FoodNet Canada

2019 Integrated Findings Report

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

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Foreword & Acknowledgements

The Public Health Agency of Canada's (PHAC) FoodNet Canada surveillance system is pleased to present the 2019 Integrated Findings Report. The report highlights FoodNet Canada findings from its sentinel sites in British Columbia, Alberta, Ontario and Quebec. The Integrated Findings Report focuses on the integration of trends in enteric pathogen disease rates and in potential disease sources throughout the farm-to-fork continuum (i.e. retail food, manure from food producing animals on farms, and water).

The report is a unique compilation of cohesive chapters, which highlights the results of surveillance activities conducted in 2019 as well as surveillance trends from 2015 to 2019 with focus on the impact of enteric pathogen trends on public health. 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

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

Executive Summary

FoodNet Canada (FNC), the integrated sentinel site surveillance network for enteric disease in Canada, conducts continuous and episodic surveillance activities in four sentinel sites by collecting information on human cases of enteric disease and levels of pathogen exposure from food, animal, and water sources. This report summarizes 2019 data, as well as integrated surveillance findings from 2015 to 2019, with a focus on how enteric pathogen trends impact public health. It also expands on surveillance trends in enteric disease rates, as well as trends in the prevalence of these pathogens found on potential food, animal, and water sources as reported in the FoodNet Canada Tables and Figures 2019 Report.

In 2019, FNC implemented a fourth sentinel site in Quebec located in the Région sociosanitarie de la Montérégie, where activities included enhanced human disease surveillance, as well as active surveillance of enteric pathogens in retail meat and farm manure. Ongoing surveillance in this site will help inform trends over time and permit integrated analyses with the other sentinel sites, allowing for a more nationally representative surveillance system.

KEY FINDINGS

Enteritidis was the most common *Salmonella* serovar causing endemic human infection in 2019 and was also frequently found in broiler chicken manure, retail chicken breast, and retail frozen breaded chicken product (FBCP) samples. The majority (87%) of 2019 retail, farm, and water *Salmonella* Enteritidis (SE) isolates sequenced were found to fall within human whole genome sequencing (WGS) clusters defined by PulseNet Canada, reflecting the continued importance of poultry and the environment as a potential risk factor for SE infection.

Although Enteritidis was the most common serovar identified, the incidence rate of endemic human SE cases decreased in 2019. A significant decrease was also observed in the percent of FBCP and broiler chicken manure samples positive for SE in 2019 compared to 2018. The significant decrease in SE observed on FBCP is associated with the Canadian Food Inspection Agency directive to industry to reduce *Salmonella* to below detectable limits in FBCP that are packaged for retail sale by April 1, 2019. This directive increased the availability of cooked products sold at retail.

S. Reading was the top *Salmonella* serovar among FNC outbreak-related cases and among the top five *Salmonella* serovars for all reported FNC cases in 2019. In addition, the prevalence of *S.* Reading in retail turkey and farm turkey manure samples increased in 2019 compared to previous years, with the majority of these *S.* Reading positive samples falling within a human WGS cluster defined by PulseNet Canada, including a national outbreak of *S.* Reading.

The incidence rate of invasive listeriosis in 2019 remained relatively low for all FNC sites combined; however, *Listeria* remains a risk for severe illness, with 80% of endemic cases being hospitalized. Raw or undercooked ground beef is a potential source for *Listeria* infection as the prevalence continued to be high in 2019 (25%), with a higher prevalence found on samples from small stores (e.g., butcher shops) compared to large stores. Targeted consumer education efforts, particularly towards high-risk populations (i.e., pregnant people, the elderly, and those who are immunocompromised) to increase awareness of raw or undercooked ground beef as a potential source of listeriosis, are warranted.

The incidence rate of non-O157 shigatoxigenic *Escherichia coli* (STEC) increased in 2018 and 2019 and reflects an increase in testing of non-O157, suggesting that, previously, non-O157 had been underdiagnosed. Analysis comparing indicators of severity (e.g., bloody diarrhea, vomiting, emergency room visits, hospitalizations, virulence genes) suggests that *E. coli* O157 is more severe than non-O157.

Increased non-O157 STEC testing has improved the ability to identify common serogroups across FNC components and, therefore, improved the ability to identify exposure sources. Exposure to irrigation water, beef manure, and pork meat products sold at the retail level present a risk to public health for the top seven priority serogroups of clinically significant concern through environmental exposure and food consumption.

Among reported cases of parasites, *Giardia* and *Cryptosporidium* cases increased in 2019 compared to previous years, while cases of *Cyclospora* decreased. The introduction of Polymerase chain reaction (PCR) laboratory testing methods for the detection of *Giardia* and *Cryptosporidium* may have contributed to the changing incidence rates. Drinking untreated or raw water, canoeing, kayaking, hiking, or camping, and swimming in natural waters were found to be potential risk factors for *Giardia* infection from the exposure data collected by FNC.

International travel continues to be a risk for gastrointestinal illness in Canadians, with 25% of FNC cases between 2015-2019 classified as international travel-related. Among these international travel-related cases, the majority were infected with *Campylobacter*, *Salmonella*, or *Giardia*. Among SE cases in 2019, approximately 30% were classified as international travel-related, with most of these cases reporting travel to the Americas (Central, South, and Caribbean). Whole Genome Sequencing analysis of international travel-related SE cases from 2017-2019 showed that the majority of SE sequences clustered by country for the three most reported travel destinations: Mexico, Cuba, and Dominican Republic. The use of WGS has helped to better inform our understanding of travel-related cases clustering by country, and also within a country. For example, within Mexico, the majority of isolates from cases that reported travel to the west coast of the country clustered separately from cases that reported travel to the east coast.

FoodNet Canada's targeted sampling activities in 2019 included sampling of raw ground beef, raw chicken breast, and raw pork sausage sold at farmers' markets in the Alberta and Ontario sentinel sites, and domestic seafood (i.e., raw mussels and oysters) in the British Columbia, Alberta, and Ontario sentinel sites. A higher prevalence of *Campylobacter*, *Listeria,* and STEC was found among certain retail meats collected from farmers' markets, compared with those collected from chain or independent grocery stores, representing a potential emerging source of enteric illness. Retail store samples of raw mussels and oysters tested positive for bacteria, parasites, and viruses, with *Vibrio* representing the most frequently isolated bacterium from these foods. Since oysters are commonly eaten raw, ongoing monitoring and testing of shellfish products by federal food safety partners is important to understand the risk for human infection and implications for the health of Canadians.

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 trends in enteric pathogens in Canada.

In collaboration with public health jurisdictions and provincial public health laboratories, FoodNet Canada conducts continuous and episodic surveillance activities in four 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 potential sources of 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:

- Centre for Foodborne, Environmental and Zoonotic Infectious Diseases (CFEZID)
  - Foodborne Disease and Antimicrobial Resistance Surveillance Division (FDASD)
    - Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS)
    - National Enteric Surveillance Program (NESP)
    - Enhanced National Listeriosis Surveillance Program
  - Outbreak Management Division (OMD)
- 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.

For information on data collection and reporting and surveillance strategy please see Appendix A.

For further information on trends in enteric pathogen disease rates, as well as trends in the prevalence of these pathogens found on potential disease sources (retail meats, manure from food producing animals and water), please refer to the FoodNet Canada Tables and Figures 2019 Report.

Definitions

Cluster: A group of genetically similar isolates. Based on common-pattern combination studies and well-characterized outbreak investigations, most events show that isolates within a 10 allele range may be epidemiologically linked.

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

Exposure: 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.

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

Minimum Spanning Tree (MST): Graph constructed to connect isolates based on a mathematical algorithm that connects the most similar isolates to each other using the minimum allele span possible. Epidemiological data can easily be overlaid to enhance a MST if desired.

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

Outbreak: Outbreak-related cases of disease are 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, BC and QC sentinel 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.

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

Travel: Travel-related cases of disease (excludes non-endemic cases) are individuals who travelled outside of Canada, and where the travel dates overlap with the expected disease incubation period (varies depending on the pathogen).

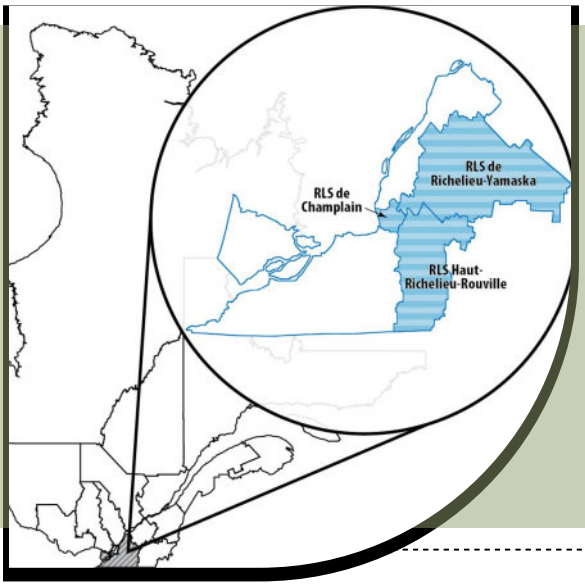
Whole genome multilocus sequence typing (wgMLST) analysis method [1]: Allele information from coding regions of new sequences are compared with an existing allele database that contains all genes used to create the scheme. Whole genome MLST schemes contain the whole or pan genome, which includes all core genes in addition to any accessory genes.

1) Nadon, C., Van Walle, I., Gerner-Smidt, P., Campos, J., Chinen, I., Concepcion-Acevedo, J., Gilpin, B., Smith, A. M., Man Kam, K., Perez, E., Trees, E., Kubota, K., Takkinen, J., Nielsen, E. M., Carleton, H., & FWD-NEXT Expert Panel. (2017). PulseNet International: Vision for the implementation of whole genome sequencing (WGS) for global food-borne disease surveillance. *Euro surveillance : European communicable disease bulletin*, *22*(23), 30544.

Abbreviations

AB	Alberta
BC	British Columbia
CFIA	Canadian Food Inspection Agency
CIPARS	Canadian Integrated Program for Antimicrobial Resistance Surveillance
CNDSS	Canadian Notifiable Diseases Surveillance System
FBCP	Frozen Breaded Chicken Products
FNC	FoodNet Canada
MST	Minimum Spanning Tree
NESP	National Enteric Surveillance Program
NML	National Microbiology Laboratory
NT	Not Tested
ON	Ontario
PCR	Polymerase chain reaction
PHAC	Public Health Agency of Canada
QC	Quebec
RLS	Réseau local de services
SE	*Salmonella* Enteritidis
STEC	Shigatoxigenic *Escherichia coli*
WGS	Whole Genome Sequencing

An Introduction to the Quebec Sentinel Site



Chapter Highlights

- The FoodNet Canada sentinel site in Quebec was officially established in July 2019.
- From July to December 2019, the top three pathogens among reported cases were *Campylobacter* (53%), *Salmonella* (18%) and *Giardia* (15%).
- Retail and farm manure sampling were implemented throughout 2019 in collaboration with CIPARS.

The fourth FoodNet Canada sentinel site was officially established in July 2019, in the Région sociosanitarie de la Montérégie, in Quebec.

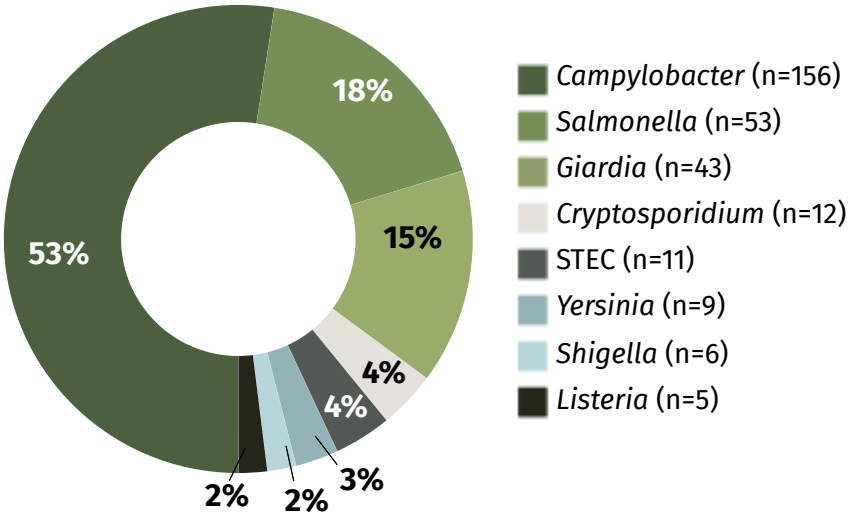
The QC site includes the territories of three RLS regions including Richelieu-Yamaska, Haut-Richelieu-Rouville and Champlain-Charles LeMoyne, and has approximately 640,000 residents.

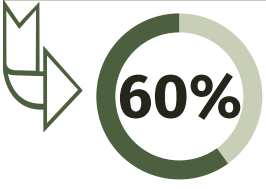
Ongoing surveillance in the Quebec site will help inform trends over time and allow for integrated analyses with the other sentinel sites.

