FOODNET CANADA ANNUAL REPORT 2016

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.
—Public Health Agency of Canada

Également disponible en français sous le titre :
FoodNet Canada Rapport annuel 2016

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This publication can be made available in alternative formats upon request.

Publication date: September 2018

Cat.: HP37-17/1E-PDF
ISBN: 2292-8073
Pub.: 180167

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FOREWORD

The Public Health Agency of Canada's FoodNet Canada surveillance system is pleased to present the new annual report. In the past, FoodNet Canada produced both a 'short' and 'long' report to disseminate surveillance results on an annual basis. Based on feedback obtained through stakeholder consultation, these two reports have been replaced with one streamlined annual report. The current report outlines the results of our surveillance activities conducted in 2016.

The report highlights FoodNet Canada findings from its sentinel sites in British Columbia, Alberta and Ontario. It focuses on trends in enteric pathogen disease rates, as well as trends in the prevalence of these pathogens found on potential disease sources: retail meats, food-animal manure and water. We also highlight the impact of enteric pathogen trends on public health. In 2016, FoodNet Canada added feedlot beef manure sampling in the Alberta site and turkey manure sampling in the Ontario site, which further informs our 'farm to fork' surveillance approach.

It is our hope that this report will be used to inform and shape discussions on food safety issues regarding enteric diseases and their sources.

ACKNOWLEDGEMENTS

FoodNet Canada acknowledges the significant investments made by our partners in the three sentinel sites, our provincial and federal government agency colleagues, and academic and industry collaborators who help to make this program a continued success.

INFORMATION TO THE READER

FoodNet Canada is a multi-partner sentinel site surveillance system led by the Public Health Agency of Canada (PHAC) that monitors changes in enteric pathogens in Canada.

In collaboration with public health jurisdictions and provincial laboratories, FoodNet Canada conducts continuous and episodic surveillance activities in three sentinel sites collecting information across four components: human, retail (meat and produce), on-farm (farm animals), and water. Continuous surveillance occurs throughout the year to identify trends in human disease occurrence, exposure sources, and attributes illnesses to sources and settings for targeted enteric pathogens. Information on the sources of greatest risk to human health helps direct food and water safety actions and programming as well as public health interventions, and to evaluate their effectiveness. Specifically, FoodNet Canada's core objectives are to:

- determine what food and other sources are making Canadians ill;
- determine significant risk factors for enteric illness;
- accurately track enteric disease rates and risks over time; and
- provide practical prevention information to assist local and provincial public health officials to:
    - prioritize risks;
    - compare interventions, direct actions and advance policy; and
    - assess effectiveness of food safety activities / public health interventions and measure performance.

This report draws on knowledge from a variety of sources to present a comprehensive and meaningful interpretation of trends and issues identified through FoodNet Canada data, as well as from collaborating programs within PHAC. Examples include the Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS), the National Enteric Surveillance Program (NESP), the Enhanced National Listeriosis Surveillance Program, the Outbreak Management Division (OMD), and the National Microbiology Laboratory (NML). Information from these programs is used to support and enhance findings through the integration and assessment of relationships observed over time between human illness, contamination levels in retail foods, food-animal farm manure and water. Known interventions implemented within the food industry were also considered when interpreting surveillance trends.

DATA COLLECTION AND REPORTING

Each FoodNet Canada sentinel site relies on a unique partnership with the local public health authority, private laboratories, water and agri-food sectors as well as the provincial and federal institutions responsible for public health, food safety, and water safety. The sites include Ontario (Middlesex-London Health Unit), British Columbia (Fraser Health Authority) and Alberta (Calgary and Central Zones of Alberta Health Services). The Ontario (ON) site data collection began in August of 2014; however, for the purpose of yearly comparisons in this Report, data from the ON pilot sentinel site (Region of Waterloo) (2011-Mar 2014) have been included for select analyses. The British Columbia (BC) site was officially established in April 2010 and includes the communities of Burnaby, Abbotsford, and Chilliwack. The province of Alberta (AB) contains the third site and data collection began in June of 2014.

Results are reported for all three sites unless otherwise stated. Readers should be cautious when extrapolating these results to areas beyond the sentinel communities. 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 estimates for all of Canada.

In 2016, the farm and retail components were implemented across all sites in ON, AB, and BC whereas the water component was only implemented in AB and BC. The non-human surveillance data collected by FoodNet Canada represents possible exposure sources for human enteric illnesses within each sentinel site. The data are meant to be interpreted aggregately and cannot to be used to directly attribute a specific human case reported to FoodNet Canada to a positive isolate obtained from an exposure source. In this report, the non-human and human data are integrated using descriptive methods. The term “significant” is reserved in this report for describing trends that are statistically significant.

FoodNet Canada retail and farm sampling is integrated with 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 (http://www.phac-aspc.gc.ca/cipars-picra/index-eng.php).

SURVEILLANCE STRATEGY

HUMAN SURVEILLANCE

Public health professionals 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 are conducted for further integration with non-human source information.

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 on a weekly basis from randomly selected grocery stores within each site. FoodNet Canada collects samples of raw unfrozen skinless chicken breasts and ground beef on a weekly basis. Each year, FoodNet Canada and its partners assess knowledge gaps and from this process, select targeted retail products to sample for a given year (see Appendix A for 2016 details). In past years targeted meats have included but were not limited to pork chops, ground chicken and turkey, and uncooked frozen breaded chicken products, such as nuggets and strips. In 2016 FoodNet Canada opted to continue the targeted investigation of frozen breaded chicken products that began in 2011. Testing continued in 2016 as in previous years with *Campylobacter* and *Salmonella* being tested for among all chicken products, *Listeria spp.* for all retail meat products, and Shigatoxigenic *Escherichia coli* (STEC) for ground beef samples. In addition, vegetables and ready to eat slaws were tested for the presence of *Listeria, Cyclospora, Cryptosporidium, Giardia*, Norovirus, and Rotavirus.

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 an important source in the farm-to-fork transmission chain. In 2016, the farm component was active across all three sites, although commodities varied by site (Appendix A). Manure samples were collected from beef cattle, swine, broiler chicken, layer chicken, and turkey farms in order to estimate the pathogen levels on farms. Approximately 30 farms of each type of participating farm commodities were visited each year in each site. A short management survey, and up to six manure samples (usually fresh pooled samples) were obtained at each farm visit. All samples were tested for *Campylobacter* and *Salmonella* with the beef samples additionally being tested for *E. coli* O157 and STEC. Throughout the report, farm results are reported at both the sample-level and farm-level to account for clustering within farms. Sample-level results include all manure samples collected on each farm, while farm-level results are based on a threshold of one positive manure sample per farm to report a farm as positive.

WATER SURVEILLANCE

Water is another environmental source of enteric pathogens collected in the FoodNet Canada surveillance program. In 2016 irrigation water was sampled in both the BC and AB sentinel sites and tested for *Campylobacter*, *Salmonella*, and STEC (Appendix A). Similar to 2015, sampling in BC was bi-weekly throughout the year and monthly in AB from June to September.

DEFINITIONS

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

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

International travel-related case of disease: Affected individual who travelled outside of Canada, and where the travel dates overlap with the expected disease incubation period (varies depending on the pathogen).

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

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

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

Shigatoxigenic Escherichia coli (STEC): *Escherichia coli* are normal intestinal inhabitants in humans and animals, and most strains do not cause enteric disease. However, the group of shigatoxigenic *E. coli* includes certain toxin-producing strains that can cause severe diarrhea and, in some people (particularly young children), a form of acute kidney failure called hemolytic uremic syndrome. In terms of nomenclature, shigatoxin (ST) -producing *E. coli* can also be referred to as Shiga-toxin-producing *E. coli*[1].

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

CAMPYLOBACTER

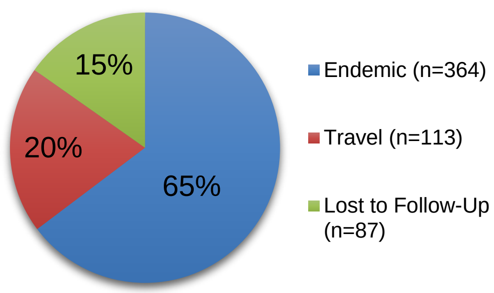
HUMAN SURVEILLANCE SUMMARY

Table 1.1: Incidence rates (per 100,000 person-years) of *Campylobacter* spp. by case classification and FoodNet Canada sentinel site, 2016 (with 2015 shown for reference).

	ON Site		AB Site		BC Site		All Sites	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Endemic	10.07	15.98 ↑	15.85	17.90	21.90	21.38	15.90	18.28
International Travel	5.24	4.57	5.25	4.48	6.38	9.34	5.52	5.67
Outbreak	0.42	0.00	0.00	0.00	0.00	0.00	0.10	0.00
Non-Endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lost to Follow-Up	4.61	7.27	3.86	3.21	3.83	3.94	4.04	4.37
Total	20.34	27.82 ↑	24.97	25.59	32.10	34.66	25.56	28.32

↑/↓Indicates a significant increase/decrease in incidence compared to 2015.

Figure 1.1: Relative proportion of *Campylobacter* by case classification.



Isolates with species information:
499/564 (88%)

- *C. jejuni*: 91%
- *C. coli*: 5%
- *C. upsaliensis*: 3%
- *C. lari*: <1%
- *C. ureolyticus*: <1%

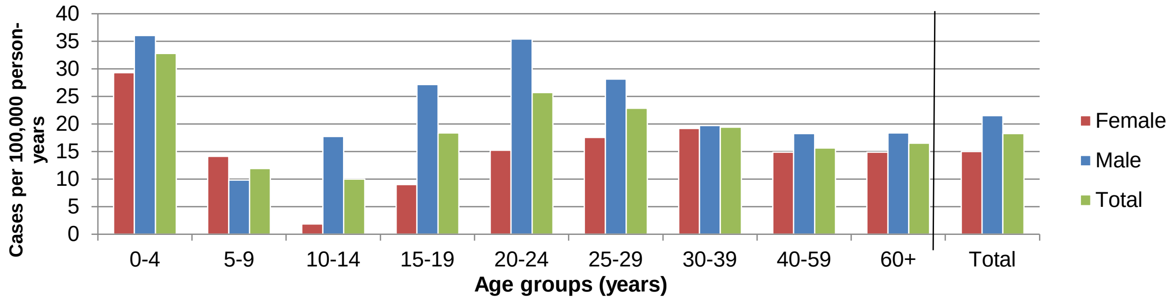
Significant changes in endemic, travel, and total incidence rates:

- There were significant increases in the ON site endemic and total incidence rates from 2015 to 2016.

Clinical profile of endemic cases:

- **Most commonly reported symptoms:**
  - Diarrhea: 99%
  - Abdominal pain: 77%
  - Fever: 64%
  - Fatigue: 60%
  - Anorexia: 58%
- **Indicators of severity:**
  - Bloody diarrhea: 35%
  - Emergency room visits: 58%
  - Hospitalizations: 8%
  - Antimicrobial prescriptions: 57%

Figure 1.2: Age and gender specific incidence rates (per 100,000 person-years) for endemic *Campylobacter* spp. cases within FoodNet Canada sentinel sites, 2016.



FOOD, ANIMAL AND ENVIRONMENTAL SURVEILLANCE SUMMARY

Table 1.2: Prevalence of *Campylobacter* spp. by sample type and FoodNet Canada sentinel site, 2016.

Sample Type		ON Site	AB Site	BC Site	All Sites
Chicken Breast		37% (48/131)	38% (50/132)	45% (59/132)	40% (157/395)
Ground Pork		0% (0/132)	1% (1/132)	1% (1/132)	<1% (2/396)
Broiler Chicken Manure	**Sample-level**	5% (4/88) ↓	20% (24/120) ↓	24% (31/128)	18% (59/336)
	Farm-level	5% (1/22)	20% (6/30)	28% (9/32)	19% (16/84)
Turkey Manure	**Sample-level**	56% (65/116)	NT	68% (79/116) ↓	62% (144/232)
	Farm-level	59% (17/29)	NT	72% (21/29)	66% (38/58)
Layer Chicken Manure	**Sample-level**	54% (28/52)	NT	NT	54% (28/52)
	Farm-level	62% (8/13)	NT	NT	62% (8/13)
Feedlot Beef Manure	**Sample-level**	NT	72% (56/78)	NT	72% (56/78)
	Farm-level	NT	100% (13/13)	NT	100% (13/13)
Irrigation Water		NT	22% (7/32) ↑	20% (22/110)	18% (24/132)

↑/↓Indicates a significant increase/decrease in prevalence compared to 2015; NT-not tested.

