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C-EnterNet 2008 Annual Report

...National Integrated Enteric Pathogen Surveillance Program

Canada

To promote and protect the health of Canadians through leadership, partnership, innovation and action in public health.

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C-EnterNet Annual Report
2008

...National Integrated Enteric Pathogen Surveillance Program

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Executive Summary

C-EnterNet is a multi-partner program facilitated by the Public Health Agency of Canada to detect changes in trends in human enteric disease and in levels of pathogen exposure from food, animal and water sources in Canada. The design is based on a sentinel site surveillance model and involves enhanced epidemiological and microbiological surveillance of reportable human enteric diseases in the sentinel communities. In addition, the active surveillance of pathogens in retail food, water and food animal operations are designed to be carried out within the same geographical areas. This C-EnterNet Annual Report presents the results from the surveillance data collected from its first sentinel site, the Regional Municipality of Waterloo, Ontario, during the year 2008 thanks to the multiple partnerships coordinated there to collect all the data from the human side and the non human side.

A total of 462 human cases of 11 bacterial (6), viral (1) and parasitic (4) enteric diseases were reported to the local public health authority within Sentinel Site 1 during 2008. The number of outbreak-related cases was higher in 2008 and comprised 7% (31) of the cases reported, while 25% (116) were travel-related and 68% (315) were classified as endemic. Endemic cases include those acquired locally or during travel within Canada. The four most frequently reported diseases (campylobacteriosis, salmonellosis, giardiasis, and amoebiasis) in Sentinel Site 1 in 2008 accounted for 87% of the endemic cases.

In 2008, travelling abroad appeared to be an important risk factor for reported acute enteric diseases, as observed in previous years. The travel-related proportion of cases, compared with endemic, was higher for shigellosis (83%) and cyclosporiasis (67%). Thirty-five percent of *Salmonella Enteritidis* infections were contracted abroad, while cases of *S.* Typhimurium and *S.* Newport were primarily of domestic origin (12/14 and 4/6, respectively). Based on PFGE subtyping results, several specific subtypes were associated with the travel-related cases.

The identification of potential risk factors among endemic cases that were identified through follow-up in the C-EnterNet site warrants further investigation. For example, using a private well as the main water source, swimming, contact with household pets, and living on a farm or in a rural area are all potential risk factors for giardiasis and for cryptosporidiosis. Using municipal water sources, drinking unpasteurized milk and eating at restaurants appears to be risk factors for campylobacteriosis, whereas pet exposure to reptiles may be a risk factor for salmonellosis.

Within the retail food component, surveillance continued as in 2007 except a change for sampling retail chicken to skin-off chicken breasts instead of skin-on. The influence of this change is noted in the increase in *Campylobacter* detected on retail chicken. Within the on-farm component, a more sensitive detection method for *Campylobacter* was implemented, having a measurable effect on prevalence for the year. Within the water component, new laboratories were contracted for the analytical work in March of 2008, which had an influence on pathogen prevalence estimates within the local watershed, despite the standardization of microbiological methods.

Pathogens capable of causing enteric diseases in humans were found in the local dairy, swine, beef and broiler chicken operations sampled in 2008, to various levels depending on the food commodity and the pathogen. *Giardia* and *Cryptosporidium* occurred frequently in untreated surface water, and several *Salmonella* serotypes, verotoxigenic *Escherichia coli* (VTEC), and *Campylobacter* were occasionally detected in the local watershed. *Campylobacter*, *Salmonella*, and *Listeria* were detected on meats (pork, chicken and beef) sold at retail, raw chicken meat generally being more often contaminated. *Yersinia* was found in retail pork, but all strains were non-pathogenic. VTEC was detected in a small number of beef samples.

Temporal trends were analysed for 2005-2008 surveillance data. Analysis of endemic cases by month showed a potential seasonal cycle of disease occurrence, with more cases during summer and fall, with the exception of yersiniosis. Retail chicken contamination by *Campylobacter* was significantly lower in winter compared to other seasons, while retail pork contamination by *Yersinia* was more frequent in the summer than the fall. *Yersinia* contamination rates also differed by year, more common in 2006 compared to 2007 or 2008. Prevalence of *Campylobacter* increased significantly in swine, dairy and beef at the farm level in 2008 compared to 2007 and 2006. However, the increase is likely due to changes in laboratory methodology that were implemented in 2008. No statistically significant year or season effects were observed within the water component.

Source attribution activities are ongoing. C-EnterNet has produced two quantitative microbial risk assessments to quantify the public health risk for cryptosporidiosis in Sentinel Site 1. Analysis of travel-related enteric disease is being done to quantify the role of travel in the burden of enteric disease. In addition, an expert elicitation survey was implemented to determine what food safety experts consider to be most important regarding enteric disease and public health risk. Case-control analyses are also planned for the past four years of surveillance data from Sentinel Site 1 for twelve enteric diseases.

Table of Contents

List of Figures

List of Tables

1. Introduction

C-EnterNet is a multi-partner sentinel site surveillance program facilitated by the Public Health Agency of Canada. Its core objectives are to: 1) detect changes in trends in human enteric disease and in levels of pathogen exposure from food, animal and water sources in a defined population; 2) generate human illness attribution values (proportion of human cases due to exposure via water, food and animals); and 3) improve the analysis, interpretation and reporting of laboratory and epidemiological data for public health, water and agri-food purposes.

Each sentinel site is based on a unique partnership with the local public health unit, 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 first sentinel site – the Region of Waterloo, Ontario – is a community of approximately 500,000 residents, with a mix of urban and rural activities, and innovation in public health and water conservation. A second site was officially launched in the Fraser Health Authority, British Columbia in June 2010.

C-EnterNet conducts continuous and episodic surveillance activities in four components: human, food, water, and food animals. For a description of the suite of pathogen testing see Appendix A. Continuous surveillance occurs throughout the year to identify trends in human disease occurrence, exposure sources and source attribution for eleven enteric pathogens. Episodic surveillance activities are limited in time and provide specific information to complement the continuous activities. Detailed descriptions of the C-EnterNet design, laboratory methods and the enteric disease case questionnaires, are available at our website (http://www.phac-aspc.gc.ca/c-enternet/index.html).

The 2008 report begins with a summary of the reported infectious enteric disease cases in humans in Sentinel Site 1, summarizing the outbreak- and travel-related cases separately from the endemic cases (Chapter 2). Chapters 3 through 8 provide information on human cases and exposure source surveillance for 2008 by pathogen, as in previous years. These chapters provide detailed epidemiological and laboratory information for the year from the human endemic cases and active surveillance results for the agriculture, retail food and water components.

This year, the report also includes a section describing the temporal variations observed in the human cases and among the potential exposures (Chapter 9). All observations and analyses dealing with trends and seasonality are addressed in this section.

The surveillance data provided in this report only relate to the first sentinel site. Therefore, the accuracy of generalizing these results beyond this community decreases when moving further from the specific geographical area. As additional sentinel sites are implemented, comprehensive information from laboratory and epidemiological data within and between sites will provide more representative national trends in enteric disease occurrence and among exposure sources. This will ultimately provide human illness attribution data for Canada.

C-EnterNet's second objective is to address the issue of source attribution for cases of infectious gastroenteritis. There are a number of methods that are internationally recognized to address the complex task of source attribution, including: a) analysis of outbreak data; b) comparisons of pathogen profiles among sources and human cases; c) case control studies; d) risk assessments, and; e) expert opinion. Despite the pilot nature of the program, C-EnterNet has made significant progress in refining the Canadian approach to source attribution, even with the limited amount of data currently available. C-EnterNet's approaches to generating estimates of human illness attribution are outlined in Chapter 10.

2. Human Case Summary

2.1 Overview of Human Cases

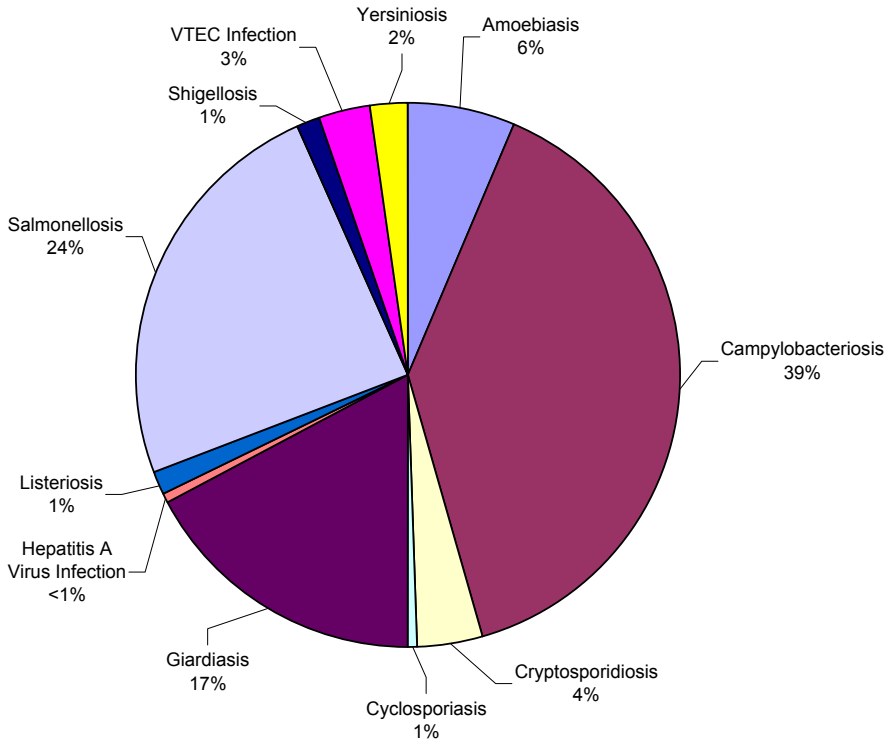
A total of 462 cases of 11 bacterial, viral and parasitic enteric diseases were reported to the local public health authorities within Sentinel Site 1 in 2008 (Table 2.1). The three most frequently reported diseases (salmonellosis, campylobacteriosis and giardiasis) accounted for 81% of those cases (Figure 2.1).

Information on potential exposures was obtained for 85% (top 7 of the 11 enteric diseases listed in Table 2.1) of the reported cases within the sentinel site in 2008. Public health inspectors administered a standardized questionnaire to the cases or proxy respondents. Preliminary analyses of this information were used to determine case status (travel versus endemic) and compare exposures (Appendix B).

TABLE 2.1
Number of cases and incidence rates per 100,000 person-years of laboratory-confirmed enteric diseases in Sentinel Site 1 in 2008

Disease	Exposure Period	Number of Cases				Incidence Rate	
		Outbreak	Travel	Endemic	Total	Endemic	Total
Amoebiasis	2-4 weeks	0	11	19	**30**	3.79	**5.98**
Campylobacteriosis	10 days	26	32	123	**181**	24.51	**36.07**
Cryptosporidiosis	1-12 days	0	2	15	**17**	2.99	**3.39**
Cyclosporiasis	1-12 days	0	2	1	**3**	0.20	**0.60**
Giardiasis	26 days	0	32	48	**80**	9.57	**15.94**
Hepatitis A	15-50 days	0	1	1	**2**	0.20	**0.40**
Listeriosis	3-70 days	3	0	3	**6**	0.60	**1.20**
Salmonellosis	3 days	1	27	84	**112**	16.74	**22.32**
Shigellosis	1-10 or 8-14 days	0	5	1	**6**	0.20	**1.20**
Verotoxigenic *E. coli* (VTEC)	2-10 days	1	1	13	**15**	2.59	**2.99**
Yersiniosis	10 days	0	3	7	**10**	1.39	**1.99**
Total		**31**	**116**	**315**	**462**		

FIGURE 2.1
Relative proportion of enteric diseases reported in Sentinel Site 1 in 2008



2.2 Outbreak-associated Cases

In 2008, there was an increase in the number of outbreak-associated enteric disease, with a total of 32 reported cases compared to the previous two years where 4 cases each were reported. The majority of outbreak-associated cases (26/32) in 2008 were *Campylobacter* cases (all cases linked to one event), whereas in previous years, no *Campylobacter*-associated outbreaks were reported. The one *E. coli* outbreak case was associated with a multi-jurisdictional outbreak, with no source identified. The one *Salmonella* outbreak case was associated with an increase provincially in Ontario and Quebec (*S.* Bovismorbificans) where a number of sources of infection were identified. There were a total of three *Listeria* associated outbreak cases linked to the Canada-wide outbreak. One listeriosis case linked to an outbreak in Québec was associated with unpasteurized cheese.

In 2008, 51 institutional enteric outbreaks were identified and investigated. Twenty-five outbreaks occurred in childcare centres (CCC), 14 in long-term care facilities (LTCF), 6 in hospitals, and 6 in residential facilities/group homes. A causative agent was identified in 16% of outbreaks in residential facilities/group homes and 7% of outbreaks in LTCF. LTCF outbreaks, where the causative agent was identified, were due to calicivirus, and for residential facilities, rotavirus was identified.

2.3 Travel-related Cases

Of the reported cases, 25% (117/462) were classified as travel-related (Table 2.1). Salmonellosis, giardiasis and campylobacteriosis were the three most common diseases, contributing to 79% of the travel-related cases. Most of the cases had visited Mexico and the Caribbean region or Asia prior to acquiring their illness (Table 2.2); a trend that possibly reflects travel preferences of the sentinel site population. Over half of the travel-related *Salmonella* cases (16/27) had been to Mexico and the Caribbean region whereas giardiasis was the most frequent disease in people who had travelled to Africa (10/19) and Asia (14/34). There was only one travel-associated VTEC infection reported in 2008, suggesting that *E. coli* O157:H7 is a domestically-acquired infection.

TABLE 2.2
Travel-related cases in Sentinel Site 1 in 2008

Disease	Africa	Asia	Europe	Mexico & Caribbean	USA	Multiple Destinations & Others	Total
Amoebiasis	2	5	1	2	1	0	**11 (9%)**
Campylobacteriosis	5	7	9	8	3	0	**32 (28%)**
Cryptosporidiosis	1	1	0	0	0	0	**2 (2%)**
Cyclosporiasis	0	0	0	2	0	0	**2 (2%)**
Giardiasis	10	14	1	4	3	0	**32 (28%)**
Hepatitis A	0	1	0	0	0	0	**1 (1%)**
Salmonellosis	0	5	3	16	1	2	**27 (23%)**
Shigellosis	1	0	0	3	1	0	**5 (4%)**
Verotoxigenic *E. coli*	0	0	0	0	1	0	**1 (1%)**
Yersiniosis	0	0	0	3	0	0	**3 (3%)**
Total	19 (16%)	33 (28%)	14 (12%)	38 (33%)	10 (9%)	2 (2%)	**116 (100%)**

2.4 Endemic Cases

The data presented in the remainder of this report refer to endemic cases in Sentinel Site 1. While outbreak cases are also attributed to local sources of exposure, they represent unusual events. By excluding outbreak and travel cases, more stable estimates of disease incidence are provided, and attribution estimates will not be overly influenced by unusual events. Note that reported national and provincial annual incidence rates for each pathogen include both endemic and travel cases and are from 2008.

In each of the following chapters, potential exposures are noted when the proportion for the specific disease is at least 5% greater than the exposure for other enteric diseases combined. Due to the small number of cases each year in the sentinel site, exposure information was not stratified by age or gender. The exposures reported here represent overall exposures for the general population, and are not valid for age-specific subgroups (e.g. children). Refer to the C-EnterNet website (http://www.phac-aspc.gc.ca/c-enternet/index.html) to see the complete list of exposures from the worksheet (questionnaire) used in Sentinel Site 1 for case follow-up investigations.

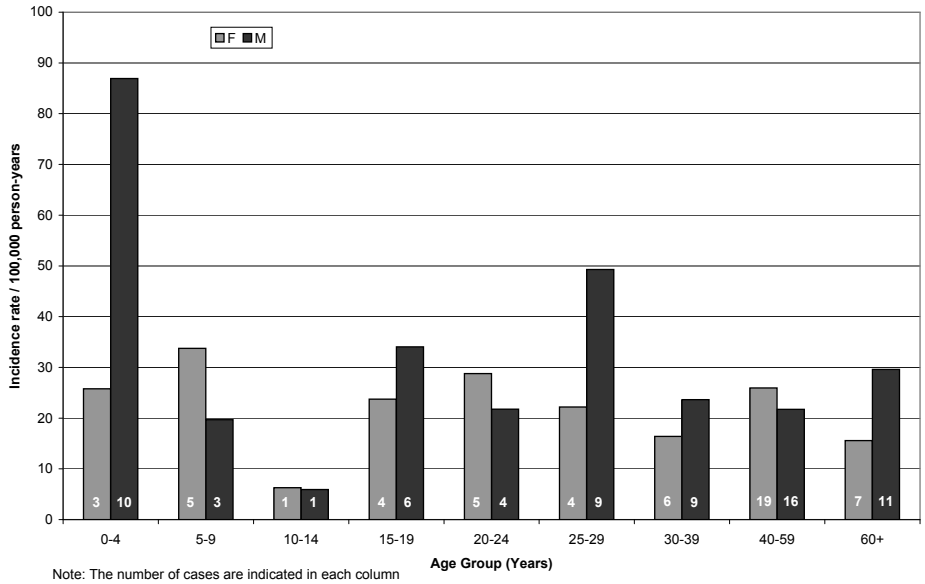
3. Campylobacter

3.1 Human Cases

In 2008, there were a total of 181 (36.1/100,000 person-years) reported cases of *Campylobacter* infection. Of these 181 cases, 18% (32/181) were travel-related (6.4/100,000 person-years), 14% (26/181) were outbreak related (5.2/100,000 person-years), and 68% (123/181) were classified as endemic (24.5/100,000 person-years). In comparison, the annual incidence rates for campylobacteriosis in 2008 in Canada and Ontario were 28.4/100,000 and 29.4/100,000, respectively.[1]

The age- and gender-specific endemic incidence rates were highest in males less than 5 years of age (Figure 3.1). A breakdown by gender shows that 54 cases were female (21.4/100,000) and 69 were male (27.6/100,000).

FIGURE 3.1
Incidence rates of endemic campylobacteriosis in Sentinel Site 1 by gender and age group in 2008



Note: The number of cases are indicated in each column

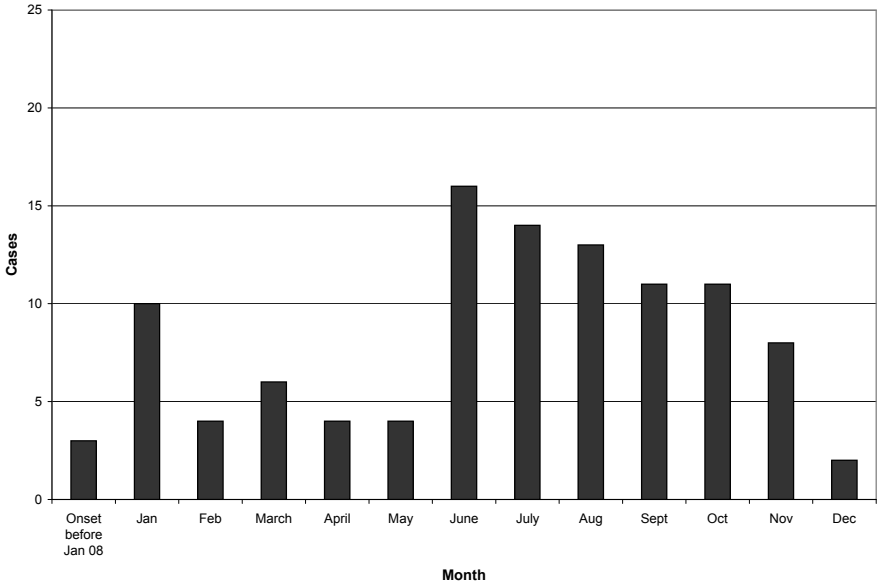
The majority (97%) of endemic campylobacteriosis cases were identified as *C. jejuni* while *C. coli* and *C. fetus s.s. fetus* accounted for the remaining 3% (Table 3.1).

