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C-EnterNet 2006 Annual Report

...National Integrated Enteric Pathogen Surveillance Program

Canada

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C-EnterNet Annual Report

2006

...National Integrated Enteric Pathogen Surveillance Program

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Executive Summary

C-EnterNet's 2006 annual report represents a full calendar year of surveillance data collected from the pilot sentinel site – Region of Waterloo – in four component areas including human, retail meat, water and on-farm. This information, in conjunction with the C-EnterNet's 2005 surveillance data, serves as a solid baseline for comparisons with future findings and determination of trends in the occurrence of enteric illness in the human population and pathogen detection in the exposure sources. Molecular subtyping results, which are essential to integrating the results from the four components, have been included in this report. The replication of these activities in additional sentinel sites to represent approximately 10% of the Canadian population will provide national representation of enteric illness in Canada. Although still in its pilot phase, C-EnterNet's integrated surveillance program has produced results that highlight key areas of interest for stakeholders involved in public health and food and water safety issues.

A total of 420 human cases of 10 bacterial, viral and parasitic enteric diseases were reported to the local public health authorities within the pilot sentinel site. One percent (4) of the cases were outbreak-related, 31% (131) were travel-related and 68% (285) were classified as endemic. The four most frequently reported diseases (salmonellosis, campylobacteriosis, giardiasis, verotoxigenic *E. coli* (VTEC) infection) accounted for 82% of the reported cases.

When the enhanced C-EnterNet surveillance data is compared to historical data in the sentinel site, it appears that overall the prevalence of acute gastro-intestinal illness has been relatively stable over the last decade. Among the most frequent diseases, campylobacteriosis and giardiasis have slightly decreased, while salmonellosis has remained steady. For the less frequent diseases, yersiniosis has gradually increased and the incidence rates for VTEC infection, cryptosporidiosis and Hepatitis A infection were higher over the last couple of years compared to ten years ago.

Travel continues to be associated with enteric disease. Overall, 31% of the human gastrointestinal illness cases in the sentinel site were associated with travelling outside of Canada. However, the proportion of travel-associated cases was higher for some pathogens including Hepatitis A (67%), shigellosis (50%), giardiasis (48%) and salmonellosis (44%). Conversely, cases of *E. coli* O157:H7 and yersiniosis appeared to be mainly acquired domestically. Some patterns emerged when the travel-related cases were examined according to subtype. For example, 58% of *Salmonella* Enteritidis infections were contracted abroad, while no travel-associated cases of *S.* Typhimurium and *S.* Heidelberg were reported. In addition, while the majority of *C. jejuni* cases were endemic, the majority of *C. coli* cases were associated with travelling abroad. In addition, the antimicrobial resistant profiles of the *Campylobacter* isolates displayed multidrug resistance.

The standardized questionnaires that are the cornerstone of the surveillance program highlighted risk factors that warrant further investigation. For example, reptiles and dogs appear to be potential risk factors for *Salmonella* and *Campylobacter* infections, respectively, in humans.

In addition, non-municipal drinking water, swimming in a pool, and visiting a farm animal area appear to be important risk factors for *giardia* cases in the sentinel site.

C-EnterNet detected pathogens capable of causing human enteric illness on the 3 meat commodities tested, emphasizing the need for proper handling and cooking of raw meat. Following quantitative assessment by the Most Probable Number (MPN) method, a majority of the samples had levels below the limit of detection. These samples most likely represent a lower risk given that the level of these organisms was sufficient for detection using enrichment culture methods, however they were not high enough for enumeration (<0.3 MPN/g).

The subtyping results indicated that in some cases the specific subtypes found on the retail meat were similar to those that caused human illness. For example, for *Salmonella* Enteritidis, PFGE pattern SENXAI.0038 was the most common *Salmonella* Enteritidis pattern in retail chicken samples and the most common pattern in endemic human cases. In comparison, *Salmonella* Enteritidis PFGE pattern SENXAI.0001 was the most common among travel-related human illness and was not detected on any retail meat samples. In addition, *C. jejuni* was the most common species found on the raw chicken meat and was also the predominant species in human cases. Conversely, some subtypes were of less concern. For example, *Salmonella* Kentucky was the most common serotype among retail chicken meat samples, however this serotype was not found in any human cases in the sentinel site. Although *Yersinia* was detected on retail pork samples, further subtyping determined that they were non-pathogenic strains.

Analysis of the retail data for the seasonal occurrence of pathogens resulted in no patterns in *Salmonella* prevalence. However, the prevalence of *Campylobacter* on retail chicken meat doubled in the fall of 2006. It is interesting to note that this peak followed the typical rise in human *Campylobacter* cases seen in the summer months.

Surveillance in the dairy and swine operations in the sentinel site detected some pathogen subtypes known to cause human enteric illness. For example, *S.* Typhimurium was the top *Salmonella* serotype in humans and on swine farms, and the second most frequent on dairy farms. *Giardia* Assemblage B and *Cryptosporidium parvum*, which are pathogenic to humans, were found in pooled swine and pooled dairy manure samples. Conversely, although pathogenic strains of *E. coli* were detected in pooled dairy manure samples and untreated surface water, the PFGE subtyping revealed no identical patterns between the human and non-human isolates, suggesting that different strains are circulating in these components. In 2007, the on-farm component has been expanded to include beef and poultry operations in the sentinel site.

Untreated surface water cannot be ignored as a potential exposure route for several enteric pathogens. For example, 13 of the 32 *Salmonella* isolates had serotypes also found in human cases. In addition, the detection of VTEC, *C. jejuni* and *C. coli* demonstrate the potential risk posed by natural recreational water, as a source for human enteric illness. *Giardia* and *Cryptosporidium* occurred frequently in untreated surface water, and in the early part of the year there appeared to be a correlation between human endemic cases and the average concentration of *Giardia* cysts in the untreated surface water. The two most common human pathogenic strains, *C. hominis* and *C. parvum* bovine genotype, were detected in untreated surface water samples.