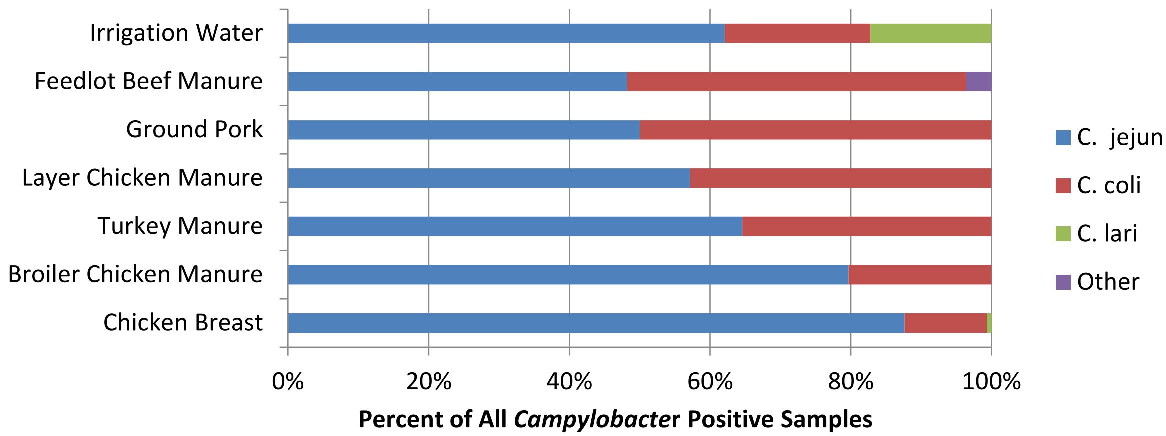
Significant difference in prevalence since 2015:

- Broiler chicken manure (sample-level): ON decreased to 5% in 2016 from 24% in 2015. AB decreased to 20% in 2016 from 34% in 2015.
- Turkey manure (sample-level): BC decreased to 68% in 2016 from 86% in 2015.
- Irrigation water: AB increased to 22% in 2016 from 5% in 2015.

Regional differences:

- Farm-level: Broiler chicken manure in BC had the highest *Campylobacter* prevalence. Prevalence was significantly higher than ON but not AB.
- Water: *C. jejuni* was the most common subtype in BC (10/15) from June to September, as compared to *C. lari* (5/7) in AB during this time period.

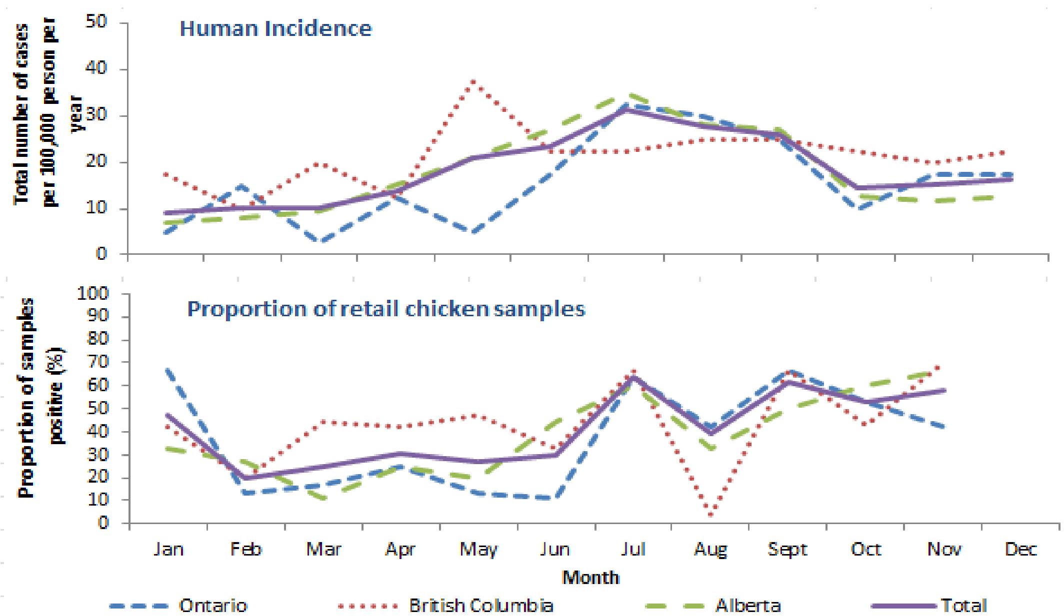
Figure 1.3: Distribution of *Campylobacter* spp. subtypes among food, animal and environmental samples, FoodNet Canada, 2016



PUBLIC HEALTH IMPACT

Seasonality in the incidence of *Campylobacter* cases and in the proportion of positive retail chicken products positive for this pathogen was observed in 2016, with higher rates and proportions reported in the month of July (Figure 1.4). While there was a marked decrease in the incidence of human campylobacteriosis at the end of the summer season, the proportion of retail chicken samples positive for *Campylobacter* remained stable and at higher levels compared to the winter and spring seasons.

Figure 1.4: Human incidence rate (per 100,000 person-years) for endemic *Campylobacter* cases and proportion of retail chicken samples positive for *Campylobacter* by month across FoodNet Canada's sentinel sites, 2016.

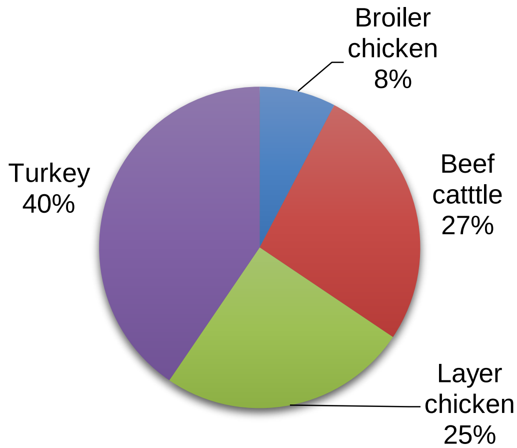


Data for retail samples collected in December have been excluded due to the low sample size (less than five) collected.

Campylobacter jejuni was the primary pathogen identified in both human cases and retail chicken samples across all sentinel sites. This subtype is also common in samples collected from irrigation canals, broiler chicken and turkey farms (Figure 1.3). Among human cases, *Campylobacter coli* are less frequently associated with disease, representing 5% of all subtyped human infections. However, within the animal sector, *C. coli* represented 20% and 35% of *Campylobacter* isolated from farm broiler chicken and turkey manure samples, respectively.

Food products have been identified as one of the most likely sources of infection in humans followed by animal contact. At the retail level, *Campylobacter* was frequently detected on chicken breasts (40%, 157/395) and less frequently on ground pork (2/396) in 2016. There are multiple sources of exposure at the farm level and Figure 1.5 presents the proportion of *Campylobacter* that was identified by farm type.

Figure 1.5: Proportion of manure samples positive for *Campylobacter* by farm type across FoodNet Canada's sentinel sites, 2016.



Overall, when comparing the human and food trend information it is clear that there are other potential sources of exposure for human illness beyond chicken products purchased at the retail level. If chicken were to be the only source of exposure, we would expect to observe the trends of human illness to mirror those of retail chicken products and continue to be reported at higher levels after the summer season. Continuing surveillance of other retail products, farm animals and the environment for *Campylobacter* will allow us to better identify and understand the contribution of multiple sources to Canadian illnesses, as well as to guide future surveillance activities.

SALMONELLA

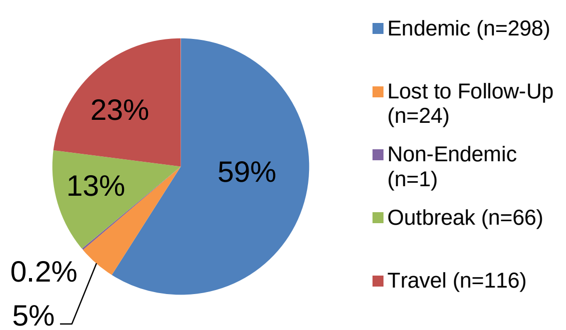
HUMAN SURVEILLANCE SUMMARY

Table 2.1: Incidence rates (per 100,000 person-years) of *Salmonella* spp. by case classification and FoodNet Canada sentinel site, 2016 (with 2015 shown for reference).

	ON Site		AB Site[a]		BC Site		All Sites	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Endemic	10.49	12.66	16.05	14.69	17.43	17.85	15.03	14.96
International Travel	5.45	4.98	6.34	5.35	6.59	7.68	6.18	5.83
Outbreak	0.84	6.44	2.48	1.17	0.85	4.77	1.69	3.31
Non-Endemic	0.00	0.00	0.30	0.00	0.43	0.21	0.26	0.05
Lost to Follow-Up	0.00	0.42	2.48	1.56	3.19	1.25	2.04	1.21
Total	16.78	24.49 ↑	27.65	22.77	28.49	31.76	25.20	25.36

↑/↓Indicates a significant increase/decrease in incidence compared to 2015.
[a]Typhi and Paratyphi (except Paratyphi B var Java) not reported by AB site.

Figure 2.1: Relative proportion of *Salmonella* by case classification.



Isolates with serovar information:
503/505 (99.6%)

Top 5 *Salmonella* serovars:

- Enteritidis: 52%
- Typhimurium: 12%
- Heidelberg: 4%
- Infantis: 4%
- ssp. 4,[5],12:i:-: 4%

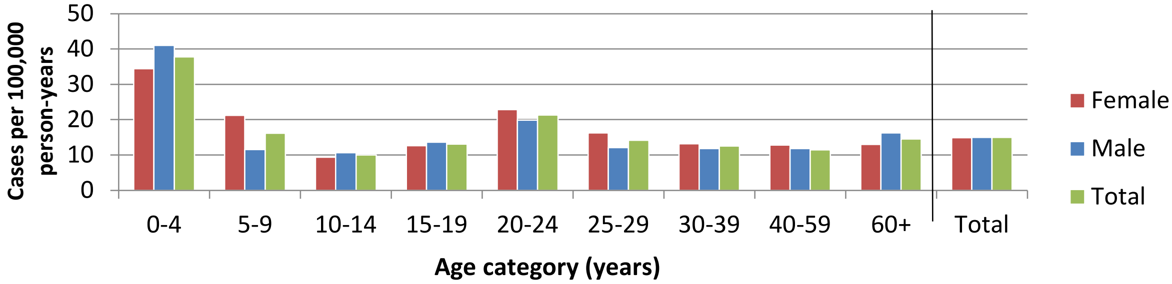
Significant changes in endemic, travel, and total incidence rates:

- A significant increase in the ON site total incidence rate between 2015 and 2016 was observed. This increase was influenced by a slight increase among endemic cases, but largely driven by the increase among outbreak-related cases.

Clinical profile of endemic cases:

- **Most commonly reported symptoms:**
  - Diarrhea: 96%
  - Abdominal pain: 83%
  - Fatigue: 74%
  - Fever: 71%
  - Anorexia: 69%
- **Indicators of severity:**
  - Bloody diarrhea: 38%
  - Emergency room visits: 61%
  - Hospitalizations: 11%
  - Antimicrobial prescriptions: 46%

Figure 2.2: Age and gender specific incidence rates (per 100,000 person-years) for endemic *Salmonella* spp. cases within FoodNet Canada sentinel sites, 2016.