Cases of Reported Human Illness

295 cases of enteric illness were reported from July to December in 2019 in the QC sentinel site

All Cases Reported in the QC Site by Pathogen from July to December 2019





of reported cases were classified as **endemic** (177 cases)

Indicators of Severity for Endemic Cases*

9%	44%	53%
of cases were hospitalized	of cases visited an emergency room	of cases were prescribed antibiotics

**Listeria* cases (n=5) are not included in the calculations for the cases who visited an emergency room or were prescribed antibiotics as this information is not collected.

Retail & Farm Sampling

Retail and farm manure sampling were implemented throughout 2019 in collaboration with CIPARS.

Retail Sampling*

In QC, the prevalence of *Salmonella* in retail chicken breast was higher than *Campylobacter*. QC had the highest prevalence of *Salmonella* in chicken breast across all the sentinel sites in 2019 (46%) compared to 23% for BC, 15% for ON and 12% for AB.

The prevalence of *Listeria monocytogenes* was highest in frozen breaded chicken products and pork sausage, but *Listeria* was also found in chicken breast and ground beef.

STEC was not commonly recovered from retail samples, with no ground beef and only one pork sausage with a positive identification (O187:NM).

	Salmonella	*Campylobacter*	*Listeria*	STEC
Chicken Breast	46% (22/48)	29% (14/48)	10% (5/48)	NT
FBCP	14% (4/29)	NT	13% (6/46)	NT
Ground Beef	NT	NT	8% (4/48)	0% (0/45)
Pork Sausage	3% (1/30)	NT	13% (6/48)	2% (1/45)

NT indicates the samples were not tested.

Retail sampling occurred from March-June and September-December 2019 in the QC site.

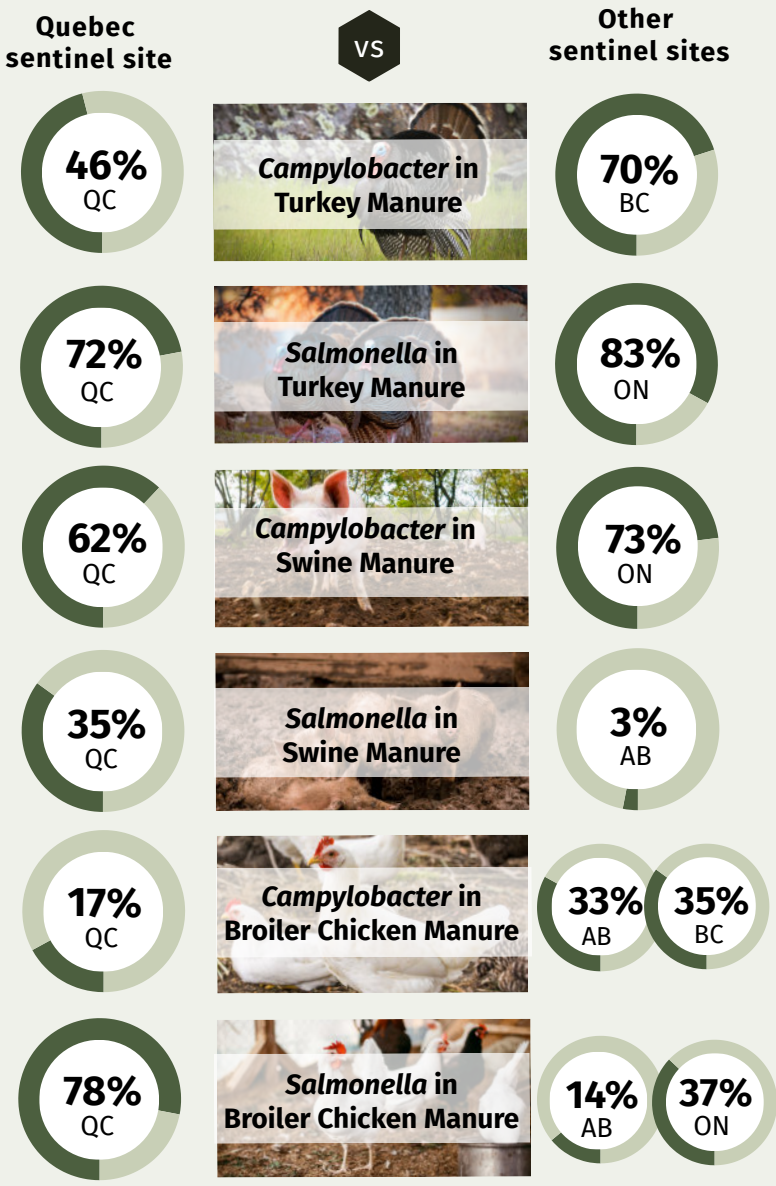
Farm Sampling*

Similar to retail chicken breast, there was a higher prevalence of *Salmonella* in broiler chicken manure and turkey manure than *Campylobacter* in QC. However, the prevalence of *Campylobacter* was higher than *Salmonella* in swine manure.

When comparing QC to the other sentinel sites, there were multiple differences identified (see figure).

Regarding contact with poultry, 17.6% of endemic *Campylobacter* and *Salmonella* human cases had contact with poultry in the QC sentinel site, the highest of all FoodNet Canada sites. The next highest was in ON with 14.3% of cases, followed by 10.6% in AB and 7.2% in BC, for the same time period (July to December 2019).

Farm broiler chicken and swine manure sampling occurred January to December 2019 and turkey manure sampling occurred February to December 2019 in the QC site.



**Only significant differences at the sample-level are reported*

Listeria monocytogenes

Chapter Highlights

- The rate of invasive listeriosis remains relatively low but *Listeria* still remains a risk **for severe illness.**
- The elderly are at higher risk for invasive listeriosis with 71 being the median age of FNC cases.
- Raw or undercooked ground beef is a **potential source** for *Listeria* infection.

While invasive listeriosis is an uncommon disease in Canada, **pregnant people, the elderly, and those who are immunocompromised**, are populations considered to be at higher risk for **severe complications and illness**. [1,2]

The incidence rate for invasive listeriosis in **2019**, for all FNC sites overall, was **0.45 per 100,000 population,** which is comparable to the nationally reported rate of 0.47 per 100,000 population. [3,4]

Reported cases of invasive listeriosis to FNC in 2019

11 cases were reported.*

55% of cases were **female.**

71 was the median age of cases.

80% of endemic cases were **hospitalized**.

30% of endemic cases **deceased**; however, it is unknown if *Listeria* contributed (and to what extent) to the cause of death.

*10 endemic cases, 1 case was lost to follow-up.

Small stores (e.g., butcher shops) have a **higher prevalence** of *Listeria* on meat products sampled (with the exception of frozen **uncooked** breaded chicken products) versus large grocery store chains.

The prevalence of *Listeria* on ground beef continues to be high in 2019.

25%

22% (large stores)

35% (small stores)

According to the Canadian Food Inspection Agency, in 2019, various foods were **recalled** due to possible *Listeria* contamination. Foods recalled were: [5]

- various vegetables
- certain cheeses
- deli meats/trays
- processed chicken and salmon products
- pâté
- cured meat
- sausages/wieners
- sandwiches

Consumer awareness of foods as potential sources for *Listeria* continues to be important. Targeted consumer education efforts, particularly towards **high risk populations** continue to be of value in **reducing the rate** of listeriosis.

1) World Health Organization and Food and Agriculture Organization of the United Nations. Risk assessment of *Listeria monocytogenes* in ready-to-eat foods: microbiological risk assessment series 5. Geneva and Rome: WHO/FAO, 2004.
2) Government of Canada. Risks of listeriosis (Listeria). Available at: https://www.canada.ca/en/public-health/services/diseases/listeriosis/risk-listeriosis.html. Accessed September 2020.
3) Government of Canada. Canadian Notifiable Diseases Surveillance System online database. Available at: https://diseases.canada.ca/notifiable/charts-pre-built. Accessed September 2020.
4) Government of Canada. National Enteric Surveillance Program Annual Summary 2019: Public Health Agency of Canada, Guelph, 2020.
5) Government of Canada. 'Food recall warnings and allergy alerts' online database. Available at: https://www.inspection.gc.ca/food-recall-warnings-and-allergy-alerts/eng/1351519587174/1351519588221. Accessed September 2020.

The chapters in the remainder of the report include data from the BC, AB and ON sentinel sites only.

Salmonella Enteritidis (SE)

Chapter Highlights

- **Significant decrease** in the annual incidence rate for endemic SE infections since 2017.
- **Significant decrease** in the percent of samples positive for SE for FBCP and broiler chicken farms since 2018.
- **Majority (87%)** of 2019 retail, farm and water SE isolates sequenced fell within a human WGS cluster.

Integrated Trends Across Components

Human

Retail

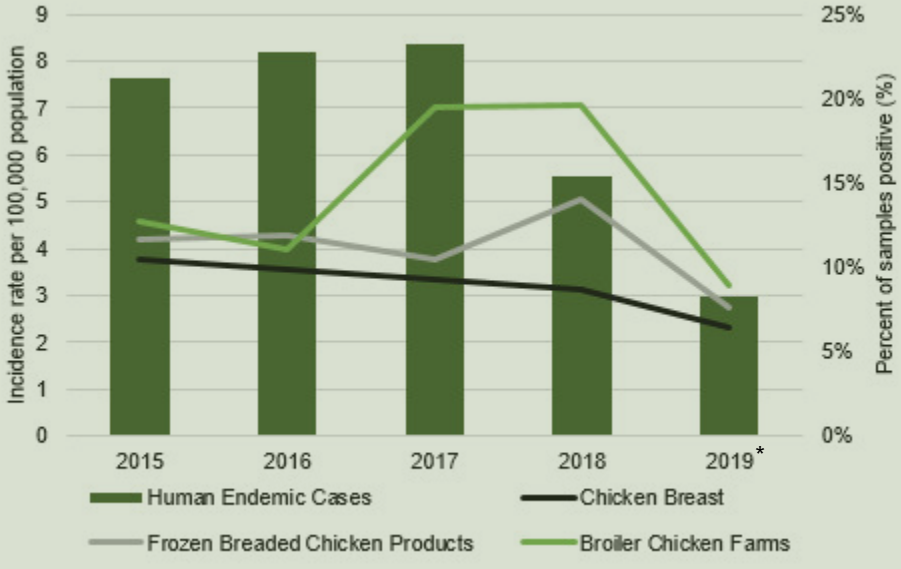
Farm

The incidence rate for endemic SE was **3.0 cases per 100,000 population** across all sites in 2019 (Figure 3.1).

This is the **lowest rate** reported between 2015 and 2019.

The % of samples positive for SE **decreased for retail chicken breast, FBCP and on broiler farms** (Figure 3.1).

- **Significant decrease** for FBCP and broiler chicken farms compared to 2018.



*Includes cooked and uncooked FBCP

Figure 3.1. Annual human incidence rate for endemic SE cases and percentage of retail chicken breast samples, FBCP samples and broiler chicken manure samples positive for SE for the combined FNC sentinel sites (ON, AB, BC), 2015-2019.

Reduction in SE

In the AB site, the **prevalence of SE** has significantly **decreased** in **chicken breast and broiler manure** since 2018. Similarly, the incidence rate of endemic SE cases in the AB site has been decreasing since 2017.

Intervention programs applied at the breeder flock level in AB in mid-2018 (**i.e., vaccination of broilers at day old**) may explain some of the reduction in SE prevalence.[1]

The significant **decrease of SE observed on FBCP** is associated with the CFIA directive to industry.

This directive required the mandatory implementation of measures at the manufacturing level to **reduce *Salmonella* to below detectable amounts in FBCP** that are packaged for retail sale by April 1, 2019.[2]

Salmonella Serovar Trends

Top Serovars

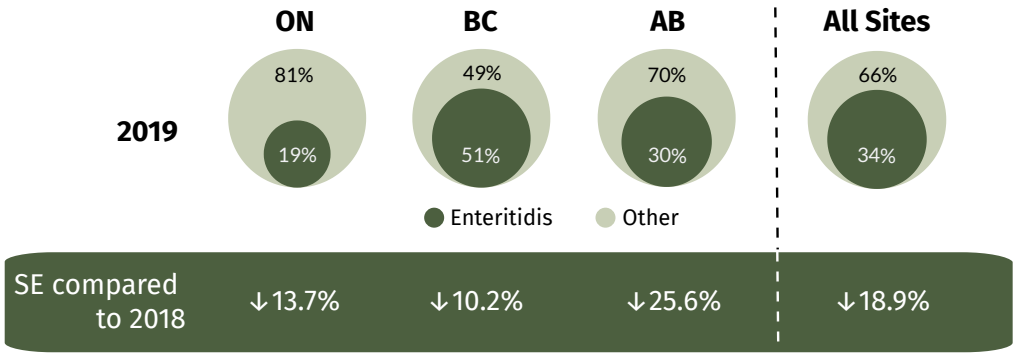
SE was the most common serovar identified in 2019 among:

- **FNC human endemic cases**
- **Retail poultry products** (chicken breast and FBCP)

***S.* Kentucky** was the top serovar identified **among broiler chicken farms** in 2019.

- In 2019, a higher proportion of endemic *Salmonella* cases in the BC site were Enteritidis compared with the AB and ON sites.
- The proportion of endemic *Salmonella* cases that were Enteritidis decreased in all sites in 2019 compared to 2018.