Several episodic studies were conducted in the sentinel site in 2006. A food consumption survey conducted between November 2005 and March 2006 in the sentinel site provided baseline data on food consumption and information about food handling in the healthy population. Results from the survey indicated that the majority (76%) of consumers purchased meat from large chain stores while a smaller proportion (<10%) shopped at non-chain stores (e.g. butcher/independent). In addition, this survey confirmed that the top three purchase choices for residents within the sentinel site were ground beef, pork chops and chicken breasts, supporting the decision made to sample those meats at the retail level.

C-EnterNet data (June 2005 – December 2006) was analyzed to compare enteric disease among travellers (international) and non-travellers (endemic and outbreak cases). Many *Salmonella* cases (30/64), had been to Mexico and the Caribbean region; the majority of Hepatitis A (7/9) and amoebiasis cases (7/9) reported travelling to Asia; and *Giardia* cases were most commonly associated with travel to Asia, Mexico and the Caribbean region. Conversely, *E. coli* O157: H7 appears to be a domestically acquired pathogen as demonstrated by 59 non-travel cases compared to one international travel case.

In collaboration with the Bureau of Microbial Hazards of Health Canada, a short-term study was performed to determine the occurrence of norovirus and rotavirus in retail meat and manure samples from swine and dairy operations within the sentinel site. A human GII.4-like norovirus was detected in the swine and dairy manure and one pork chop, although it was unclear whether this strain is infectious to humans. Rotavirus Group A, a strain capable of causing human illness was found in all types of meat and manure tested.

These highlights from C-EnterNet's activities in 2006 provide a synopsis of the results from this surveillance system. The body of the report provides additional details related to the trends observed during 2006. As the surveillance system progresses to encompass more sentinel sites, data from these activities will produce results that can be generalized to the broader Canadian population. The findings will directly inform national policy on food and water safety, thereby ensuring our ability to maintain Canada's safe food and water supply in the face of new challenges and changes in our environment.

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1. Introduction

1.1 Background

C-EnterNet is a multi-partner surveillance initiative facilitated by the Public Health Agency of Canada and funded primarily by Agriculture and Agri-Food Canada through the 2003-2008 Agricultural Policy Framework. It is designed to provide information to evaluate and guide activities that will reduce the burden of enteric (gastrointestinal) disease in Canada, similar to the CDC's FoodNet in the USA.

C-EnterNet, based on a sentinel surveillance model, is a leading-edge surveillance approach that utilizes enhanced surveillance activities within selected areas to obtain information that would not be possible on a broader scale. Each sentinel site requires 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. C-EnterNet's pilot sentinel site – the Regional Municipality of Waterloo, Ontario – is a community of approximately 500,000 residents, a mix of urban and rural activities, and demonstrates innovation in public health and water conservation. Four additional sites are planned to provide a national representation of enteric disease.

The core objectives of the C-EnterNet program 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.

C-EnterNet conducts continuous and episodic surveillance activities in four components: human, food, water, and food animals. Continuous surveillance activities are undertaken throughout the year to derive trends in human disease occurrence, exposure sources and source attribution for the most important enteric pathogens and exposure sources. Episodic surveillance activities are limited in time and provide specific information to complement the continuous activities (e.g. inclusion of emerging pathogens, focus on specific exposure sources, focus on specific human subpopulations).

1.2 Scope and Content

This report provides the results from our pilot sentinel site for the 2006 calendar year. The previous annual report covered the period of June 2005 to May 2006. Therefore, there is some overlap of data in this transitional report. Future reports will allow year-to-year comparisons.

The C-EnterNet 2006 report begins with an overview of the reported human cases of enteric disease followed by pathogen-specific results, including some subtyping, from the human, agri-food and water continuous surveillance activities. The report concludes with the results from the 2006 episodic activities. Human illness attribution will be addressed in a separate report.

C-EnterNet is in the pilot phase and extrapolation of results to a national level will be made once C-EnterNet has been expanded to several sentinel sites. For additional details on the pilot site, please refer to the 2005-2006 Annual Report.[1] Detailed descriptions of the C-EnterNet design and plan, and the enteric disease case questionnaires are available at our website (http://www.phac.gc.ca/c-enternet/index.html). C-EnterNet is currently compiling a summary of sampling and laboratory methods that will be available at our website in the near future.

Limitations inherent to this pilot phase of the program include low numbers of samples and incremental incorporation of various activities. As additional sentinel sites are implemented, comprehensive information from laboratory and epidemiological data will provide national trends in enteric disease occurrence, in exposure sources, and inform and strengthen our understanding of human illness attribution in Canada.

[1]Government of Canada. National Integrated Enteric Pathogen Surveillance Program (C-EnterNet) 2005-2006. Guelph, ON: Public Health Agency of Canada, 2006.