FOOD, ANIMAL AND ENVIRONMENTAL SURVEILLANCE SUMMARY

Table 2.2: Prevalence of *Salmonella* spp. by sample type and FoodNet Canada sentinel site, 2016

Sample type		ON Site	AB Site	BC Site	All Sites
Chicken Breast		13% (17/131)	29% (38/132)	30% (39/132)	24% (94/395)
Frozen raw breaded chicken nuggets		36% (48/132)	25% (33/132)	26%(34/131)	29% (115/395)
Ground Pork		23% (31/132)	4% (5/132)	1% (1/132)	9% (37/395)
Broiler Chicken Manure	**Sample-level**	25% (22/88) ↓	43% (51/120)	57% (73/128) ↓	43% (146/336)
	Farm-level	41% (9/22)	63% (19/30)	72% (23/32) ↓	61% (51/84)
Swine Manure	**Sample-level**	22% (34/156)	7% (8/108)	NT	16% (42/264)
	Farm-level	54% (14/26)	22% (4/18)	NT	41% (18/44)
Turkey Manure	**Sample-level**	60% (70/116)	NT	43% (50/116)	52% (120/232)
	Farm-level	83% (24/29)	NT	59% (17/29)	71% (41/58)
Feedlot Beef Manure	**Sample-level**	NT	4% (3/78)	NT	4% (3/78)
	Farm-level	NT	15% (2/13)	NT	15 % (2/13)
Irrigation Water		NT	0% (0/32)	18% (18/100)	14% (18/132)

↑/↓Indicates a significant increase/decrease in prevalence compared to 2015; NT – not tested.

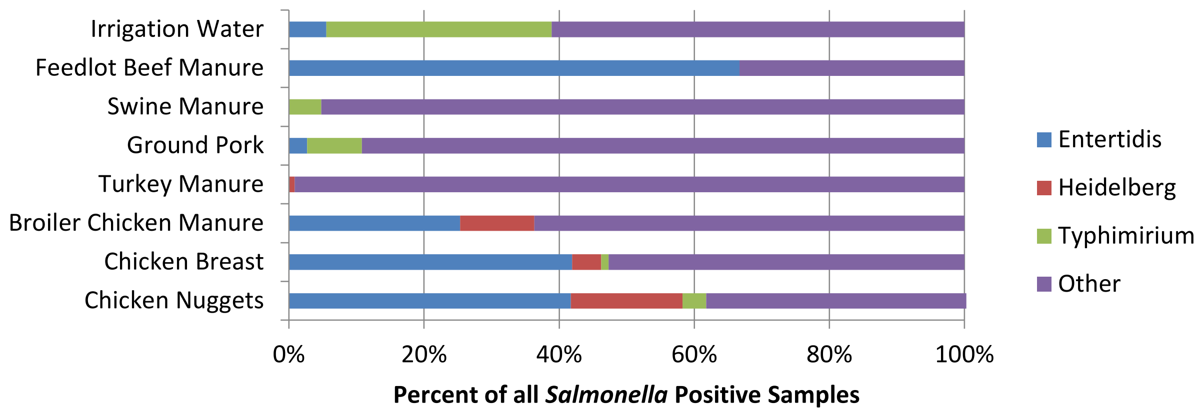
Significant difference in prevalence since 2015:

- **Broiler chicken manure (sample-level):**
  - ON – decreased to 25% in 2016 from 45% in 2015.
  - BC – decreased to 57% in 2016 from 72% in 2015.
- **Broiler chicken manure (farm-level):**
  - BC – decreased to 72% in 2016 from 92% in 2015.

Regional differences:

- *Salmonella* prevalence in retail ground pork is significantly higher in the ON site compared to AB and BC sites.

Figure 2.3: Distribution of *Salmonella* spp. serovars among food, animal and environmental samples, FoodNet Canada, 2016.



*For a breakdown of the "Other" serovars, please refer to Table 2.3.

Table 2.3: Top 5 *Salmonella* spp. serovars identified in 2016 across the human (endemic), retail, farm and environmental surveillance components, by sentinel site, FoodNet Canada.

Human endemic cases	Retail			Farm				Irrigation water
	Chicken breast	Frozen breaded chicken	Ground pork	Broiler chicken	Swine	Beef cattle	Turkey	
Ontario								
(n=61)	**(n=16)**	**(n=48)**	**(n=31)**	**(n=22)**	**(n=34)**		**(n=70)**	
Typhimurium (25%)	Kentucky (31.3%)	Enteritidis (31%)	Derby, Infantis (13% each)	Kentucky (27%)	Derby (35%)	No sampling conducted for this commodity	Muenchen (33%)	No sampling conducted
Enteritidis (23%)	Heidelberg (25.0%)	Infantis (15%)	Typhimurium, 4,[5],12:i:- (16% each)	Braenderup, Infantis (23% each)	Worthington, Typhimurium (18% each)		Albany (16%)	
Heidelberg (11%)	Typhimurium (12.5%)	Heidelberg (13%)	Ohio (10%)	Enteritidis (18%)	4,[5],12:i:- (12%)		Agona (11%)	
4,[5],12:i:- (7%)	Derby, Hadar, 4,[5],12:i:-, Infantis, Mbandaka (6.3% each)	Kentucky, Typhimurium (8% each)	Muenchen (7%)	Livingstone (9%)	Give, Infantis, Litchfield, Ouakam, Rissen, Uganda (3% each)		Bredeney (10%)	
Muenchen, Newport (5% each)		Thompson (6%)	Brandenburg, Enteritidis, Give, Kentucky, Livingstone, Manhattan, Mbandaka, Worthington (3% each)				Scwarzengrund (7%)	
British Columbia								
(n=86)	**(n=39)**	**(n=34)**	**(n=1)**	**(n=73)**			**(n=50)**	**(n=18)**
Enteritidis (76%)	Enteritidis (41.0%)	Enteritidis (50%)	Rissen (100%)	Kentucky (40%)	No sampling conducted for this commodity	No sampling conducted for this commodity	Hadar (60%)	Typhimurium (33%)
4,[5],12:i:-, Typhimurium (5% each)	Kentucky (33.3%)	Heidelberg (21%)		Enteritidis (32%)			Agona (22%)	Agona (22%)
Agona, Braenderup, Cleveland, Hadar, Heidelberg, Infantis, Newport, Nima, Oranienburg, Paratyphi B var. Java, Saintpaul, Thompson, Weltevreden (1% each)	Infantis (15.4%)	Kentucky (12%)		Cubana, Liverpool (7% each)			Liverpool (8%)	Cubana, Derby, Diarizonae, Enteritidis, Hadar, Infantis, Liverpool, Senftenberg (6% each)
	Hadar, I,20:-:z6, Mbandaka, Thompson (2.6% each)	Infantis, Thompson (6% each)		Heidelberg, Johannesburg (6% each)			Senftenberg (6%)	
		IIIA:48:g,z51:-, Typhimurium (3% each)		Typhimurium (3%)			Berta, Idikan (2% each)	

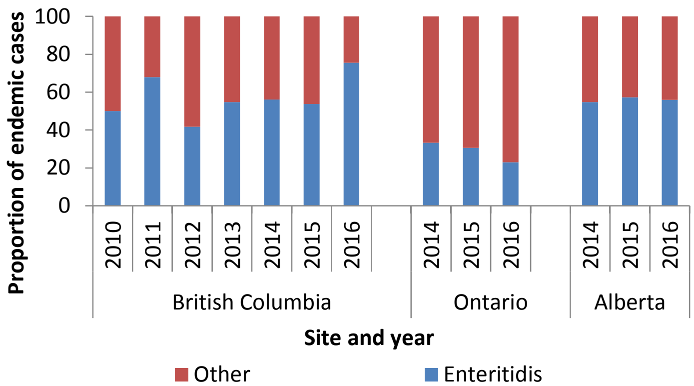
Table 2.3 continued: Top 5 *Salmonella* spp. serovars identified in 2016 across the human (endemic), retail, farm and environmental surveillance components, by sentinel site, FoodNet Canada.

Human endemic cases	Retail			Farm				Irrigation water
	Chicken breast	Chicken nuggets	Ground pork	Broiler chicken	Swine	Beef cattle	Turkey	
Alberta								
(n=151)	**(n=38)**	**(n=33)**	**(n=5)**	**(n=51)**	**(n=8)**	**(n=3)**		
Enteritidis (56%)	Enteritidis (61%)	Enteritidis (46%)	Infantis (40%)	Heidelberg (24%)	Derby (75%)	Enteritidis (67%)	No sampling conducted for this commodity	No positive samples were identified
Infantis (7%)	Kentucky (16%)	Infantis (21%)	Derby, Kentucky, Muenchen (20% each)	Enteritidis (20%)	Mbandaka, Senftenberg (13% each)	Infantis (33%)		
Heidelberg (5%)	Infantis (8%)	Heidelberg (18%)		Infantis (18%)				
Typhimurium (5%)	Braenderup, Derby, Hadar, 4,[5],12:i:-, Mbandaka, Thompson (3% each)	Kentucky (6%)		Kentucky, Senftenberg (10% each)				
4,[5],12:i:- (3%)		IIIA:48:g,z51:-, Schwarzengrund, Thompson (3% each)		Mbandaka (4%)				

SALMONELLA ENTERITIDIS

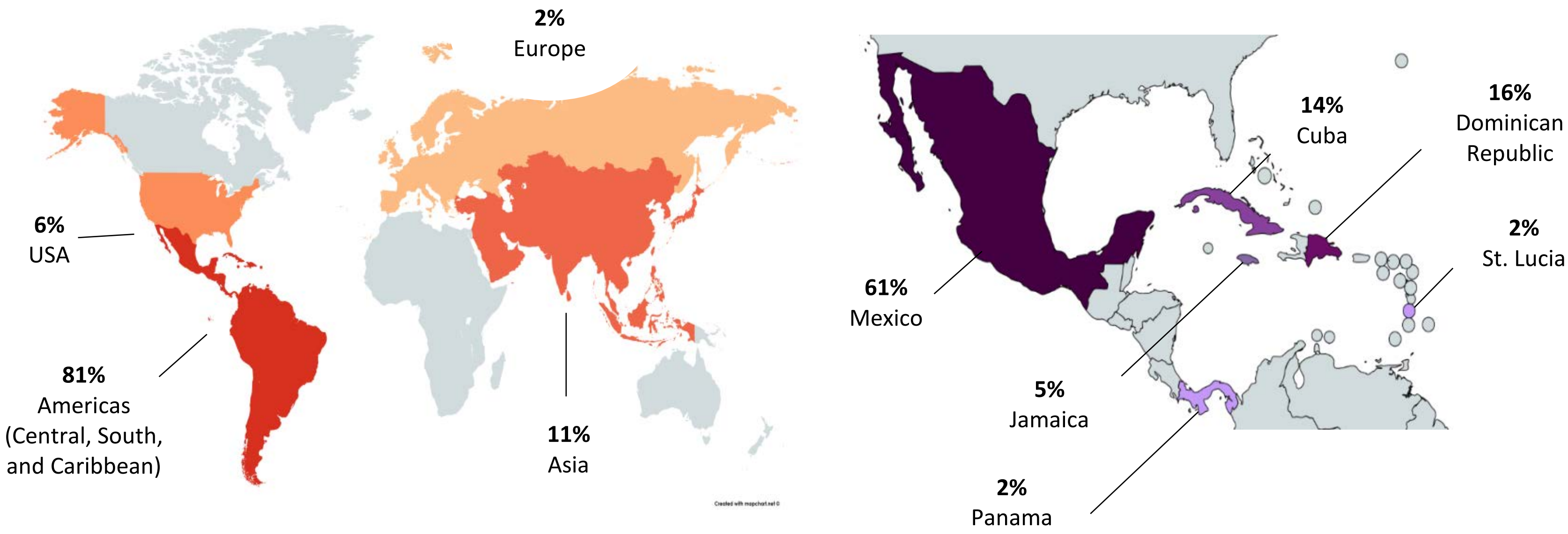
Salmonella Enteritidis (SE) is the most common serovar causing human illness in Canada. In 2016, 3,400 cases were reported to NESP, representing 44% of all reported human *Salmonella* infections[2]. Within the FoodNet Canada sentinel sites, SE is the main serovar observed among endemic cases of salmonellosis in the British Columbia (76%) and Alberta (56%) sentinel sites, while it ranks as the second most common serovar (after Typhimurium) among endemic cases in the Ontario sentinel site (23%) (Figure 2.4). As a result, the British Columbia and Alberta sites have much higher incidence rates of human endemic SE cases compared to the Ontario site.