Characterization of *Campylobacter* in humans and other sources in 2008 revealed a wide range of genotypes with no strains specific to any component or commodity. In 2008, genotyping and antimicrobial resistance testing continued for human samples, but was discontinued for farm and retail samples, due in part to the lack of strain specificity by component, as well as funding and laboratory capacity.

1 National Notifiable Disease representative (Adam Medaglia) 2008 [personal communication]. Note: 2008 numbers contain travel and endemic cases, do not include Nunavut or the Northwest Territories, and are preliminary and subject to change.

The incidence rate of endemic *Campylobacter* was higher during the summer months (June, July, August) than during the spring (March, April, May; Fisher's Exact Test: $p<0.05$) and winter (December, January, February; $p<0.05$). Also, the incidence rate of endemic *Campylobacter* was higher in the fall (September, October, November) than in the spring ($p=0.02$) (Figure 3.2).

FIGURE 3.2
Temporal distribution of human endemic *Campylobacter* cases in Sentinel Site 1 reported in 2008



Eighty-nine percent (110/123) of the endemic *Campylobacter* cases provided potential exposure information for the 10 days prior to onset of illness (Appendix B). Use of municipal water source (66%), eating in a restaurant (45%), attending a barbeque (30%), eating undercooked food (10%), and visiting farm animal areas (13%) were reported more frequently among *Campylobacter* cases than among other enteric cases. *Campylobacter* cases had a higher proportion of household pet contact (67%), especially with dogs (47%) than other enteric cases.

TABLE 3.1
***Campylobacter* detection and speciation data (culture-based methods) from integrated surveillance activities in Sentinel Site 1 in 2008**

	Human	Retail Food			Food Animals (Manure)				Untreated Surface Water
	Endemic Cases	Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Grand River
Detection		Pork chop	Chicken breast	Ground beef	30 Farms	25 Farms	28 Farms	28 Farms	5 sample points on Grand River
# tested	Unknown	178	185	180	111	100	112	112	100
# positive	123	0	80	2	76 (28 farms)	10 (3 farms)	85 (27 farms)	84 (26 farms)	24
% positive		0%	43%	1%	68%	10%	76%	75%	24%
Subtyping									
# subtyped	121		80	2	76	10	85	84	22
C. coli	2 2%		11 14%	1 50%	66 87%		17 20%	5 6%	
C. jejuni	118 97%		69 86%		5 7%	10 100%	66 78%	73 87%	18 (A,B,C,D) 82%
C. lari				1 50%					4 (A,B,C,D) 18%
C. upsaliensis									
Other	1 1%				5 7%		2 2%	6 7%	

Water Sampling Locations in Grand River Watershed:
A - Canagagigue Creek
B - Conestogo River
C - Upper Grand River
D - Grand River, near drinking water intake
E - Grand River, near one wastewater treatment plant effluent point

3.2 Exposure Surveillance

Retail

The number of *Campylobacter* isolates from chicken breasts rose significantly from 2007 to 2008 (P = 0.007) and likely reflects a change in sampling methodology from "skin-on" samples in 2007 to "skin-off" in 2008 (Appendix C).[2] Only 2 ground beef samples tested positive for *Campylobacter* and no raw retail pork samples tested positive (Table 3.1). *C. jejuni* was the predominant species on the chicken samples positive for *Campylobacter*. In general, of the retail samples positive for *Campylobacter*, the enumeration levels were low (Appendix D).

On-Farm

In January 2008, a culture-based method with increased sensitivity for *Campylobacter* detection was implemented in C-EnterNet's on-farm surveillance component. As a result, there was a significant increase in *Campylobacter* detection rates in the beef, dairy and swine manure. In contrast, *Campylobacter* was isolated from only 10% of samples collected on broiler chicken farms. Interestingly, *C. jejuni* was detected at a higher frequency in some commodities including swine manure, where it had not previously been detected. A significant rise in the proportion of samples with *C. jejuni* was also observed in dairy manure for 2008.

Water

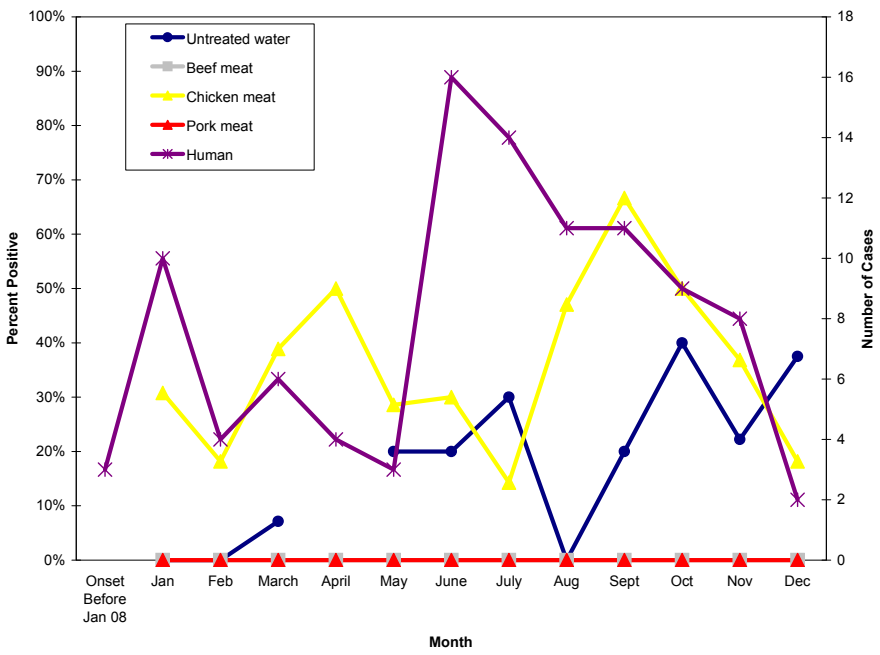
In 2008, *C. jejuni* constituted the greatest proportion of the species isolated. Also, no *C. coli* were detected in 2008. It is important to note that the culture method may underestimate bacteria levels because it cannot detect low numbers of organisms present in the sample matrix and cannot detect non-culturable but viable cells (NCBV).

3.3 Temporal Distribution

A peak in the incidence of campylobacteriosis (*C. jejuni* infections was observed in January, followed by a higher peak during the summer months). Higher prevalence of *C. jejuni* was observed for retail chicken and surface water compared to other exposure sources. Prevalence in raw retail chicken peaked in the early fall following the rise in human incidence, whereas prevalence in surface water appeared to be random throughout the year (Figure 3.3).

2 These results differ from the analyses presented in Chapter 10. This difference is attributed to different analysis objectives. The temporal trend analysis presented in Chapter 10 included data from 2005-2008, as well as some additional targeted study data that mixed skin-on and skin-off samples within years. The data presented here are specific to determining the effect of retail chicken sample type (skin-on, 2007; skin-off, 2008) on prevalence.

FIGURE 3.3
Seasonal distribution of *Campylobacter jejuni* contamination from all sources in Sentinel Site 1 in 2008



3.4 Summary of *Campylobacter* Results

- Campylobacteriosis is the most frequently reported enteric disease in Sentinel Site 1.
- *C. jejuni* is the most common species associated with human campylobacteriosis.
- Raw chicken meat contaminated with *Campylobacter* carries a high proportion of *C. jejuni*. Retail pork and beef are rarely contaminated with *Campylobacter*.
- *C. jejuni* was newly detected in swine farms and constituted the highest proportion of positive isolates on beef and dairy farms.
- *C. coli* was detected on swine, beef and dairy farms, but not on poultry farms.
- *C. jejuni* and *C. lari* were detected in untreated surface water; *C. jejuni* was the predominant species.

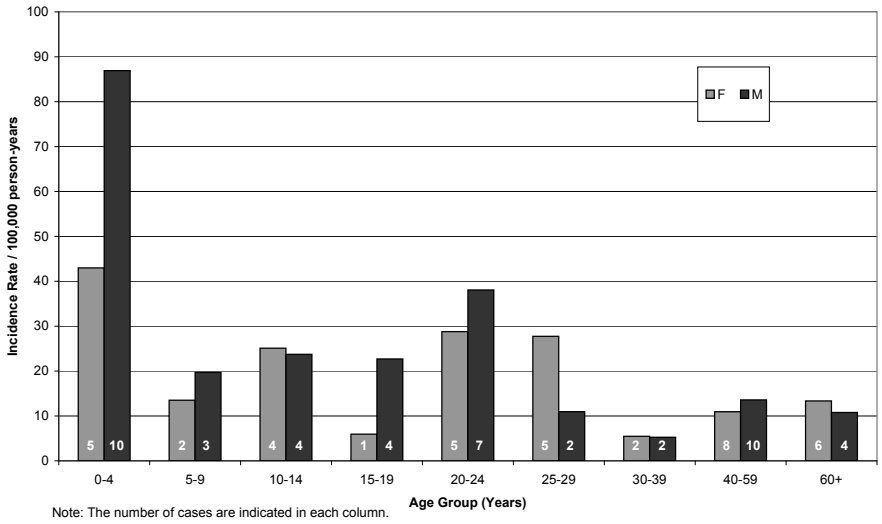
4. *Salmonella*

4.1 Human Cases

In 2008, a total of 112 cases of salmonellosis were reported (22.3/100,000 person-years). Of these 112 cases, 24% (27) were travel-related, 1% (1) were outbreak-related and 75% (84) were classified as endemic (16.7/100,000 person-years). In comparison, the annual incidence rates for salmonellosis in 2008 in Canada and Ontario were 18.2/100,000 and 18.9/100,000, respectively.[3]

The age, gender and seasonal distributions fit patterns that have been historically observed for *Salmonella* (Figures 4.1 and 4.2).

FIGURE 4.1
Incidence rates of endemic salmonellosis cases by gender and age group in Sentinel Site 1 in 2008



Note: The number of cases are indicated in each column.

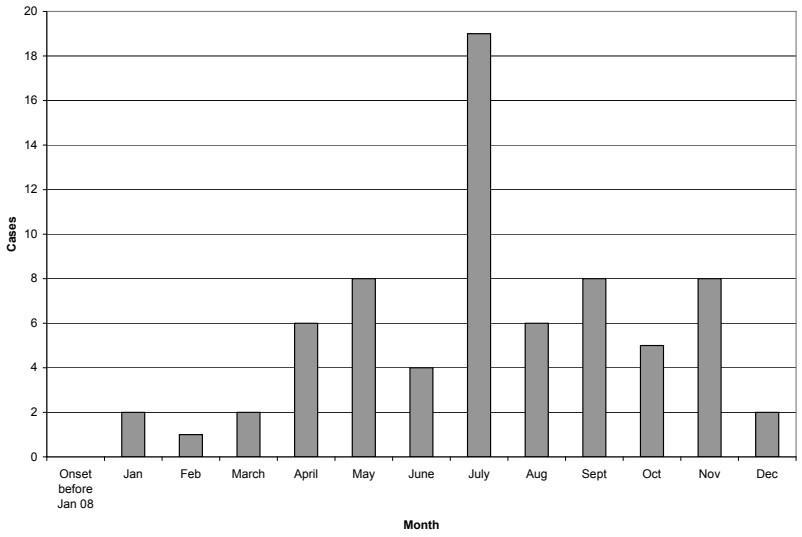
There were 28 different serotypes detected among the 82 endemic cases in 2008, for which the serotype was known. The top four serotypes, *S.* Enteritidis, *S.* Typhimurium, *S.* Infantis, and *S.* Newport comprised 65% of isolates that were serotyped (Table 4.1). Comparison of travel versus endemic *Salmonella* cases indicated that *S.* Typhimurium (12/14) and *S.* Newport (4/6) serotypes were primarily of domestic origin, while over one third of (15/43) the *S.* Enteriditis cases were travel-related.

Potential exposure information for the three days prior to onset of illness was collected for 86% (72/84) of the reported endemic *Salmonella* infections (Appendix B). Few meaningful risk factors were identified from the case-case comparison; however, household pet exposure to reptiles did appear to be a risk factor for *Salmonella* cases.

3 National Notifiable Disease representative (Adam Meduglia) 2008 [personal communication]. Note: 2008 numbers contain travel and endemic cases, do not include Nunavut or the Northwest Territories, and are preliminary and subject to change.

The incidence rate of endemic *Salmonella* was higher during the spring (March, April, May; Fisher's Exact Test: p=0.03), summer (June, July, August; p<0.05) and fall (September, October, November; p=0.01) months than during the winter months (December, January, February) (Figure 4.2).

FIGURE 4.2
Temporal distribution of human endemic salmonellosis cases in Sentinel Site 1 reported in 2008



4.2 Exposure Surveillance

Retail

Salmonella was commonly detected on raw chicken breasts with the skin removed, but rarely found on raw pork chops or ground beef (Table 4.1). Although retail sampling of chicken breast switched from "skin-on" to "skin-off", the prevalence of *Salmonella* did not change (see Appendix C). In general, low enumeration levels of *Salmonella* were detected on the retail meats with the exception of a single chicken sample (Appendix D).

The three most frequent serotypes found on chicken meat included: *S.* Kentucky, *S.* Heidelberg and *S.* Enteritidis (the top serotypes detected in humans) (Table 4.1). The single serotypes found on pork chops and ground beef were *S.* Kentucky and *S.* Infantis, respectively.

On-Farm

The prevalence of *Salmonella* in pooled manure samples from swine, broiler chickens, beef and dairy farms in 2008 was 28%, 62%, 6%, and 8%, respectively (Table 4.1). On broiler chicken farms, *S.* Kentucky was the most common serotype detected, while *S.* Hadar and *S.* serovar 1:4,12:i:- were tied for second. On swine farms, *S.* Typhimurium and *S.* Derby were the most frequently isolated *Salmonella* serotypes (Table 4.1). The most frequently isolated *Salmonella* serotypes from dairy operations were *S.* Kentucky and *S.* Typhimurium. On beef farms, *S.* Cerro and *S.* Enteritidis were detected.

Water

Of the 34 isolates subtyped, *S.* Kentucky and *S.* Newport were the most frequently detected serotypes, closely followed by *S.* Typhimurium and *S.* Oranienberg (Table 4.1). *Salmonella* was most frequently detected at sample site E (close to a waste water treatment effluent point on the Grand River). One or more serotypes were detected at all sample locations.

TABLE 4.1
Salmonella detection and serotyping data (culture-based methods) from the integrated surveillance activities in Sentinel Site 1 in 2008

	Endemic Cases	Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Grand River
		Pork chop	Chicken breast	Ground beef					5 sample points on Grand River
Detection									
# tested	Unknown	178	185	180	111	100	112	112	100
# positive	84	1	60	1	31	62	7	9	34
% positive		1%	32%	1%	28%	62%	6%	8%	34%
Serotyping[b]									
# serotyped	**76**	**1**	**60**	**1**	**33***	**62**	**7**	**9**	**34**
Agona					2				
Berta	1								
Branderup	1								
Cerro							4	1	1 (A)
Derby	1				5				
Enteritidis	8								2(A,B)
Enteritidis PT1a	1								
Enteritidis PT4	2								
Enteritidis PT5b	1								
Enteritidis PT8	9		5			1	1		
Enteritidis PT13	1					1			
Enteritidis PT13a	6		2						
Enteritidis Atypical						1			
Give					1				1 (E)
Group B	3								
Hadar			5			4			
Havana	1							1	
Heidelberg			14			1			
I:4,12:i:-					3	4			
I:23:-:I,w					3				
I:ROUGH-O:i:z6						3			
Infantis	4		2	1	1				1 (D)
Indiana									2 (A)
Kentucky	1	1	22		1	39		5	7 (A,D,E)
Kiambu			1			1			1(A)
London	1				2				
Mbandaka	2		1			2			
Montevideo	1		1						
Newport	4								5 (B,D,E)
Ohio					2				
Oranienberg									4 (B,E)
Poona	2								
Schwarzengrund	1					3			1(A)
Senftenberg			1						1(C)
Thompson	1		1						2 (E)
Typhimurium									4(A,B,C)
Typhimurium DT104[a]			1					2	
Typhimurium 2					1				
Typhimurium 8	1								
Typhiumurium 10	1								
Typhimurium 12	1								
Typhimurium U302[a]	1				1				
Typhimurium 104b[a]	2				5				
Typhimurium 108	4		1			1			
Typhimurium 120	1								
Typhimurium 135			2						
Typhimurium 193	1								
Typhimurium 208[a]			1						
Typhimurium Untypable[a]					4				
Uganda					1		1		
Other[b]	12				1	1	1		2

Serotype ranking within each component
- most frequent serotype
- second most frequent serotype
- third most frequent serotype

[a] Includes var 5-.

[b] Serotypes that were identified once in a single component are listed below and are NOT listed in Table 4.1:
Human: Arizona, Chester, Flutern, Jangwani, Java, Litchfield, Muenchen, Muenster, Oslo, Rubislaw, Saintpaul, ssp enterica (I) OR: (Z)
Swine operations: Worthington
Chicken operations: Livingstone
Beef operations: I:28:y:-
Untreated water: I:6,7:-;1,5 6,7:-5 (B)

Water Sampling Locations in Grand River Watershed:
A - Canagagigue Creek
B - Conestogo River
C - Upper Grand River
D - Grand River, near drinking water intake
E - Grand River, near one wastewater treatment plant effluent point

* Two manure pits were sampled twice each, resulting in two additional *Salmonella* isolates for subtyping

The PFGE patterns of *Salmonella* isolated in 2008 by the C-EnterNet program were compared to patterns identified in 2008 in the PulseNet Canada National Databases. PulseNet houses clinical isolates that are uploaded by provincial public health labs during routine laboratory-based surveillance[4]. The C-EnterNet PFGE results presented herein are for 2008 only, although for comparison we have included PFGE results for isolates from previous surveillance years (2005-2007) in parentheses in Table 4.2.

Proportionally, C-EnterNet identified a higher diversity of serotypes among the human cases than is seen nationally, based on PulseNet data. Approximately twenty-five percent of *Salmonella* serotypes identified nationally were observed in the C-EnterNet human cases in 2008. *Salmonella* serotypes identified among the human cases were representative of the national occurrence of Enteritidis and Typhimurium. Nationally, *Salmonella* Heidelberg is one of the top serotypes identified in human cases. However, it was not detected in any human case in Sentinel Site 1 in 2008.