Human Endemic SE Cases by Site



Incidence Rates for Human Endemic SE Cases by Site

Incidence Rate Per 100,000 Population

Sentinel Site	2015-2018	2019
BC	10.7	5.3
AB	8.1	2.7
ON	2.6	1.2

The overall incidence rate for endemic SE cases decreased in 2019 compared to previous years (Figure 3.1).

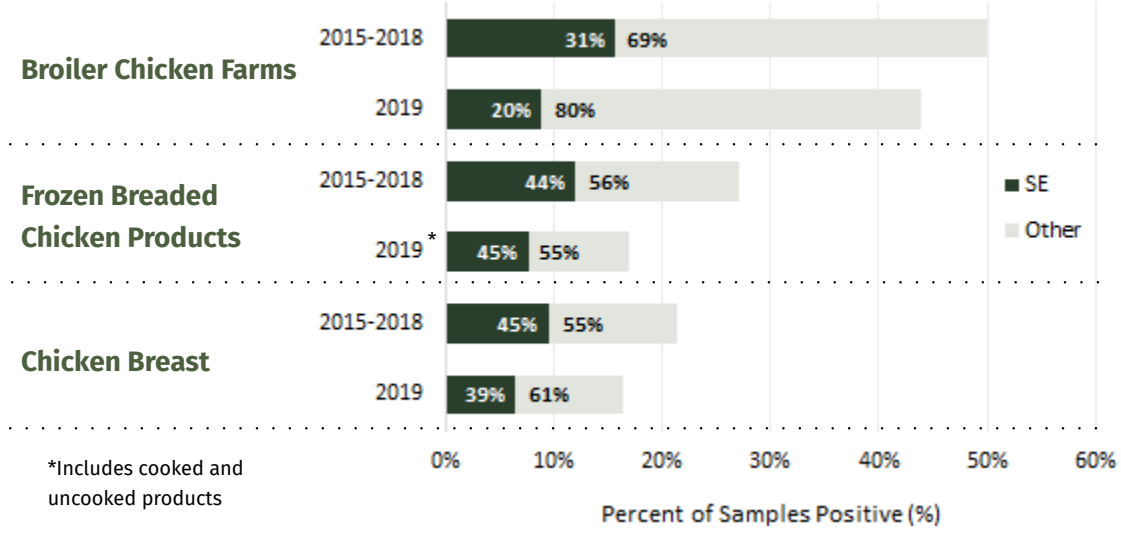
When looking at the sentinel site level, **notable decreases** were observed in each of the sites in 2019 compared to 2015-2018.

- **Significant decrease** for BC and AB

Non-Human SE Trends

Proportion of *Salmonella* positive isolates that were SE **decreased in broiler chicken farms and on retail chicken breast** in 2019 (Figure 3.2).

- No SE identified in broiler chicken farms and chicken breast in ON in 2019.



*Includes cooked and uncooked products

FBCP Samples

CFIA's directive[2] increased availability of cooked products

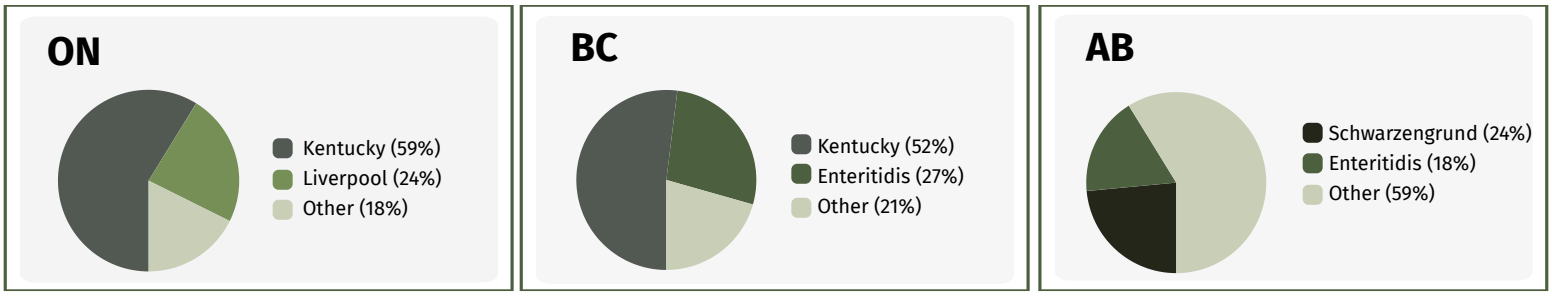
FNC began sampling cooked FBCP in 2019 (28% of products)

Only **uncooked** FBCP were found to be **positive for SE**

- Majority collected/produced prior to the CFIA directive
- Also included products not part of the directive (e.g. made with whole muscle cuts), which remain a risk for SE infection

Figure 3.2. Percentage of retail chicken breast samples, FBCP samples and broiler chicken manure samples positive for *Salmonella* (shown with proportion SE) for the combined sentinel sites (ON, AB, BC), 2015-2019.

Regional Differences of *Salmonella* Serovars among Broiler Chicken Farms, 2019



***S.* Enteritidis** was **not identified** in broiler chicken farms in 2019 in **ON**.

Large increase in the proportion of *Salmonella* positive samples identified as ***S.* Kentucky** in **ON** between 2018 and 2019 (**0% vs 59%**, respectively).

The proportion of *Salmonella* positive samples identified as **SE decreased** between 2018 and 2019 in both **AB** (**44% vs 18%**, respectively) and **BC** (**38% vs 27%**, respectively).

The majority of the **'Other'** category was comprised of ***S.* Johannesburg** for **BC**. This is considered a **rare serovar** reported among human clinical isolates, with two cases of *S.* Johannesburg reported to NESP in 2019.[3] There was a large diversity of serovars in the 'Other' category for AB.

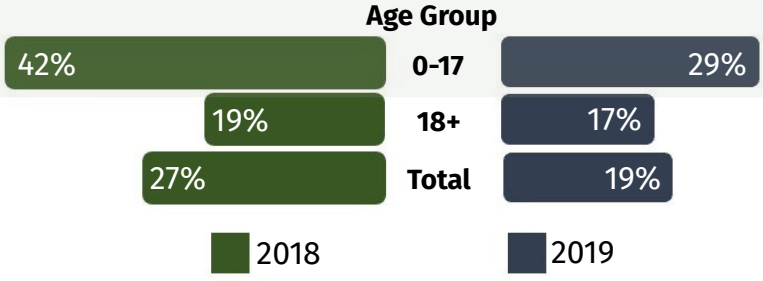
SE is the most common cause of human salmonellosis and is the serovar most frequently isolated from retail poultry products. While **other serovars (e.g., Kentucky) are prominent among the food and animal samples collected, they do not appear to cause a high burden of human disease**.

SE Trends with Frozen Breaded Chicken Products

Consumption of FBCP by endemic SE cases in the combined FNC sites **decreased** in 2019.

27% in 2018 **vs** **19%** in 2019

A **larger decrease** was seen in cases **0-17 years old** compared to cases 18+ years old.



In addition to the decrease in endemic SE cases reporting consumption of FBCP, there was also a significant decrease in the percent of FBCP samples that tested positive for SE in 2019 compared to 2018.

These decreases seem to be driven in part to the **CFIA directive** that went into effect on April 1, 2019.[2]

Product recalls, increased risk communications and media coverage warning the public about the risk of *Salmonella* infection associated with eating **uncooked** FBCP may also explain the lower prevalence of consumption of FBCP among SE endemic cases.[4]

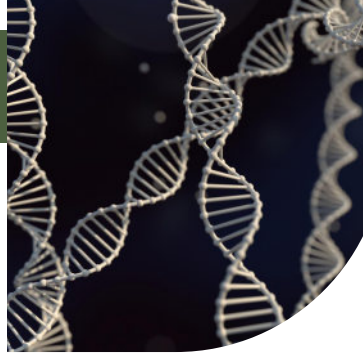
Cooking Practices

An **increase** was observed in microwave use for cooking FBCP (**3%** in 2018 vs **33%** in 2019) among SE cases.

However, the oven continued to be the most popular method of cooking in 2019 **(58%).**

CFIA's directive led to increased availability of 'fully cooked' products on the market. Cooking instructions for these products include the option for microwave cooking.[5] This could explain the observed increase in microwave cooking practices among SE cases reporting consumption of FBCP.

Whole Genome Sequencing (WGS) Trends



Ongoing WGS of *Salmonella* isolates, including *S.* Enteritidis isolates, has contributed to the integrated and timely analysis of human, retail, farm, and water data. This has enhanced the detection of emerging issues and our understanding of pathogen transmission pathways.

Salmonella Enteritidis isolates recovered from FoodNet Canada retail, farm and water 2019 samples were sequenced and analyzed to assess their inclusion in human WGS clusters defined by PulseNet Canada.[6]

85 isolates were sequenced

74 isolates **(87%)** fell within a human WGS cluster

Broiler Chicken Manure	31
FBCP	28
Chicken Breast	25
Irrigation Water	1

Broiler Chicken Manure	30	(97%)
FBCP	19	(68%)
Chicken Breast	24	(96%)
Irrigation Water	1	(100%)

Farm-Level

The 31 broiler chicken manure isolates were from 14 farms. Of these farms, 93% (13/14) had a SE isolate that fell within a human WGS cluster (30 isolates).

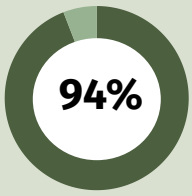
These 74 FoodNet Canada farm, retail and water isolates fell within

17 human WGS clusters

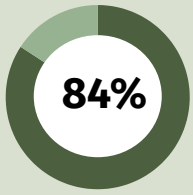
Sample Type(s) (# of Isolates)	# of Clusters
FBCP (16)	13
Chicken Breast (1), FBCP (1)	1
Chicken Breast (1), Broiler Chicken Manure (1)	1
Chicken Breast (4), FBCP (1), Irrigation Water (1)	1
Chicken Breast (18), FBCP (1), Broiler Chicken Manure (29)	1
Total	**17**

Of these 17 human WGS clusters, 4 included multiple sample types.

Frozen Breaded Chicken Products



of clusters included FBCP isolates (16/17)



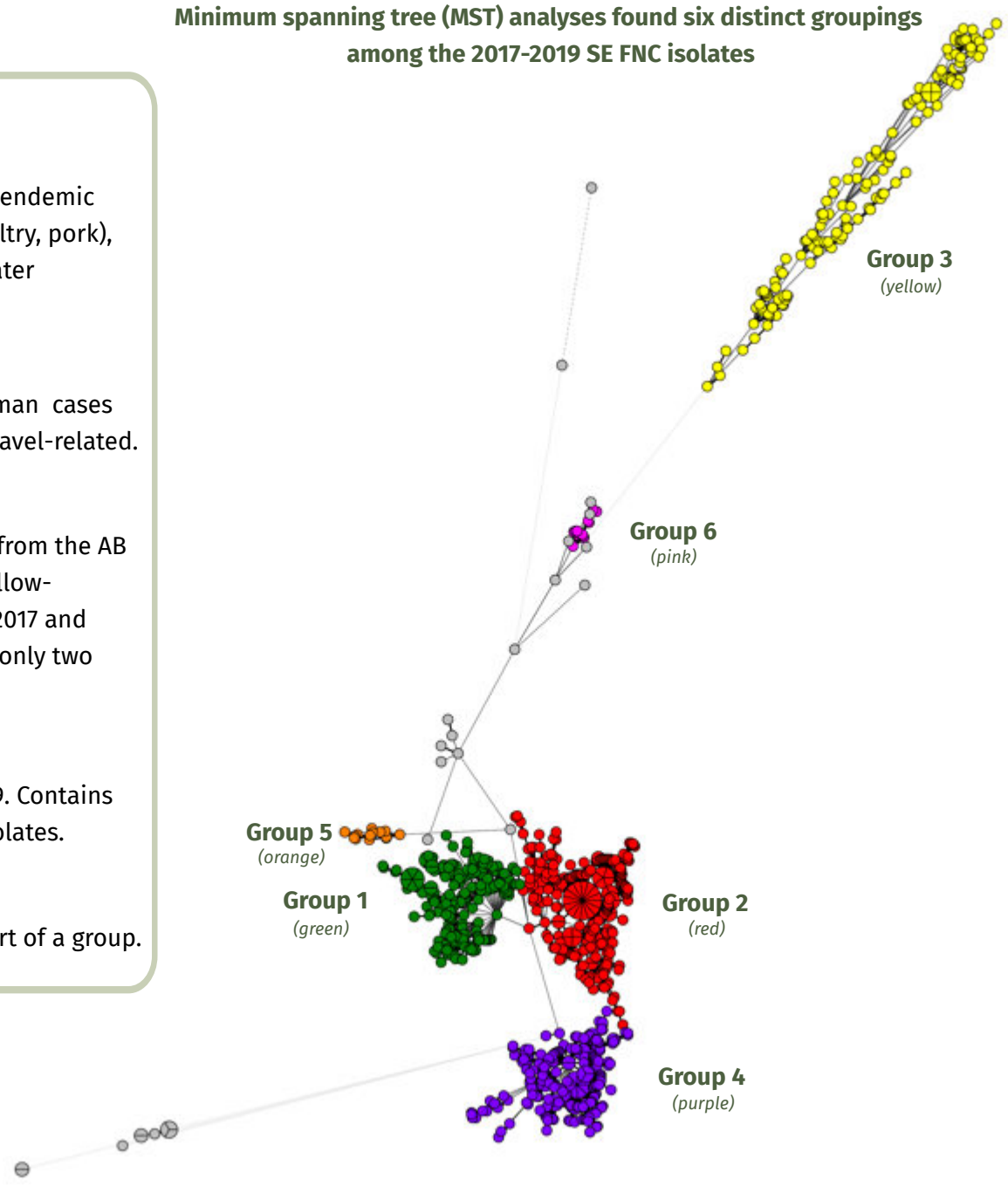
of FBCP isolates were from January to June 2019 (16/19)

While the prevalence of SE decreased in FBCP, we continued to see a large proportion of SE clusters containing these samples in 2019. However, 84% of these samples were from January to June 2019, reflecting product that may have been on the shelf before and shortly after the CFIA directive.