Figure 2.4: Proportion of endemic human *Salmonella* spp. cases classified as *S.* Enteritidis and other serovars, FoodNet Canada.



In 2016, there were a total of 54 international travel-related cases of SE across the sentinel sites. The majority of these cases (81%) travelled to the Americas (Central, South and Caribbean), with 61% reporting travel to Mexico, followed by the Dominican Republic and Cuba (Figure 2.5). Molecular subtyping has shown that SE acquired through international travel is different from the strains observed among domestically acquired cases. Furthermore, strains differ by country of travel and have also shown diversity within a country.

Figure 2.5: Region of travel reported in 2016 among *Salmonella* Enteritidis cases classified as international travel—related cases within FoodNet Canada sentinel sites. (source: https://mapchart.net/world.html)



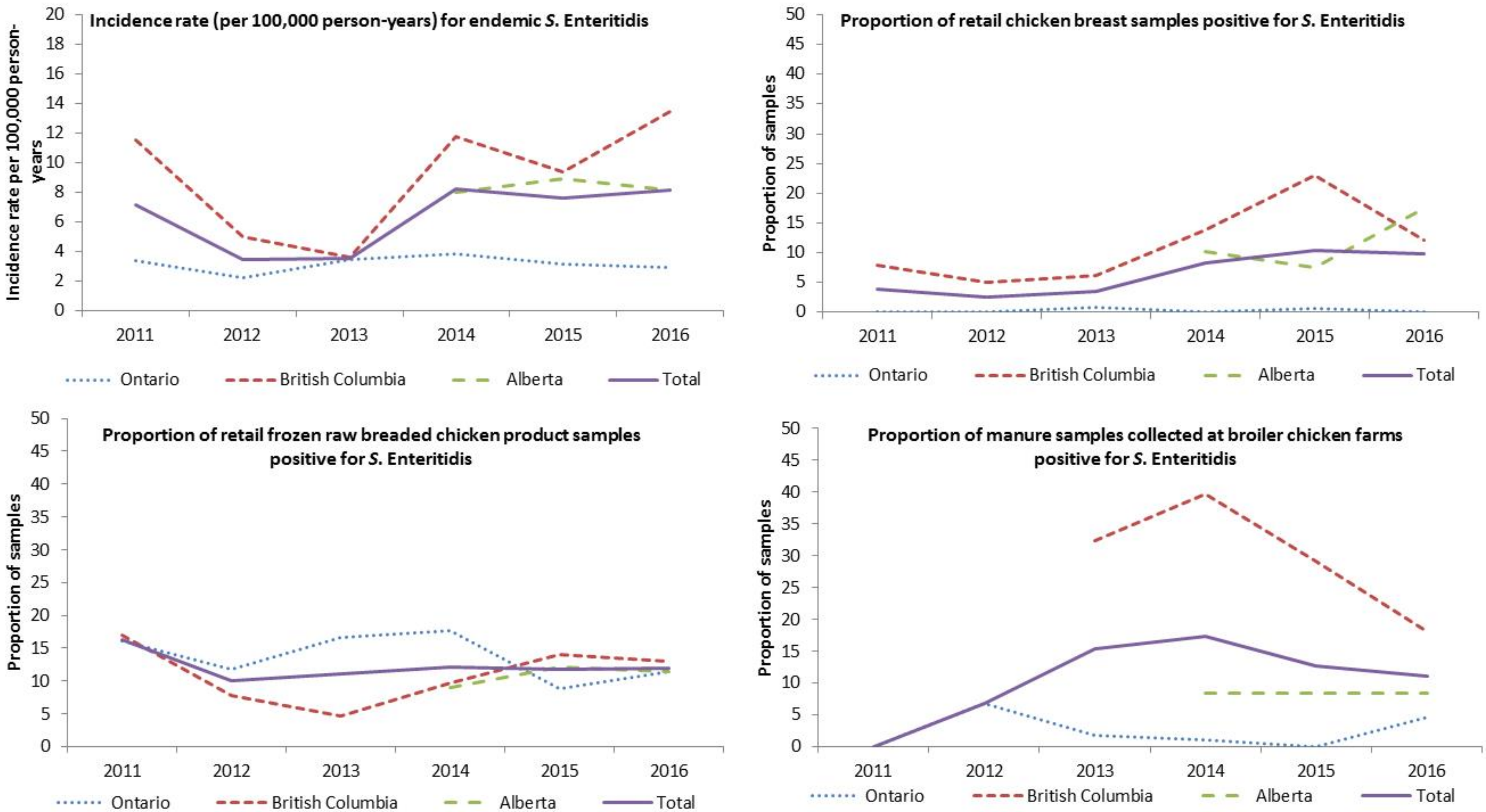
Between 2015 and 2016, the human incidence of SE in the British Columbia site increased, whereas the proportion of positive retail chicken breast and broiler chicken manure samples for SE decreased, and the proportion of positive frozen raw breaded chicken products remained the same. In contrast in the Alberta site, the proportion of SE identified in broiler chicken manure and frozen raw breaded chicken products samples remained the same with a slight decline in human incidence during these two years. However, the overall proportion of SE identified among retail chicken breast samples more than doubled, increasing significantly from 8% in 2015 to 17% in 2016 (Figure 2.6).

The distribution of chicken breast products across the country tends to be regionalized, with products processed through abattoirs remaining largely within that region for consumption. This knowledge allows us to better assess the trends observed in humans, retail and farm levels and to determine the impact that each has on the presence of SE observed. The strong regional component of food processing would suggest a relationship between what is found on food products and human illness.

In 2013 a multi-serovar vaccine (Enteritidis, Kentucky, Typhimurium, Heidelberg and Infantis) was introduced across farms in the province of Ontario to reduce the levels of SE[3] and the impact of this intervention can be observed in the Ontario site data. Surveillance from "farm to fork" provides the information for evaluating the effect of introducing this vaccine on the presence of SE in broiler chickens, the presence of SE in retail chicken products and the impact on human incidence. Data collected in both Ontario sites, the Region of Waterloo and the Middlesex-London Health Unit, has shown that the proportion of broiler chicken manure samples positive for SE decreased from 7% in 2012 to 2% in 2013 to 0% in 2015. In 2016, only four broiler chicken manure samples (out of 88) collected were found to be positive with SE, representing half and a third of the proportion observed of SE in broiler chicken manure samples collected in the Alberta and British Columbia sites, respectively. Simultaneously, there were no positive samples identified among retail chicken breast in 2016, and the reported human incidence of SE is the lowest across all three sites. However, in 2016, 12% of all frozen raw breaded chicken products sampled in Ontario were found to be positive for SE, thereby contributing to the maintenance of the human incidence levels, together with other potential sources, such as eggs.

Although SE is primarily isolated from chicken manure and retail samples collected through FoodNet Canada, SE has also been identified in samples from irrigation water and ground pork samples collected from the sentinel sites. Although the occurrence of SE in these products (6% and 3% identified, respectively) is lower compared to chicken sources, these should still be considered possible sources of infection for endemic cases. In addition, there are other food products not currently sampled by FoodNet Canada that are also known to be sources of SE, particularly eggs. One of FoodNet Canada's main objectives is to collect information in order to evaluate the impact of any interventions implemented for pathogen reduction. As such, it is important to continue surveillance of products that are known to be a source of human infection, as well as to continue collecting enhanced case level information to determine the role that other food products have in the overall incidence of SE infections in Canada.

Figure 2.6: Human incidence rate (per 100,000 person-years) for endemic *Salmonella* Enteritidis cases and proportion of retail chicken samples, retail frozen raw breaded chicken products and broiler chicken manure samples positive for *S.* Enteritidis across FoodNet Canada's sentinel sites, 2011-2016[a].



[a] Please note that in 2014 Ontario site data was collected in the Region of Waterloo from January to March with data collection beginning in August in the Middlesex-London Health Unit.

OTHER SALMONELLA SEROVARS OF INTEREST

Over the last few years a fairly stable level of *Salmonella* prevalence has been observed within the food and animal samples collected across all three sentinel sites, as well as within the overall human incidence for salmonellosis (Figure 2.8). However, changes over time have been observed within the distribution of *Salmonella* serovars identified from these samples and cases, with different serovars being identified depending on the sampled commodity and sentinel site.

SALMONELLA KENTUCKY

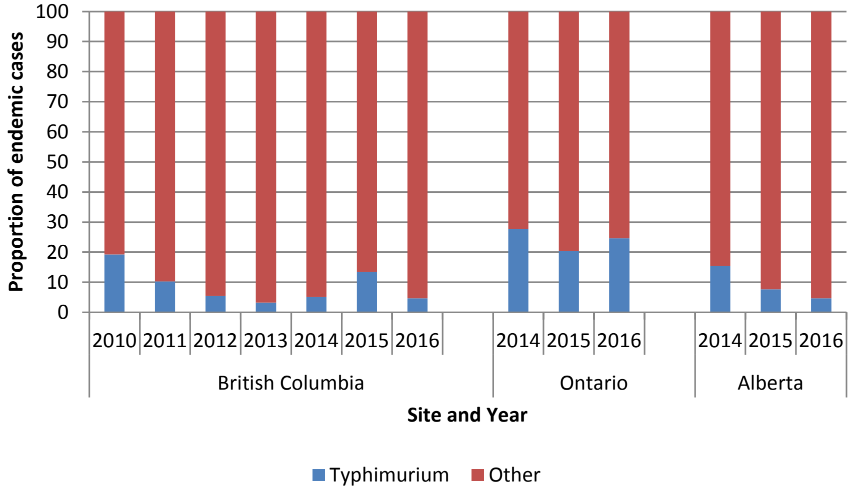
Although *Salmonella* Enteritidis is the most common cause of human salmonellosis and the serovar most frequently isolated from poultry products, there are other serovars that are prominent among the food and animal samples collected under FoodNet Canada's surveillance activities that do not appear to cause a high burden of human disease (Figure 2.8). Within the poultry samples, *S.* Kentucky is the second most commonly isolated serovar, followed by *S.* Heidelberg and *S.* Typhimurium. While in 2016 *S.* Kentucky represented 16% of all *Salmonella* isolated from poultry samples (retail and farm), this serovar has only been reported once (2015) as the source of human endemic salmonellosis within the current sentinel sites and for 36 cases at the national level in 2016 to NESP[2]. This serovar can also be found within swine samples (retail and farm), but at much lower proportions (2% in 2016).

SALMONELLA TYPHIMURIUM (*S.* I 4,[5],12:I:1,2) AND *SALMONELLA* I 4,[5],12:I:-

At the national level, *S.* Typhimurium and *S.* 4,[5],12:i:- ranked 2nd and 6th amongst the most common serovars causing human illness in 2016, respectively[2]. Within the FoodNet Canada sites, salmonellosis due to *S.* Typhimurium was the most common serovar reported among endemic cases in the Ontario sentinel site, while ranking 2nd and 3rd of the most common serovars reported among endemic cases in the British Columbia and Alberta sites, respectively (Figure 2.7 and Table 2.3). In contrast, less than 5% of human salmonellosis is reported to be caused by *S.* 4,[5],12:i:- within these sites. Interestingly, these two serovars are the most commonly identified within the swine/pork samples collected through FoodNet Canada signaling that they could be contributing to salmonellosis caused by these serovars within the sentinel sites (Figure 2.8).

Other potential sources for these organisms should also be considered when looking at possible risks for Canadians. In recent years, Canada has experienced cases of *S.* 4,[5],12:i:- and *S.* Typhimurium resulting from exposure to frozen feeder rodents, some of which were part of an international outbreak investigation[4,5]. The findings of these investigations underscore the importance of collecting enhanced case-level information in order to identify rare sources of exposure and have informed exposure questions included in FoodNet Canada's enhanced questionnaires to ensure that these risks continue to be monitored over time.

Figure 2.7: Proportion of endemic human *Salmonella* cases of *S.* Typhimurium compared to all other serovars, FoodNet Canada.