2. Human Case Summary

2.1 Overview of Human Cases

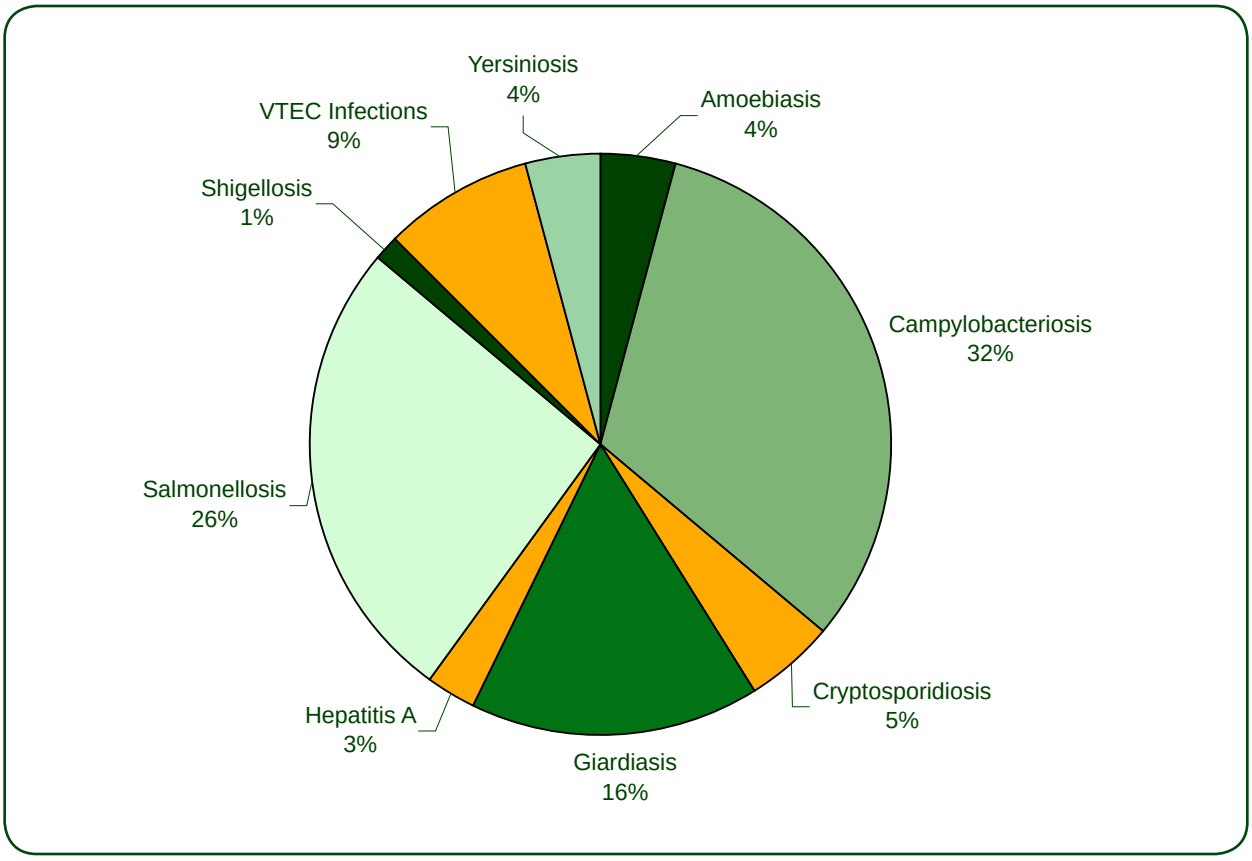
A total of 420 cases of 10 bacterial, viral and parasitic enteric diseases were reported to the local public authorities within Sentinel Site 1 in 2006 (Table 2.1). The three most frequently reported diseases (salmonellosis, campylobacteriosis and giardiasis) accounted for 74% of those cases (Figure 2.1).

Information on potential exposures was obtained from 91% of the reported cases within the sentinel site in 2006. Public health inspectors administered a standardized questionnaire to the cases or proxies. Preliminary analyses of this information were used to determine case status (travel versus endemic) and compare exposures (Appendix A).

Table 2.1
Number of cases and incidence rates per 100,000 person-years of laboratory-confirmed enteric diseases in Sentinel Site 1 in 2006

Disease	Number of Cases				Incidence Rate	
	Outbreak	**Travel**	**Endemic**	**Total**	**Endemic**	**Total**
Amoebiasis	0	6	12	**18**	2.5	**3.7**
Campylobacteriosis	0	26	108	**134**	22.4	**27.8**
Cryptosporidiosis	0	6	15	**21**	3.1	**4.4**
Cyclosporiasis	0	0	0	**0**	0	**0**
Giardiasis	0	32	35	**67**	7.3	**13.9**
Hepatitis A	0	8	4	**12**	0.8	**2.5**
Salmonellosis	2	48	60	**110**	12.4	**22.8**
Shigellosis	0	3	3	**6**	0.6	**1.2**
Verotoxigenic *E. coli* (VTEC)	2	1	32	**35**	6.6	**7.3**
Yersiniosis	0	1	16	**17**	3.3	**3.5**
Total	**4**	**131**	**285**	**420**		

Figure 2.1
Relative proportion of enteric diseases reported in Sentinel Site 1 in 2006



Historically, from 1990 to 2006, numbers for enteric diseases showed an overall decline in Sentinel Site 1 (Figures 2.2 & 2.3). A total of 9,008 cases of ten reportable enteric illnesses, including endemic, travel and outbreak cases, were reported from 1990 to 2006. *Campylobacter* spp., *Giardia* and *Salmonella* spp. accounted for over 80% of the enteric illness cases during that sixteen-year period.

Recent Trends

- VTEC infections increased in 2005 and are still elevated in 2006.
- Yersiniosis has been increasing since 2000.
- Cryptosporidiosis showed an increase in 2006.
- Hepatitis A increased in 2005 due to an outbreak and remains elevated compared to recent years.
- Salmonellosis, which showed a sharp increase in 2005, as a result of the *S.* Enteritidis PT 13 province-wide outbreak, declined in 2006 to previous levels.

Figure 2.2

Temporal trends of the three most frequent enteric diseases, and total bacterial, viral and parasitic enteric diseases from Sentinel Site 1, 1990 to 2006 (the red box indicates data collected in 2006)