Whole Genome Sequencing Patterns 2017-2019

Salmonella Enteritidis FoodNet Canada human, retail, farm and water isolates from 2017 to 2019 were sequenced and analyzed together. Minimum spanning trees were used to look at the data.

Minimum spanning tree (MST) analyses found six distinct groupings among the 2017-2019 SE FNC isolates



Groups:

Groups 1, 2 and 4:
Contain the majority of FNC endemic cases, along with retail (poultry, pork), farm (poultry, swine) and water (irrigation) isolates.

Group 3:
Contains the majority of human cases classified as international travel-related.

Group 5:
Contains only human cases from the AB site (11 endemic, 3 lost to follow-up). This group emerged in 2017 and expanded in 2018; however, only two isolates were added in 2019.

Group 6:
New group identified in 2019. Contains human and retail poultry isolates.

Ungrouped: (grey circles)
Isolates not clustering as part of a group.

WGS integrated analysis has demonstrated that predominant strains of SE differ by region. Endemic SE lineages within each region persist across the farm-to-fork continuum.

Continued analysis of WGS data in conjunction with other FNC data sources, such as human case questionnaire and animal health data, will provide further evidence to help inform action among regulators and industry groups.

International Travel-Related SE Cases

For more information on international travel and enteric infections, see Chapter 7 (page 32).

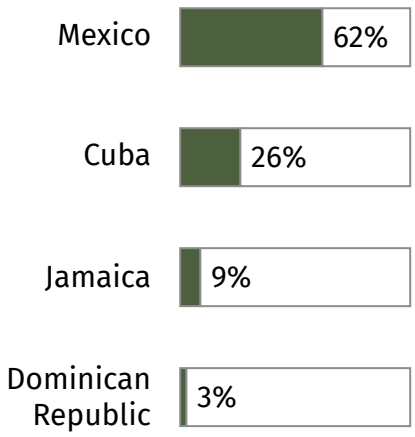
Thirty-one percent

(40/129) of all SE cases were related to international travel in 2019.

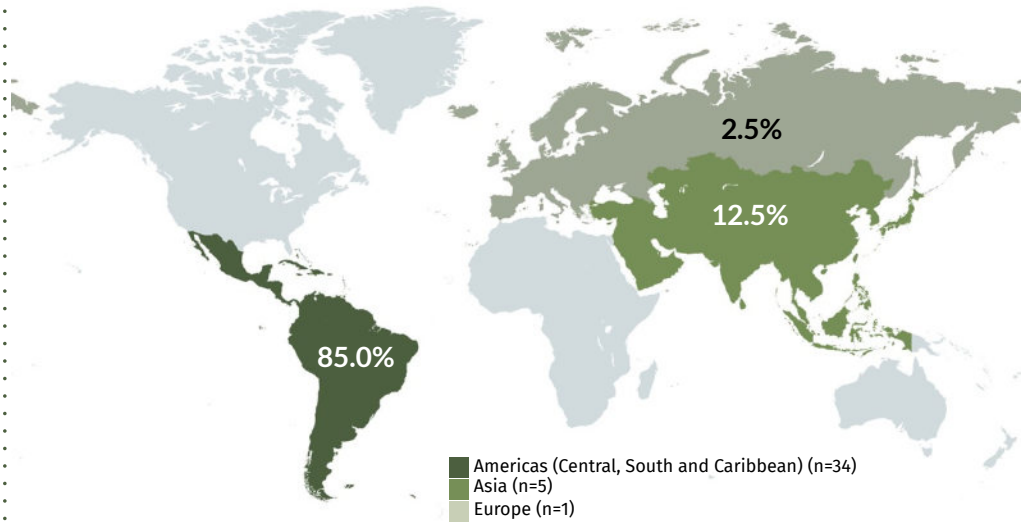
The incidence rate of travel-related infections of SE for all sites combined remained stable between 2018 and 2019.

The rate decreased in the AB and ON sites, but slightly increased in the BC site.

Of these 2019 travel-related SE cases, the majority (34/40) travelled to the **Americas (Central, South & the Caribbean)**



Region of travel reported in 2019 among *Salmonella* Enteritidis cases classified as international travel-related [7]



WGS of International Travel-Related SE Cases

International travel-related cases from 2017 to 2019 were analyzed.

Within group 3 (see above), there were 110 international travel-related cases.

The majority (83.6%) of these cases travelled to Mexico, Cuba and the Dominican Republic.

Top 3 Travel Destinations [8]

N

A closer look at Mexico...

Of the cases that reported travel to Mexico:

- 38.8% travelled to the East coast
- 59.2% travelled to the West coast

*Travel location was unknown for one case (2.0%)

Regional Differences

WGS analysis of isolates from these top 3 travel destinations showed that the majority of SE sequences clustered by country (Figure 3.3).

The majority of isolates from cases that reported travel to the west coast of Mexico clustered separately from cases that reported travel to the east coast of Mexico (Figure 3.4).

West Coast:

- Travel to Mexican states that connect to the Pacific Ocean/Gulf of California

East Coast:

- Travel to Mexican states that connect to the Gulf of Mexico/Caribbean Sea

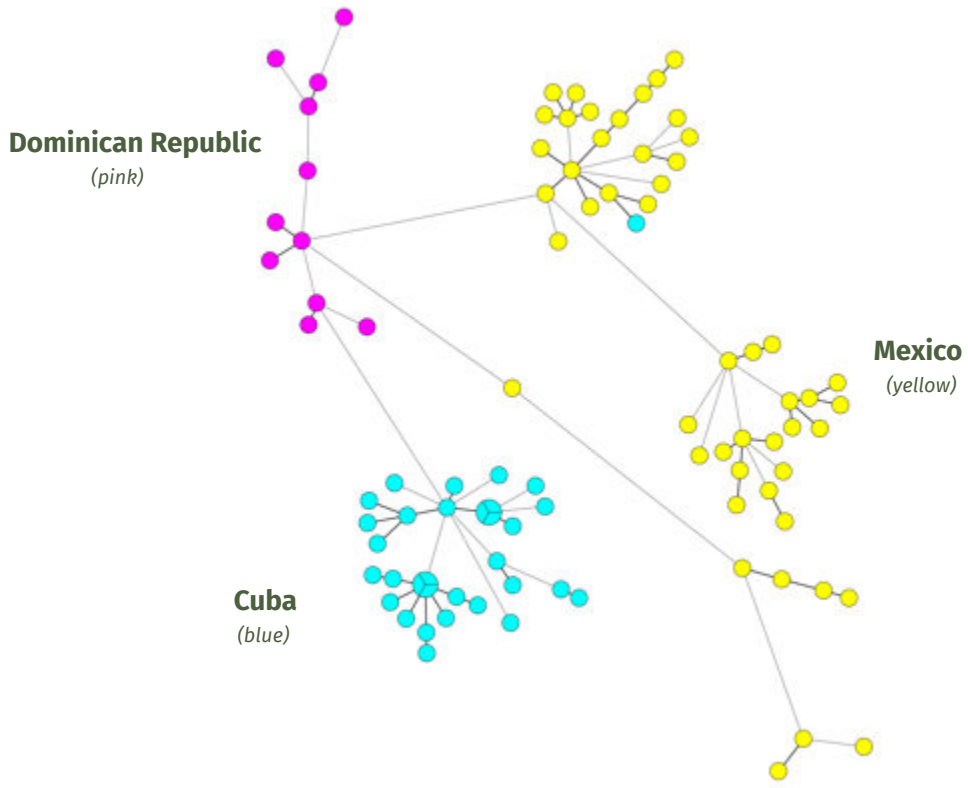


Figure 3.3. Minimum spanning tree of SE cases for the top 3 travel destinations, 2017-2019

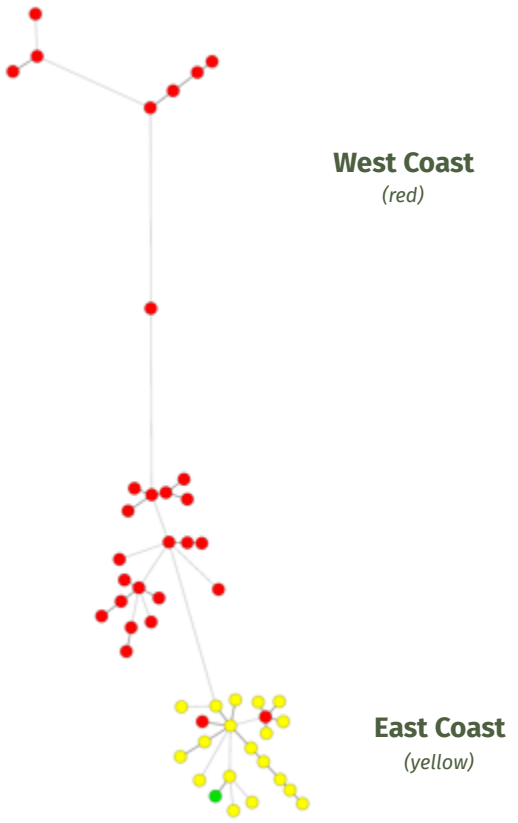
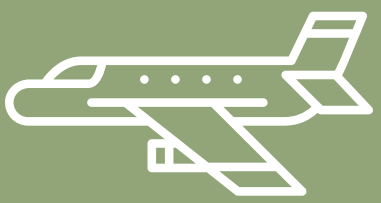


Figure 3.4. Minimum spanning tree of SE cases for the top travel destination - Mexico, 2017-2019*

*One case had an unknown coast (green)

The use of WGS for enteric disease surveillance is helping to better inform our understanding of incubation periods for target pathogens and more accurately assign case classifications. For example, we are able to identify cases that travelled outside of their incubation periods who closely cluster with other travel-acquired isolates. Therefore, analyzing WGS results may help us refine our case classification categories.



1) A. Agunos, personal communication, September 2020.
2) Government of Canada. Questions and answers: New measures to reduce salmonella in frozen raw breaded chicken products. Available at: https://inspection.canada.ca/preventive-controls/meat/salmonella-in-frozen-raw-breaded-chicken/faq/eng/1554140834819/1554140994648. Accessed March 2022.
3) Government of Canada. National Enteric Surveillance Program Annual Summary 2019: Public Health Agency of Canada, Guelph, 2020.
4) Glass-Kaastra, S., Dougherty, B., Nesbitt, A., Viswanathan, M., Ciampa, N., Parker, S., Nadon, C., MacDonald, D., & Thomas, M.K. (2022). Estimated reduction in the burden of Nontyphoidal *Salmonella* illness in Canada circa 2019. *Foodborne Pathogens and Disease*, *19*(11), 744-749.
5) Janes® Ready for Anything!. Pub Style Chicken Strips. Available at: https://www.janesfoods.com/products/pub-style-chicken-strips-2/. Accessed May 2021.
6) Government of Canada. PulseNet Canada. Available at: https://www.canada.ca/en/public-health/programs/pulsenet-canada.html
7) MapChart 2021. Available at: https://mapchart.net/world.html. Accessed July 2021.
8) MapChart 2021. Available at: https://mapchart.net/world.html. Accessed October 2021.

