooked dishes with multi-food ingredients (23%) were the largest source, and to a lesser extent other meats (10.8%), dairy products (9.5%), produce (5.4%), other multi-ingredient foods (5.4%), sausage meats (4.1%), pork meats (2.7%) and ready-to-eat meats (2.7%) (**25**).

Together, point estimates from the outbreak, most likely source of infection and expert elicitation methods suggest the foodborne route for VTEC infection is the most important, with values roughly ranging between 40% and 60%. The top food products by a large margin within the foodborne route is beef meat, and to a lesser extent, dairy products and meats other than beef, pork, poultry, sausage, wild game, or those that are ready-to-eat. This is a descriptive summary; FoodNet Canada is looking into ways to better combine results from various methods.

APPENDIX A: 2013 LABORATORY TESTS PERFORMED ON FOODNET CANADA SAMPLES

Component	Sample Type	Isolation or Microscopic ID	Molecular ID	Enumeration (MPN or Oocyst/cyst per 100L)	Serotyping/ Biotyping	Phagetyping	Ribotyping	PFGE	Genotyping	Comparative Genomic Fingerprinting
RETAIL MEAT	Skinless chicken breasts Ground beef Frozen chicken nuggets Ground chicken	*Salmonella* (chicken only) *Campylobacter* (chicken only) VTEC (beef only) *Listeria*		*Salmonella* (ground chicken and nuggets only) *Campylobacter* (ground chicken only) *Listeria* (ground chicken and nuggets only)	*Salmonella* *Campylobacter* VTEC *Listeria*	*Salmonella* (specific serovars)	*Listeria*	*Salmonella* VTEC (O157 and top 6) *Listeria*		*Campylobacter*
RETAIL PRODUCE	Leafy greens	*Listeria monocytogenes* *Cryptosporidium* *Giardia* *Cyclospora*	*Cryptosporidium* *Giardia* *Cyclospora* Norovirus Rotavirus		*Listeria*		*Listeria*	*Listeria*	*Cryptosporidium* *Giardia* *Cyclospora* Norovirus Rotavirus	
ON-FARM (manure)	Beef Dairy Broiler chickens Layer chickens Turkey	*Salmonella* *Campylobacter* VTEC/*E. coli* O157			*Salmonella* *Campylobacter* VTEC/*E. coli* O157	*Salmonella* (specific serovars)		*Salmonella* VTEC/*E. coli* O157		*Campylobacter*
WATER	Raw surface water Beaches Irrigation ditches	*Salmonella* *Campylobacter* VTEC *Giardia* (surface water and beaches only) *Cryptosporidium* (surface water and beaches only)		*Campylobacter* (select samples) *Salmonella* (select samples) *Cryptosporidium* (select samples) *Giardia* (select samples)	*Salmonella* *Campylobacter* VTEC	*Salmonella* (specific serovars)		*Salmonella* VTEC	*Cryptosporidium* *Giardia*	*Campylobacter*
HUMAN	Human specimens	*Salmonella* *Campylobacter* *Yersinia* VTEC *Cryptosporidium* *Giardia* *Shigella* *Listeria*			*Salmonella* *Listeria* *Yersinia*	*Salmonella*		*Salmonella* VTEC *Listeria*		*Campylobacter*

APPENDIX B: HUMAN QUESTIONNAIRE RESULTS, BOTH SITES COMBINED, 2013

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	**228**	**197**	**99**	**326**	**21**	**404**	**20**	**405**	**45**	**380**	**12**	**413**	**425**
	%	%	%	%	%	%	%	%	%	%	%	%	%
Age(years)													
0 to 4	14	15	17	13	19	14	10	15	9	15	17	14	14
5 to 19	11	21	20	15	**43***	15	10	16	16	16	33	15	16
20 to 29	22	14	13	20	14	19	30	18	9	19	17	18	18
30 to 59 (ref)	35	31	25	35	14	34	35	33	51	31	25	33	33
>60	18	19	**24***	17	10	19	15	19	16	19	8	19	18
Gender													
Male	57	47	45	54	48	52	55	52	44	53	58	52	52
Female (ref)	43	53	55	46	52	48	45	48	56	47	42	48	48
Season													
Summer	36	32	36	34	38	34	20	35	27	35	33	34	34
Fall, Winter, Spring (ref)	64	68	64	66	62	66	80	65	73	65	67	66	66
Occupation													