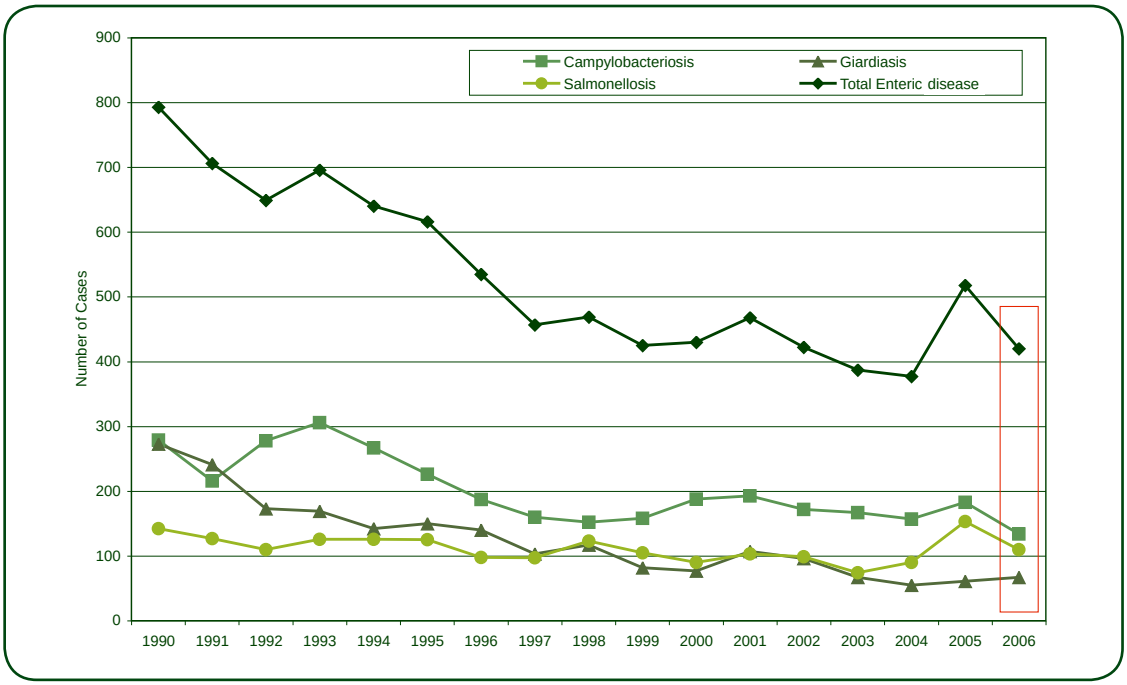
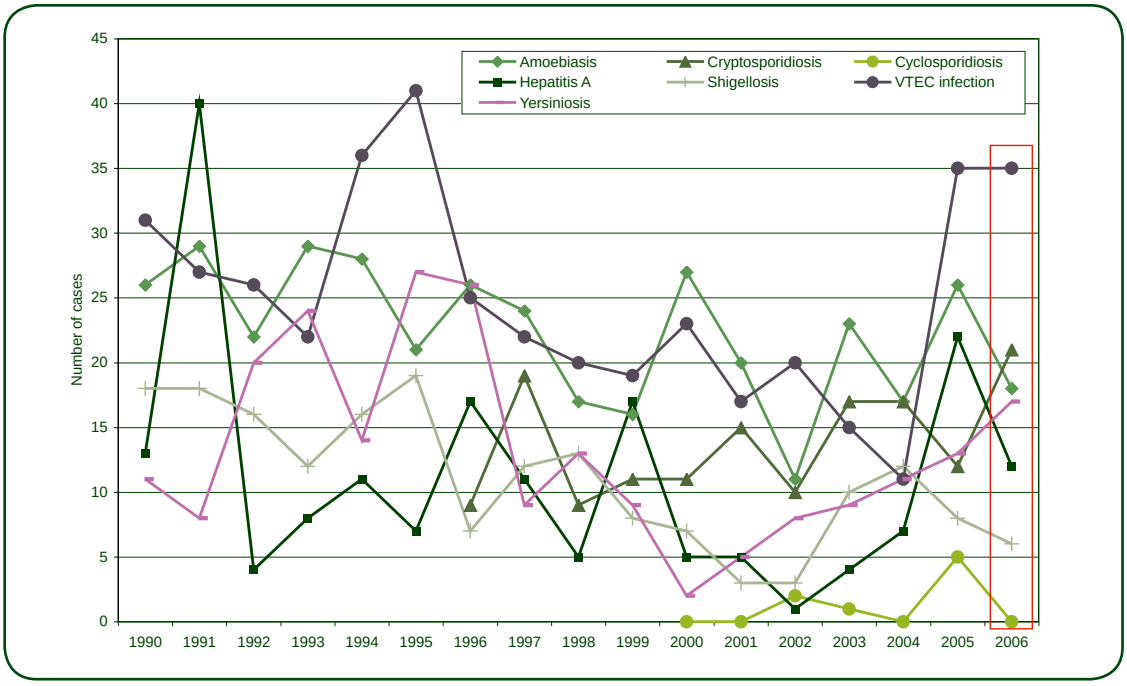


Figure 2.3

Temporal trends of seven enteric diseases from Sentinel Site 1, 1990 to 2006 (the red box indicates data collected in 2006)



2.2 Outbreak-related Cases

There were no large community outbreaks identified within the sentinel site – Region of Waterloo – in 2006, unlike in 2005 when outbreaks of *E. coli* O157, *Salmonella* Enteritidis PT 13, and Hepatitis A were detected.

There were four outbreak-associated enteric cases reported in the sentinel site. Two cases of *E. coli* O157:H7 were associated with a home daycare. A source for the index case was not identified, but there was apparent person-to-person transmission within the home daycare setting, according to the children's onset dates. Contact tracing of daycare attendees and household contacts did not identify any further cases. The third outbreak-associated case, a *Salmonella* Heidelberg infection, was an incidental finding during an investigation of a viral outbreak in a day care setting. *Salmonella* Heidelberg was not the causative agent in this outbreak. The fourth outbreak-associated case, a *Salmonella* Typhimurium infection, was connected to a community outbreak that occurred outside of the sentinel site. Using the enteric case questionnaire, it was determined that the case attended a catered wedding in another health region and was one of a number of ill attendees.

In 2006, a total of 67 institutional enteric outbreaks were identified and investigated. Thirty-one enteric outbreaks occurred in long-term care facilities (LTCF) and 36 occurred in childcare centres (CCC). In total, a causative agent was identified in 15% of the Region of Waterloo institutional outbreaks. All of the LTCF and CCC outbreaks where a causative agent was identified were attributed to norovirus and rotavirus infections, respectively.

2.3 Travel-related Cases

Of the reported cases, 31% (131/420) were classified as travel-related (Table 2.1). Salmonellosis, giardiasis and campylobacteriosis were the three most common diseases, contributing to 81% 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. Most of the travel-related *Salmonella* cases, 22/48, had been to Mexico and the Caribbean region, and most of these, 10/22, had *S.* Enteritidis (phagetypes 6a, 4, 4a, 1 and 1a). The majority of Hepatitis A cases (7/8) reported travelling to Asia, as compared to zero to Mexico and the Caribbean region. *Giardia* cases were most commonly associated with travel to Asia and Mexico and the Caribbean region.