The 281 *Salmonella* isolates from 2008 C-EnterNet surveillance among all components represented 115 unique PFGE patterns. Five of these PFGE patterns matched a human case and a source (water, animal or food). These included; KenXAI.0012 (Kentucky); SENXAI.0003, SENXAI.0006, and SENXAI.0038 (Enteritidis); and STXAI.0312 (Typhimurium) (Table 4.2).

Retail pork, ground beef, and dairy manure isolates rarely match patterns commonly isolated from human cases in Canada, according to the PulseNet Canada database.

Chicken manure isolates included the most common patterns of *S.* Enteritidis, Heidelberg and Typhimurium (among human cases), although most of the isolates were PFGE patterns of *S.* Kentucky rarely isolated in humans.

The only *Salmonella* isolate identified from retail pork (*S.* Kentucky) had a PFGE pattern rarely seen in the PulseNet database. The only *Salmonella* isolate identified from retail ground beef (*S.* Infantis) also had a PFGE pattern rarely seen in the PulseNet database. The top four *Salmonella* serotypes identified in retail chicken were Heidelberg, Enteritidis and Typhimurium (including the most common PFGE patterns identified by PulseNet), and Kentucky (patterns rarely seen in the PulseNet database).

Many of the *Salmonella* isolates identified from water include common patterns seen in PulseNet for *S.* Typhimurium, Thompson and Oranienburg, and many with no associated human illness identified in the PulseNet database.

4 PulseNet Canada, National Microbiology Laboratory, Public Health Agency of Canada (Celine Nadon) 2008 [Personal Communication].

TABLE 4.2
PFGE results for the most common *Salmonella* serotypes for all components in Sentinel Site 1 in 2008 (values in brackets refer to 2005-2007 cumulative data for comparisons)

	Human		Retail Food			Food Animals (Manure)				Untreated Surface Water
			Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Grand River
	Non-travel Cases[a]	Travel-related Cases	Pork chop	Chicken breast	Ground beef					5 sample points on Grand River
Typhimurium										
# samples with PFGE results	12 (15)	1 (1)	0 (3)	5 (7)	0 (0)	11 (48)	5 (0)	0 (2)	2 (5)	4 (5)
STXAI.0001	(4)		(1)	1		4 (11)		(2)	1 (4)	1 (5)
STXAI.0006	(1)									
STXAI.0010							4			
STXAI.0013						1 (1)				1
STXAI.0027	1(1)			(1)		(16)				
STXAI.0029						(4)				
STXAI.0044	(1)									
STXAI.0067	(4)									
STXAI.0098	(1)					(1)				
STXAI.0184				2						
STXAI.0193	(3)									
STXAI.0195	1(1)									
STXAI.0203	(1)									
STXAI.0214						1 (2)				
STXAI.0233	(2)									
STXAI.0239	(1)									
STXAI.0243	(1)									
STXAI.0270									(1)	
STXAI.0286			(1)			(1)				
STXAI.0291									1	
STXAI.0302						1				
STXAI.0312	4 (11)	1		1 (4)			1			1
STXAI.0314	1		(1)							
STXAI.0330	1									
STXAI.0339						(1)				
STXAI.0349	(1)									
STXAI.0361	(1)			(1)		(1)				
STXAI.0362						(1)				
STXAI.0364						4 (4)				
STXAI.0376	(1)									
STXAI.0406				(1)						
STXAI.0425	(1)	(1)								
STXAI.0433	1									
STXAI.0434						(2)				
STXAI.0436						(1)				
STXAI.0440						(1)				
STXAI.0441						(1)				
STXAI.0444	(1)									
STXAI.0452	(1)									
STXAI.0479	(1)									
STXAI.0544	1									
STXAI.0546	1									
STXAI.0554										1
STXAI.0556	1									
STXAI.0592				1						
Enteritidis										
# samples with PFGE results	20 (26)	5 (25)	0 (0)	7 (8)	0 (1)	0 (1)	3 (4)	1	0	2
SENXAI.0001	3 (2)	1 (17)								
SENXAI.0002	(1)	(1)								
SENXAI.0003	8 (6)	2		5 (1)			2 (2)	1		
SENXAI.0004	(2)	(2)								
SENXAI.0006	4			2						
SENXAI.0007	3									
SENXAI.0008	1	2 (2)								
SENXAI.0009	(1)									
SENXAI.0038	1 (14)			(7)	(1)	(1)	1 (2)			2
SENXAI.0079		(1)								
SENXAI.0093		(1)								
SENXAI.0123		(1)								
Heidelberg										
# samples with PFGE results	0 (8)	0	0	14 (27)	0	0	1 (5)	0	0	0 (2)
SHEXAI.0001	(1)			4 (12)			1 (5)			(1)
SHEXAI.0006	(1)			(5)						(1)
SHEXAI.0007				3						
SHEXAI.0009	(4)									
SHEXAI.0011	(2)			3 (3)						
SHEXAI.0015				(1)						
SHEXAI.0020				3 (4)						
SHEXAI.0187				(1)						

TABLE 4.2 (continued)
PFGE results for the most common *Salmonella* serotypes for all components in Sentinel Site 1 in 2008 (values in brackets refer to 2005-2007 cumulative data for comparisons)

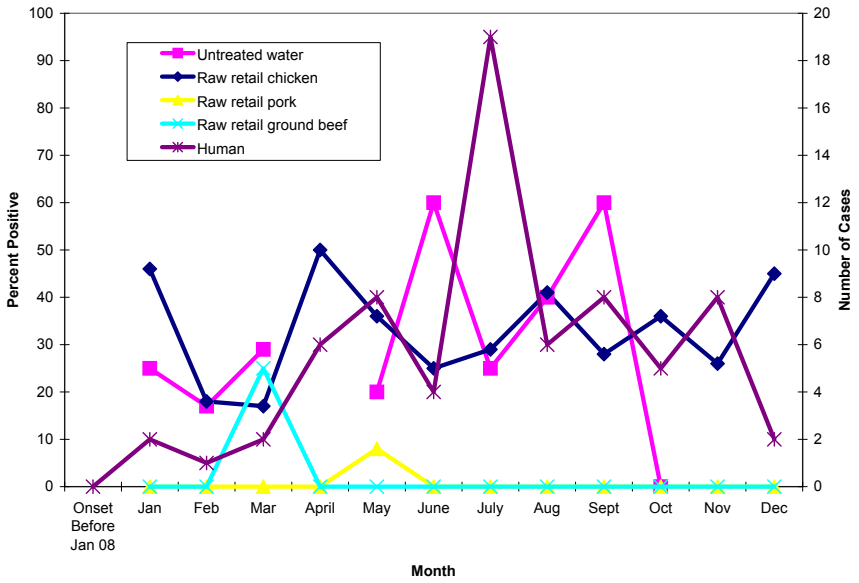
Kentucky										
# samples with PFGE results	1 (1)	0 (1)	1 (1)	22 (54)	0 (0)	1 (0)	39 (5)	0 (2)	5 (18)	7 (6)
KenXAI.0005	(1)			3 (15)			9 (2)			
KenXAI.0012	1			1 (5)						
KenXAI.0013			1	11 (27)			15 (3)			
KenXAI.0016				1 (1)			1	(2)	5 (17)	7 (6)
KenXAI.0021							1			
KenXAI.0023			(1)							
KenXAI.0024				(1)						
KenXAI.0025									(1)	
KenXAI.0029				2 (2)			9			
KenXAI.0030				(1)						
KenXAI.0032				(1)						
KenXAI.0033				(1)						
KenXAI.0034		(1)								
KenXAI.0035				1						
KenXAI.0036							1			
KenXAI.0041							2			
KenXAI.0042				1			1			
KenXAI.0043				1						
KenXAI.0044						1				
KenXAI.0045				1						
Thompson										
# samples with PFGE results	1(4)	0 (2)	0 (2)	1 (1)	0 (0)	0 (0)	0 (3)	0 (0)	0 (1)	4 (8)
STHXAI.0001				1			(3)		(1)	(2)
STHXAI.0002	(1)	(1)								1(3)
STHXAI.0011		(1)								
STHXAI.0022										1
STHXAI.0046	(1)			(1)						1(3)
STHXAI.0056	(1)									
STHXAI.0060	(1)									
STHXAI.0062			(2)							
STHXAI.0068	1									
STHXAI.0069										1

[a] Non-travel includes endemic and outbreak cases.

4.3 Temporal Distribution

There are no obvious seasonal trends in the *Salmonella* exposure sources evaluated in Sentinel Site 1 (Figure 4.3). Nineteen human cases were reported in July and a range of 1-8 cases was recorded over other months of the year.

FIGURE 4.3
Temporal distribution of *Salmonella* detected in human endemic cases, untreated surface water and retail meat samples in Sentinel Site 1 in 2008



4.4 Summary of *Salmonella* Results

- *Salmonella* Enteritidis was the most commonly detected serotype in human cases and the third most commonly detected serotype in retail chicken meat. The prevalence of human cases of PFGE pattern SENXAI.0003 appears to reflect a higher prevalence of this PFGE pattern in retail food and manure. Of the *S.* Enteritidis cases, 35% (15/43) were travel-related.
- *Salmonella* Typhimurium was the second most commonly detected serotype in human cases and the most commonly detected serotype from swine farms. None of the swine isolate PFGE patterns matched human cases in the sentinel site but each pattern had been identified in human cases in the PulseNet database. The most common PFGE pattern of human cases, STXAI.0312, matched isolates from retail chicken meat, a chicken farm and water.
- *Salmonella* Infantis and *S.* Newport were the third most commonly detected serotypes in human cases. *S.* Newport was the most commonly detected serotype in untreated surface water samples (tied with *S.* Kentucky). *S.* Infantis was detected once in a ground beef isolate and in one water sample.
- *Salmonella* Kentucky was the most commonly detected *Salmonella* serotype on poultry and dairy farms, in chicken and pork retail samples, and in water samples in Sentinel Site 1. However, presence of this serotype does not appear to be associated with human cases; it was isolated in only one endemic human case. The single endemic human case isolate (PFGE pattern KENXAI.0012) matched a single isolate recovered from retail chicken meat.

- *Salmonella* Heidelberg was not associated with any human cases in the sentinel site, although it was found in chicken meat and in poultry manure samples. This serotype is the third most prevalent seen in human cases at both provincial (Ontario) and national levels.
- The *Salmonella* serotype and PFGE data could support an association between human illness, chicken and the chicken environment. However, these observations are limited by small sample size and lack of exposure data from the human cases. The integrated surveillance results (water, farm and retail beef and pork) do not provide any clear associations with other sources at this time.

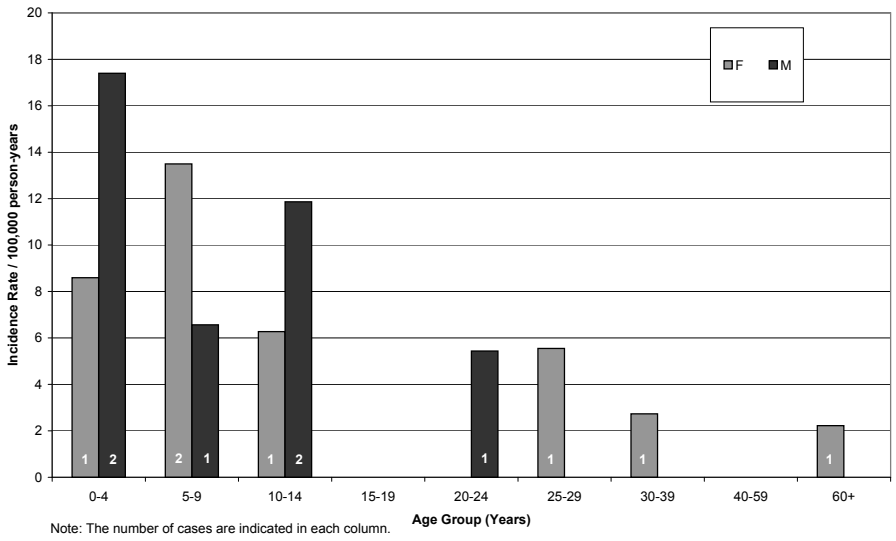
5. Pathogenic *E. coli*

5.1 Human Cases

In 2008, in Sentinel Site 1, there were 15 reported cases of *E. coli* O157:H7 (3.0/100,000 person-years). Of those 15 cases, 1 was outbreak-related, 1 was travel-related and 13 were classified as endemic (2.8/100,000 person-years). In comparison, the annual incidence rates for *E. coli* O157:H7 in 2008 in Canada and Ontario were 2.3/100,000 and 2.2/100,000, respectively.[5]

The age- and gender-specific incidence rates among the 13 endemic cases were highest among children less than fourteen years of age (Figure 5.1).

FIGURE 5.1
Incidence rates of endemic *E. coli* O157:H7 in Sentinel Site 1 by gender and age group in 2008



Note: The number of cases are indicated in each column.

Exposure information for the ten days prior to the onset of illness was collected for 100% (13/13) of the reported endemic cases of *E. coli* O157:H7 (Appendix B). A higher number of *E. coli* O157:H7 cases was observed for the following exposures: using a private well; swimming (in a lake and in a pool); attended a barbecue; shopped at a butcher shop; contact with household cats; lived on a farm; and on-farm animal contact with poultry. Other risk factors observed among *E. coli* O157:H7 cases included travel by car (within Canada;), canoeing, kayaking, hiking or camping, use of reverse osmosis as in-home treatment system, swimming in a hot tub, shopped at a farmer's market and working/attending a day care.

5 National Notifiable Disease representative (Adam Medaglia) 2008 [personal communication]. Note: 2008 numbers contain travel and endemic cases, do not include Nunavut or the Northwest Territories and are preliminary and subject to change.

5.2 Exposure Surveillance

TABLE 5.1
Verotoxigenic *E. coli* detection data from the integrated surveillance activities in Sentinel Site 1 in 2008

	Human	Retail Food			Food Animals (Manure)				Untreated Surface Water
	Endemic Cases	Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Grand River
Detection		Pork chop	Skin-off breast	Ground beef	30 Farms	24 Farms	26 Farms	26 Farms	5 sample points on Grand River
# tested	Unknown	178	185	178	111	96	104	104	100
# positive	13	0	0	2	2 (2 farms)	2 (2 farms)	14 (8 farms)	4 (3 farms)	1
Percentage positive (%)		0%	0%	1%	2%	2%	14%	4%	1%
VTEC		0	0	2					
O157 (non-H7)					1	2			1 (B)
O157:H7	13				1		14	4	

Water Sampling Locations in Grand River Watershed:
B - Conestogo River

Retail

Verotoxigenic *E. coli* (VTEC) was detected on 1% of retail beef samples (Table 5.1). VTEC was not detected on retail pork or chicken samples.

On-Farm

E. coli O157:H7 was isolated from 14% of the pooled manure samples collected from beef operations and from 4% of the pooled manure samples collected from dairy operations (Table 5.1). *E. coli* O157:H7 was also isolated from 1 swine manure pit sample. It is possible however, that this pathogen may have originated from beef cattle since the manure pit also received manure from beef cattle. None of the broiler chicken manure samples tested positive for *E. coli* O157:H7.

Water

E. coli O157:H7 was identified in one sample by culture-based method (Table 5.1).

TABLE 5.2
PFGE results for *E. coli* O157:H7 for all components, in Sentinel Site 1 in 2008 (values in brackets refer to pooled 2006 and 2007 data for comparison)

	Human		Food Animals (Manure)			Untreated Surface Water
	Non-travel Cases	Travel-related Cases	Swine	Beef Cattle	Dairy Cattle	Grand River
						5 sample points on Grand River
# of isolates with PFGE results	6(42)[a]	0(3)	1	14 (7)[b]	4 (38)[b]	1 (6)[b]
ECXAI.0001	(5)			2	1	
ECXAI.0002	(1)					
ECXAI.0006				3	(3)	
ECXAI.0007	(1)					
ECXAI.0008	(2)			1	(1)	(1)
ECXAI.0017	(3)					
ECXAI.0023					(1)	
ECXAI.0052	(2)	(1)				
ECXAI.0063	(1)					
ECXAI.0073				(1)		
ECXAI.0096	1					
ECXAI.0140				(1)		
ECXAI.0247	(1)					
ECXAI.0262	(9)					
ECXAI.0309	(1)					
ECXAI.0317					(1)	
ECXAI.0378					(1)	
ECXAI.0407				2		
ECXAI.0776				(1)		
ECXAI.0825				1		
ECXAI.0841	(1)					
ECXAI.1164				1		
ECXAI.1175	(1)				(1)	
ECXAI.1248	(1)					
ECXAI.1267				(1)	(1)	
ECXAI.1304					(1)	
ECXAI.1477	(1)					
ECXAI.1478	(1)					
ECXAI.1495	(1)					
ECXAI.1501	(1)					
ECXAI.1526	(1)					
ECXAI.1537	(1)					
ECXAI.1556						(4)
ECXAI.1557						(1)
ECXAI.1577	(2)					
ECXAI.1578	(1)					
ECXAI.1610	(1)					
ECXAI.1611					(3)	
ECXAI.1612					(3)	
ECXAI.1613					(2)	
ECXAI.1614					(1)	
ECXAI.1687					(6)	
ECXAI.1688					(1)	
ECXAI.1689					(1)	
ECXAI.1690					(4)	
ECXAI.1691					(1)	
ECXAI.1692	1				(2)	
ECXAI.1694	(1)				(2)	
ECXAI.1714		(1)				
ECXAI.1737	(2)					
ECXAI.1777		(1)				
ECXAI.1844						1
ECXAI.1855					(1)	
ECXAI.1857					(1)	
ECXAI.1858				(1)		
ECXAI.1859				(1)		
ECXAI.1860				(1)		
ECXAI.1898	1					
ECXAI.1901	1					
ECXAI.1940	1					
ECXAI.1972	1					
ECXAI.2003					1	
ECXAI.2108				1		
ECXAI.2109					1	
ECXAI.2110				2		
ECXAI.2111			1			
ECXAI.2112					1	
ECXAI.2172				1		

[a] Non-travel includes endemic and outbreak cases.
[b] 2005-2007 data.

Within Sentinel Site 1, PFGE analysis of the 2008 *E. coli* O157:H7 isolates showed 26 isolates comprising 20 distinct PFGE patterns and no overlap between human cases and isolates from non-human sources (Table 5.2).

When comparing three years of surveillance data (2006-2008), some overlap was found among PFGE patterns. PFGE pattern ECXAI.0008 was detected in human endemic cases, beef cattle manure and untreated surface water samples. PFGE pattern ECXAI.0001 was detected in human endemic cases and manure from dairy and beef farms. Three PFGE patterns (ECXAI.1175, ECXAI.1692, ECXAI.1694) were detected in both human endemic cases and dairy manure. In the on-farm component, PFGE patterns ECXAI.0001, ECXAI.0006, ECXAI.0008 and ECXAI.1267 were detected in both beef and dairy cattle manure samples. The single pattern isolated from swine manure, ECXAI.2111, was not observed in either beef or cattle manure.