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	**228**	**197**	**99**	**326**	**21**	**404**	**20**	**405**	**45**	**380**	**12**	**413**	**425**
	%	%	%	%	%	%	%	%	%	%	%	%	%
Agriculture/Food handler	12	7	5	11	10	10	0	10	7	10	25	9	10
Health care	3	2	2	2	5	2	0	2	0	3	8	2	2
Day care	4	4	4	3	5	3	0	4	4	3	0	4	4
Other	40	31	25	40	24	37	45	36	47	35	17	37	36
Student, unemployed, retired	41	56	**64***	43	57	48	55	48	40	49	50	48	48
Travelled within Canada	11	13	8	13	24	11	10	12	20	11	8	12	12
Drank untreated water	4	4	1	5	0	4	5	4	**11***	3	8	4	4
Swam	15	19	9	19	**43***	15	15	17	**31***	15	17	17	17
In a lake	6	8	2	8	19	6	0	7	**20***	5	0	7	7
In a river	2	1	0	2	5	1	0	1	2	1	0	1	1
In a pool	8	14	6	12	**29***	10	15	10	**24***	9	8	11	11
In a hottub	4	5	3	5	10	4	15	4	2	5	0	5	4
Went canoeing, kayaking, hiking or camping	9	10	5	11	19	9	0	10	**22***	8	0	10	9

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	**228**	**197**	**99**	**326**	**21**	**404**	**20**	**405**	**45**	**380**	**12**	**413**	**425**
	%	%	%	%	%	%	%	%	%	%	%	%	%
Drank unpasteurized milk	**5***	1	0	4	10	3	0	3	0	3	0	3	3
Ate undercooked food	11	7	5	10	10	9	10	9	7	9	8	9	9
Ate spoiled food	7	8	6	7	14	7	10	7	7	7	8	7	7
Attended a barbecue	21	19	18	21	38	19	5	21	20	20	17	20	20
Attended a social gathering	15	12	11	14	24	13	10	14	9	14	17	14	14
Ate food prepared outside the home	65	58	54	64	67	61	55	62	62	62	67	62	62
Ate meat from hunting	2	3	3	2	0	2	0	2	4	2	0	2	2
Ate meat from a butcher shop	12	11	9	13	24	11	10	12	13	12	0	12	12
Ate meat from a private kill	2	1	0	2	5	1	0	1	2	1	0	1	1
Contact with household pet	59	56	53	59	71	57	45	58	64	57	50	58	58
Birds	4	5	3	5	10	4	5	4	9	4	0	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	**228**	**197**	**99**	**326**	**21**	**404**	**20**	**405**	**45**	**380**	**12**	**413**	**425**
	%	%	%	%	%	%	%	%	%	%	%	%	%
Cats	30	22	14	30	33	26	20	27	38	25	8	27	26
Dogs	40	42	42	40	43	41	35	41	42	41	50	41	41
Reptiles	2	3	5	2	0	3	0	3	2	3	0	3	3
Rodents	2	2	2	2	0	2	0	2	2	2	0	2	2
Visited farm, petting zoo or fair	13	11	4	14	10	12	5	12	20	11	**42***	11	12
Animal Exposure	10	9	3	11	10	9	5	9	13	9	**42***	8	9
Cats	1	1	0	1	5	1	0	1	2	1	0	1	1
Dogs	0	1	0	1	0	0	0	0	2	0	0	0	0
Horses	1	3	1	2	0	2	0	2	7	1	8	1	2
Cattle	4	4	1	5	10	4	0	4	2	4	**25***	3	4
Pigs	0	1	0	1	0	0	0	0	2	0	0	0	0
Poultry	3	2	1	3	5	2	5	2	0	3	0	2	2
Sheep/Goats	2	1	0	2	0	1	0	1	2	1	0	1	1
Lived on a farm/rural site	16	12	10	15	19	14	0	15	16	14	17	14	14
Animal Exposure	11	5	5	9	14	8	0	8	2	9	8	8	8
Cats	1	1	1	1	5	1	0	1	0	1	0	1	1

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	**228**	**197**	**99**	**326**	**21**	**404**	**20**	**405**	**45**	**380**	**12**	**413**	**425**
	%	%	%	%	%	%	%	%	%	%	%	%	%
Dogs	1	1	1	1	0	1	0	1	0	1	0	1	1
Horses	4	2	2	4	5	3	0	3	2	3	0	3	3
Cattle	7	4	5	6	10	5	0	6	0	6	8	6	6
Pigs	3	2	2	2	5	2	0	2	0	2	0	2	2
Poultry	5	3	4	4	5	4	0	4	0	4	0	4	4
Sheep/Goats	1	0	0	1	0	0	0	0	0	1	0	0	0
Contact with animal manure	16	9	7	14	19	12	5	13	7	13	25	12	13

[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 FOR RETAIL FOOD SAMPLES, BOTH SITES COMBINED, 2013

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								
Ground chicken	189	58	56	39 (70%)	17 (30%)	0 (0%)	0 (0%)	0 (0%)
Listeria								
Uncooked chicken nuggets	189	32	32	26 (81%)	6 (19%)	0 (0%)	0 (0%)	0 (0%)
Ground chicken	189	70	70	56 (80%)	13 (19%)	1 (1%)	0 (0%)	0 (0%)
Salmonella								
Uncooked chicken nuggets	189	66	65	63 (97%)	2 (3%)	0 (0%)	0 (0%)	0 (0%)
Ground chicken	189	114	111	100 (90%)	9 (8%)	0 (0%)	1 (1%)	1 (1%)

[a] Below the assay detection limit.

APPENDIX D: 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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