Poultry

Chapter Highlights

- As poultry products can be contaminated with *Salmonella* and *Campylobacter*, proper food handling of these products is important to reduce illness.
- In addition to proper food handling, contact with poultry may also be an important source of illness. In 2019, contact with poultry was found to be a significant risk factor for *Campylobacter*.

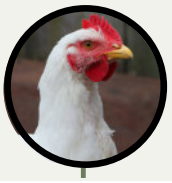
Poultry contact and **meat products** are key sources of infection for *Campylobacter* and *Salmonella*

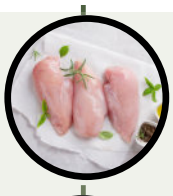
1 **Campylobacteriosis** was the **most common** enteric illness reported in 2019 in all FNC sites, with an **endemic incidence rate of 20 cases per 100,000 population**.

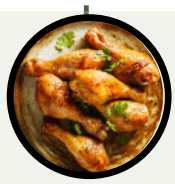
2 **Salmonellosis** was the **second most common** enteric illness reported in 2019 in all FNC sites, with an **endemic incidence rate of 9 cases per 100,000 population**.

Exposures to Poultry among Human Endemic Cases in 2019

	SALMONELLA	*CAMPYLOBACTER*
FARM	**4%** of cases had contact with poultry	**14%** of cases had contact with poultry
HANDLING	**31%** of cases handled raw chicken	**32%** of cases handled raw chicken
HANDLING	**44%** of cases handled or prepared any eggs or foods containing raw egg	**42%** of cases handled or prepared any eggs or foods containing raw egg
CONSUMPTION	**75%** of cases ate chicken	**81%** of cases ate chicken
CONSUMPTION	**31%** of the cases that ate eggs consumed them raw or undercooked	**37%** of the cases that ate eggs consumed them raw or undercooked







Poultry-Related Risk Factors

Poultry-related risk factors were examined through a case-control analysis, comparing FNC 2019 endemic *Campylobacter* and *Salmonella** cases to Foodbook controls.[1]

Campylobacter:

Odds of **poultry contact** was **5.7x** higher among cases §

Odds of **eating undercooked or raw eggs** was **3.6x** higher among cases §

***Salmonella*:**

Odds of **eating undercooked or raw eggs** was **2.8x** higher among cases §

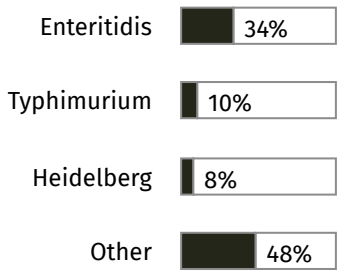
Visit these links for more information on poultry and egg food safety.

* For the *Salmonella* analysis, the ON site was excluded due to differences in the incubation period used within the site (3 days) and FoodBook (7 days).
§ Result was statistically significant.

Farm-to-Fork *Salmonella* Serovars in 2019

Human Endemic Cases

Top 3 Serovars



The top three serovars found in endemic human cases were found in some poultry farm and retail samples, with Enteritidis more commonly found in these isolates compared to Typhimurium and Heidelberg.

Reading was the top serovar among outbreak-related cases in 2019 and was also one of the top serovars identified in turkey manure samples.

FNC Non-Human Samples

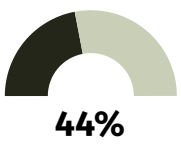
Broiler Chicken Manure

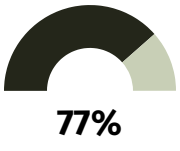
Turkey Manure

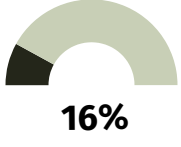
Chicken Breast

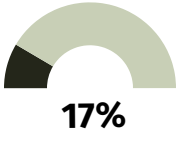
Frozen Breaded Chicken Products

Overall Prevalence

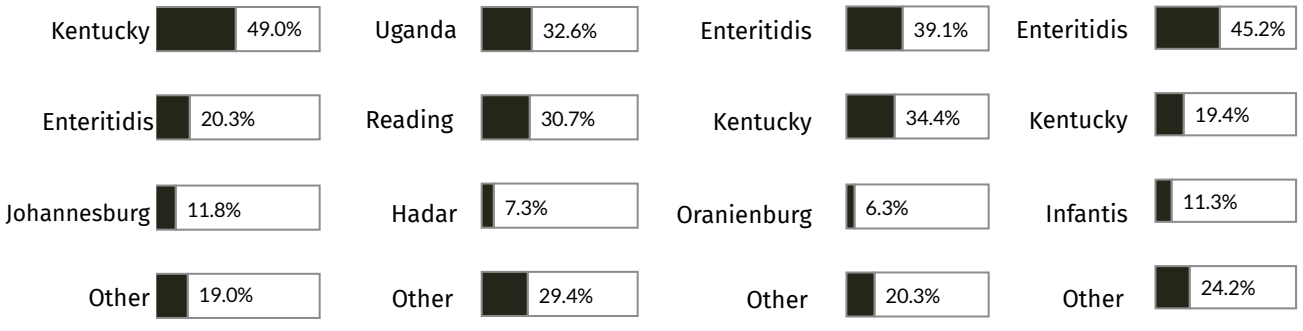






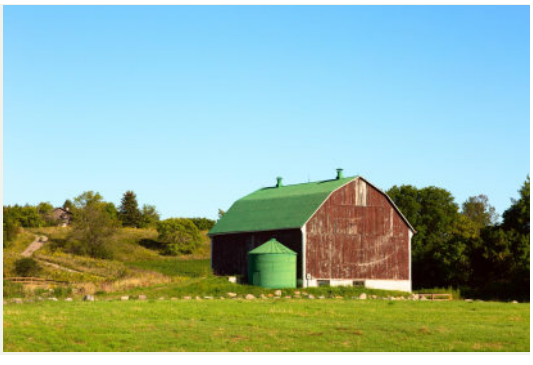


Proportion by serovar among positive samples



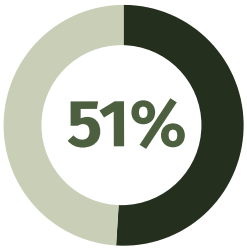
Salmonella Serovar Trends Across FNC Components

- **SE was the top serovar reported among all endemic human cases**. **Non-human samples** positive for SE were found in **broiler chicken manure**, **chicken breasts** and **FBCP**.
- **Many serovars in non-human samples are not causing a high burden of human illness**. For example, samples positive for *S.* Kentucky were found in broiler chicken manure, chicken breasts and FBCP, but there were no endemic cases of human illness reported to FNC in 2019.



Whole Genome Sequencing Patterns for *Salmonella*

***Salmonella* isolates recovered from 2019 FNC samples of poultry retail and farm manure were sequenced and analyzed to determine their relatedness to human WGS clusters defined by PulseNet Canada.**[2]



of these isolates (255/497) fell within a human WGS cluster, reflecting the importance of poultry as a potential risk factor for *Salmonella* infection.

Proportion of Isolates that Fell within a Human WGS Cluster and Their Serovar Breakdown by FNC Sample Type:

	Turkey Manure	Chicken Breast	FBCP	Broiler Chicken Manure
% Related	73%	53%	44%	22%
Serovar Breakdown	Reading 41.9% Uganda 39.4% Hadar 6.3% Other 12.5%	Enteritidis 70.6% Oranienburg 11.8% Indiana 8.8% Other 8.8%	Enteritidis 70.4% Heidelberg 14.8% Other 14.8%	Enteritidis 88.2% Schwarzengrund 8.8% Reading 2.9%
Total # Analyzed:	218	64	62	153

- SE comprised the majority of isolates that fell within a human WGS cluster among broiler chicken manure, chicken breast, and FBCP. SE was not identified among turkey manure samples.
- Although Kentucky was the top serovar identified among broiler chicken farms in 2019, none of these isolates were found to fall within a human WGS cluster. This reflects that Kentucky does not appear to cause a high burden of human disease.

Emergence of *S.* Reading in Turkey (Includes QC site data)

S. Reading was among the top 5 overall FNC human *Salmonella* serovars in 2019. The prevalence of *S.* Reading in CIPARS retail turkey and FNC/CIPARS farm turkey samples increased in 2019 compared to previous years (Figure 4.1).

In 2019, the majority of *S.* Reading positive CIPARS retail turkey and FNC/CIPARS farm turkey samples fell within a human WGS cluster, including a national outbreak of *S.* Reading with 130 confirmed human cases.[3]

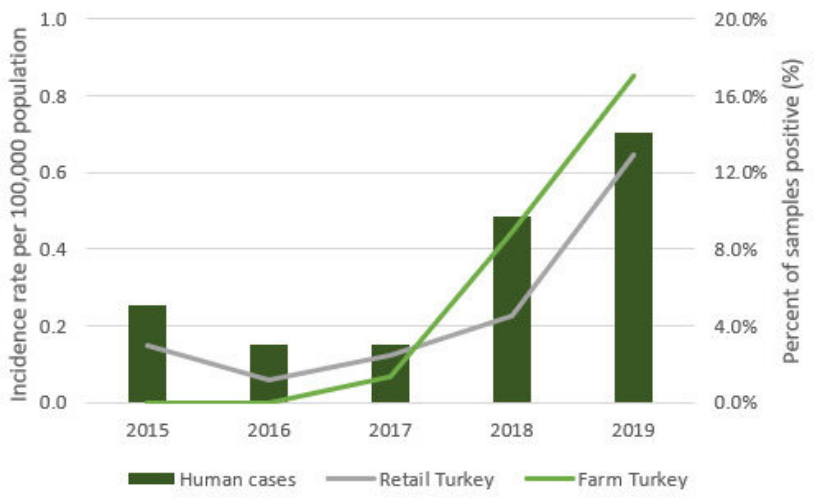


Figure 4.1. Overall *S.* Reading FNC Human Incidence Rates and Percentage of Positive *S.* Reading in CIPARS Retail Tukey and Shared FNC/CIPARS Farm Turkey samples, 2015-2019.*

*FNC human cases from BC, AB, ON and QC sites (QC site July to December 2019 only). CIPARS retail turkey samples collected from BC, AB, SK, ON and QC (partial year sampling in ON, SK and AB in 2016 to 2018) and the Atlantic Region (2015). FNC/CIPARS farm turkey samples collected from BC (2015-2019), ON (2016-2019), AB (2018-2019) and QC (2019).

Farm-to-Fork *Campylobacter* Species in 2019

FNC Samples:	 Human Endemic Cases	 Broiler Chicken Manure	 Turkey Manure	 Chicken Breast
Overall Incidence Rate and Prevalence	**20** cases per 100,000 population	 **28%**	 **57%**	 **42%**
Proportion by species among cases and positive samples	*C. jejuni* 89.2% *C. coli* 6.1% Other 4.7%	*C. jejuni* 90.8% *C. coli* 9.2% Other 0%	*C. jejuni* 63.0% *C. coli* 31.5% Other 5.6%	*C. jejuni* 89.0% *C. coli* 11.0% Other 0%

Campylobacter Species Across FNC Components

- ***C. jejuni*** was the **primary *Campylobacter* species** identified among human cases, retail chicken breast samples, broiler chicken manure and turkey manure across all sentinel sites.

- In 2019, 2.2% of *Campylobacter* human cases were determined to be ***C. upsaliensis***. Human cases of *C. upsaliensis* have been associated with exposure to **household pet dogs**. [4]

1) Government of Canada. Foodbook Report. Public Health Agency of Canada, Guelph, 2015.
2) Government of Canada. PulseNet Canada. Available at: https://www.canada.ca/en/public-health/programs/pulsenet-canada.html
3) Government of Canada. Public Health Notice — Outbreak of Salmonella illnesses linked to raw turkey and raw chicken. Final Update: February 21, 2020. Available at: https://www.canada.ca/en/public-health/services/public-health-notices/2018/outbreak-salmonella-illnesses-raw-turkey-raw-chicken.html. Accessed October 2020.
4) Parsons, B.N., Porter, C.J., Stavisky, J.H., Williams, N.J., Birtles, R.J., Miller, W.G., Hart, C.A., Gaskell, R.M., & Dawson, S. (2012). Multilocus sequence typing of human and canine C. upsaliensis isolates. *Veterinary microbiology*, *157*(3-4), 391-397.

Shigatoxigenic *Escherichia coli*

Chapter Highlights

- Increased incidence rate of STEC over the last couple of years reflects an increase in testing of non-O157. Increased non-O157 STEC infections has improved the ability to identify exposure sources.
- Exposure to irrigation water, beef manure and pork meat products sold at the retail level continue to present a risk to public health.
- In 2019, O157 cases reported more severe illness compared to non-O157 cases.

STEC by the numbers

142 cases
Reported to FNC sentinel sites in 2019

6.76 cases
per 100,000 population

63.1%
Visited the emergency room*

9.5%
Were admitted to hospital*

* Proportion of endemic STEC cases

A change in non-O157

In June of 2018, the Alberta site began testing all STEC human clinical samples for non-O157 in addition to continuing O157 testing.