Table 2.2
Travel-related cases in Sentinel Site 1 in 2006

Disease	Africa	Asia	Europe	Mexico & Caribbean	USA	Multiple Destinations & Others	Total
Amoebiasis	0	6	0	0	0	0	**6 (4.6%)**
Campylobacteriosis	1	8	5	4	6	2	**26 (19.9%)**
Cryptosporidiosis	2	0	1	3	0	0	**6 (4.6%)**
Cyclosporiasis	0	0	0	0	0	0	**0**
Giardiasis	4	11	3	11	1	2	**32 (24.4%)**
Hepatitis A	1	7	0	0	0	0	**8(6.1%)**
Salmonellosis	3	9	7	22	6	1	**48 (36.7%)**
Shigellosis	0	3	0	0	0	0	**3 (2.3%)**
Verotoxigenic *E. coli*	0	0	0	0	1	0	**1 (0.7%)**
Yersiniosis	0	0	0	1	0	0	**1 (0.7%)**
Total	11 (8.4%)	44 (33.6%)	16 (12.2%)	41 (31.3%)	14 (10.7%)	5 (3.8%)	131 (100%)

2.4 Endemic Cases

The analyses presented in the remainder of this report largely refer to the endemic cases. 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. Although C-EnterNet is not actively monitoring pathogen exposure in other potential sources (such as pet animals), these risk factors are explored through the human case follow-up questionnaire used by the local health unit.

In each of the following sections, 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 in this pilot program, exposure information was not stratified by age or gender. Thus, 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 2006, in Sentinel Site 1, there were a total of 134 reported cases of *Campylobacter* infection (27.8/100,000 person-years). Of these 134 cases, 19% (26) were travel-related and 81% (108) were classified as endemic (22.4/100,000 person-years). In comparison, the annual incidence rates for campylobacteriosis in 2006 in Canada and Ontario were 27.1/100,000 and 24.7/100,000, respectively.[2] Both of these rates are similar to the sentinel site's overall rate including the large proportion of travel-related cases. These numbers underscore the need to focus on endemic cases to establish the links between public health and domestic food and water safety issues.

The age- and gender-specific endemic incidence rates illustrate campylobacteriosis is highest in males less than 5 years of age (Figure 3.1). A breakdown by gender shows that 42 cases were female (17.0/100,000) and 66 were male (26.9/100,000). The quartile age ranges were: 0.75 years (min.), 16 (Q1), 38.5 (median), 56 (Q3), 92 (max.).

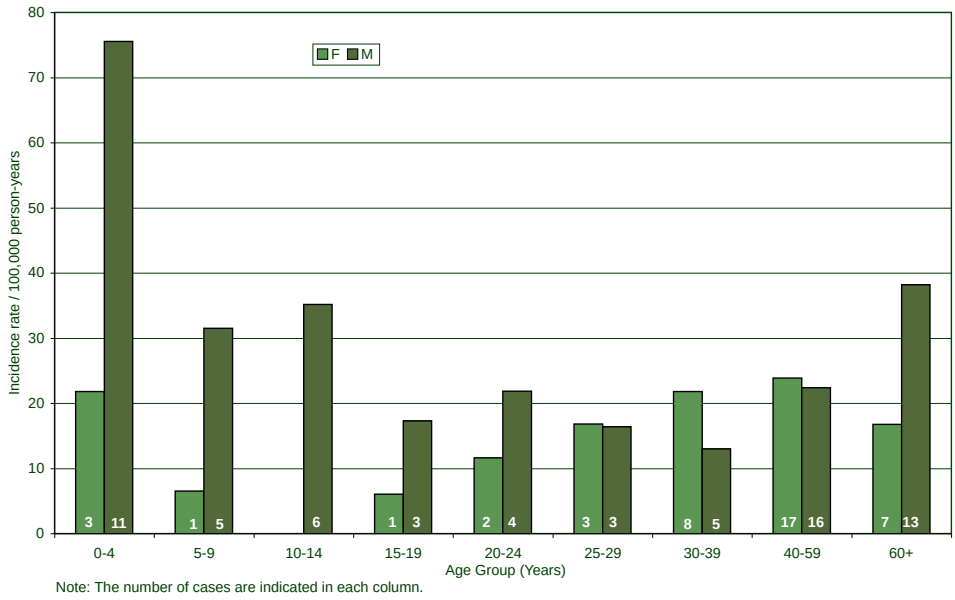
The vast majority (97%) of *Campylobacter* associated with endemic human cases were identified as *C. jejuni, C. coli* and *C. lari* accounted for the remaining 3% (Table 3.1).

The majority of *C. jejuni* cases were endemic (103/122), while the remaining 19 were travel-related. In contrast, a greater proportion of the *C. coli* cases were travel related (6/8) versus endemic (2/8).

Antimicrobial resistant profiles were determined for 64 endemic and 15 travel-related *Campylobacter* cases. Multidrug resistance and resistance to antimicrobials that are important in human medicine were detected more frequently (5 of 15) in the travel-related cases. For example, 2 travel-related *C. coli* cases had resistance to 7 antimicrobials (ciprofloxacin, azithromycin, clindamycin, gentamycin, erythromycin, naldixic acid, and tetracycline). An additional 3 travel-related cases (1 *C. coli* and 2 *C. jejuni*) had resistance to 3 antimicrobials (ciprofloxacin, nalidixic acid and tetracycline). Only 2 of the 64 endemic cases had resistance to 2 or more antimicrobials: 1 *C. coli* (ciprofloxacin, nalidixic acid and tetracycline) and 1 *C. jejuni* (azithromycin, clindamycin and erythromycin).