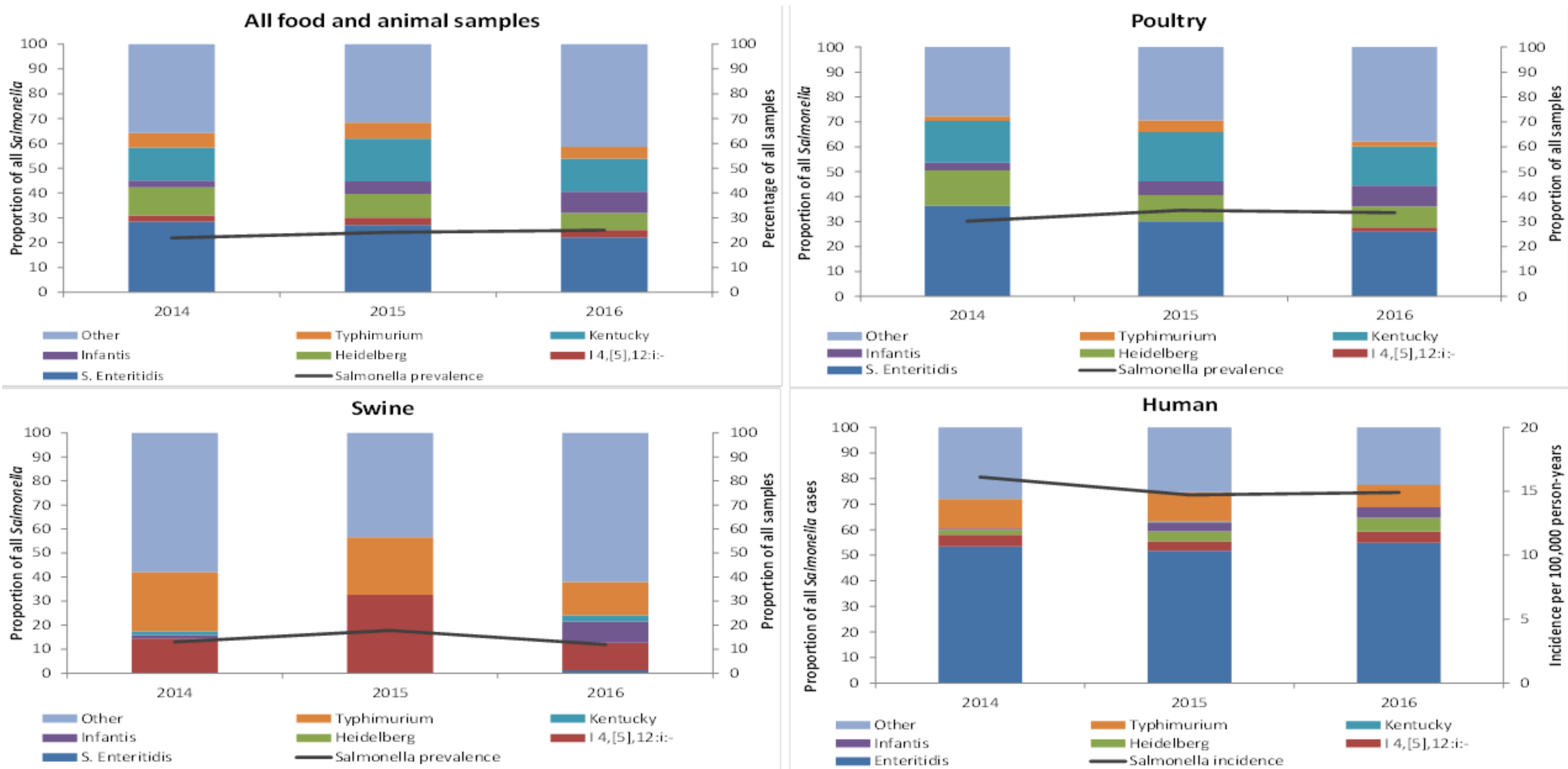
SALMONELLA HEIDELBERG AND *SALMONELLA* INFANTIS

As shown by the *Salmonella* recovery data from both retail and farm components, *S.* Heidelberg is primarily isolated from poultry samples as it was not identified among the salmonellae recovered from the swine or pork samples. When integrating both the human and non-human data, it is interesting to note the simultaneous decrease observed in the proportion of *S.* Heidelberg recovered from food or animal samples and the slight increase in the overall human disease incidence caused by this serovar (Figure 2.8). The proportion of all *Salmonella* isolates identified as *S.* Heidelberg among poultry samples has undergone a statistically significant decrease from 14% in 2014 to 8 % in 2016 (Figure 2.8). This decrease is mirrored by the reduction of the proportion of *S.* Heidelberg identified among all salmonellae recovered from frozen raw breaded chicken products, which decreased from 11% in 2014 to 5% in 2016. The decreases of *S.* Heidelberg identified among poultry samples could be a result of the introduction of the multi-strain vaccine to the poultry sector in 2013 in Ontario, which included protection against this serovar within the poultry flocks. However, within human cases, the overall incidence of *S.* Heidelberg had a slight increase from 0.3 to 0.8 cases per 100,000 person-years between 2014 and 2016, respectively, highlighting the need to continue monitoring known sources and looking for possible additional risks.

In 2016 the emergence of *S.* Infantis was observed across the human, food and animal sectors monitored through FoodNet Canada. While the incidence of disease caused by *S.* Infantis is much lower compared to the incidence of other common serovars, a slight increase in the overall incidence was observed between 2014 and 2016 (0.1 to 0.6 cases per 100,000 person-years). This increase is mainly due to an increase observed in the Alberta site, where the reported incidence for *S.* Infantis increased from 0.4 in 2015 to 1.0 cases per 100,000 person-years in 2016, while both the Ontario and British Columbia sites reported an incidence of 0.2 cases per 100,000 person-years in 2016. Increases have also been observed in the non-human data whereby the proportion of all salmonellae represented by *S.* Infantis increased from 3% in 2014 to 8% in 2016 among poultry samples and from 1% in 2014 to 9% in 2016 among swine samples (Figure 2.8). These increases have been observed within chicken manure samples (1% in 2014 to 4% in 2016 of all salmonellae) and chicken breast samples (0% in 2014 to 3% in 2016 of all salmonellae). Early in 2016, an outbreak investigation was undertaken to determine the source of *S.*

Infantis which caused a total of 110 cases across nine provinces[6]. Epidemiological and laboratory information indicated that exposure to fresh, raw chicken was the likely source of these infections. Due to its emergence, it will be critical to continue to monitor the presence of *S.* Infantis across the food continuum to identify areas where food safety measures may be necessary to prevent its further spread and human illnesses.

Figure 2.8: Distribution of *Salmonella* serovars among all *Salmonella* spp. recovered from retail and farm samples combined, as well as the incidence of *Salmonella* infections and distribution of serovars causing endemic human illness, FoodNet Canada, 2014-2016



PUBLIC HEALTH IMPACT

There are over 2200 *Salmonella* serovars identified to date, some of which are species-specific and others that are zoonotic as they can be transmitted between humans and animals. *Salmonella* surveillance across the food chain allows us to identify possible sources of specific *Salmonella* serovars commonly found to cause human illness. In Canada, the top three *Salmonella* serovars, as reported by NESP, are Enteritidis, Typhimurium and Heidelberg[2].

Surveillance conducted by FoodNet Canada has shown that the serovar prevalence varies depending on the region as the sentinel sites in both British Columbia and Alberta reported the majority of their endemic cases as SE, whereas in the Ontario site the most common serovar found in endemic cases was *S.* Typhimurium followed by SE. There is overlap between the common serovars identified in humans and across the food sector within these regions. In both British Columbia and Alberta, SE is the most common serovar recovered from retail and farm poultry samples while little to none is observed in ON. In contrast, in Ontario, *S.* Typhimurium is the most common serovar recovered from ground pork and swine farms, while little to none is observed in the other two sites.

While it is important to conduct surveillance at the national level, the information collected through FoodNet Canada has shown the value of regional representation to evaluate the differences that may exist not only on human illness but also in the possible sources of exposure. This knowledge is critical for determining the type of pathogen reduction programs that need to be implemented, as the type of program may vary depending on the food/animal sector and region in Canada.

Regional differences are present in the distribution of the most common serovars causing human illness and those found on retail and farm manure samples:

- *S.* Enteritidis in the Alberta and British Columbia sites
- S. Typhimurium in the Ontario site.

S. Kentucky is prevalent across broiler chicken farm and retail chicken breast samples while not a prevalent cause of human salmonellosis:

- Thirty-six human cases or 0.5% of all *Salmonella* cases were reported at the National level and none within the FoodNet Canada sites.

S. Infantis appears to be an emerging serovar within poultry and swine samples (retail and farm) as well as among human infections.

Two interesting observations have become evident through the collection of *Salmonella* information across the food chain. First, recognizing that there are regional differences in the *Salmonella* prevalence and serovars identified within the chicken and pork commodities, it is important to note the differences within the serovars present at the farm and retail levels. In Ontario, while *S.* Kentucky was the primary serovar identified from both broiler chicken farms and retail chicken breast samples, other serovars identified in the farm samples were not identified within the positive retail chicken breast samples (Table 2.3). The identification of these other serovars at the retail level may represent the introduction of *Salmonella* serovars present in chicken breasts obtained from other Canadian regions or from international sources or simply due to the limited sampling (30 farms per year). Secondly, serovars that are highly prevalent in the food and animal sector, such as *S.* Kentucky within the poultry sector and *S.* Derby within the swine sector, do not appear to cause human illness within these sentinel sites. This is also supported by the small number of cases reported at the national level to NESP on an annual basis for these and other serovars.

Although not all of the *Salmonella* serovars have the same ability to cause human illness, it is important to conduct ongoing surveillance across the food chain to better understand trends over time. It is through the collection of surveillance data from farm to fork on an annual basis that provides public health the ability to identify emergent strains and to determine the source of this emergence, whether at the farm, abattoir or retail levels. This is demonstrated in this report with the provision of information for on-going (e.g. SE) and emerging (e.g. *S.* Infantis) food safety issues to assist in the evaluation and identification of areas requiring further attention.

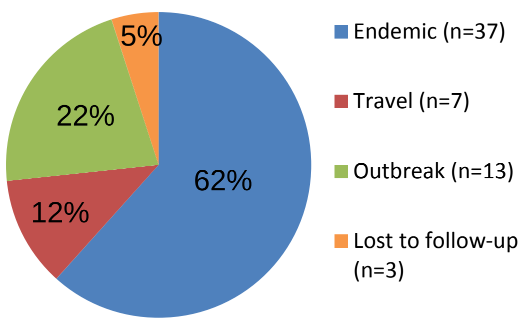
SHIGATOXIGENIC *E. COLI* (STEC)

HUMAN SURVEILLANCE SUMMARY

Table 3.1: Incidence rates (per 100,000 person-years) of STEC by case classification and FoodNet Canada sentinel site, 2016 (with 2015 shown for reference).

	ON Site		AB Site		BC Site		All Sites	
	2015	2016	2015	2016	2015	2016	2015	2016
Endemic	1.26	0.62	2.58	2.72	2.34	1.25	2.20	1.86
International Travel	0.21	0.00	0.69	0.68	0.43	0.00	0.51	0.35
Outbreak	0.42	0.00	0.79	1.26	0.00	0.00	0.51	0.65
Non-Endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lost to Follow-Up	0.00	0.00	0.30	0.29	0.00	0.00	0.15	0.15
Total	1.89	0.62	4.36	4.96	2.76	1.25	3.37	3.01

Figure 3.1: Relative proportion of STEC by case classification.



Isolates with subtype information: 60 (100%)

Top STEC Subtypes:

- O157:H7 (72%)
- O26:H11 (5%)
- O117:H7 (3%)
- O157 (3%)
- O103:H2 (2%)
- O118:H16 (2%)
- O118:H undetermined
- O121:H1 (2%)
- O121:H19 (2%)
- O157:NM (2%)
- O5:NM (2%)
- O Rough:H25 (2%)
- Other STEC (3%)

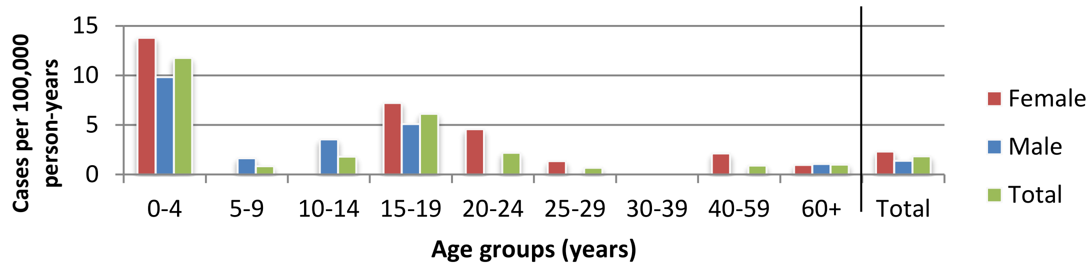
Significant changes in endemic, travel, and total incidence rates:

- There were no significant changes from 2015 to 2016.