There are some overlaps between isolates from human and non-human sources and the top five PFGE patterns observed among human cases in the PulseNet Canada database for 2008, including ECXAI.0001 and ECXAI.1898. Among non-human components, ECXAI.0008 was isolated from both untreated surface water and beef cattle. ECXAI.0008 is rated as the sixth most common pattern identified among human cases nationally in 2008, according to the PulseNet Canada database.[6]

Interestingly, the most frequently occurring PFGE pattern among human clinical isolates reported to PulseNet Canada for 2008, ECXAI.0017, was not found among any C-EnterNet human cases or exposure sources. ECXAI.0001 was the second most common pattern in the PulseNet Canada database in 2008, but was not found in any of C-EnterNet's human cases. However, it was found in beef and dairy cattle manure isolates. Twelve of the patterns found in 2008 are uncommon or rare patterns in the PulseNet Canada database; this likely reflects the diversity of patterns found in *E. coli* O157:H7 in Sentinel Site 1.

5.3 Temporal Distribution

Endemic VTEC cases were reported between May and November. The highest number of cases (6 cases) was reported in September.

5.4 Summary of Pathogenic *E. coli* Results

- *E. coli* O157:H7 appears to be a domestically-acquired infection as demonstrated by the low proportion of travel-related cases in 2008.
- PFGE subtyping of the human and non-human isolates from 2008 revealed no overlapping patterns, suggesting that different strains are circulating in these components. However, when reviewing data from multiple years, some overlap exists (5 patterns observed).

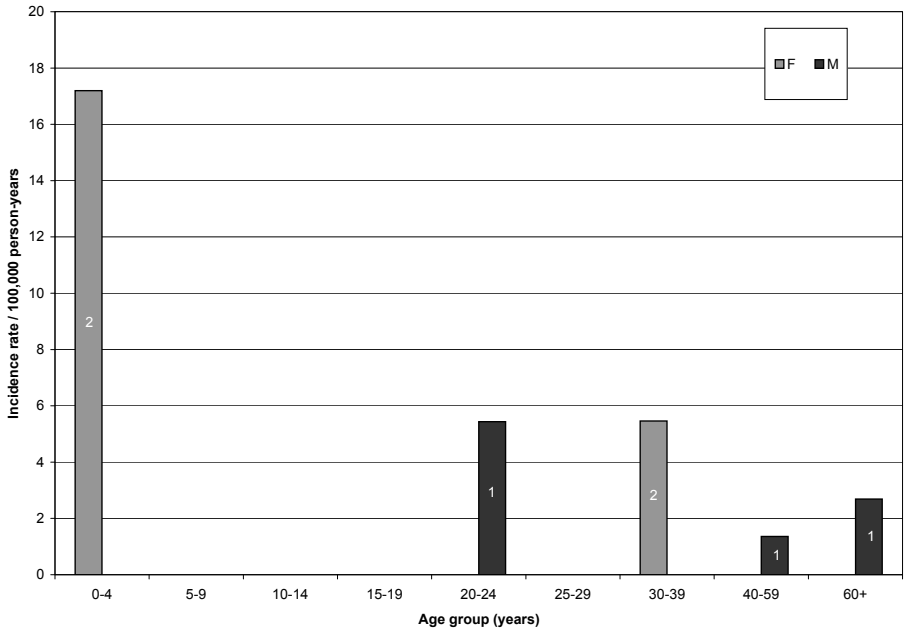
6 PulseNet Canada, National Microbiology Laboratory, Public Health Agency of Canada (Lorelee Tschetter) 2008 [personal communication].

6. Yersinia

6.1 Human Cases

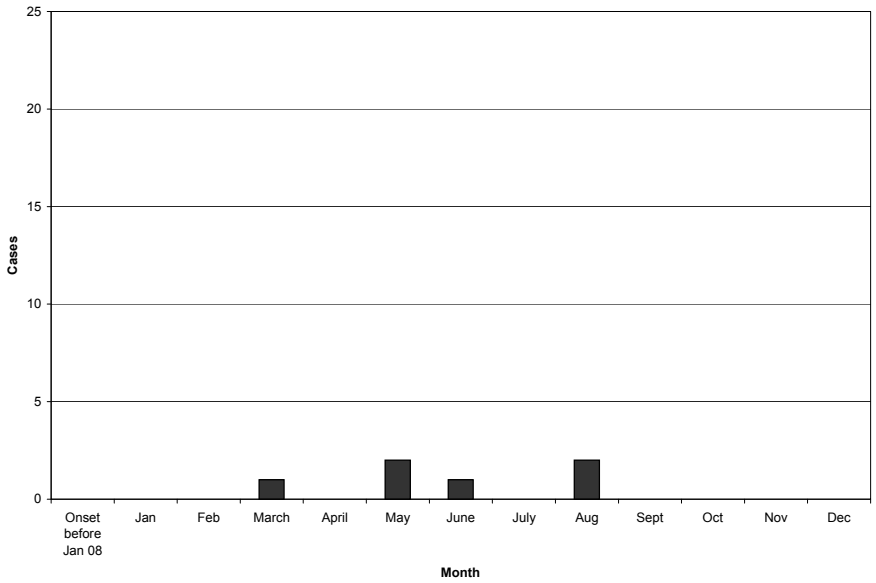
In 2008 in Sentinel Site 1, there were 10 reported cases of *Yersinia* infection (2.0/100,000 person-years). Of these 10 cases, 30% (3) were travel-related (0.60/100, 000 person-years), and 70% (7) were classified as endemic (1.39/100,000 person-years). Currently, *Yersinia* is not a nationally-notifiable disease, and so the annual national and provincial incidence rates are not available for comparison. The age-specific incidence rate from the 7 endemic cases was highest among female children less than five years of age. (Figure 6.1).

FIGURE 6.1
Incidence rates of endemic *Yersinia* infection by gender and age group in Sentinel Site 1 in 2008



All human *Yersinia* infections were subtyped as *Y. enterocolitica* biotype 4 O:3-, considered to be a pathogenic strain. The cases were uniformly spread over the year ranging from zero to two cases per month without obvious seasonal patterns (Figure 6.2).

FIGURE 6.2
Temporal distribution of human *Yersinia* cases in Sentinel Site 1 reported in 2008



Potential exposure information for the seven days prior to the onset of illness was collected for 100% (7/7) of the reported endemic yersiniosis cases (Appendix B). A higher number of reported yersiniosis cases were observed for the following exposures: swimming in a lake, eating under-cooked food, eating meat from a butcher shop, eating in a restaurant, contact with household pets (cats) and visiting a farm animal area.

6.2 Exposure Surveillance

TABLE 6.1
***Yersinia* detection and speciation data from the integrated surveillance activities in Sentinel Site 1 in 2008**

	Human	Retail Food	Food Animals (Manure)	Untreated Surface Water
	Endemic Cases	Pork	Swine	Grand River
Detection		Pork chop	30 farms	5 sample points on Grand River
# tested	Unknown	178	111	100
# positive	7	6	4 (4 farms)	11
% positive		3%	4%	11%
Subtyping				
# subtyped	7	6	4	11[a]
Y. aldovae - non-pathogenic				
Y. bercovieri - non-pathogenic				5 (B,C,D,E)
Y. enterocolitica - pathogenic	7		3	
Y. enterocolitica - non-pathogenic		4	1	3 (A,B,C,D)
Y. frederiksenii - non-pathogenic				2 (B,C)
Y. intermedia - non-pathogenic		2		3 (A,C)
Y. kristensenii - non-pathogenic				
Y. mollaretti - non-pathogenic				
Y. rohdei - non-pathogenic				1 (D)

[a] Multiple isolates were detected in more than one samples, 14 isolates in total

Water Sampling Locations in Grand River Watershed:
A - Canagagigue Creek
B - Conestogo River
C - Upper Grand River
D - Grand River, near drinking water intake
E - Grand River, near one wastewater treatment plant effluent point

Retail

Yersinia was isolated from 3% (6/178) of the raw pork chops sampled (Table 6.1), all of which had levels of *Yersinia* below the MPN detection limit (Appendix D).

The six isolates were subtyped and found to be non-pathogenic (*Y. enterocolitica* serotypes O:5,8, O:Untypable , and *Y. intermedia*).

On-Farm

Yersinia was isolated from 4% (4/111) of the pooled swine manure samples collected (Table 6.1). Three isolates were pathogenic *Y. enterocolitica* serotypes (O:3) and the fourth was a non-pathogenic serotype (O:34).

Water

All *Y. enterocolitica* isolates (serotypes O:5 and O:7,13) from the untreated surface water samples were non-pathogenic.

6.3 Summary of *Yersinia* Results

- Based on this year and previous year's data, *Yersinia* continues to be a domestically-acquired infection, as demonstrated by the low proportion of travel-related cases.
- Epidemiologically, contact with cats, eating at restaurants and swimming in a lake may be important risk factors for yersiniosis.
- Pathogenic (biotype O:3) and non-pathogenic (O:34) *Yersinia enterocolitica* were identified in pooled swine manure samples.
- All *Yersinia* detected on retail pork samples and in untreated surface water were non-pathogenic.

7. Listeria

7.1 Human Cases

Human listeriosis is rare and is typically identified with severe, hospitalized cases among immuno-compromised individuals. An annual national incidence rate for listeriosis is not currently available from the NND. Health Canada's Listeria Reference Services, however, reports the incidence remains below 0.72 cases per 100,000 person-years nationally.[7] Six cases (3 endemic and 3 outbreak) in 2008 were found only among adults 60 years and older, with the onset of one case in 2007. There were a total of three *Listeria* outbreak-associated cases linked to the Canada-wide outbreak.The three endemic cases were not found to be associated with the national outbreak.

7.2 Exposure Surveillance

In 2008, *Listeria monocytogenes* testing was not continuous. On the retail side, testing was discontinued in March 2008 due to budgetary reasons. On the farm side, each commodity is tested for *Listeria monocytogenes* for one year following the initiation of sampling. In 2008 a full year of sampling concluded in March 2008. Testing occurred in retail raw meat and beef farm manure from January to March. For broiler chicken farms, testing occurred from January to November.

TABLE 7.1
***Listeria monocytogenes* detection data from the integrated surveillance activities in Sentinel Site 1 in 2008**

	Human		Retail Meat			Farm Animals (Manure)	
	Endemic	Outbreak	Pork[a]	Chicken[a]	Beef[a]	Broiler Chickens[b]	Beef Cattle[a]
Detection			Pork Chop	Skin-off breast	Ground beef	22 Farms	9 Farms
# samples tested	Unknown	Unknown	43	42	43	88	36
# positive	3	3	2	8	11	7	23
% positive			5%	19%	26%	8%	64%

[a] Sampled between January and March

[b] Sampled between January and November

Retail

Given the short duration of testing for *Listeria monocytogenes* on retail meats no direct comparisons amongst commodities or surveillance years are made (Table 7.1). Enumeration results indicated that the majority of positive samples were below detection limits (Appendix D).

On-Farm

Of the pooled beef and pooled broiler chicken manure samples, 64% (23/36) and 8% (7/88), respectively, tested positive for *Listeria monocytogenes* (Table 7.1). As in the retail section, comparisons to previous years have not been made due to partial sampling years.

7 Personal communication. Listeria Research Laboratory and Listeriosis Reference Service, Food Directorate, Bureau of Microbial Hazards, Health Canada

Subtype Comparisons

Listeria monocytogenes serotypes 1/2a, 1/2b and 4b were the 3 most frequently detected serotypes in the exposure sources tested and are reported to be the predominant serotypes in Canada causing human illness.[8] In this sentinel site, the 3 outbreak cases were *Listeria monocytogenes* 1/2a while the endemic cases were *Listeria monocytogenes* 1/2a and 4b. *Listeria monocytogenes* 1/2a and 1/2b were detected on retail meats, broiler chicken and beef farms. *Listeria monocytogenes* 4b was most frequently detected on beef farms (Table 7.2).

TABLE 7.2
***Listeria monocytogenes* serotype data from the integrated surveillance activities in Sentinel Site 1 in 2008 (values in brackets refer to 2007, 2006 and 2005 data for comparisons)**

Serotype	Human		Retail Meat			Farm Animals (manure)				Non-HumanTotal
			Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	
	Endemic	Outbreak	Pork Chop	Skin-off breast	Ground beef		22 Farms	9 Farms		
# serotyped	2 (1)	3	2 (41)	8 (128)	11 (96)	(4)	7 (1)	23 (51)	(15)	51
1/2a	1 (1)	3	1 (17)	6 (86)	4 (41)	(1)	4 (1) (2 farms)	9 (24) (5 farms)	(2)	24
1/2b			1 (12)	(27)	5 (52)	(3)	3 (2 farms)	4 (8) (3 farms)	(4)	13
1/2c			(10)	2 (4)	1 (3)					3
3a			(1)	(2)	1					1
3b				(5)						
4a								(4)		
4b	1		(1)	(4)				9 (12) (3 farms)	(5)	9
4c								1 (3)	(4)	1

In comparing PFGE patterns from human, retail meat samples and farm manure, no predominant subtype emerges across species and sampling levels, although there are a few minor overlaps (Table 7.3). As an example, there is overlap with PFGE pattern LMAAI.0093 (human, retail beef, broiler chickens, and beef cattle). PulseNet data were used to identify the top five human PFGE patterns to compare the sentinel site data with national numbers. The other endemic case PFGE pattern, LMAAI.0265, did not overlap with the other components, but was found to be associated with unpasteurized cheese consumption in Québec and was the second most common pattern reported in the PulseNet Canada database. The three outbreak cases (associated with a national outbreak) had PFGE pattern LMAAI.0001 (not the outreak strain), which was also found on retail ground beef in 2008 and previously on retail chicken breast and pork chops. LMAAI.0001 was the third most common pattern reported in the PulseNet Canada database and was associated with AscI enzyme patterns LMACI.0001, LMACI.0002 and LMACI.0040. PFGE pattern LMAAI.0433 was found on both chicken farms and retail chicken meat, but was not reported in the PulseNet Canada database.

8 Clark, C.G. et al. 2010. Surveillance for Listeria monocytogenes and listeriosis, 1995-2004. Epidemiol. Infect. 138:559-572

TABLE 7.3

***Listeria monocytogenes* PFGE data from the integrated surveillance activities in Sentinel Site 1 in 2008 (values in brackets refer to 2007, 2006 and 2005 data for comparison).**

	Human		Retail Meat			Farm Animals (Manure)					
PFGE Pattern	Endemic Cases		Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Non-human Total	Top ten human ranking
	Endemic	Outbreak	Pork Chop	Skin-off breast	Ground beef	0 Farms	6 Farms	7 Farms	0 Farms		
Number subtyped	2 (1)	3	2 (41)	8 (128)	11 (96)	(4)	7 (1)	23 (51)	(15)		
LMAAI.0001	(1)	3	(3)	(17)	1 (4)					25	3
LMAAI.0003			(1)	(1)	(1)					3	1
LMAAI.0007								1 (2)		3	
LMAAI.0013			(8)	1 (23)	2 (21)					55	4
LMAAI.0014			(1)							1	
LMAAI.0017								(1)		1	
LMAAI.0024			1 (1)	1	(4)					7	
LMAAI.0028				(5)	(1)					6	
LMAAI.0049				(2)	(1)			(2)		5	
LMAAI.0074				(3)				(2)	(1)	6	
LMAAI.0090								(1)	(1)	2	
LMAAI.0093	1				(1)		1	(11)		13	
LMAAI.0097				(9)						9	
LMAAI.0126				1 (3)	(3)			2[b] (3)		12	7
LMAAI.0147			(2)							2	
LMAAI.0149											
LMAAI.0204								3[c] (6)	(5)	14	
LMAAI.0223			(9)	(2)	2 (43)					56	
LMAAI.0256			(1)		(1)					2	
LMAAI.0265	1										2
LMAAI.0266								(5)		5	
LMAAI.0333								(1)	(1)	2	
LMAAI.0360				(2)						2	
LMAAI.0377				(3)						3	
LMAAI.0378			(5)		(2)					7	
LMAAI.0381				1 (1)						2	
LMAAI.0383				(2)						2	
LMAAI.0384			(1)		(1)					2	
LMAAI.0402				(10)						10	
LMAAI.0411				1				1		2	
LMAAI.0423			(1)					1		2	
LMAAI.0432						(2)				2	
LMAAI.0433				1			1			2	
LMAAI.0454				(3)						3	
LMAAI.0455				1 (1)						2	
LMAAI.0465				(7)						7	
LMAAI.0467				(2)	(1)					3	
LMAAI.0472				(2)						2	
LMAAI.0498				(2)						2	
LMAAI.0531				(2)						2	
LMAAI.0565			1		4					5	
Other patterns[a]			(8)	(23)	2 (12)	(2)	5	14 (11)	(4)	81	
No PFGE designation				(3)			(1)	(6)	(3)	13	

[a] PFGE patterns that were identified once in a single component

[b] Isolates found on the same farm

[c] Isolates found on the same farm

7.3 Summary of *Listeria monocytogenes* Results

- As in previous years, pathogenic strains of *Listeria monocytogenes* were found on all retail meats and on farms, especially beef cattle farms.
- Literature suggests that abattoirs and meat processing environments rather than farm animals may be an important source of *Listeria monocytogenes*;[9] however, the data in 2008 do not strongly support this.
- Of the three most common PFGE patterns found on retail meat and farms in Sentinel Site 1, two (LMAAI.0001 and LMAAI.0013) are ranked among the top five patterns associated with human illness in Canada (Table 7.3).
- Although only 2 endemic cases had PFGE and phage type data, when comparing human endemic results to non-human results there is overlap with PFGE pattern LMAAI.0093 (human, beef, broiler chickens, and beef cattle) and with serotypes 1/2a and 4b (retail meat and farm manure).

9 Iida T, Kanzaki M, Nakama A, Kokubo Y, Maruyama T, and Kaneuchi C. Detection of Listeria monocytogenes in humans, animals and foods. J Vet Med Sci. 1998 Dec; 60(12):1341-3.

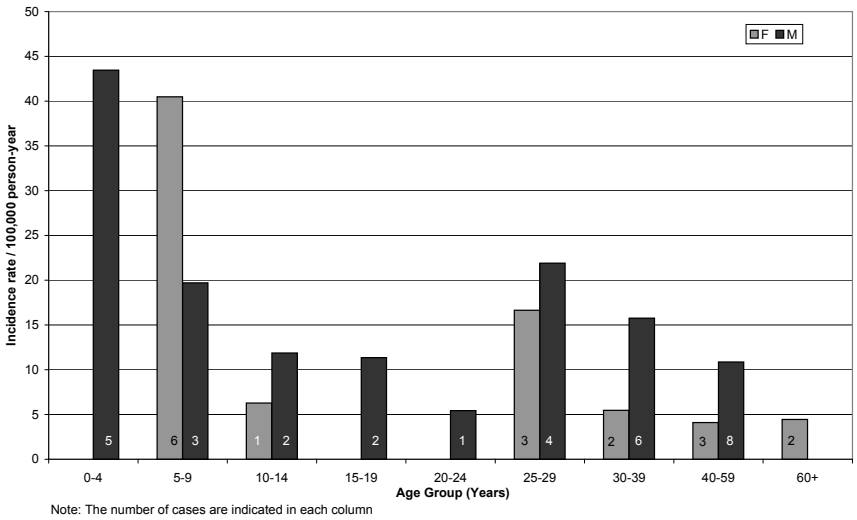
8. Parasites

8.1 *Giardia*

In 2008, there were a total of 80 reported cases of giardiasis (15.9/100,000 person-years). Of these 80 cases, 32 (40%) were travel-related (6.4/100,000 person-years) and 48 were classified as endemic (9.6/100,000 person-years). There were no outbreak-related cases. In comparison, the annual incidence rates for giardiasis in 2008 in Canada and Ontario were 12.7/100,000 and 12.4/100,000, respectively.[10] *Giardia lamblia* was found in all 80 cases.