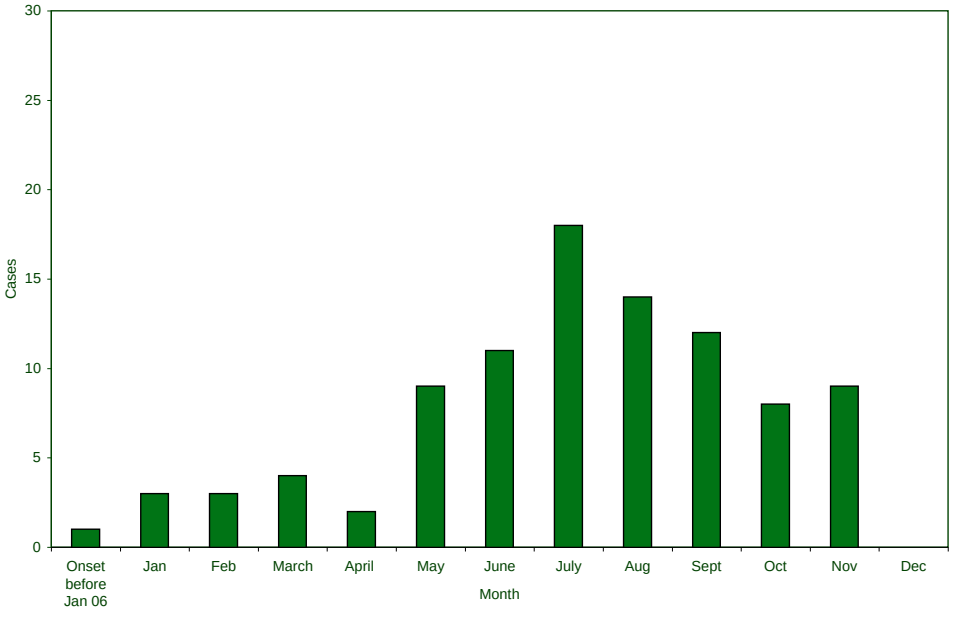
[2]Public Health Agency of Canada. Notifiable Diseases On-Line. Posted at http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/#top_list and updated by Carole Scott; 2007 [personal communication]. Note: 2006 numbers are preliminary and subject to change.

Figure 3.1
Incidence rates of endemic campylobacteriosis in Sentinel Site 1 by gender and age group in 2006



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

Figure 3.2
Monthly distribution of endemic human *Campylobacter* cases in Sentinel Site 1 reported in 2006



The majority of endemic *Campylobacter* cases were reported between May and November 2006 (Figure 3.2).

Eighty-seven percent (94/108) of the endemic *Campylobacter* cases provided potential exposure information for the 10 days prior to onset of illness (Appendix A). Eating in a restaurant (39%) and the use of private wells as a source of drinking water (21%) were reported more frequently in *Campylobacter* cases than in other enteric cases. For exposure to animals, *Campylobacter* cases had a higher proportion of household pet contact with dogs (42%) than other enteric cases.

3.2 Exposure Surveillance

Table 3.1

***Campylobacter* detection and speciation data for integrated surveillance activities in Sentinel Site 1 in 2006**

	Human		Retail Food			Food Animals (Manure)		Untreated Surface Water	
	Endemic Cases		Pork	Chicken	Beef	Swine	Dairy Cattle	Grand River	
Detection			Pork chop	Skin-on breast	Ground beef	30 Farms	45 Farms	5 sample points on Grand River	
# tested	Unknown		140[a]	145[a]	139[a]	120[a]	179[a]	140[a]	140[b]
# positive	108[a]		0	45	0	15 (12 farms)	44 (27 farms)	13	78
% positive			0%	31%	0%	13%	25%	9%	56%
Subtyping									
# subtyped	106			45		15	44	12[c]	0
C. coli	2	2%		5		6	6	1	
C. jejuni	103	97%		40		0	23	2	
C. lari	1	1%		0		0	0	10	
Other						9	15		

[a]Culture method.
[b]Molecular method (16S rRNA).
[c]Two serotypes were detected in 1 sample

Retail

Campylobacter was isolated from 31% (45/145) of the skin-on chicken breasts sampled and was not detected in the raw retail pork and beef samples (Table 3.1). The positive raw chicken samples were further analyzed with the Most Probable Number (MPN) technique to quantify the bacterial load. Of the positive samples, 30/45 were found to be below the MPN detection limit, 14/45 were between 0.3 and 10 MPN *Campylobacter*/g and 1/45 was between 11-100 MPN *Campylobacter*/g (Appendix B).

Of the raw chicken breasts that tested positive for *Campylobacter*, 40/45 were *C. jejuni*, and the remaining 5/45 were *C. coli*.

Farm

Campylobacter was isolated from 13% (15/120) of the pooled manure samples collected from 30 swine farms and from 25% (44/179) of the pooled manure samples collected from 45 dairy farms (Table 3.1).

C. coli was identified from 6/15 of the pooled swine manure samples that tested positive for *Campylobacter*. Using biochemical tests, the *Campylobacter* species could not be determined on the remaining 9/15 positive samples. Among the positive samples collected from the dairy operations, 23/44 were *C. jejuni*, and 6/44 were *C. coli*. The remaining 15/44 could not be speciated by biochemical tests.

Water

Untreated surface water (i.e. before treatment by the municipal water treatment plant) was tested for *Campylobacter* using both culture and molecular methodologies (Appendix C). Using the culture technique, *Campylobacter* was detected in 9% (13/140) of the untreated water samples, while 56% (78/140) were positive by the molecular method (Table 3.1). Therefore, the true prevalence of viable *Campylobacter* may be somewhere between these two estimates.

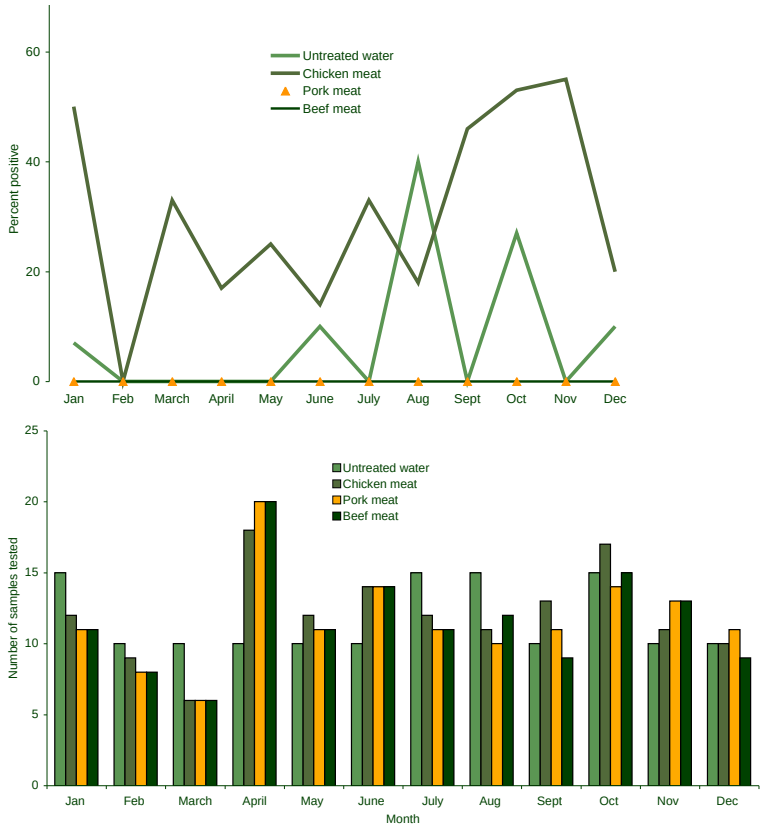
C. lari was the most frequent species detected in the untreated surface water, (10/12), but *C. jejuni* and *C. coli* were also detected.