Prior to this change, FNC reported annual non-O157 incidence rates of:

0.72 per 100,000 in 2015
0.50 per 100,000 in 2016
0.94 per 100,000 in 2017

Following this change, FNC reported annual non-O157 incidence rates of:

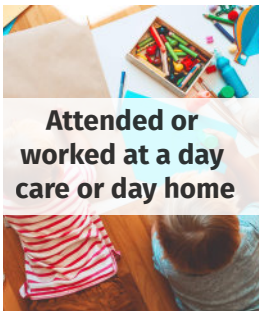
2.32 per 100,000 in 2018
3.95 per 100,000 in 2019

During this same period (2015-2019), incidence rates of O157 did not vary. The increase in incidence rate of non-O157 after a change in testing policy suggests that previously non-O157 had been under-diagnosed.

High-risk Exposures

When comparing the exposures of endemic cases reported to FNC, there were two exposures that were significantly higher in STEC cases than other enteric pathogens.

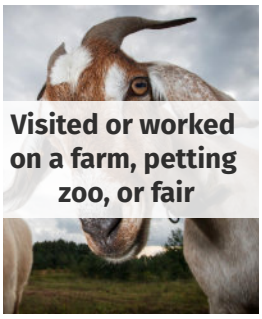
STEC vs Other enteric pathogens*



Attended or worked at a day care or day home

10.7%

3.1%



Visited or worked on a farm, petting zoo, or fair

25.6%

14.4%

*Other enteric pathogens includes *Campylobacter*, *Salmonella*, *Giardia*, *Shigella*, *Yersinia*, and *Cryptosporidium*

Indicators of Severity O157 vs non-O157

Adding to the existing body of evidence, data from multiple components of FNC found that indicators of severity are higher in O157 than non-O157.

Compared to non-O157, O157 was found to have...

- higher proportion of **bloody diarrhea** in clinical cases reported in 2019*
- higher proportion of **vomiting** in clinical cases reported in 2019
- higher proportion of **ER visits** and **hospitalizations** for clinical cases reported in 2019
- higher proportion of **virulence genes encoded** (stx2, eae, hly) in farm and retail samples from 2015-2019*

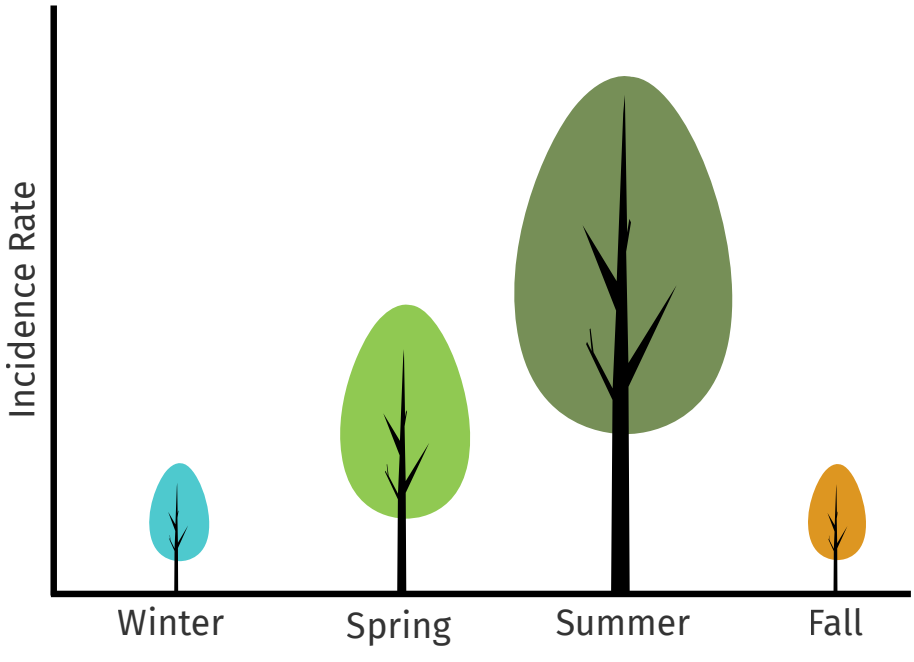
*Significant

STEC Seasonality

In 2019, endemic STEC cases reported to FNC showed a strong seasonal trend.

The incidence rate for cases with onset of illness in the **summer** was **2x** greater than in the **spring**, and about **4x** greater than in the **winter** or **fall**.

Higher incidence rates were also observed in the summer from 2015 to 2018.



STEC across FNC components

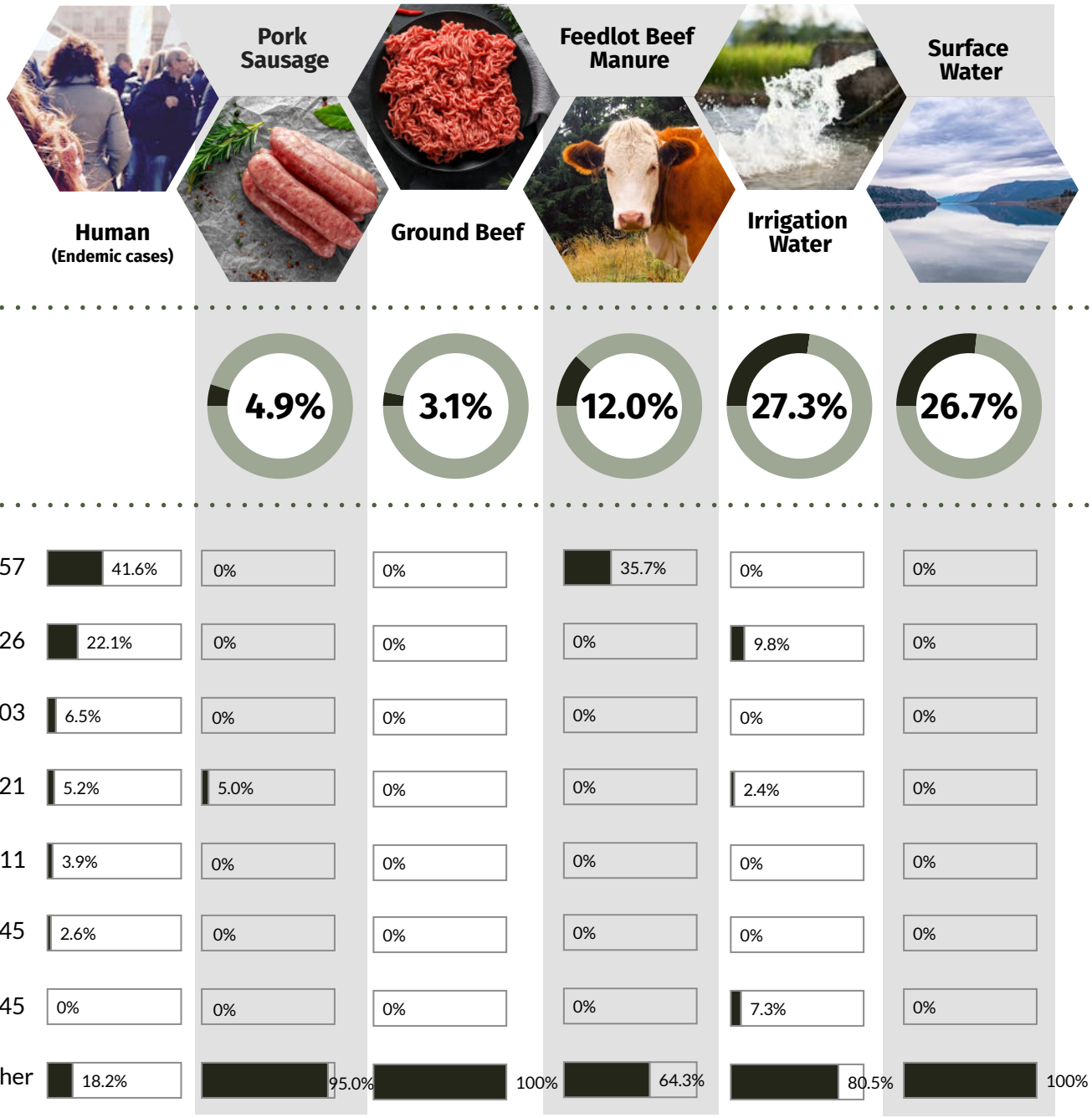


*Figure shows the proportion of the top 7 priority serogroups of clinically significant concern.[1]

- While 36% of STEC isolated from beef manure samples were positive for O157 in 2019, no O157 was isolated from any FNC retail samples tested. Due to improvements in hygiene practices and control measures in Canadian beef processing plants from 1996 to 2016,[2] the prevalence of STEC in ground beef at retail has declined since 2000 and has shown consistently low (<5%) prevalence among FNC retail beef samples in the last 5 years.
- Surface water sampling was introduced in the Ontario sentinel site in 2019. Although STEC was present in over 25% of samples, none were top 7 subtypes of clinical significance.
- O26 continues to be among the top serogroups causing human illness, and among the top serogroups identified among irrigation water samples.

1) Huszczynski, G., Gauthier, M., Mohajer, S., Gill, A., & Blais, B. (2013). Method for the detection of priority Shiga toxin–producing Escherichia coli in beef trim. *Journal of food protection*, *76*(10), 1689-1696.

2) Pollari, F., Christidis, T., Pintar, K.D.M., Nesbitt, A., Farber, J., Lavoie, M.C., Gill, A., Kirsch, P., & Johnson, R.P. (2017). Evidence for the benefits of food chain interventions on E. coli 0157:H7/NM prevalence in retail ground beef and human disease incidence: A success story. *Canadian Journal of Public Health*, *108*(1), e71-e78.

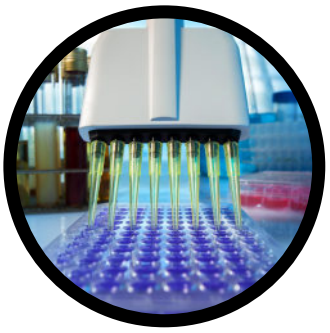
Parasites

Chapter Highlights

- Drinking untreated or raw water, canoeing, kayaking, hiking or camping, and swimming in natural waters were found to be potential risk factors for *Giardia* infection.
- In 2019, there was an increase in travel-related *Cryptosporidium* cases compared to 2015 to 2018. The introduction of more sensitive testing methods may be contributing to the changes identified in incidence rates.

Notable Changes in Laboratory Methods

- **PCR laboratory testing methods were introduced in 2017 in ON and 2019 in BC and AB for the detection of *Giardia* and *Cryptosporidium*.**
  - **These methods improve the ability to detect these pathogens compared to non-PCR based methods.[1]**
  - **The uptake of PCR laboratory testing methods may explain changes observed in incidence rates within FNC sentinel sites.**



Parasites at a Glance (2019)

Giardia

256 cases
reported to FNC in 2019

12.2 cases
per 100,000 population

Highest incidence rate
since 2015

29.3% of cases were travel-related in 2019

Cryptosporidium

102 cases
reported to FNC in 2019

4.9 cases
per 100,000 population

Highest incidence rate
since 2015

49.0% of cases were travel-related in 2019

*Cyclospora**

6 cases
reported to FNC in 2019

0.29 cases
per 100,000 population

Lowest incidence rate
since 2015

33.3% of cases were travel-related in 2019

*No further details on *Cyclospora* are provided due to low case counts.

Giardia and Endemic Sex-based Differences (2015-2019)

64% of endemic *Giardia* cases reported to FNC were **male**.

Higher incidence rates were observed among male *Giardia* cases compared to female cases across **almost all age groups** (except 0-4).*

Similar to FNC cases, **other countries** have observed more cases of *Giardia* among males.[2-4]

Endemic Environmental Exposures and Behaviours

The following figure compares **sex-based differences** in environmental exposures among **endemic cases** of *Giardia* and endemic cases of other enteric pathogens combined **reported to FNC between 2015-2019.**

Giardia			Other Enteric Pathogens**	
Female	**Male**		**Female**	**Male**
12.1%	20.5%	 Drinking untreated or raw water	1.3%	2.6%
26.2%	27.1%	 Canoeing, kayaking, hiking or camping	6.3%	8.7%
22.7%	19.3%	 Swimming in natural water***	6.9%	7.3%

*Age groups: 0-4, 5-9, 10-14, 15-19, 20-24, 25-29, 30-39, 40-59, and 60+ years.
**Other pathogens includes *Campylobacter*, *Salmonella*, STEC, *Shigella*, *Yersinia, Cryptosporidium*, and *Cyclospora*
***Data only available from 2018-2019.

- Exposures including drinking untreated or raw water, canoeing, kayaking, hiking or camping, and swimming in natural water were reported much **more frequently in cases of *Giardia*** than other pathogens combined between 2015-2019.
- Although similar levels of water activity exposures were reported between males and females, **male cases of *Giardia* were more likely to report drinking untreated or raw water.**
- Identified risk factors of *Giardia* cases from other countries include swimming in or drinking from natural bodies of water,[4] international travel,[4,5] contact with animals or wildlife,[5] and male-male sexual contact.[4]

Cryptosporidium and Travel

For more information on international travel and enteric infections, see Chapter 7 (page 32).