Of the endemic cases, 17 were female (6.7/100,000) and 31 were male (12.4/100,000) (Figure 8.1). Only male cases were reported among 0-4 year, 15-19 year and 20-24 year age groups.

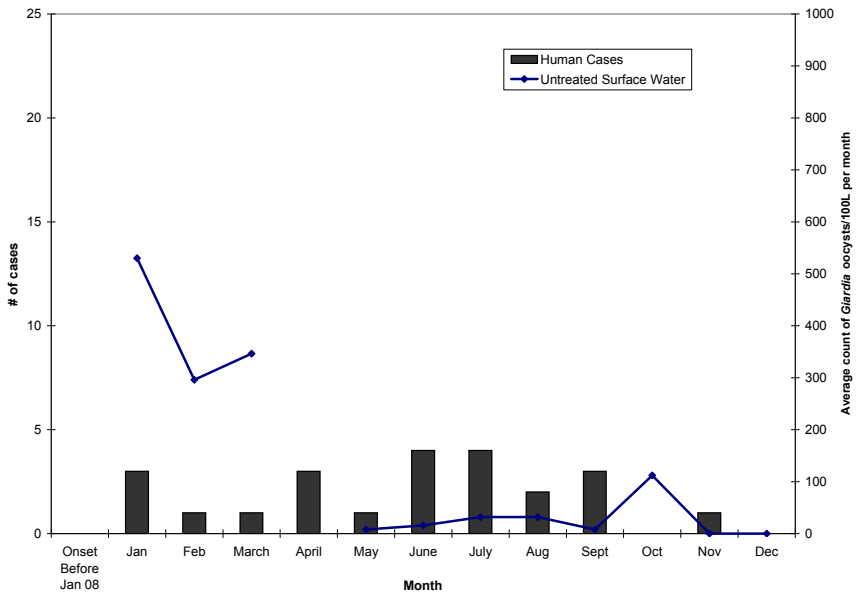
FIGURE 8.1
Incidence rates of endemic giardiasis cases by gender and age group in Sentinel Site 1 in 2008



Note: The number of cases are indicated in each column

10 National Notifiable Disease representative (Adam Medaglia) 2008 [personal communication]. Note: 2008 numbers are preliminary, do not include Nunavut and the Northwest Territories and subject to change.

FIGURE 8.2
Monthly distribution of *Giardia* cases and detection in untreated surface water sampled in Sentinel Site 1 in 2008



The monthly numbers of cases varied from none to 4 with the highest numbers in June and July (Figure 8.2).

Potential exposure information for the 25 days prior to the onset of illness was available for 33/48 (69%) of the endemic cases (Appendix B). The *Giardia* cases had higher reported proportions compared to the other enteric cases for the following exposures: using a private well, municipal water source, drank untreated water, swimming (in a lake and in a river), attended a barbecue, and living on a farm or in a rural area (and contact with dogs). Other exposures observed more frequently among *Giardia* cases included knowing someone with a diarrheal disease the week before illness, travel within Canada and drinking water from other water sources. Other water sources reported included boiled lake water, water from river, and spring water at a cottage.

8.1.1 Exposure Surveillance

On-Farm

In 2008, using microscopy techniques, 56% of the beef (January to March) and 0% of the broiler chicken (January to November) pooled manure samples, respectively, tested positive for *Giardia* (Table 8.1). Using PCR methods, 69% and 14% of the beef and broiler chicken pooled manure samples, respectively, were positive for *Giardia*. DNA sequencing revealed that Assemblage E, a non-zoonotic assemblage, was the only sequence found in the beef manure. Conversely, three different assemblages were detected in the broiler chicken samples, Assemblages A and B (zoonotic) and Assemblage E (non-zoonotic).

Water

Giardia was detected in 96% of the untreated surface water samples collected bi-weekly throughout the year from all 5 sites along the Grand River watershed in Sentinel Site 1, indicating a high prevalence of this potential pathogen (Table 8.1). Further molecular subtyping was not performed on these samples. The average concentrations of *Giardia* cysts were highest between January and April (Figure 8.2).

TABLE 8.1
***Giardia* detection and subtyping data from the integrated surveillance activities in Sentinel Site 1 in 2008 (values in brackets refer to data from 2005-2007)**

	Human	Food Animals (Manure)				Untreated Surface Water
	Endemic Cases	Swine	Broiler Chickens[a]	Beef [a]	Dairy	Grand River
		(2005-2006)	2008 (2007)	2008 (2007)	(2005-2006)	5 sample points on Grand River
Microscopic Results						
# tested	Unknown	(122)	93 (33)	36 (76)	(179)	22
# positive	48	(62)	0 (0)	20 (52)	(72)	21 (A,B,C,D,E)
% positive		(51%)	0% (0%)	56% (68%)	(40%)	96%
PCR Results						
# tested		(122)	93 (33)	36 (76)	(179)	
# positive		(80)	11 (1)	25 (52)	(54)	
% positive		(66%)	12% (3%)	69% (68%)	(30%)	
Sequencing results						
# samples with sequencing results		(63)	6 (1)	25 (48)	(43)	
Assemblage A			1		(3)	
Assemblage B		(58)	3 (1)		(18)	
Assemblage E		(5)	2	25 (48)	(22)	

[a] In 2008, beef farms were tested for parasites between January and March; poultry farms were tested between January and November

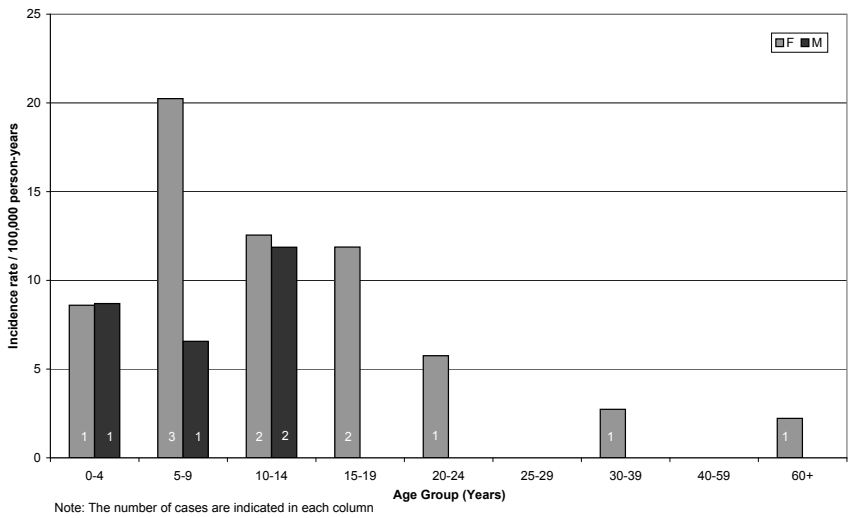
Water Sampling Locations in Grand River Watershed:
A - Canagagigue Creek
B - Conestogo River
C - Upper Grand River
D - Grand River, near drinking water intake
E - Grand River, near one wastewater treatment plant effluent point

8.2 *Cryptosporidium*

In 2008, there were a total of 17 reported cases of cryptosporidiosis (3.4/100,000 person-years). Of these 17 cases, 2 (12%) were travel-related (0.4/100,000 person-years) and 15 were classified as endemic (3.0/100,000 person-years) (Figure 8.3). In comparison, the annual incidence rates for cryptosporidiosis in 2006 in Canada and Ontario were 2.4/100,000 and 2.6/100,000, respectively.[11] Of the endemic cases, 11 were female (4.4/100,000) and 4 were male (1.6/100,000).

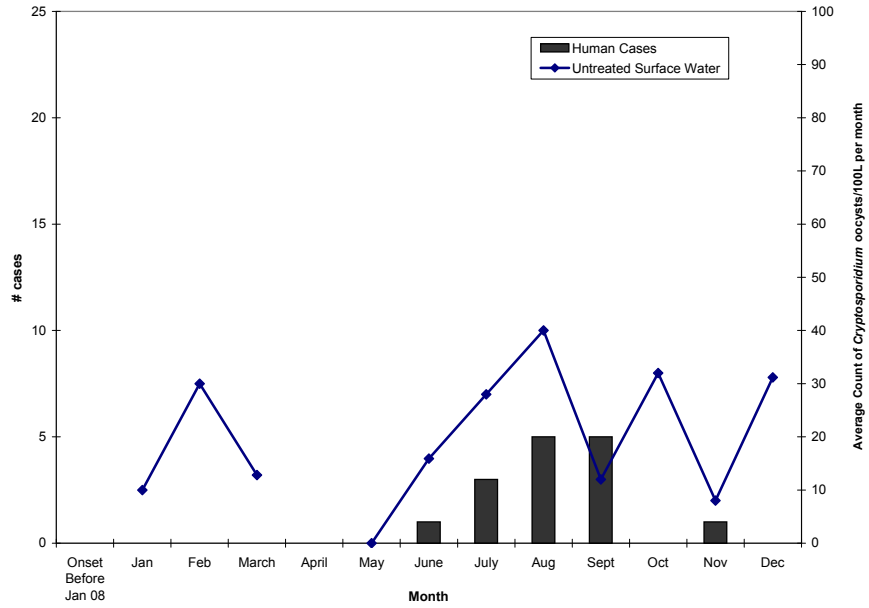
11 National Notifiable Disease representative (Adam Medaglia) 2008 [personal communication]. Note: 2008 numbers are preliminary, do not include Nunavut and the Northwest Territories and subject to change.

FIGURE 8.3
Incidence rates of endemic cryptosporidiosis cases by gender and age group in Sentinel Site 1 in 2008



Potential exposure information for the 12 days prior to the onset of illness was available for 15/15 endemic cases (Appendix B). The *Cryptosporidium* cases had higher reported proportions compared to the other enteric cases for the following exposures: using a private well, drank untreated water, swimming (in a pool), drinking unpasteurized milk, attended a barbecue, eating meat from a butcher shop, eating meat from private kill, shopping at a butcher shop, living on a farm or in a rural area, on-farm exposure to cats, poultry and sheep, and visiting a farm animal area (dog, cattle, pig, poultry). Other exposures observed more frequently among *Cryptosporidium* cases included travel by car (within Canada), drinking other unpasteurized products, shopped at farm (laneway), and attended a social gathering.

FIGURE 8.4
Monthly distribution of *Cryptosporidium* cases and detection in untreated surface water sampled in Sentinel Site 1 in 2008



Endemic cryptosporidiosis cases occurred from June to September and in November (Figure 8.4). *Cryptosporidium* oocyst levels remained variable throughout the year. The average concentration of *Cryptosporidium* oocysts in untreated surface water peaked in August, and fluctuated between 0 and 107 oocysts/100L for the remainder of the year (Figure 8.4). There appeared to be no temporal relationship between the appearance of *Cryptosporidium* in untreated surface water and the onset of human cases.

8.2.1 Exposure Surveillance

TABLE 8.2
***Cryptosporidium* detection and subtyping data for the integrated surveillance activities in Sentinel Site 1 in 2008 (values in brackets refer to data from 2005-2007)**

	Human	Food Animals (Manure)				Untreated Surface Water
	Endemic Cases	Swine	Broiler Chickens[c]	Beef[c]	Dairy	Grand River
						5 sample points on Grand River
Microscopic Results		(2005-2006)	2008 (2007)	2008 (2007)	(2006)	2008
# tested	Unknown	(122)	93 (33)	36 (76)	(179)	24
# positive	15	(54)	0 (0)	5 (22)	(14)	22 (A,B,D,E)
% positive		(44%)	0% (0%)	14% (29%)	(8%)	92%
PCR Results						
# tested		(122)	93 (33)	36 (76)	(179)	
# positive		(68)	13 (0)	11 (20)	(40)	
% positive		(56%)	14% (0%)	31% (26%)	(22%)	
Sequencing results						
# samples sequenced		(53)	7 (0)	10 (18)	(23)	12 (multiple genotypes per sample)[d]
C. andersoni[a]			1	10 (17)	(9)	10 (A, B, D, E)
C. baileyi chicken genotype (CB01)						
C. bovis					(2)	
C. cervine[a]						
C. muris		(3)	1			1 (E)
C. hominis[a,b]						1 (E)
C. muskrat genotype I (Cluster W 7)						2 (E)
C. muskrat genotype II (Cluster W 15)						
C. parvum (bovine genotype)[a]		(31)	6	(1)	(11)	
C. ryanae[a]					(2)	
C. suis[a]		(1)				
C. chipmunk genotype						
C. ferret-like genotype						
C. fox genotype (Cluster W 24)						
C. sp. 2622 host-cattle						
C. skunk genotype						
C. pig genotype: II[a]		(20)				

[a] Known to be pathogenic to humans
[b] Only found in humans
[c] In 2008, beef farms were tested for parasites between January and March; poultry farms were tested between January and November
[d] In 2008, genotyping was only performed from January to March for the water samples
Note: Some samples have more then one sequencing result, therefore the column total may exceed the total number sequenced

Water Sampling Locations in Grand River Watershed:
A - Canagagigue Creek
B - Conestogo River
D - Grand River, near drinking water intake
E - Grand River, near one wastewater treatment plant effluent point

On-Farm

In 2008, using microscopy techniques, 14% and 0% of the pooled beef (January to March) and broiler chicken (January to November) manure samples, respectively, tested positive for *Cryptosporidium* (Table 8.2). Using PCR methods, 31% and 14% of the pooled beef and broiler chicken manure samples, respectively, were positive for *Cryptosporidium*. Sequencing work detected the pathogenic strain *C. andersoni* in both broiler chicken and beef manure samples as well as *C. parvum* in beef manure samples.

Water

Consistent detection of *Cryptosporidium* in untreated surface water samples indicates a high prevalence of this potential pathogen in the watershed (Table 8.2). Further subtyping determined that *C. andersoni* was the most common genotype, supporting trends observed in previous sample years. It should be noted that *C. andersoni*, while not commonly associated with human infections, has recently been reported in some immunocompetent cases[12,13], suggesting that it might indeed be mildly infectious. The second human pathogenic strain, *C. hominis*, was detected in one of the 24 samples tested. More than one genotype was detected in some of the samples.

12 Leoni F, et al. Genetic analysis of Cryptosporidium from 2414 humans with diarrhoea in England between 1985 and 2000. J Med Micro. 2006;55:703-707
13 Morse TD, et al. Incidence of cryptosporidiosis species in paediatric patients in Malawi. Epidemiol Infect. 2007;135:1307-1315

Integrated Overview

- In the sentinel site, *Cryptosporidium* appears to be endemic in untreated surface water. There appears to be no correlation between high levels of *Cryptosporidium* oocysts in the untreated surface water and human cases (Figure 8.4).
- *C. hominis*, which is host specific to humans, was detected in untreated surface water. *C. andersoni*, although rarely reported in human cases, was also found in untreated surface water.
- Commonalities among the four farm commodities sampled since 2006 include the presence of the pathogenic strain *C. parvum* and the absence of the human specific strain *C. hominis*.

8.3 Cyclosporiasis

Two travel-related (0.4/100,000 person-years) cases and one endemic case (0.2/100,000 person-years) were reported in Sentinel Site 1 in 2008.

Cyclosporiasis is not considered to be endemic to Canada. Therefore, active surveillance for *Cyclospora* was not performed among the food, agriculture and water sources included in the C-EnterNet program.

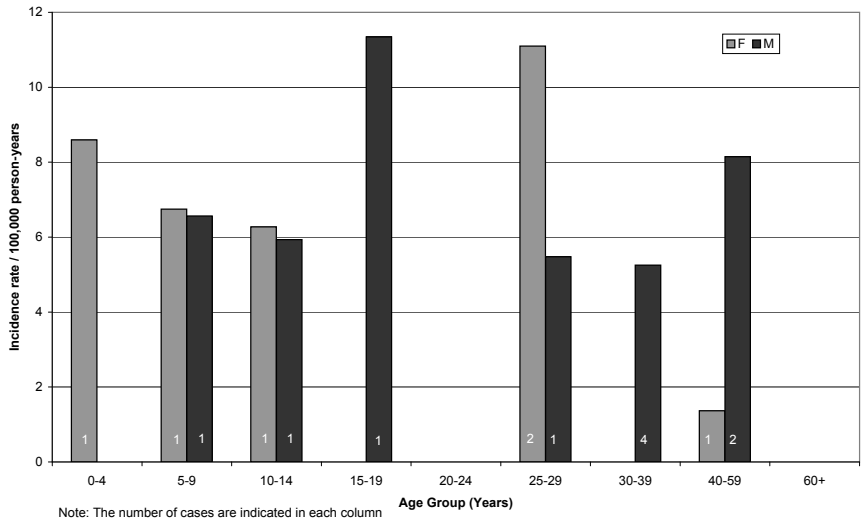
8.4 Amoebiasis

In 2008, there were a total of 30 reported cases of amoebiasis (6.0/100,000 person-years). Of these 30 cases, 11 were travel-related (2.2/100,000 person-years) and 19 were classified as endemic (3.8/100,000 person-years). Of the endemic cases, 6 were female (2.4/100,000) and 13 were male (5.2/100,000) (Figure 8.5).

Amoebiasis was removed from national surveillance as of January 2000;[14] therefore, comparative incidence data cannot be provided for Canada.

14 Centre for Infectious Disease Prevention and Control, Public Health Agency of Canada, National Notifiable Diseases, 2005. http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/list_e.html

FIGURE 8.5
Incidence rates of endemic amoebiasis cases by gender and age group in Sentinel Site 1 in 2008



Potential exposure information for 2 to 4 weeks prior to the onset of illness was available for 12 of the 19 cases (63%) (Appendix B). The following proportions were higher for the amoebiasis cases compared to other enteric cases: municipal water source, drank untreated water, and visiting a farm animal area (horses).

Entamoeba is a human intestinal pathogen. While not considered a zoonotic agent, *Entamoeba* has been known to infect dogs. It was not assessed in the various exposure sources (food, agriculture and water) in Sentinel Site 1.