Clinical profile (endemic cases only):

- **Most commonly reported symptoms:**
  - Diarrhea: 95%
  - Abdominal pain: 84%
  - Bloody diarrhea: 73%
  - Fatigue: 68%
  - Anorexia: 65%
- **Indicators of severity:**
  - Emergency room visits: 73%
  - Hospitalizations: 19%
  - Antimicrobial prescriptions: 27%

Figure 3.2: Age and gender specific incidence rates (per 100,000 person-years) for endemic STEC cases within FoodNet Canada sentinel sites, 2016.



FOOD, ANIMAL AND ENVIRONMENTAL SURVEILLANCE SUMMARY

Table 3.2: Prevalence of STEC spp. in 2016 by commodity and FoodNet Canada sentinel site.

Sample Type		ON Site	AB Site	BC Site	All Sites
Ground Beef		1.5% (2/131)	0% (0/131)	2.3% (3/131)	1.3% (5/393)
Feedlot Beef Manure	**Sample-level**	NT	10% (8/78)	NT	10% (8/78)
	Farm-level	NT	54% (7/13)	NT	54% (7/13)
Irrigation Water		NT	47% (15/32)	24% (26/110)	29% (41/142)

↑/↓Indicates a significant increase/decrease in prevalence compared to 2015; NT: not tested

Retail Ground Beef:

- No samples tested positive for serotype O157:H7 or any of the seven priority pathogenic types (O157, O26, O45, O103, O111, O121, O145) in 2016.
- No samples tested positive for STEC in AB in 2016.

Feedlot Beef Manure:

- One sample tested positive for STEC, serotype O157:H7. The remaining seven STEC positive isolates had serotypes that were not in the seven priority pathogenic types (O168:H8, O2:NM, O2:H27, O163:H19, O76:H21, O163:H7, O109:H5).
- Four additional samples were positive for serotype O157, but were non-STEC.

Irrigation Water:

- Ten STEC positive samples had serotypes in the seven priority pathogenic types, these samples encompassed all top seven serotypes.
- One STEC positive sample from BC had two isolates identified as O157:NM and O113:H21.

PUBLIC HEALTH IMPACT

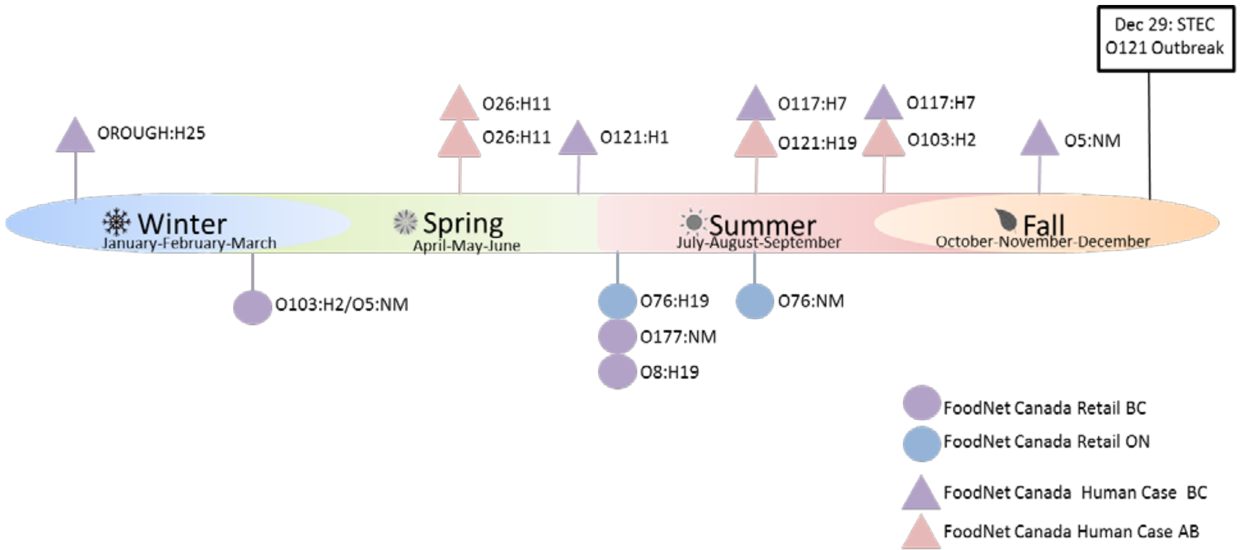
Shigatoxigenic *Escherichia coli* are a specific group of *E. coli* organisms categorized based on their presence of shigatoxins. Since implementation of all three current FoodNet Canada sentinel sites a stable prevalence of non-O157 STEC in retail, farm, and water samples, with few O157:H7 strains identified, has been found. In contrast, nearly three quarters of all human cases of STEC reported to FoodNet Canada were identified as *E. coli* O157:H7. This difference may be partially influenced by testing practices conducted by public health laboratories in the identification of O157 isolates in comparison to other STEC subtypes. Although there are over 200 different non-O157 subtypes that have been associated with human illness[7], six of these have been prioritized with regards to human health: serogroups O26, O45, O103, O111, O121 and O145[8]. In FoodNet Canada surveillance, serogroups O26, O103 and O121 were identified among human cases and irrigation water, while only O103 was identified among the retail ground beef samples. Through comparison of FoodNet Canada retail and human samples, non-O157 STEC is observed throughout the year in both streams, with a potential seasonality in the spring and summer months (Figure 3.3). While clinical labs routinely test for STEC O157, few clinical laboratories routinely test for non-O157 STEC resulting in under-detection of these pathogens. Additionally, even when non-O157 STEC are identified, further subtyping is not always conducted.

In more recent years, clinical laboratories have introduced the use of culture independent diagnostic tests (CIDT), which are PCR-based tests used for the rapid identification of one or more organisms. Although the use of these CIDTs provides timely results for the clinician to treat patients, it does not provide an isolate to conduct further subtyping or other molecular tests required for surveillance and outbreak detection purposes. This may cause issues for identifying non-O157 STEC subtypes further, as currently PCR-based methods are routinely only used to identify O157 STEC. A lack of more discriminatory subtyping information has been observed through NESP which in 2016 reported an increase in *E. coli* non-O157 reports without additional sub-typing information to 56% in 2016[2]. The increased use of CIDTs for the detection of STEC without reflex culture will exacerbate current issues, with concern to further non-O157 subtyping, and hinder the ability to monitor trends in non-O157 cases over time. Ability to identify potential outbreaks, whether local or multi-jurisdictional may also become difficult when subtype information is limited, or not able to be produced by reflex culture. FoodNet Canada will continue to monitor if these trends appear in data contributed to the program.

> Non-O157 priority serotypes were identified among:
>
> - Human and irrigation water samples: O26, O103 and O121
> - Retail ground beef samples: O103
> - National outbreak investigation related to flour: O121
>
> Increased use of CIDTs has been observed through NESP:
>
> - FoodNet Canada will continue to monitor the use of these methods and evaluate impacts of missing serotyping information on surveillance.

Although a small proportion of FoodNet Canada food samples were found to be positive with non-O157 STEC, these products should still be considered as a potential source of human illness for these subtypes in Canada. Both O157 and non-O157 STEC were also found in feedlot beef manure and irrigation water samples, representing potential environmental sources of exposure. Continued collection of thorough case-exposure information will help to identify other possible sources that are not currently captured through surveillance programs or that are emergent. For example, a new source of non-O157 STEC was identified in December of 2016 through a multi-jurisdictional outbreak investigation. Based on information collected from cases, flour was identified to be the source of infection[9]. It is for this reason that continued efforts are needed at both human and food/animal laboratories to further identify the subtypes for STEC isolates to better understand which STEC subtypes are causing human illness, which sources are most commonly found to contain these subtypes, and how different is the burden of disease associated with these subtypes. This information would be needed to evaluate programs implemented to reduce STEC in specific sectors, but to also prioritize STEC subtypes for surveillance, regulatory, and policy purposes.

Figure 3.3: Timeline of 2016 non-O157 STEC in FoodNet Canada retail samples, human, and outbreaks.



LISTERIA MONOCYTOGENES

Table 4.1: Incidence rates (per 100,000 person-years) of *Listeria monocytogenes* by case classification and FoodNet Canada sentinel site, 2016 (with 2015 shown for reference).

	ON Site		AB Site		BC Site		All Sites	
	2015	2016	2015	2016	2015	2016	2015	2016
Endemic	0.00	0.00	0.10	0.19	0.00	0.21	0.05	0.15
Travel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outbreak	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.10
Non-Endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lost to Follow-Up	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.42	0.10	0.19	0.00	0.21	0.05	0.25

Significant changes in endemic, travel, and total incidence rates:

- There were no significant changes from 2015 to 2016

Table 4.2: Prevalence of *Listeria monocytogenes* in 2016 by commodity and FoodNet Canada sentinel site.

Commodity	ON Site	AB Site	BC Site	All Sites
Chicken Breast	18% (24/131)	14% (18/132)	33% (44/132) ↑	22% (86/395) ↑
Ground Beef	24% (32/132)	13% (17/132)↓	26% (39/132)	22% (88/396)
Frozen raw breaded chicken products	16% (21/132)	14% (18/132)	13% (17/131)	14% (56/395)
Ground Pork	24% (32/132)	6% (8/132)	14% (18/132)	15% (58/396)
Ready to Eat Slaws	0% (0/210)	0% (0/210)	0.5% (1/205)	0.2% (1/625)

↑/↓Indicates a significant increase/decrease in prevalence compared to 2015.

Significant difference in prevalence since 2015:

- **Chicken Breast:**
  - *L. monocytogenes* prevalence was significantly higher in chicken breast sampled for FoodNet Canada in 2016 (22%) compared to 2015 (14%).
  - *L. monocytogenes* prevalence was significantly higher in the FoodNet Canada BC site in 2016 (33%) compared to 2015 (18%).
- **Ground beef:**
  - *L. monocytogenes* prevalence was significantly lower in 2016 (13%) compared to 2015 (31%).

Notable Findings:

- The single produce positive sample for *L. monocytogenes* from 2016 was an imported broccoli slaw from the US.

Regional differences:

- AB had a significantly lower prevalence of *L. monocytogenes* in ground beef samples compared to ON and BC.
- ON ground pork samples had a significantly higher prevalence of *L. monocytogenes* compared to AB and BC.
- BC chicken breast samples had a significantly higher prevalence of *L. monocytogenes* compared to AB and ON

PUBLIC HEALTH IMPACT

In Canada it is estimated that each year about one in eight Canadians (four million people) experience an episode of domestically acquired foodborne illness, of which 178 would be attributed to *Listeria monocytogenes*[10]. Although invasive listeriosis is a rare disease, it can result in severe symptoms such as sepsis, encephalitis, and meningitis[11]. Those most vulnerable to infection include the elderly or immunocompromised individuals, as well as pregnant women and their unborn children[12]. Listeria is more likely to cause death than other foodborne bacteria, with approximately 20-30% of high risk cases dying from this infection[13].