3.1x

more travel-related cases in 2019 than in 2015-2018

2015-2018

Average of **16** travel-related cases reported each year

2019

Total of **50** travel-related cases reported

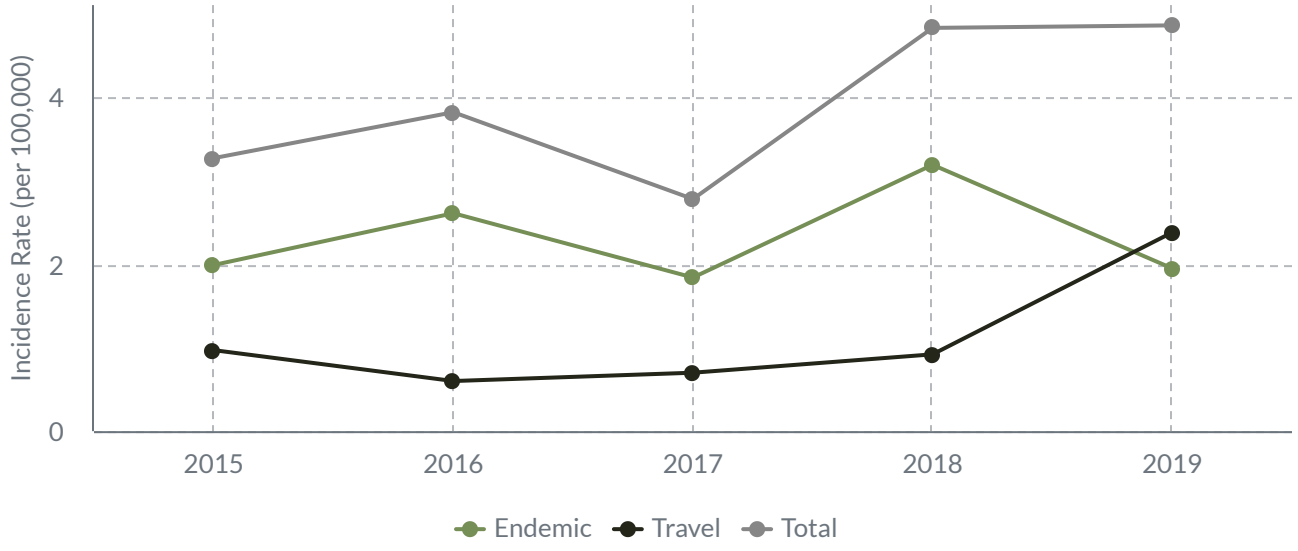


Fig 6.1. The endemic, travel-related, and total incidence rates of cryptosporidiosis cases reported to FNC from 2015-2019

- There were a **greater number of cryptosporidiosis cases related to international travel in 2019** compared to the 2015-2018 average.
- This increase was **not observed in endemic cases**, where the incidence rate has remained relatively stable since 2015.
- However, there was a **substantial increase in the travel-related incidence rate** among cases of cryptosporidiosis in 2019, which was consistent across sentinel sites and across travel destinations.

Discussion

- **The overall incidence rate of international travel-related cryptosporidiosis was 2.38 cases per 100,000 population across all sites in 2019. This is the highest rate reported between 2015 and 2019.**
- **It is unclear if the cause of this increase is a true rise in internationally-acquired cryptosporidiosis or due to other reasons such as the change to more sensitive testing methods.**
- **FNC will continue to monitor and research cases of cryptosporidiosis for more information.**

1) Bursle, E. (2016). Non-culture methods for detecting infection. *Australian Prescriber,* 39(5), 171-175.
2) Espelage, W., an der Heiden, M., Stark, K., & Alpers, K. (2010). Characteristics and risk factors for symptomatic *Giardia lamblia* infections in Germany. *BMC Public Health, 10*, 41.
3) Ellam, H., Verlander, N.Q., Lamden, K., Cheesbrough, J.S., Durband, C.A., & James, S. (2008). Surveillance of giardiasis in Northwest England 1996-2006: impact of an enzyme immunoassay test. *Eurosurveillance, 13*(37).
4) Reses, H.E., Gargano, J.W., Liang, J.L., Cronquist, A., Smith, K., Collier, S.A., Roy, S.L., Eng, V., Bogard, A., Lee, B., Hlavsa, M.C., Rosenberg, E.S., Fullerton, K.E., Beach, M.J., & Yoder, J.S. (2018). Risk factors for sporadic *Giardia* infection in the USA: a case-control study in Colorado and Minnesota. *Epidemiology and Infection, 146*.
5) Zajaczkowski, P., Mazumdar, S., Conaty, S., Ellis, J.T., & Fletcher-Lartey, S.M. (2019). Epidemiology and associated risk factors of giardiasis in a peri-urban setting in New South Wales Australia. *Epidemiology and Infection, 147*(e15).

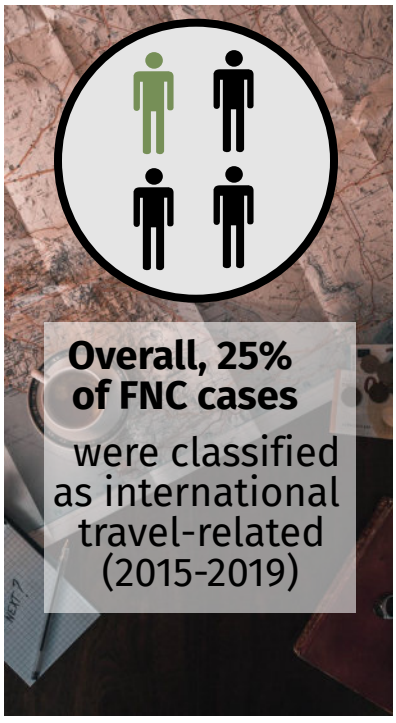
Travel

Chapter Highlights

- International travel continues to be a risk for gastrointestinal illness in Canadians.
- 25% of reported cases of enteric disease between 2015-2019 were related to international travel.
- Among these international travel related cases, the top three pathogens reported were *Campylobacter, Salmonella,* and *Giardia.*

Note: For this chapter, international travel-related outbreak cases and cases of *S.* Typhi and *S.* Paratyphi were excluded.

Burden related to travel

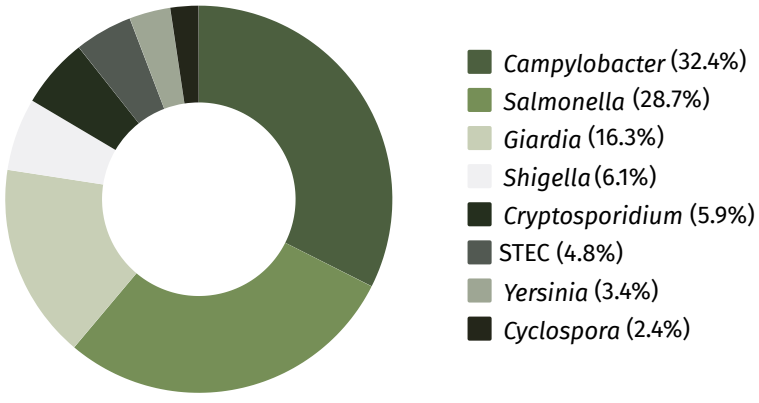


The percentage of FNC cases classified as international travel-related varied by pathogen (2015-2019).

*Other includes cases classified as endemic, outbreak-related, non-endemic, and lost to follow-up

International travel-related cases

The majority of international-travel related cases from 2015 to 2019 had ***Campylobacter*** (32%) or ***Salmonella*** (29%)



Region of Travel

Note: One case was missing region of travel and excluded

1	46%	Americas (Central, South, Caribbean)
2	32%	Asia
3	8%	Europe
4	7%	United States of America
5	4%	Africa
6	3%	Multiple/Other*

*Includes cases that travelled to multiple countries across different regions or cases that travelled to countries that fall under 'Oceania'.

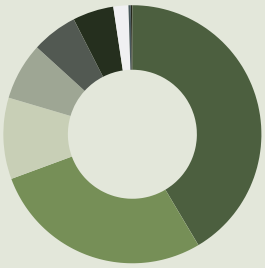
Top 6 countries and pathogen distribution (2015-2019)

*Excludes cases that travelled to multiple countries or cases with unknown country of travel

Canada

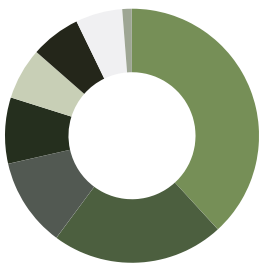
Endemic cases are displayed for country comparisons.

While the profile of pathogens acquired by international travel varied between countries, similarities can be seen within continents.



- *Campylobacter* (41.5%)
- *Salmonella* (27.9%)
- *Giardia* (10.2%)
- *Yersinia* (7.2%)
- STEC (5.7%)
- *Cryptosporidium* (5.1%)
- *Shigella* (1.9%)
- *Listeria* (0.3%)
- *Cyclospora* (0.2%)

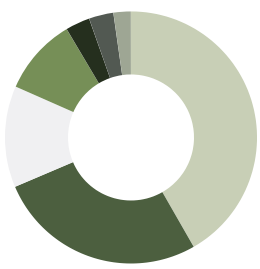
Mexico



- *Salmonella* (38.2%)
- *Campylobacter* (22.0%)
- STEC (11.3%)
- *Cryptosporidium* (8.4%)
- *Giardia* (6.6%)
- *Cyclospora* (6.4%)
- *Shigella* (6.0%)
- *Yersinia* (1.2%)

n = 487

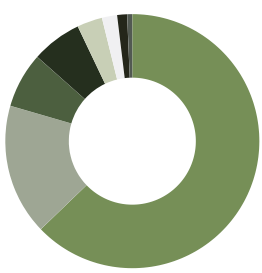
India



- *Giardia* (41.7%)
- *Campylobacter* (26.9%)
- *Shigella* (13.0%)
- *Salmonella* (9.9%)
- *Cryptosporidium* (3.1%)
- STEC (3.1%)
- *Yersinia* (2.2%)

n = 223

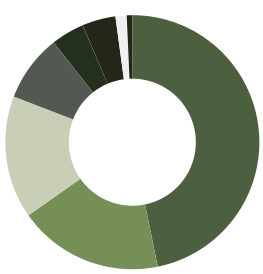
Cuba



- *Salmonella* (62.8%)
- *Yersinia* (16.7%)
- *Campylobacter* (7.1%)
- *Cryptosporidium* (6.4%)
- *Giardia* (3.2%)
- *Shigella* (1.9%)
- *Cyclospora* (1.3%)
- STEC (0.6%)

n = 156

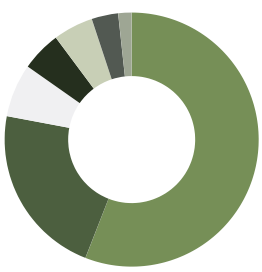
United States



- *Campylobacter* (46.8%)
- *Salmonella* (18.4%)
- *Giardia* (15.6%)
- STEC (8.5%)
- *Cryptosporidium* (4.3%)
- *Yersinia* (4.3%)
- *Shigella* (1.4%)
- *Cyclospora* (0.7%)

n = 141

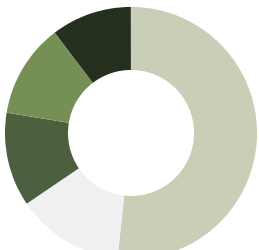
Dominican Republic



- *Salmonella* (55.9%)
- *Campylobacter* (22.0%)
- *Shigella* (6.8%)
- *Cryptosporidium* (5.1%)
- *Giardia* (5.1%)
- STEC (3.4%)
- *Yersinia* (1.7%)

n = 59

Pakistan



- *Giardia* (51.7%)
- *Shigella* (13.8%)
- *Campylobacter* (12.1%)
- *Salmonella* (12.1%)
- *Cryptosporidium* (10.3%)

n = 58

Farmers' Markets

Chapter Highlights

- For some meat-bacteria combinations, there is a **higher prevalence** of contamination on farmers' market meat samples than those sampled from grocery stores.

Farmers' market shopping has been identified as a growing trend in recent years across Canada.

In 2019, *Campylobacter, Salmonella* and STEC endemic cases* with onset dates from May to August in the ON and AB sites reported eating the following from a farmers' market/farm laneway:

8% produce **10%** eggs **8%** meat

*Data not available for *Listeria* cases.

In 2019, FNC continued targeted sampling of raw ground beef, raw chicken breast, and raw pork sausage sold at farmers' markets in AB and ON.