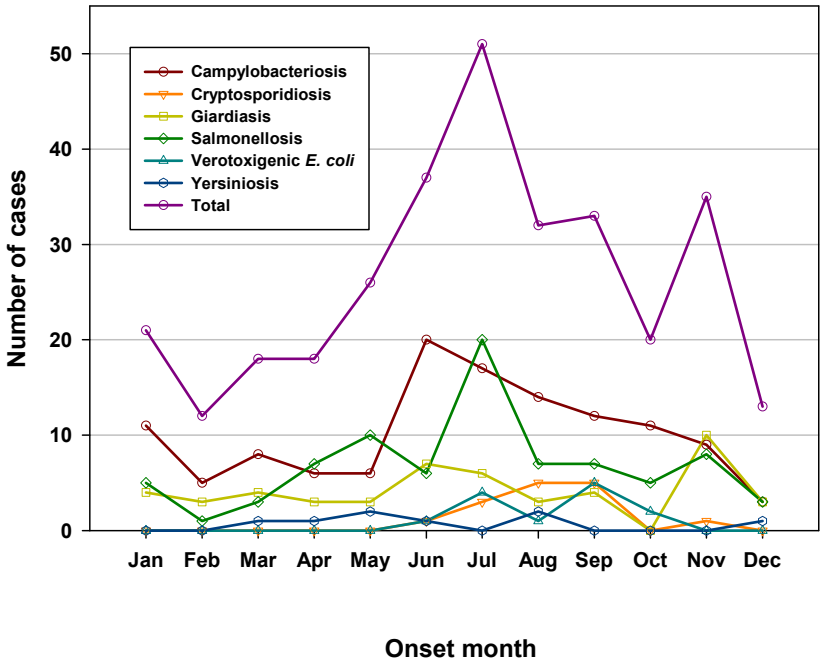
9. Temporal Variations

Identifying temporal trends or seasonal and other cyclical variations over time is a key function of health surveillance. It allows interpretation of the current state of health problems in the context of historical background and to forecast future problems and related consequences in the absence of relevant changes.

9.1 Temporal Variations in Enteric Disease Incidence

The monthly counts of endemic cases are shown for all diseases in 2008 (Figure 9.1) and since C-EnterNet's implementation in Sentinel Site 1 from June 2005 to December 2008 (Figure 9.2). These figures show a potential seasonal cycle of disease occurrence with more cases during summer or fall, with the exception of yersiniosis.

FIGURE 9.1
Monthly distribution of onset dates for endemic cases reported in Sentinel Site 1 in 2008 for selected enteric diseases



A Poisson regression model was used for each disease separately to formally test for both annual and seasonal trends. The full years of data were used: 2006, 2007, and 2008. Depending on the number of cases, the seasonal trend was based on month[15] (for *Campybacter*, *Salmonella*, and *Giardia*) or quarter (for giardiasis, cryptosporidiosis, yersiniosis, and verotoxigenic *E. coli* infections). The following results were statistically significant at $p<0.01$ (Table 9.1):

15 Winter: December to February; Spring: March to May; Summer: June to August; Fall: September to November

- Campylobacteriosis was higher in June, July and August compared to the other months;
- Salmonellosis was higher in July compared to each of the other months;
- Salmonellosis was lower in 2006 compared to 2007 even though overall year was not a statistically significant variable in the model;
- Cryptosporidiosis was higher in summer and fall compared to the two other seasons (winter and spring) when regrouped;
- While no monthly statistical differences were detected for giardiasis, this disease was more frequent during summer compared to spring and to winter;
- No differences were statistically significant for yersiniosis and verotoxigenic *E. coli* infections.

TABLE 9.1
Statistical results of Poisson regression modelling of monthly counts of endemic cases on years and month or season

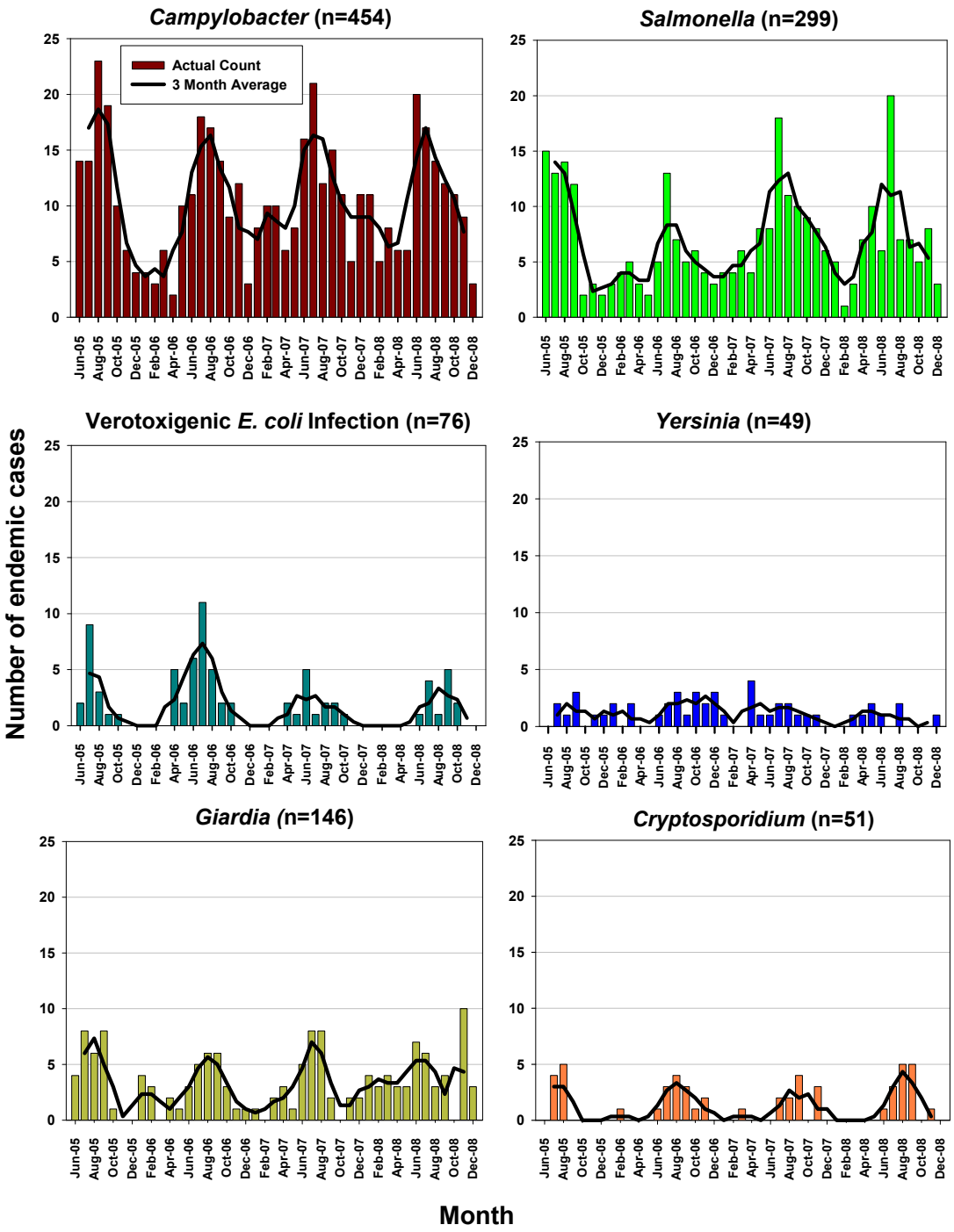
	Campylo-bacteriosis	Salmonellosis	VTEC infections	Yersiniosis	Crypto-sporidiosis	Giardiasis (season not included)	Giardiasis
Year	p=0.34	P=0.0167	P=0.14	P=0.45	p=0.56	p=0.21	P=0.34
'06 vs. 07	NT[a]	P=0.0038	NT	NT	NT	NT	NT
'07 vs 08	NT	P=0.29	NT	NT	NT	NT	NT
Season[b]	NI[c]	NI	P=0.053	P=0.56	p=0.0029	NI	P=0.0111
Su vs. Sp					p=0.0001		P=0.0041
Su vs. Fa					p=0.67		P=0.055
Su vs. Wi							P=0.0081
Fa vs. Sp					p=0.0001		P=0.033
Fa vs. Wi							P=0.046
Sp vs. Wi							P=0.082
Month	p=0.0029	p=0.0029	NI	NI	NI	p=0.0029	NI

a NT=Not Tested

b winter : December to February; spring : March to May; summer : June to August; fall : September to November

c NI=Not included into the model

FIGURE 9.2
Monthly distribution (based on onset dates) of endemic cases reported in Sentinel Site 1 from June 2005 to December 2008 for selected enteric diseases



9.2 Temporal Variations in Exposure Source

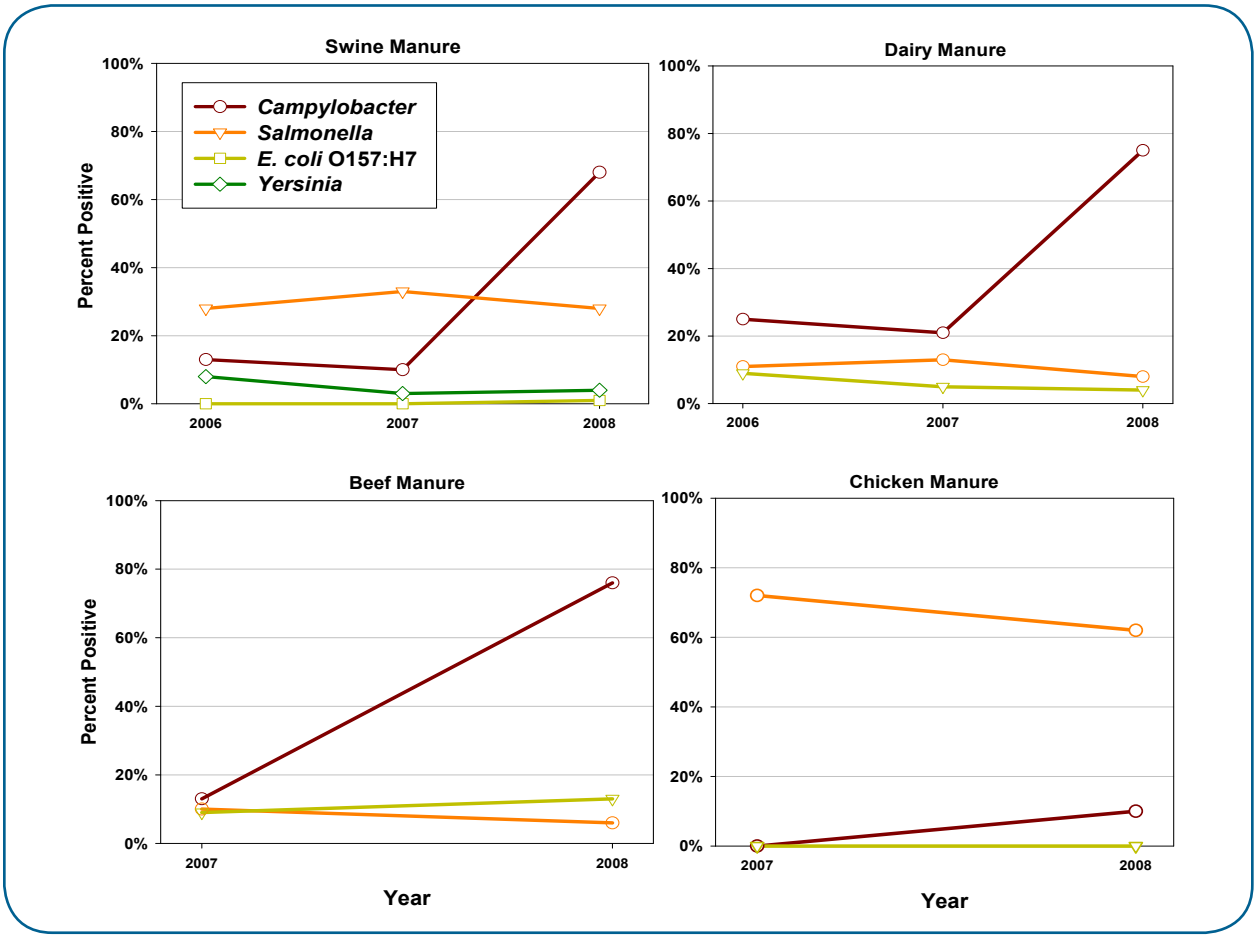
Agriculture Component

Detection of enteric pathogens on farms represents an environmental exposure source. In 2008, all four commodity groups (dairy, beef, swine, and broiler chickens) were sampled. Each month 2-3 farms per commodity are enrolled and visited for a total of approximately 30 farms per commodity per year. The visit involves the administration of a short management survey and sampling of three fresh pooled manure samples from different age groups of animals and one stored manure sample.

Results are presented at the sample level (Figure 9.3). In 2008, the same 30 swine farms were enrolled and sampled as in 2007 and 2006. In contrast, in 2008 13 and 15 of the beef and dairy farms, respectively, had been previously sampled in 2007. Also, the poultry farms sampled in 2008 had not been previously sampled in 2007.

The prevalence of *Campylobacter* increased significantly ($p<0.05$) in swine, dairy and beef at the farm level in 2008 compared to 2007 and 2006 and is most likely due to the implementation of a more sensitive laboratory methodology at the beginning of 2008, rather than a true prevalence increase.

FIGURE 9.3
Annual variations in pathogens detected from manure samples in Sentinel Site 1, 2006-2008



Water Component

Since 2005, five sites along the Grand River have been sampled for exposure surveillance within the C-EnterNet sentinel site to understand the dynamics of pathogen levels in the environment and the transmission of enteric pathogens from both point and non-point sources within the watershed. In 2008, only culture-based methods were used for the detection of pathogens in untreated surface water.

Potential yearly and seasonal changes are shown in Figures 9.4 and 9.5, respectively. Such potential effects on the probability of a sample to be positive were tested using logistic regression model for various pathogens between winter 2006 and fall 2008. The repetition of the sampling at the same 5 sites along the river was considered in the model. No statistically significant year or season effects ($p>0.01$) were observed for *Campylobacter*, *Salmonella*, and *Yersinia* (Table 9.2). The statistical model could not be run for *E. coli* O157:H7 because of the low number of positive samples or for *Giardia* and *Cryptosporidium* because of the low number of negative samples.

FIGURE 9.4
Proportion (with 95% confidence interval) of positive untreated surface water samples tested by culture method for selected enteric pathogens in Sentinel Site 1 between June 2005 and December 2008

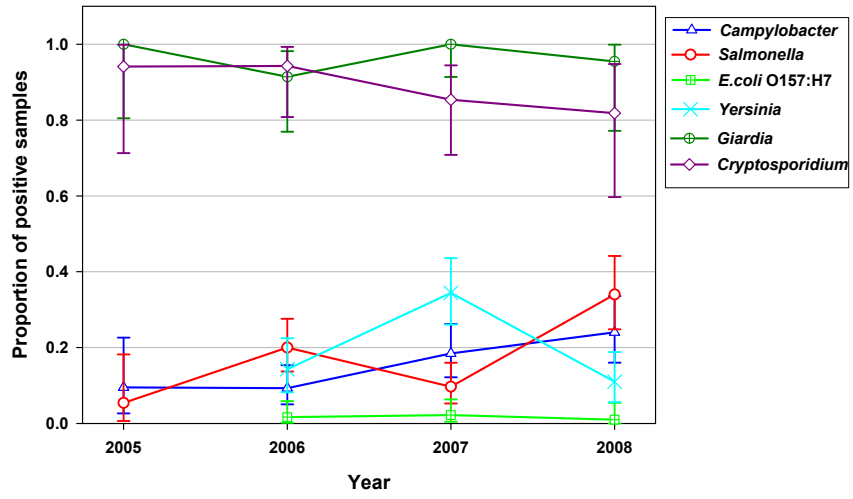
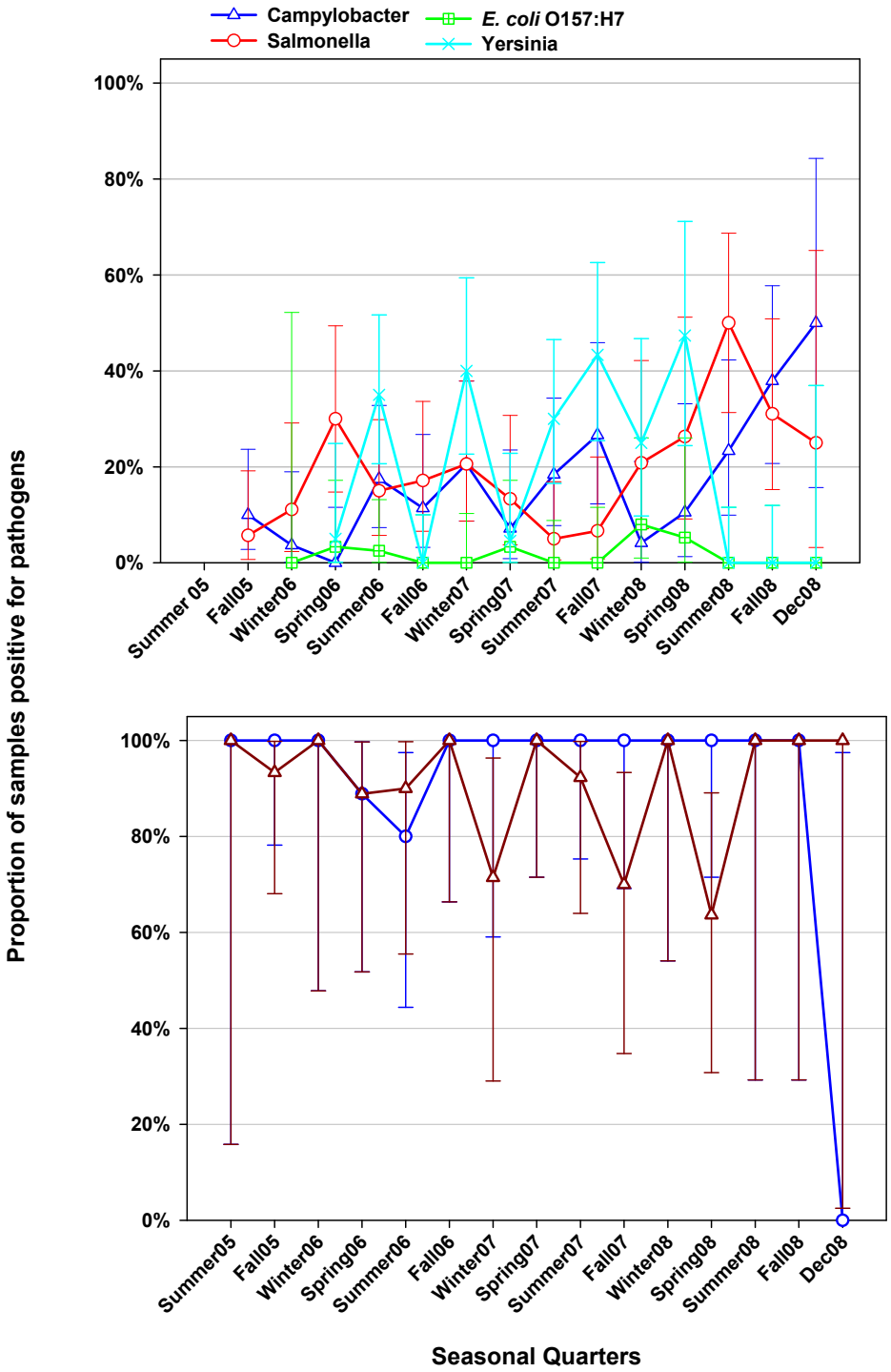