Regional differences are present in the recovery rates of *Listeria monocytogenes* among retail food samples:

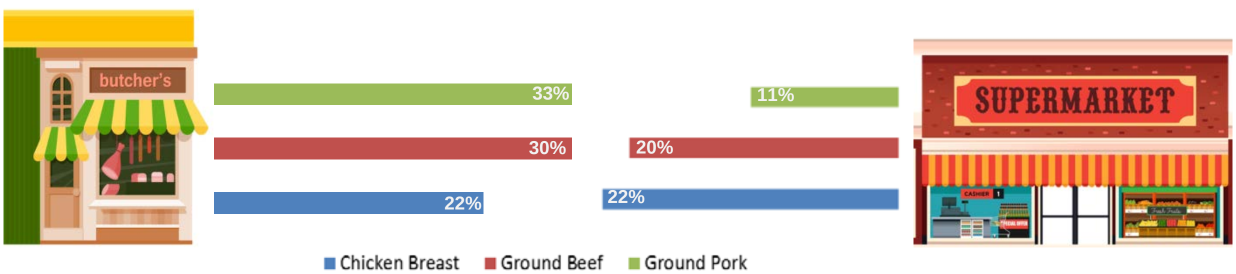
- Retail chicken breast: British Columbia has higher prevalence, which increased in 2016 compared to 2015
- Retail ground beef: Alberta has lower prevalence for retail ground beef, which decreased in 2016 compared to 2015
- Retail ground pork: Ontario has higher prevalence compared to the other sites.

Although the incidence of invasive listeriosis across all three sentinel sites was low in 2016 (0.25 cases per 100,000 person-years), there were two outbreaks identified in Canada in that same year. In January 2016 the Canadian Food Inspection Agency (CFIA) conducted a recall of packaged salad products produced in the United States[14]. This led to the identification of 14 cases across the Eastern Canadian provinces in addition to the 19 cases identified across the United States. This outbreak was later followed by a recall of chocolate milk products in Ontario as they were linked to an outbreak of listeriosis cases in that same province[15].

Due to the severity of disease and the high risk to vulnerable populations, surveillance of *Listeria monocytogenes* along the food continuum is important for identifying potential sources of illness. In 2016, retail sampling consisted of raw meat products (chicken breast, ground pork and beef) and ready to eat slaws. After a significant increase in the recovery of *Listeria monocytogenes* from ground beef samples was observed in 2015 compared to 2014 in the FoodNet Canada Alberta and British Columbia sentinel sites, a decrease in prevalence to previous levels was observed in Alberta in 2016 while still remaining high in samples purchased within the British Columbia sentinel site. Prevalence of *L. monocytogenes* has remained relatively stable in ground beef sampled in Ontario. All retail products were sampled from either an independent shop, such as butcher shops, or from chain grocery stores to better understand risks associated with different types of retail establishment. In 2016, the prevalence of *L. monocytogenes* recovered from ground beef and ground pork samples collected at independent shops were significantly higher when compared to the *L. monocytogenes* prevalence from these types of samples purchased at chain stores. The reasons for this are not well understood. It is possible that, due to processing in-store, opportunities for cross-contamination are increased at independent butcher shops during processing steps, as this difference is not seen in less processed meat products like chicken breast. Although raw meat products were found to be contaminated with *Listeria monocytogenes*, it should be noted that the majority of outbreaks and sporadic cases are predominantly associated with ready to eat products or contaminated produce. However, this trend in *Listeria* presence on ground meats sampled from independent shops can indicate potential opportunities of cross-contamination of other pathogens.

Listeria monocytogenes is sensitive to heat treatment and can be removed through proper cooking processes[16]. As such, one must always follow cooking instructions, verify internal temperatures after cooking raw meat products, and ensure that all bowls, utensils and surfaces are washed with hot water and soap to prevent further cross-contamination. The presence of *Listeria monocytogenes* in cooked products can be attributed to cross-contamination after processing or during storage and handling[17].

Figure 4.1: Comparison of *Listeria monocytogenes* prevalence in samples collected at independent stores and chain stores.



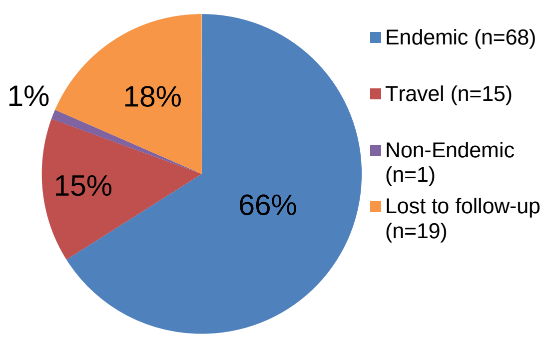
YERSINIA

Table 5.1: Incidence rates (per 100,000 person-years) of *Yersinia* cases by case classification and FoodNet Canada sentinel site, 2016 (with 2015 shown for reference).

	ON Site		AB Site[a]		BC Site		All Sites	
	2015	2016	2015	2016	2015	2016	2015	2016
Endemic	0.42	0.62	1.29	1.95	4.68	9.34 ↑	1.89	3.41 ↑
Travel	0.42	0.00	0.40	0.68	0.64	1.66	0.46	0.75
Outbreak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Endemic	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.05
Lost to Follow-Up	0.21	0.42	0.30	0.39	0.43	2.70	0.31	0.95
Total	1.05	1.04	1.98	3.02	5.74	13.91 ↑	2.66	5.17 ↑

↑/↓Indicates a significant increase/decrease in incidence compared to 2015.
[a]AB site does not include or follow-up *Yersinia* Intermedia cases.

Figure 5.1: Relative proportion of *Yersinia* by case classification.



Isolates with species information:
103 (100%)

Top *Yersinia* subtypes:

- Enterocolitica (95%)
- Pseudotuberculosis (3%)
- Frederiksenii (2%)

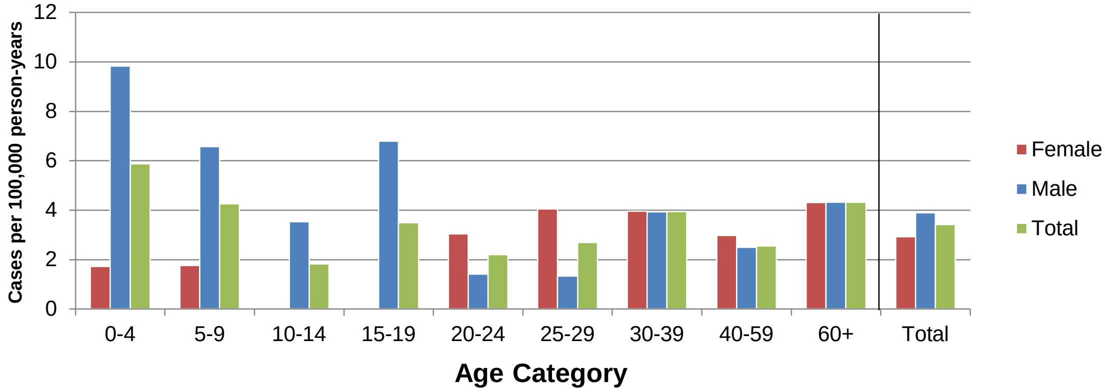
Significant changes in endemic, travel, and total incidence rates:

- There were significant increases in the BC site endemic and total incidence rates from 2015 to 2016.
- There were significant increases in the all sites endemic and total incidence rates from 2015 to 2016.

Clinical profile (endemic cases only):

- **Most commonly reported symptoms:**
  - Diarrhea: 85%
  - Abdominal pain: 69%
  - Anorexia: 54%
  - Fatigue: 53%
  - Weakness: 47%
- **Indicators of severity:**
  - Bloody diarrhea: 21%
  - Emergency room visits: 28%
  - Hospitalizations: 12%
  - Antimicrobial prescriptions: 44%

Figure 5.2: Age and gender specific incidence rates (per 100,000 person-years) for endemic *Yersinia* cases within FoodNet Canada sentinel sites, 2016.



PUBLIC HEALTH IMPACT

The BC site incidence rates for both endemic and total cases of yersiniosis have significantly increased since 2016. This is due to changes in laboratory method protocols introduced in June 2016, which increased the detection of this organism by using cold enrichment together with protocols stating that all stool samples were to be tested for the presence of *Yersinia.* Currently, *Yersinia* is not a nationally-notifiable disease, and so the annual national incidence rate is not available for comparison. Yersiniosis appears to be predominantly a domestically-acquired infection, as demonstrated by the low proportion of travel-related cases (15%).

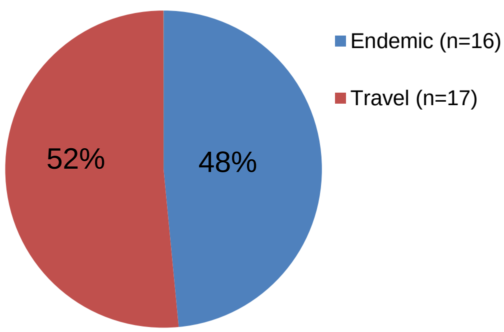
It is not clear what role food and animals have on the incidence of human yersiniosis. In 2010, FoodNet Canada discontinued the testing for *Yersinia* on retail pork due to low prevalence of human-pathogenic strains. Similarly, *Yersinia* testing was stopped across all commodities in the farm component in 2012 due to low prevalence detected. In previous years, *Yersinia* was detected in untreated surface water collected in the FoodNet Canada sentinel sites, but was also identified as non-pathogenic. Therefore, it is important to continue collecting enhanced case level information on *Yersinia* cases to determine the sources that may be contributing to human infections in Canada.

SHIGELLA

Table 6.1: Incidence rates (per 100,000 person-years) of *Shigella* by case classification and FoodNet Canada sentinel site, 2016 (with 2015 shown for reference).

	ON Site		AB Site		BC Site		All Sites	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Endemic	0.00	0.83	0.40	0.88	1.28	0.62	0.51	0.80
Travel	0.63	0.62	1.68	0.78	1.49	1.25	1.38	0.85
Outbreak	0.00	0.00	0.00	0.00	0.21	0.00	0.05	0.00
Non-Endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lost to Follow-Up	0.21	0.00	0.20	0.00	0.85	0.00	0.36	0.00
Total	0.84	1.45	2.28	1.65	3.83	1.87	2.30	1.66

Figure 6.1: Relative proportion of *Shigella* by case classification.



Isolates with species information:
33 (100%)

Top *Shigella* Subtypes:

- Sonnei (52%)
- Flexneri (45%)
- Boydii (3%)

Significant changes in endemic, travel, and total incidence rates:

- There were no significant changes from 2015 to 2016.

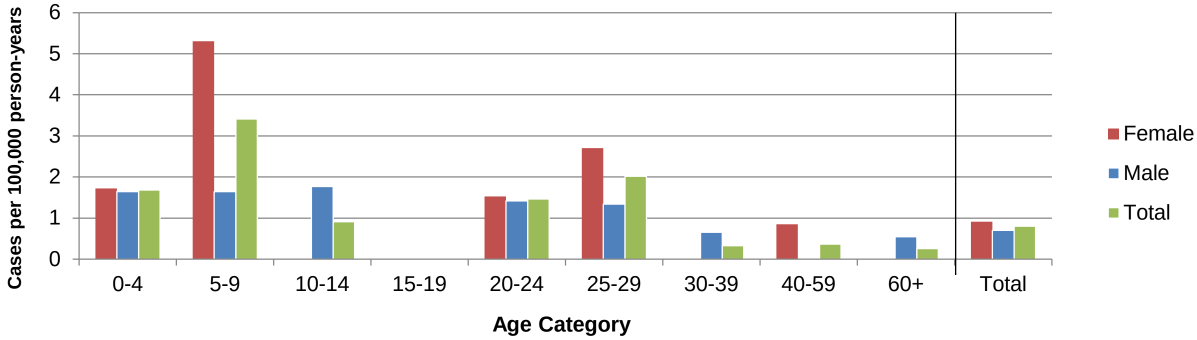
Clinical profile (endemic cases only):

- **Most commonly reported symptoms:**
  - Diarrhea: 100%
  - Fever: 88%
  - Abdominal pain: 81%
  - Malaise: 75%
  - Anorexia: 69%
  - Chills: 69%
  - Weakness: 69%
  - Fatigue: 69%
- **Indicators of severity:**
  - Bloody diarrhea: 63%
  - Emergency room visits: 75%
  - Hospitalizations: 25%
  - Antimicrobial prescriptions: 38%

2016 travel cases: 17 (52%)

- **Cases by region travelled to:**
  - Asia: 47%
  - Americas (Central, South and Caribbean): 35%
  - Africa: 6%
  - Multiple/Other: 12%

Figure 6.2: Age and gender specific incidence rates (per 100,000 person-years) for endemic *Shigella* cases within FoodNet Canada sentinel sites, 2016.