Alberta

Ontario

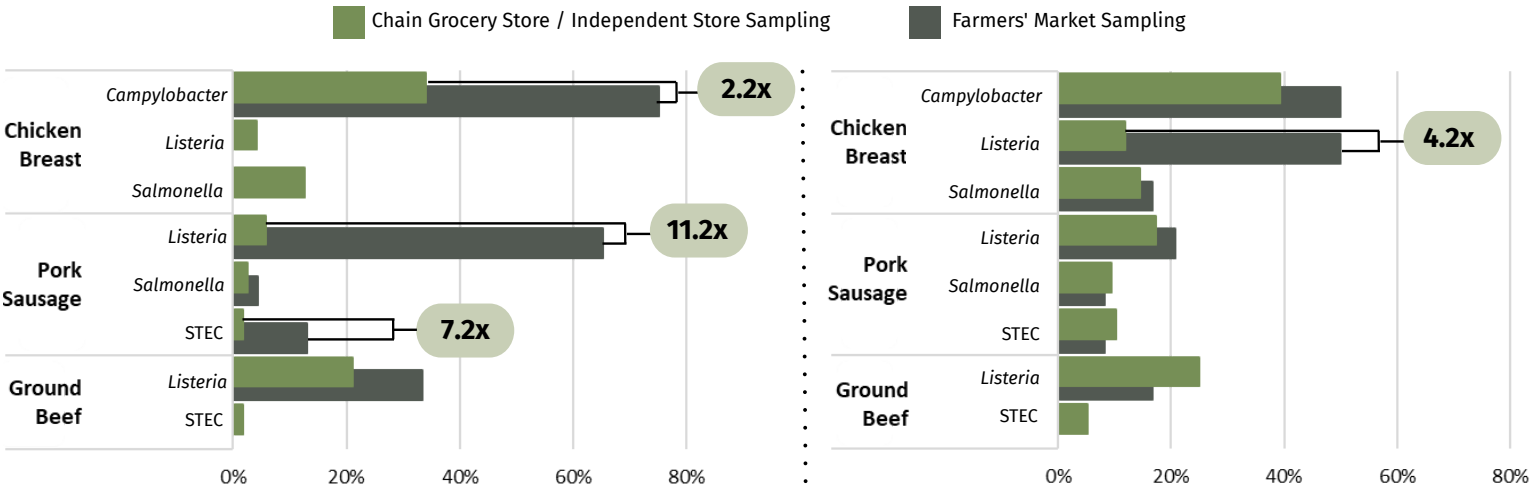
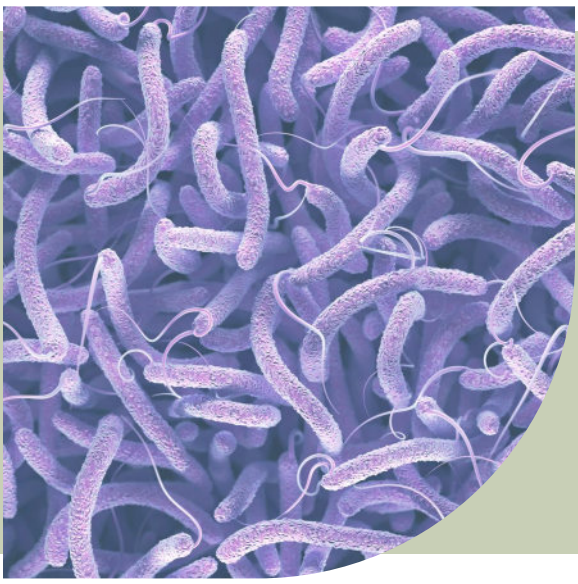


Figure 8.1. Comparison of farmers' market and chain grocery store/ independent store sampling in AB and ON.
Note. *Campylobacter* was not tested for in pork sausage samples; STEC was not tested for in chicken breast samples.

Elevated levels of bacteria identified among retail meat samples collected from farmers' markets as compared with those collected from chain or independent grocery stores represents a potential emerging source of enteric illness. It is recommended that raw meat, poultry, fish and seafood from any source, be thoroughly cooked according to national food safety recommendations.[1]

1) Government of Canada. Food Safety. Available at https://www.canada.ca/en/services/health/food-safety.html. Accessed August 2021.

Targeted Seafood Study



Chapter Highlights

- Mussels and oysters can be contaminated with *Vibrio* and/or other pathogens. Therefore, ongoing monitoring and testing of shellfish products by federal food safety partners is important to understand the risk for human infection.
- Since oysters are commonly eaten raw, they pose a higher risk for causing enteric illness.
- *Vibrio* infections can vary from mild to severe, and in some instances can lead to death, particularly in the immunocompromised.

Background

Raw shellfish is eaten by Canadians

According to Foodbook data, 0.4% of Canadians reported consuming raw oysters in the previous seven days.[1]

Eating raw shellfish can cause *Vibrio* infection

Bacteria on raw shellfish can cause intestinal tract upset ranging from mild to severe symptoms.

Two multi-jurisdictional outbreaks of *V. parahaemolyticus*

Within the past five years, two multi-jurisdictional outbreaks linked to consumption of raw shellfish have been reported in Canada. In the 2015 outbreak, 82 cases were reported, and more recently in the 2020 outbreak, 23 cases were reported. The majority of these illnesses were specifically linked to eating raw oysters.[2,3]

Methods

A targeted two-year retail seafood study sampled largely domestic raw mussels and oysters from 2018 to 2019. Samples were collected every two weeks from the BC, AB and ON FoodNet Canada sites and tested for the following pathogens: generic *E. coli*, *Listeria*, *Salmonella*, *Vibrio*, *Cryptosporidium*, *Giardia*, *Toxoplasma*, Hepatitis A and Norovirus.

Results

Retail store samples of raw mussels and oysters tested positive for bacteria, parasites[4] and viruses, including generic *E. coli*, *Listeria*, *Salmonella* (oysters only), *Vibrio*, *Cryptosporidium*, *Giardia*, *Toxoplasma* (mussels only) and Norovirus (mussels only).

The bacteria most frequently found in these samples was *Vibrio*.

Results continued

Of the *Vibrio* positive mussel and oyster isolates, approximately

2/3 were *V. alginolyticus*

and

1/4 were *V. parahaemolyticus*

The proportion of samples positive for each *Vibrio* strain:

Mussels (249 samples)		Oysters (128 samples)
47.0%	*V. alginolyticus*	63.3%
17.3%	*V. parahaemolyticus*	28.9%
3.2%	*V. cholerae*	7.0%
3.6%	*V. vulnificus*	2.3%
0.0%	*V. fluvialis*	0.8%

The prevalence of *Vibrio* in raw mussels and oysters was highest from

June to November

These seasonal trends align with NESP data (2018-2019), where the majority of clinical *Vibrio* isolates in Canada (82%) were reported from June to November.[5]

Discussion

Ongoing monitoring and testing of shellfish products by federal food safety partners is important because mussels and oysters can be contaminated with *Vibrio* and/or other pathogens, that when eaten raw, can cause illness.

The clinical implications of the *Vibrio* findings in this study are unknown since the amount of bacteria on the samples was not measured.

Since oysters are commonly eaten raw (e.g., freshly shucked), this is a potential source of enteric illness.

To avoid illness from *Vibrio*, follow safe food handling and cooking practices for mussels and oysters. For more information visit: https://www.canada.ca/en/health-canada/services/meat-poultry-fish-seafood-safety/shellfish-food-safety.html

1) Government of Canada. Foodbook Report. Public Health Agency of Canada, Guelph, 2015.
2) Government of Canada. Public Health Notice - Outbreak of *Vibrio parahaemolyticus* linked to raw shellfish. Final Update: October 15, 2015. Available at: https://www.canada.ca/en/public-health/services/public-health-notices/2015/public-health-notice-outbreak-vibrio-parahaemolyticus-linked-shellfish.html. Accessed September 2020.
3) Government of Canada. Public Health Notice - Outbreak of *Vibrio parahaemolyticus* infections linked to shellfish. Final Update: December 9, 2020. Available at: https://www.canada.ca/en/public-health/services/public-health-notices/2020/outbreak-vibrio-parahaemolyticus-infections-linked-shellfish.html. Accessed September 2020.
4) Merks, H., Boone, R., Janecko, N., Viswanathan, M., & Dixon, B.R. (2023). Foodborne protozoan parasites in fresh mussels and oysters purchased at retail in Canada. *International Journal of Food Microbiology*, 399, 110248.
5) Government of Canada. Personal correspondence with the National Enteric Surveillance Program (NESP) [data accessed May 9, 2023]. Public Health Agency of Canada, Guelph, 2023.

Appendices

APPENDIX A - 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), Alberta (Calgary and Central Zones of Alberta Health Services) and Quebec (Région sociosanitarie de la Montérégie). The Ontario (ON) site data collection began in August of 2014; data from the ON pilot sentinel site (Region of Waterloo) (2005–March 2014) were not included in this report. The British Columbia (BC) site was officially established in April 2010. The province of Alberta (AB) contains the third site and data collection began in June of 2014. The fourth site was established in Quebec (QC) in July 2019. Please refer to https://www.canada.ca/en/public-health/services/surveillance/foodnet-canada/sentinel-sites.html for further details on the site boundaries.

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 webpage (https://www.canada.ca/en/public-health/services/surveillance/canadian-integrated-program-antimicrobial-resistance-surveillance-cipars.html).

For further information on surveillance strategy, please refer to the FoodNet Canada Tables and Figures 2019 report.

APPENDIX B - DATA CONSIDERATIONS

As the Quebec sentinel site was established in July 2019, the data are only included in *Chapter 1: Introduction to the Quebec Sentinel Site* (page 11) and *Chapter 2: Listeria monocytogenes* (page 13).

Missing responses for the severity of illness and symptom questions from the human enteric case questionnaires were included in proportion calculations. However, missing responses were excluded from proportion calculations for all risk factor questions (e.g., food, water and animal exposures). As such, the denominators for risk factor proportions may vary within a specific pathogen.

Minimum spanning trees featured in *Chapter 3: Salmonella Enteritidis* (page 15) were generated in BioNumerics 7.6.3.[1] This is a bioinformatics software platform using the whole genome multilocus sequence typing (wgMLST) analysis method.

In 2019, the farm and retail components were active across all sentinel sites in ON, AB, BC, and QC whereas the water component was active in ON, AB and BC. A comprehensive sampling table by component is provided in Appendix C. Throughout the report, farm results are reported at the sample-level which includes all manure samples collected on each farm. For farm-level results, please refer to the FoodNet Canada Tables and Figures 2019 Report.

1) BioNumerics (version 7.6.3), created by bioMérieux (Applied Maths NV, St Martens Latem, Belgium).

APPENDIX C - SAMPLING TABLE BY COMPONENT

Site	Year	Retail	Farm	Water
BC	**2015**	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, fresh berries, fresh herbs	Broiler chickens, turkeys	Irrigation
	2016	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, ground pork, ready-to-eat slaws & vegetables	Broiler chickens, turkeys	Irrigation
	2017	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, veal, frozen berries	Broiler chickens, turkeys	Irrigation
	2018	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, pork sausage, bivalve molluscs	Broiler chickens, turkeys	Irrigation
	2019	**Ground beef, skinless chicken breast, frozen breaded chicken products (cooked/uncooked), pork sausage, bivalve molluscs**	**Broiler chickens, turkeys, dairy***	**Irrigation**
AB	**2015**	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, fresh berries, fresh herbs	Broiler chickens, feedlot beef	Irrigation
	2016	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, ground pork, ready-to-eat slaws & vegetables	Broiler chickens, feedlot beef	Irrigation
	2017	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, veal, frozen berries	Broiler chickens, feedlot beef	Irrigation
	2018	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, pork sausage, bivalve molluscs	Broiler chickens, turkeys, feedlot beef	Irrigation
	2019	**Ground beef, skinless chicken breast, frozen breaded chicken products (cooked/uncooked), pork sausage, bivalve molluscs**	**Broiler chickens, swine, turkeys, feedlot beef, dairy***	**Irrigation**
ON	**2015**	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, fresh berries, fresh herbs	Broiler chickens, swine	Surface
	2016	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, ground pork, ready-to-eat slaws & vegetables	Broiler chickens, layer chickens, turkeys, swine	Not Tested
	2017	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, veal, frozen berries	Broiler chickens, layer chickens, turkeys, swine	Not Tested
	2018	Ground beef, skinless chicken breast, frozen uncooked breaded chicken products, pork sausage, bivalve molluscs	Broiler chickens, turkeys, swine	Not Tested
	2019	**Ground beef, skinless chicken breast, frozen breaded chicken products (cooked/uncooked), pork sausage, bivalve molluscs**	**Broiler chickens, swine, turkeys, dairy***	**Surface**
QC	**2019**	**Ground beef, skinless chicken breast, frozen breaded chicken products (cooked/uncooked), pork sausage**	**Broiler chickens, swine, turkeys, dairy***	**Not tested**

*Dairy sampling was a new farm commodity added in 2019. Due to delays in sample testing, these data are not presented in the 2019 FNC Reports.