FIGURE 9.5

Proportion (with 95% confidence interval) of positive untreated surface water samples tested for selected enteric pathogens by culture method in Sentinel Site 1 between June 2005 and December 2008 (winter : December to February; spring : March to May; summer : June to August; fall : September to November)



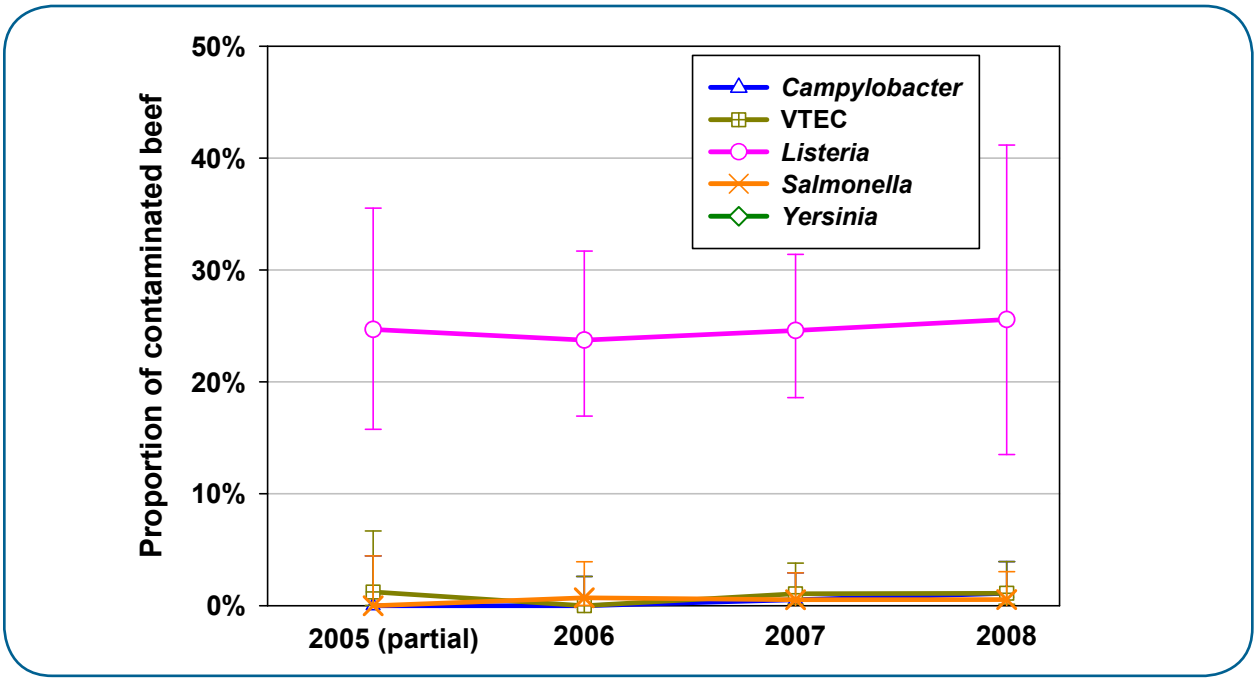
Retail Component

Since mid-2005, C-EnterNet has systematically sampled fresh raw pork, chicken and beef from randomly selected grocery stores within the sentinel site on a weekly basis.

Figure 9.6 and Figure 9.7 show the yearly and quarterly distribution of positive samples of raw retail meats from June 2005 to December 2008. Differences between years and between seasons,[16,17] were tested using a logistic regression model for each pathogen and for each kind of meat separately between winter 2006 and fall 2008. To respect the sampling scheme of the active monitoring put in place for food at retail, the type of store (chain vs. independent) was included in the model as a covariate and re-sampling within the same store was considered a repetition and was set as such in the statistical algorithm. The following results are significant at $p<0.01$ (Table 9.2):

- the seasonal variation of retail chicken contamination by *Campylobacter* spp.; the contamination being significantly the lowest in winter compared to each of the other quarter;
- the yearly differences in pork contamination by *Yersinia* spp.; contamination being more frequent in 2006 compared to 2007 and 2008, which were comparable;
- the seasonal variation in pork contamination by *Yersinia* spp. was almost significant (p=0.0113); contamination being more frequent in summer compared to fall (p=0.0046).

FIGURE 9.6
Proportion (with 95% confidence interval) of retail meat positive for selected pathogens in Sentinel Site 1 between June 2005 and December 2008



16 winter : December to February; spring : March to May; summer : June to August; fall : September to November

17 These results differ from the analyses presented in Chapter 10. This difference is attributed to different analysis objectives. The temporal trend analysis presented in Chapter 10 included data from 2005-2008, as well as some additional targeted study data, diluting the effect of skin-on vs skin-off on prevalence. The data presented here are specific to determining the effect of retail chicken sample change on prevalence.

FIGURE 9.6 (continued)
Proportion (with 95% confidence interval) of retail meat positive for selected pathogens in Sentinel Site 1 between June 2005 and December 2008

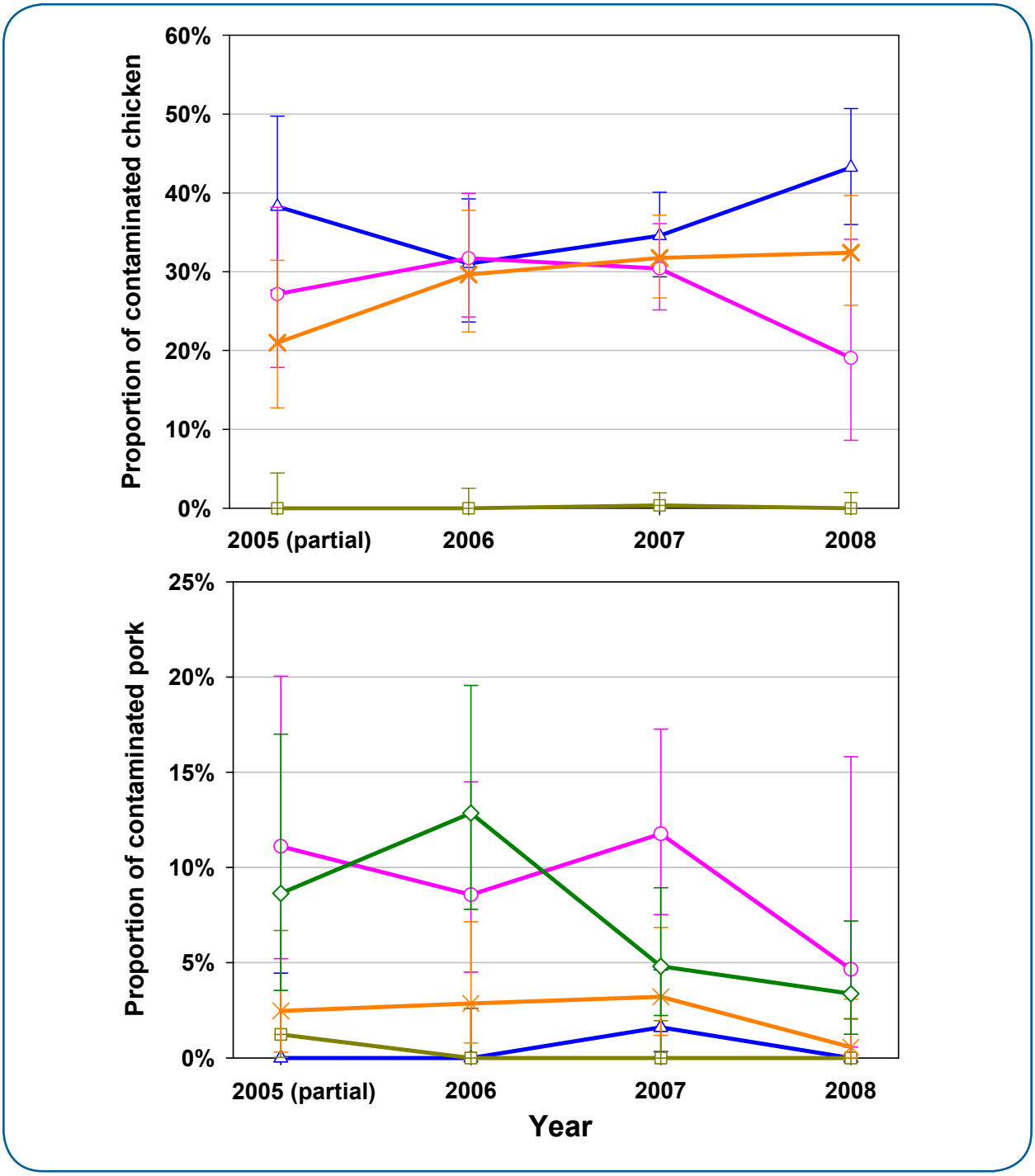


FIGURE 9.7

Proportion (with 95% confidence interval) of retail meats positive for selected enteropathogens in Sentinel Site 1 between June 2005 and December 2008 (winter : December to February; spring : March to May; summer : June to August; fall : September to November)

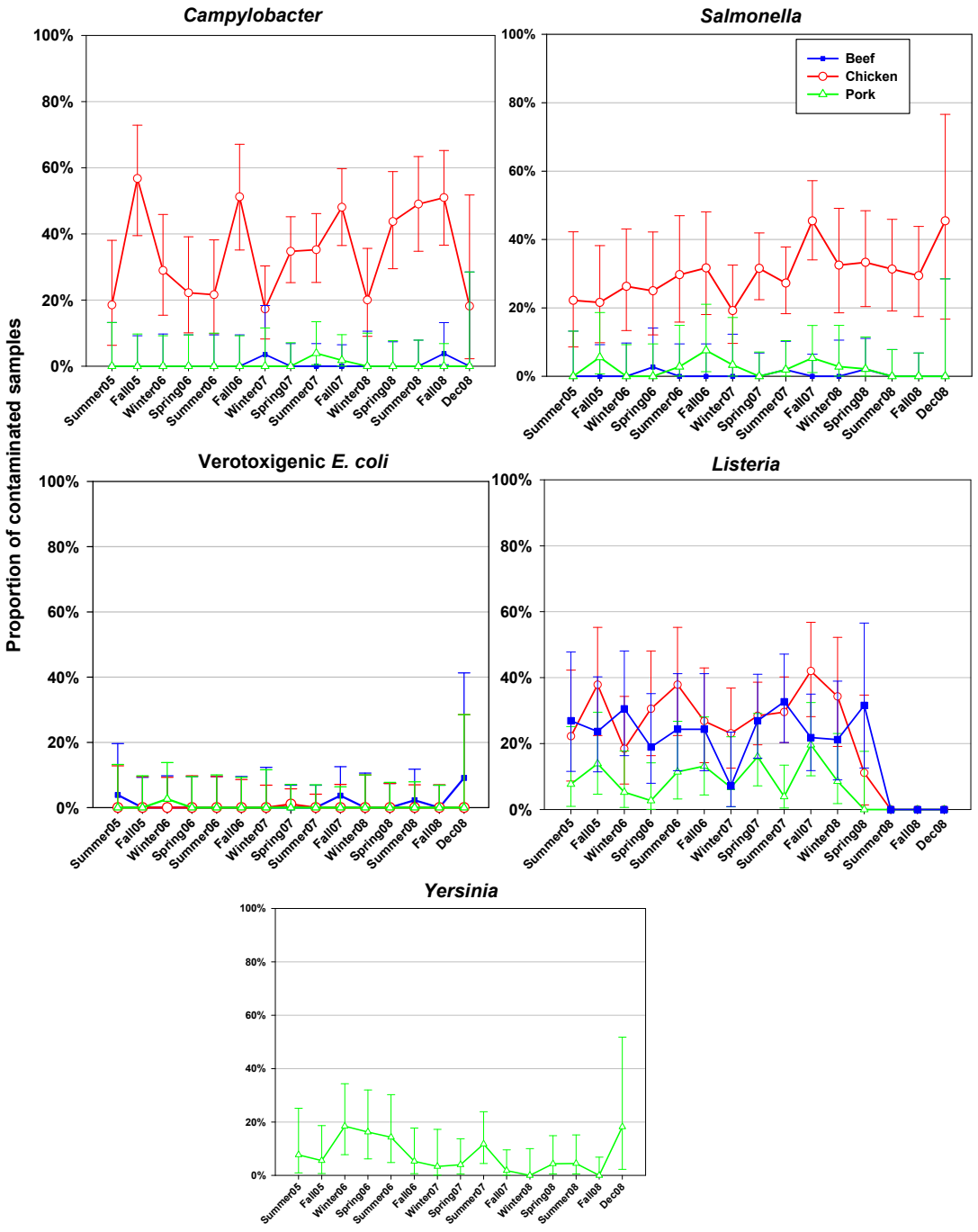


TABLE 9.2
Statistical results of logistic regression analyses of annual and seasonal influences on the contamination of water and retail meat sampled by selected pathogens in Sentinel Site 1 from January 2006 to December 2008

Pathogen	Surface Water	Beef	Chicken	Pork
Campylobacter spp.	Year: p=0.15 Season: p=0.25	NST*	Year: p=0.13 Season: p=0.0007	NST
L. monocytogenes	Year: p=0.19 Season: p=0.87	Year: p=0.69 Season: p=0.68	Year: p=0.77 Season: p=0.33	Year: p=0.40 Season: p=0.17
S. enterica	Year: p=0.19 Season: p=0.87	NST	Year: p=0.84 Season: p=0.12	
VTEC	NST*	NST	NST	NST
Yersinia spp.	Year: p=0.14 Season: p=0.25	-	-	Year: p=0.0038 Season: p=0.0113

* NST: not statistically tested because of too few positive samples.

10. Source Attribution

Since its beginning, the C-EnterNet program has had two specific objectives:

- Surveillance: detect changes in trends of human enteric disease incidence and pathogen exposure levels from food, animal and water sources ;
- Human illness source attribution[18] : determine the proportion of human cases that are due to water, food & animal contact.

Activities related to source attribution

With regards to its second objective, the C-EnterNet team has planned and undertaken several projects to generate information on source attribution useful for the various decision-makers involved in food safety, water safety and the prevention and control of human infectious gastrointestinal illness in Canada (Table 1).

Several broad methodological approaches have been reviewed and advocated to generate estimates of human illness attribution:

- Microbial subtyping approach
- Quantitative microbial risk assessment (QMRA)
- Comparative exposure assessment
- Analysis of data from outbreaks
- Case-control studies
- Intervention studies
- Expert elicitation

Each method has its specific advantages and limitations, and experts on source attribution have concluded that none of the currently available methods yields accurate estimates for source attribution on its own. Actually, these approaches are so different in various ways (e.g., concept, method including definition of source, input data, and data source) that they address slightly different questions; thus their results are considered more complementary than comparable. As a result, the C-Enternet Scientific Team has decided to explore all approaches by trying and adapting (when required) any specific method potentially useful in the Canadian context.

18 Human illness "source attribution" may be defined as the partitioning of the human disease burden of one or more foodborne infections to specific sources, where the term source includes animal reservoirs and vehicles (e.g., foods) (Pires et al. Attributing the human disease burden of foodborne infections to specific sources. *Foodborne Pathogens and Disease*, 2009 ; 6: 417-424)

TABLE 10.1
C-EnterNet plan and achievements with regards to Source Attribution

Approach / Objective	Data used	Status*	Main results/conclusions	Main output
1. Microbial subtyping				
1.a Informal, descriptive comparison of subtyping data for various pathogens between the humans and the potential sources	Annual subtyping data (e.g., serotypes, phagetypes, PFGE patterns) obtained through C-EnterNet's active food, animals, and water surveillance and the enhanced human surveillance in Sentinel Site 1	D Each year	-Travel- and non travel-related human cases do differ in terms of subtyping (e.g., *Salmonella* sero and phagetypes) - overall, the match between subtypes seen in human cases and those observed in sources is weak to limited	2006, 2007, and 2008 C-EnterNet's Annual Reports (particularly the Exposure Sources section in the 2007 Annual Report)
1.b Adaptation of the 'Danish Salmonella source account' model to the Canadian data	Published sero- and phagetyping data from NML for the human side and sero- and phagetyping from LFZ and CFIA for the source side Data between 2003 and 2007	I	Data analysis planned for second half of 2009	Expected publication in 2010
2. Quantitative microbial risk assessment				
2.a QMRA of cryptosporidiosis related to recreational water	Data collected through the C-EnterNet's active water surveillance in Sentinel Site 1 from March 2005 to Dec 2007 plus extra data from literature or other data sources	D	See the Results section below (Result #1)	Pintar et al. *A risk assessment model to evaluate the role of fecal contamination in recreational water on the incidence of cryptosporidiosis in a South-Western Ontario community*. Risk Analysis, 2010, 30(1):49-64
2.b QMRA of cryptosporidiosis related to municipally treated water	Data collected through the C-EnterNet's active water surveillance in Sentinel Site 1 from March 2005 to Dec 2007 plus data from the episodic survey on water consumption habits conducted by C-EnterNet in its sentinel site #1 plus extra data from literature or other data sources	D	See the Results section below (Result #2)	Pintar et al. *Assessing the risk of infection by Cryptosporidium via consumption of municipally treated drinking from a surface water source in a Southwestern Ontario Community*. Publication expected in 2010
3. Risk exposure assessment				
3.a *Campylobacter* risk exposure assessment	Data of detection and quantity of *Campylobacter* in retail meat, food animals and water collected through C-EnterNet in its sentinel site #1 plus extra data collected in the same area from other sources	P	Planned for 2010	
4. Outbreak data analysis				
4.a Descriptive analysis of foodborne outbreak data from all over the world with comparison between large geographical regions	4,093 reports of foodborne outbreak that occurred worldwide between 1998 and 2007. They had been compiled by the LFZ Food Safety and Risk Assessment group through a systematic scan on the Internet	D	See the Results section below (Result #3)	Greig and Ravel. Analysis of foodborne *outbreak data reported internationally for source attribution*. International Journal of Food Microbiology. 2009, 130: 77-87.