Seasonal Trends in Exposure Sources

The temporal distribution of positive samples from the exposure sources indicates higher peaks in the later portion of 2006 (Figure 3.3). The prevalence of *Campylobacter* on raw chicken samples was highest in the fall of 2006 (September–November). A similar trend was observed in the C-EnterNet 2005 retail chicken data.[3] Positive samples of untreated surface water were sparse, with peaks in August and October.

Figure 3.3

Temporal distribution of *Campylobacter* detected in untreated surface water and retail meat samples in Sentinel Site 1 in 2006



[3]Government of Canada. National Integrated Enteric Pathogen Surveillance Program (C-EnterNet) 2005-2006. Guelph, ON: Public Health Agency of Canada, 2006.

3.3 Integrated Overview

- In Sentinel Site 1, *C. jejuni* was the predominant species in human cases, retail chicken meat and pooled dairy manure samples.

- *C. coli* was rarely associated with human illness, was frequent in pooled swine and pooled dairy manure, less frequent in retail chicken meat, and was occasionally detected in untreated surface water.

- *C. lari* was associated with fewer human illness and was the predominant species detected in untreated surface water.

- The summer peak in human *Campylobacter* cases (Figure 3.2) precedes the observed elevations in the retail and water samples (Figure 3.3).

- Although *Campylobacter* was relatively common on retail chicken, the majority of positive samples had low MPN levels (67% below detection limits) (Appendix B).

- Epidemiologically, dogs appear to be a potential risk factor for *Campylobacter* infections in humans, however, further investigation is needed.

- Molecular typing methods including pulsed-field gel electrophoresis (PFGE), Oxford multi-locus sequence typing (MLST), flagellin (flaA gene) short-variable region sequencing (flaA SVR), and a novel multiplex PCR method, termed hypervariable gene fingerprinting (HVGF), are being used on C-EnterNet isolates to improve data integration and identify clusters of *Campylobacter* cases. Results from these studies will be available in future reports.

4. *Salmonella*

4.1 Human Cases

In 2006, in Sentinel Site 1, a total of 110 cases of salmonellosis were reported (22.8/100,000 person-years). Of these 110 cases, 44% (48) were travel-related, 2% (2) were outbreak-related and 55% (60) were classified as endemic (12.4/100,000 person-years). In comparison, the annual incidence rates for salmonellosis in 2006 in Canada and Ontario were 14.9/100,000 and 16.1/100,000, respectively.[4]

The age- and gender-specific endemic incidence rates from the 60 endemic cases showed the highest rate in females less than five years of age (50.9/100,000) (Figure 4.1). The highest incidence rate in males was also among those less than five years of age (34.3/100,000). The quartile age ranges were: 0.2 years (min.), 6 (Q1), 23 (median), 35.5 (Q3) and 85 (max.). Of the endemic cases, 32 (13/100,000) were female and 28 (11.4/100,000) were male.

The 60 endemic cases for which the serotype was known were spread over 23 serotype categories, of which the top three were Typhimurium (15), Enteritidis (14), and Heidelberg (4), encompassing 55% of isolates that were serotyped (Table 4.1).

Comparison of travel versus endemic *Salmonella* cases indicated that all of the Typhimurium (15/15), Heidelberg (4/4), Newport (3/3) serotypes were of domestic origin, while over half of the Enteriditis (19/33) cases were travel related.

[4]Public Health Agency of Canada. Notifiable Diseases On-Line. Posted at http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/#top_list and updated by Carole Scott; 2007 [personal communication]. Note: 2006 numbers are preliminary and subject to change.

Figure 4.1
Incidence rates of endemic salmonellosis cases by gender and age group in Sentinel Site 1 in 2006