PUBLIC HEALTH IMPACT

Travel is an important source of *Shigella* among human cases in 2016. Asia and the Americas (Central, South and Caribbean) were the most frequently reported travel destinations. *Shigella* is primarily transmitted through direct contact with an infected person or by ingestion of contaminated food or water. Historically, FoodNet Canada retail testing found *Shigella* bacteria on one sample of bagged leafy greens using PCR methods, but did not yield a positive by culture, therefore viability could not be determined[18]. Continued collection of enhanced case level information on *Shigella* cases is important to determine the sources that may be contributing to human infections in Canada.

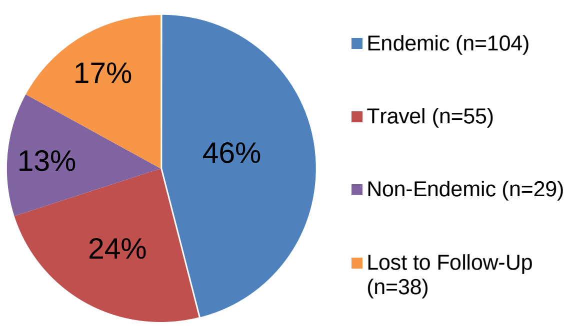
PARASITES AND VIRUSES

GIARDIA

Table 7.1: Incidence rates (per 100,000 person-years) of *Giardia* by case classification and FoodNet Canada sentinel site, 2016 (with 2015 shown for reference).

	ON Site		AB Site		BC Site		All Sites	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Endemic	5.87	3.74	4.46	6.42	5.53	4.15	5.06	5.22
Travel	1.89	1.45	3.47	3.11	2.34	3.32	2.81	2.76
Outbreak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-Endemic	0.42	0.00	2.08	2.24	0.85	1.25	1.38	1.46
Lost to Follow-Up	2.73	2.91	0.69	1.46	1.49	1.87	1.38	1.91
Total	10.91	8.10	10.70	13.23	10.21	10.59	10.63	11.35

Figure 7.1: Relative proportion of *Giardia* by case classification.



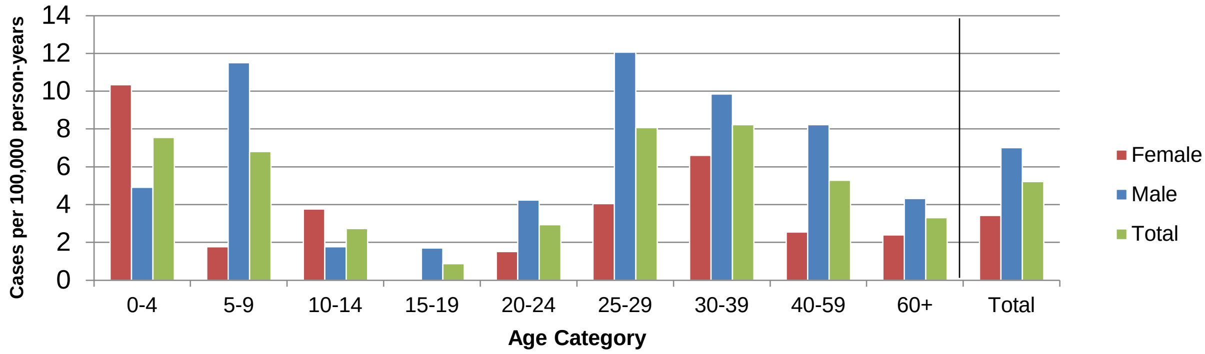
Significant changes in endemic, travel, and total incidence rates:

- There were no significant changes from 2015 to 2016

Clinical profile (endemic cases only):

- **Most commonly reported symptoms:**
  - Diarrhea: 84%
  - Abdominal pain: 65%
  - Fatigue: 63%
  - Malaise: 55%
  - Weight loss: 53%
- **Indicators of severity:**
  - Bloody diarrhea: 11%
  - Emergency room visits: 20%
  - Hospitalizations: 6%
  - Antimicrobial prescriptions: 73%

Figure 7.2: Age and gender specific incidence rates (per 100,000 person-years) for endemic *Giardia* cases within FoodNet Canada sentinel sites, 2016.



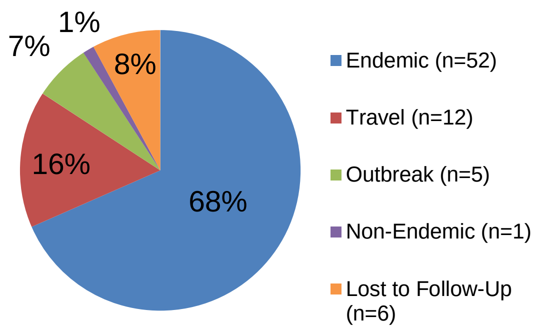
CRYPTOSPORIDIUM

Table 8.1: Incidence rates (per 100,000 person-years) of *Cryptosporidium* by case classification and FoodNet Canada sentinel site, 2016 (with 2015 shown for reference).

	ON Site		AB Site		BC Site		All Sites	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Endemic	1.89	1.25	2.58	3.79	0.85	1.45	1.99	2.61
Travel	1.26	0.00 ↓	0.99	1.07	0.64	0.21	0.97	0.60
Outbreak	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.25
Non-Endemic	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.05
Lost to Follow-Up	0.42	0.21	0.30	0.49	0.21	0.00	0.31	0.30
Total	3.57	1.45 ↓	3.86	5.93 ↑	1.70	1.66	3.27	3.82

↑/↓Indicates a significant increase/decrease in incidence compared to 2015.

Figure 8.1: Relative proportion of *Cryptosporidium* by case classification.



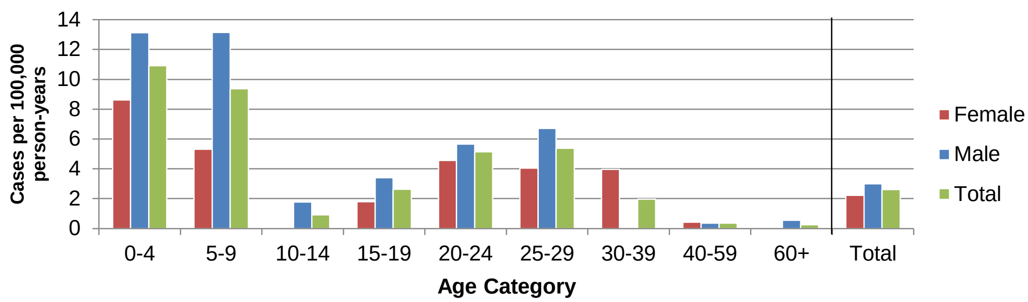
Significant changes in endemic, travel, and total incidence rates:

- There were significant decreases in the ON site travel and total incidence rates from 2015 to 2016.
- There was a significant increase in the AB site total incidence rate from 2015 to 2016.

Clinical profile (endemic cases only):

- **Most commonly reported symptoms:**
  - Diarrhea: 100%
  - Abdominal pain: 77%
  - Anorexia: 69%
  - Vomiting: 65%
  - Nausea: 62%
- **Indicators of severity:**
  - Bloody diarrhea: 13%
  - Emergency room visits: 62%
  - Hospitalizations: 8%
  - Antimicrobial prescriptions: 21%

Figure 8.2: Age and gender specific incidence rates (per 100,000 person-years) for endemic *Cryptosporidium* cases within FoodNet Canada sentinel sites, 2016.

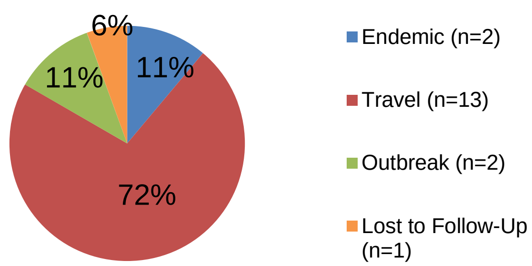


CYCLOSPORA

Table 9.1: Incidence rates (per 100,000 person-years) of *Cyclospora* by case classification and FoodNet Canada sentinel site, 2016 (with 2015 shown for reference).

	ON Site		AB Site		BC Site		All Sites	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Endemic	0.21	0.21	0.00	0.00	0.00	0.21	0.05	0.10
Travel	1.26	0.62	0.20	0.29	1.28	1.45	0.72	0.65
Outbreak	0.21	0.42	0.00	0.00	0.00	0.00	0.05	0.10
Non-Endemic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lost to Follow-Up	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.05
Total	1.68	1.45	0.20	0.29	1.28	1.66	0.82	0.90

Figure 9.1: Relative proportion of *Cyclospora* by case classification.



2016 travel cases: 13 (72%)

- **Cases by region travelled to:**
  - Americas (Central, South and Caribbean): 77%
  - Asia: 15%
  - Multiple/Other: 8%
- **Cases by country in Americas region:**
  - Mexico: 90%
  - Other: 10%

Significant changes in endemic, travel, and total incidence rates:

- There were no significant changes from 2015 to 2016.

RETAIL SAMPLING SUMMARY

PARASITES

In 2016, parasites were tested for on ready-to-eat slaws and vegetables by FoodNet Canada. A single coleslaw sample (1/608) was positive for *Cryptosporidium hominis*; two coleslaw samples (2/625) were positive for *Cyclospora cayetanensis*; and 8 samples (8/611), 7 coleslaw and 1 baby carrot, were positive for *Giardia*. All positive samples were imported samples from the United States with the exception of one coleslaw sample which had a noted country of origin as the United States and Canada. Since PCR methodologies were used for the detection of parasites, the viability of these detected pathogens and the subsequent potential risk to consumers is unknown.

VIRUSES

In 2016, FoodNet Canada tested for viruses among sampled retail ready-to-eat slaws and vegetables. Among all samples tested, none (0/625) were found to be positive for viruses (Norovirus, Rotavirus, Hepatitis A, and Hepatitis E). Human cases of viruses are not reported to FoodNet Canada by the sentinel sites.

PUBLIC HEALTH IMPACT

Compared with *Giardia* and *Cryptosporidium*, the majority of *Cyclospora* cases in 2016 were found to be travel-associated. Among the travel cases, the majority (77%) reported travel to the Americas (Central, South and Caribbean) region. Travel to Mexico was most commonly reported (90%) among cases that travelled to the Americas region. All cases that travelled to Mexico travelled between May and August, with the majority reporting travelling to Mexico's east coast. This is consistent with what was observed in 2015 and also internationally during this time period[19,20]. Since travel is a major contributor to *Cyclospora* cases in Canada, ongoing public health education regarding travel is important to help keep Canadians safe while travelling to countries where *Cyclospora* is endemic.

APPENDIX A— NON-HUMAN SAMPLE TYPES TESTED IN 2016

Site	Retail	Farm	Water
BC	Ground beef, skinless chicken breast, frozen raw breaded chicken products, ground pork, ready-to-eat slaws & vegetables	Broiler chickens, turkey	Five sampling locations in the Sumas & Matsqui irrigation canals
AB	Ground beef, skinless chicken breast, frozen raw breaded chicken products, ground pork, ready-to-eat slaws & vegetables	Broiler chickens, swine, & feedlot beef	Eight sampling locations in the Western Irrigation District
ON	Ground beef, skinless chicken breast, frozen raw breaded chicken products, ground pork, ready-to-eat slaws & vegetables	Broiler chickens, swine, turkeys & layers	

APPENDIX B— ABBREVIATIONS AND REFERENCES

ABBREVIATIONS

AB	Alberta
BC	British Columbia
CIDT	Culture Independent Diagnostic Tests
CIPARS	Canadian Integrated Program for Antimicrobial Resistance Surveillance
ER	Emergency Room
NESP	National Enteric Surveillance Program
NT	Not Tested
ON	Ontario
PCR	Polymerase Chain Reaction
PHAC	Public Health Agency of Canada
SE	*Salmonella* Enteritidis
ST	Shigatoxin
STEC	Shigatoxigenic *Escherichia coli*
US	United States

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