4.b Descriptive analysis of Canadian foodborne outbreak data with a historical perspective	Reports of Canadian food borne outbreaks combining 3 data sets covering 30 years (1976-2005). The data sets were provided by the Bureau of Microbial hazards, Health Canada, the Center for Foodborne, Environmental, and Zoonotic Infectious Diseases and the Laboratory for Foodborne Zoonoses, Public Health Agency of Canada	D	See the Results section below (Result #4)	Ravel, Greig, et al. *Estimating Human Gastrointestinal Illness Attribution in Canada through Foodborne Outbreak Data Analysis*. Journal of Food Protection, in press.
5. Case-control studies				
5.a Enteric disease case-control study	Risk factors of enteric disease cases over a 12 month period as collected through the enhanced human surveillance in C-EnterNet Sentinel Site 1 + risk factors for controls enrolled in the same area over the same period of time through an episodic study undertaken by C-EnterNet through a contract	I P	Data collection for the healthy control group to start in September 2009 Data analysis in late 2010	Publication expected for 2011
5. b General case-case comparison	Risk factors data of human enteric disease cases collected yearly through C-EnterNet in Sentinel Site 1	D each year	Relative risk factors for each enteric disease pointing out some specific potential sources (no formal testing)	2006, 2007, and 2008 C-EnterNet Annual Reports
5.c Specific case-case comparison for cryptosporidiosis	Risk factors data of human enteric disease cases collected from April 2005 to December 2007 through C-EnterNet in Sentinel Site 1	D	See the Results section below (Result #5)	Pintar et al. *A modified case-control study of cryptosporidiosis (using non-Cryptosporidium infected enteric cases as controls) in a South Western, Ontario community*. Epidemiology & Infection, 2009, 137(12):1789-1799
5.d Epidemiological and microbial description of travel-related cases compared to the domestically-acquired enteric infections	Risk factors data collected yearly through C-EnterNet's enhanced human surveillance in Sentinel Site 1	D	The travel-related cases can represent an important proportion (up to 50% or more) of all cases depending on pathogens and years	2006, 2007, and 2008 C-EnterNet Annual Reports
	Risk factors collected through C-EnterNet's enhanced human surveillance in Sentinel Site 1 from June 2005 to May 2009	I	Analysis of data from June 2005 to May 2009 to start in August 2009	One peer-reviewed publication is expected from this analysis of 4 years of data
6. Intervention study				
Feasible only through a full implementation of the C-EnterNet program				
7. Expert elicitation				
7. Food safety expert elicitation survey	Survey conducted in fall 2009 according to a methodology developed and used in the USA. A list of 150 food safety experts was built according to a snow-ball approach. The experts were from various fields (e.g., public health, govt, food safety, university, industry) and were all located in Canada. 66 of them responded.	I	Analysis in progress	Publication expected in 2010

* D= done; I= in progress; P= planned

Information generated

Result #1: A risk assessment model to evaluate the role of fecal contamination in recreational water on the incidence of cryptosporidiosis.

Summary:
A quantitative microbial risk assessment model was developed to simulate the role of recreational water contact in the transmission of cryptosporidiosis in a South-western Ontario community. Stochastic simulations were based on plausible modes of contamination of a pool (literature derived), river (site-specific) and recreational lakes (literature derived). The highest estimated risks of infection were derived from the (highly contaminated) recreational lake scenario, considered the upper end for risk of infection for both children [10 infections per 1,000 swims (5^{th} %ile: 2 infections per 1,000 swims; 95^{th} %ile: 3 infections per 100 swims)] and adults [4 infections per 1,000 swims (5^{th} %ile: 4 infections per 1,000 swims; 95^{th} %ile 1 infection per 100 swims)]. Simulating the likely *Cryptosporidium* oocyst concentration in a lane pool that a child would be exposed to following a diarrheal fecal release event resulted in the third highest mean risk of infection [4 infections per 10,000 swims (5^{th} %ile: 3 infections per 100,000; 95^{th} %ile: 10 infections per 10,000 swims)]. The findings from this study illustrate the need for systematic and standardized research to quantify *Cryptosporidium* oocyst levels in Canadian public pools and recreational beaches. There is also a need to capture the swimming practices of the Canadian public, including most common forms and frequency measures. The study findings suggest that swimming in natural swim environments and in pools following a recent fecal contamination event pose significant public health risks. When considering these risks relative to other modes of cryptosporidiosis transmission, they are significant.

Reference: Pintar et al. *A risk assessment model to evaluate the role of fecal contamination in recreational water on the incidence of cryptosporidiosis in a South-Western Ontario community*. Risk Anal. 2010 Jan;30(1):49-64.

Result #2: Assessing the risk of infection by *Cryptosporidium* via consumption of municipally treated drinking from surface water source.

Summary:
A quantitative microbial risk assessment model was developed to assess the risk of *Cryptosporidium* infection through the consumption of municipally treated drinking water in a model community. Simulations were based on site-specific surface water contamination levels, drinking water treatment plant-specific $\log_{10}$ reduction capacity, and the exponential dose response model. Model outputs are presented as the risk of infection per person per day and year. The effect of gender and age-specific tap water consumption practices on risk was examined. Risks are presented for routine and worst-case treatment scenarios, for both summer and winter months, based on both literature-derived values and site-specific data. The effect of *Cryptosporidium* oocyst infectivity in the source water on final risk estimates was also evaluated. Model results suggested that the risk of *Cryptosporidium* infection via drinking water in the model community, assuming routine operation of the water treatment plant, was negligible (4 infections in 10^{13} persons per day – 5^{th}%ile: 1 infection per 10^{15} persons per day; 95^{th} %ile: 2 infections per 10^{10} persons per day), suggesting that the risk is essentially non-existent during optimized, routine treatment operations. The model community embraces the multiple-barrier approach and achieves between 7 to 9 $\log_{10}$ *Cryptosporidium* oocyst reduction through their treatment process (chemically assisted filtration, ozonation, UV and chloramination). The results of the model simulations illustrated the importance of UV in the water treatment process for achieving these low risk estimates. Simulated UV failures increased the risk of infection by 5 orders of magnitude,

illustrating the importance of this step in the treatment. There was no difference in risk of *Cryptosporidium* infection by gender, based on volume of tap water consumed, but persons between the ages of 18 and 40 were at a slightly greater risk of infection, because they consume more tap water on a daily basis. In conclusion, risk of *Cryptosporidium* infection from the consumption of drinking water, during routine/average operations of the drinking water treatment facility, is very low, and well below the suggested acceptable level of risk of 1 infection per 10,000 persons per year. However, these results do not preclude the need for constant vigilance by both water treatment and public health professionals in this community to ensure public health protection. Human error and process down-time were not explicitly considered in these model iterations, but are worth future consideration since they may have a significant influence on final risk estimates. As with any stochastic model, there are uncertainties that exist in both the input variables and the output values, and these results are most useful when considered in relative terms rather than absolute terms. The QMRA approach provides a mechanism for local public health and water treatment professionals to evaluate integrated enteric disease surveillance data, develop what-if scenarios for future planning (related to climate change, carbon off-setting, etc), and formalize a communication framework for ongoing risk assessment, management and communication.

Reference: Pintar et al. *Assessing the risk of infection by Cryptosporidium via consumption of municipally treated drinking from a surface water source at the community level*. Manuscript currently being prepared

Result #3: Analysis of foodborne outbreak data reported internationally.

Summary:
Analysis of foodborne outbreak data is one approach to estimate the proportion of human cases of specific enteric diseases attributable to a specific food item (food attribution). Although we recognize that for a variety of reasons reported outbreaks represent only a small portion of all actual outbreaks, using outbreak data for food attribution is the only methodological approach where, theoretically, there is an actual direct link between the pathogen, its source and each infected person. The purpose of this study was to explore the usefulness of foodborne outbreak data extracted from publicly available international electronic reports and publications to provide estimates of food attribution, to derive and compare these estimates between regions, while improving the understanding of the pathogen/food vehicle combination. Electronic reports and publications of foodborne outbreaks that occurred globally since the 1980s were systematically scanned and their data were extracted and compiled in a database. A system of food categorization was developed and food vehicles assigned accordingly. The association between the aetiology and the food source was statistically described for outbreaks with both reported aetiology and incriminated food vehicle. Differences in associations between Australia and New Zealand, Canada, the European Union (EU) and the United States (US) were explored using multiple correspondence analysis and were formally tested between the EU and the US for selected pathogens and food sources. As a result, the food and aetiology cross tabulation of 4093 foodborne outbreaks that occurred globally between 1988 and 2007 is presented and discussed. For a few aetiologies and some foods the association is very specific. The lack of a specific association between the other foods and aetiologies highlights the potential roles of cross-contamination, environmental contamination and the role of the infected foodhandler along the food chain from farm to fork. Detailed analysis of the four regions highlighted some specific associations: *Salmonella* Enteritidis outbreaks occurred relatively often in the EU states with eggs as the most common source; *Campylobacter* associated outbreaks were mainly related to poultry products in the EU and to dairy products in the US; there was an association between *Escherichia* coli outbreaks and beef in

Canada; and while *Salmonella* Typhimurium outbreaks were relatively common in Australia and New Zealand, across all regions, *Salmonella* was associated with a variety of food groups. The value and limitations of the study are discussed, as well as the extrapolation of the food attribution estimates beyond their outbreak context.

Reference: Greig and Ravel. *Analysis of foodborne outbreak data reported internationally for source attribution*. International Journal of Food Microbiology. 2009, 130: 77-87.

Result #4: Estimating Human Gastrointestinal Illness Attribution in Canada through Foodborne Outbreak Data Analysis.

Summary:
Human illness attribution has been recently recognized as an important tool to better inform food safety decisions. Analysis of outbreak datasets has been suggested and used for that purpose. This study explored the usefulness of three comprehensive Canadian foodborne outbreak datasets covering the span of 30 years for estimating food attribution for gastrointestinal illness, providing Canadian food attribution estimates from a historical perspective. Information concerning the microbiological aetiology and the food vehicles recorded for each outbreak was standardized between the datasets. The agent-food vehicle combinations were described and analyzed for changes over time by using multiple correspondence analysis. Overall, 6908 foodborne outbreaks were available over three decades (1976-2005) but the agent and the food vehicle were identified in only 2107 of them. Differences between the datasets occurred in the distribution of the cause, the vehicle, the location or the size of the outbreaks. Multiple correspondence analysis showed association between *Clostridium botulinum* and wild meat and between *C. botulinum* and seafood. It also highlighted changes in food attribution over time. It generated the most-up-to-date food attribution values for salmonellosis (29% produce, 15% poultry, 15% meat other than poultry, pork and beef), campylobacteriosis (56% poultry, 22% dairy products other than fluid milk), and *Escherichia coli* infection (37% beef, 23% cooked multi-ingredient dishes, 11% meat other than beef, poultry, pork). Because of the inherent limitations of this approach, only the main findings should be considered for policy-making. The use of other human illness attribution approaches may provide further clarification.

Reference: Ravel et al. *Estimating Human Gastrointestinal Illness Attribution in Canada through Foodborne Outbreak Data Analysis*. Journal of Food Protection, in press.

Result #5: A modified case-control study of cryptosporidiosis (using non-Cryptosporidium infected enteric cases as controls).

Summary:
Data from the first sentinel site (Waterloo Region, Ontario) of the Canadian Integrated Enteric Disease Surveillance System (C-EnterNet) were used in a secondary-based case-control study of laboratory-confirmed *Cryptosporidium* infections to study the role of various exposure factors. The incidence of cryptosporidiosis in Waterloo Region was almost double both the provincial and national rates. Persons ill with one of nine other enteric infections (amoebiasis, campylobacteriosis, cyclosporiasis, giardiasis, listeriosis, salmonellosis, shigellosis, verotoxigenic *E. coli* infections, yersiniosis) captured by the surveillance system were used as the control group. Of 1204 cases of enteric illness in the sentinel area between April 2005 and December 2007, 36 cases and 803 controls were selected after excluding outbreak and international travel-related cases. Univariable analyses (Pearson x2 and

Fisher's exact tests) and multivariable logistic regression were performed. Results of the multivariable analysis found that cryptosporidiosis was associated with swimming in a lake or river (OR 2.9, 95% CI 1.2–7.4), drinking municipal water (a potential surrogate for urban respondents vs. rural) (OR 2.4, 95% CI 1.04–5.7), and having a family member with a diarrhoeal illness (OR 2.9, 95% CI 1.3–6.4).

Reference: Pintar et al. *A modified case-control study of cryptosporidiosis (using non-Cryptosporidium infected enteric cases as controls) in a SouthWestern, Ontario community*. Epidemiol Infect. 2009 Dec;137(12):1789-99.

Component	Sample Type	Speciation Or Microscopic ID	Enumeration (MPN)	Serotyping	Phagetyping	Ribotyping	AMR	PFGE	Genotyping
RETAIL	Skin-off chicken breasts Ground beef Pork chops	**Continuous:** *Salmonella* *Campylobacter* *Yersinia* (pork) VTEC	*Salmonella,* *Campylobacter* *Yersinia*	*Salmonella* *Yersinia*	*Salmonella*			*Salmonella*	
ON-FARM	Fresh and stored pooled manure (dairy, beef, swine broller chickens)	**Continuous:** *Salmonella* *Campylobacter* *Yersinia* (swine) *E.coli* O157:H7 **Poultry & beef (episodic):** *Listeria* *Giardia* *Cryptosporidium* *Rotavirus* *Norovirus*		*Salmonella* *Listeria* *Yersinia*	*Salmonella*	*Listeria*		*Salmonella* *E.coli* O157:H7	*Giardia* *Cryptosporidium* *Rotavirus* *Norovirus*
WATER	Raw surface water	*Salmonella* *Campylobacter* *Yersinia* *E.coli* O157:H7 *Giardia* *Cryptosporidium*		*Salmonella* *Yersinia*	*Salmonella*			*Salmonella* *E.coli* O157:H7	*Giardia* *Cryptosporidium*
HUMAN	Human stool samples	*Salmonella* *Campylobacter* *Yersinia* *E.coli* O157:H7 *Cryptosporidium* *Giardia* *Shigella* *Listeria*		*Salmonella* *Listeria*	*Salmonella*		*Salmonella* *Campylobacter*	*Salmonella* *E.coli* O157:H7	

APPENDIX B: Questionnaire Results

Case Information															
	Campylobacterosis		Salmonellosis		*E. coli* O157:H7		Yersiniosis		Giardiasis		Cryptosporidiosis		Amoebiasis		All
	Cases	Non-cases[b]	Cases	Non-cases[b]	Cases	Non-cases[b]	Cases	Non-cases[b]	Cases	Non-cases[b]	Cases	Non-cases[b]	Cases	Non-cases[b]	Cases
Total number endemic cases[a]	123	184	82	225	13	294	7	300	48	259	15	292	19	288	307
Number with exposure data	110	150	70	190	13	247	7	253	33	227	15	245	12	248	260
Proportion with exposure data	89.0	82.0	85.0	84.0	100.0	84.0	100.0	84.0	69.0	88.0	100.0	84.0	63.0	86.0	85.0
Exposure Information															
Private well - main water source	10	21	7	19	39	15	14	16	27	15	67	13	8	17	16
Municipal - main water source	66	57	51	64	62	61	57	61	70	59	33	62	75	60	61
Drank untreated water	9	10	5	11	0	10	0	10	21	8	21	9	14	9	9
Swam	20	30	16	29	54	24	29	26	47	22	40	25	29	26	26
in a lake	6	13	4	12	31	9	29	9	21	8	13	10	8	10	10
in a pool	12	14	7	15	54	11	0	13	15	13	20	13	8	13	13
in a river	0	4	1	3	0	3	0	2	15	0	0	2	0	2	2
Drank unpasteurized milk	7	3	0	6	8	4	0	5	0	5	20	4	0	5	5
Ate undercooked food	10	5	6	7	0	7	14	7	4	7	0	7	0	7	7
Attended a barbecue	30	24	14	32	39	26	14	27	38	25	54	25	0	28	27
Ate in a restaurant	45	31	33	39	23	38	43	37	39	37	13	39	25	38	37
Ate meat from butcher shop	9	7	3	10	0	9	14	8	12	7	27	7	0	8	8
Ate meat from private kill	3	3	0	4	0	3	0	3	3	3	13	2	8	2	3
Shopped at butcher shop	11	11	6	13	23	10	14	11	10	11	23	10	14	11	11
Contact with household pet	67	52	61	57	38	59	67	58	42	60	40	59	44	59	58
cats	28	24	29	25	39	25	43	25	21	26	0	27	8	27	26
dogs	47	32	36	40	15	40	29	39	30	40	40	38	25	39	38
reptile	2	6	9	3	0	4	0	4	6	4	0	4	8	4	4
Visited farm animal areas	13	5	0	12	0	9	14	8	7	9	13	8	29	8	9
cats	2	0	0	1	0	1	0	1	0	1	0	1	0	1	1
dogs	2	1	0	2	0	1	0	1	0	1	7	1	0	1	1
horses	0	1	0	1	0	0	0	0	0	0	0	0	8	0	0
cattle	3	1	0	3	0	2	0	2	0	2	13	1	0	2	2
pigs	0	1	0	1	0	0	0	0	0	0	7	0	0	0	0
poultry	0	1	0	1	0	0	0	0	0	0	7	0	0	0	0
Lived on a farm/rural	8	14	6	14	38	10	0	12	23	10	27	11	0	12	12
On-farm animal exposures															
cats	3	1	0	3	0	2	0	2	3	2	7	2	0	2	2
dogs	2	1	0	2	0	2	0	2	6	1	0	2	0	2	2
horses	3	1	1	2	0	2	0	2	3	2	0	2	0	2	2
cattle	3	1	1	2	0	2	0	2	3	2	0	2	0	2	2
pigs	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
poultry	1	1	0	2	8	1	0	1	0	1	7	1	0	1	1
sheep	0	1	0	1	0	0	0	0	0	0	7	0	0	0	0

Note: Potential exposures are highlighted in yellow when the percentage for the specific disease is at least 5% greater than the exposure for the other enteric diseases combined.

[a] Does not include Cyclosporiasis, Hepatitis A, Listeriosis, or Shigellosis.

[b] Non-cases include all other enteric cases with exposure information.

APPENDIX C: Method Changes in 2008

Sampling

In January 2008, C-EnterNet implemented a change in the retail chicken breast sample collection from skin-on cuts to skin-off cuts. This change was based in-part on evidence from a food consumption survey (n=2,332) conducted between November 2005 and March 2006 in Sentinel Site 1. Results from this survey indicated that of those purchasing chicken breasts, 13% purchased skin on while the remaining 87% purchased skin off. Of those purchasing beef, 70% chose ground beef and of those purchasing pork 49% chose pork chops.[19]

In addition, in 2007 a year-long episodic study was performed, with the objective to determine whether there is a statistically significant difference in pathogen levels on skin-on chicken breasts versus skin-off. In general, it was found that skin-off chicken breasts have a similar or, in the case of *Campylobacter*, a higher proportion positive than skin-on chicken breasts (unpublished data).

C-EnterNet strives to sample retail products that reflect consumer buying patterns. The retail sampling plan therefore maintained the testing of ground beef and pork chops, but changed to skin-off chicken breasts.

19 Government of Canada. Canadian National Enteric Pathogen Surveillance System (C-EnterNet) 2006. Guelph, ON, Public Health Agency of Canada, 2007.

APPENDIX D: Retail Enumeration Results

	# Samples Tested for Presence/ Absence	# Positive Samples by Presence/ Absence	MPN/g of sample				
			Below Detection (< 0.3)	0.3-10	11-100	101-1000	>1000
Campylobacter							
Pork	178	0					
Chicken	185	80	65	15			
Beef	180	2	2				
Salmonella							
Pork	178	1	1				
Chicken	185	60	53	6		1	
Beef	180	1	1				
Listeria							
Pork	43	2	2				
Chicken	42	8	6	2			
Beef	43	11	8	3			
Yersinia							
Pork	178	6	6				

NOTES