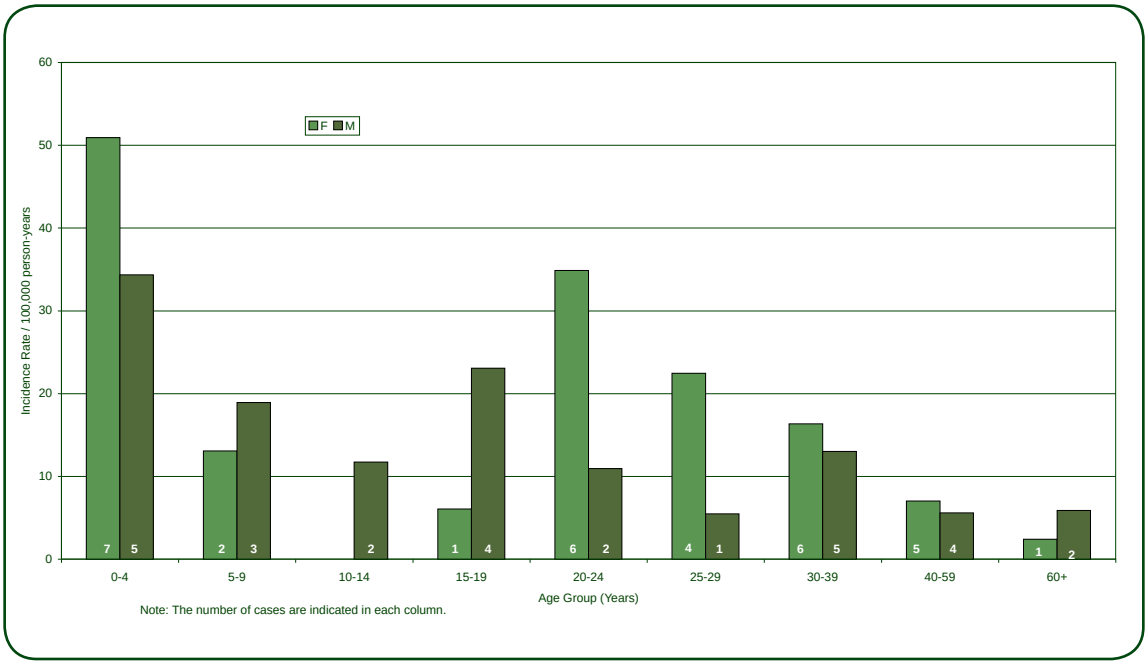
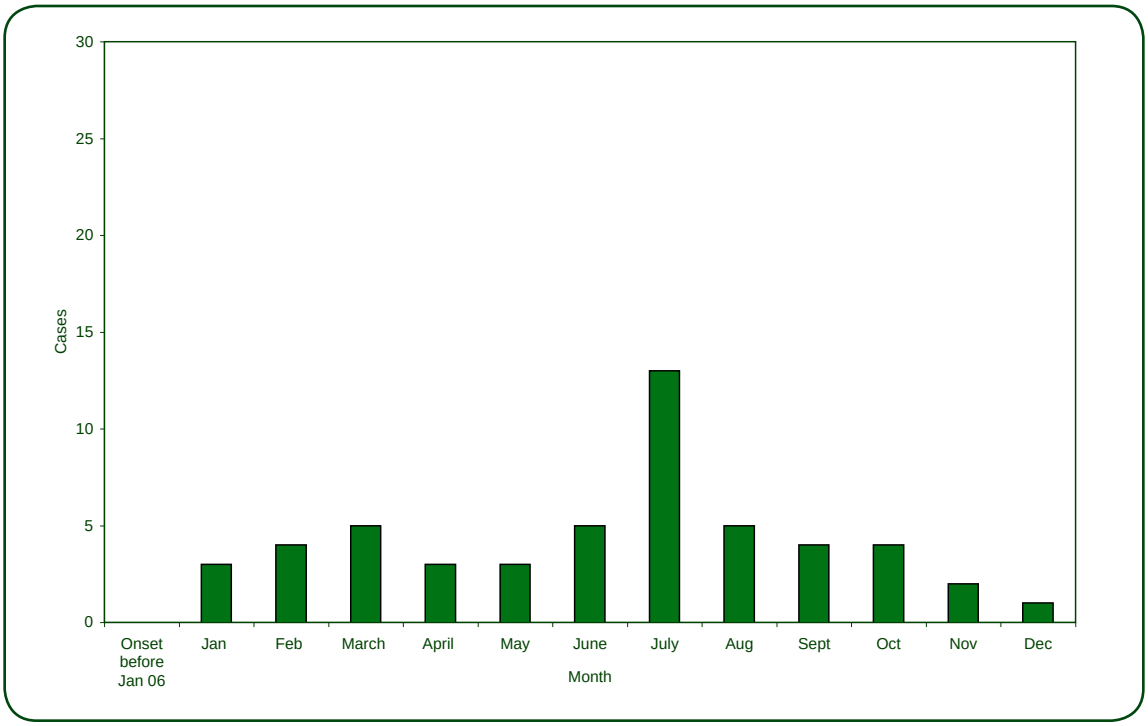


Figure 4.2
Monthly distribution of endemic human *Salmonella* cases in Sentinel Site 1 reported in 2006



The peak of endemic *Salmonella* cases (22%; 13/60) occurred in July (Figure 4.2).

Potential exposure information for the 3 days prior to onset of illness was collected for 95% (57/60) of the reported endemic *Salmonella* infections (Appendix A). For most animal exposures (household pets, and both on-farm and while visiting farm animal areas), salmonellosis cases had lower exposure than that reported from all other enteric cases. A household pet exposure, which was more frequent in *Salmonella* cases than in cases of other enteric diseases, was contact with a pet reptile (7% vs. 1%).

4.2 Exposure Surveillance

Retail

Salmonella contamination of raw pork chops and ground beef was rare, 3% (4/140) and 1% (1/139), respectively (Table 4.1). *Salmonella* was detected on 30% (43/145) of the raw chicken breasts. Of the contaminated pork and beef samples, all were below the MPN detection limit. Of the positive chicken samples, 35/43 were found to have levels below the MPN detection limit, while the remaining 8/43 had levels between 0.3-100 MPN/g (Appendix B).

The 3 most frequent serotypes found on chicken meat were: Kentucky (20/43), Heidelberg (6/43) and Enteriditis (all PT13) (5/43) (Table 4.1). The 3 serotypes found on pork chops were Thompson, Schwarzengrund and Kentucky, while the single beef isolate was serotype Orion var. 15+34+.

Farm

Salmonella was isolated from 28% (33/120) of the pooled manure samples collected from 30 swine farms (Table 4.1). *Salmonella* was isolated from 11% (20/179) of the pooled manure samples collected from 45 dairy farms.

On swine farms, Typhimurium, Derby and Infantis were the most frequently isolated *Salmonella* serotypes. The most frequently isolated *Salmonella* serotypes from dairy operations were Kentucky, Agona, and Typhimurium.

Water

The prevalence of *Salmonella* contamination in untreated surface water samples was fairly similar for the culture-based method 20% (28/140) and the molecular method 17% (24/140) (Table 4.1).

The most frequent *Salmonella* serotypes isolated from untreated surface water samples were Thompson, Kentucky, and Typhimurium.

Table 4.1
Salmonella detection and serotyping data for the integrated surveillance activities in Sentinel Site 1 in 2006

	Human	Retail Food			Food Animals (Manure)		Untreated Surface Water	
	Endemic Cases	Pork	Chicken	Beef	Swine	Dairy Cattle	Grand River	
		Pork chop	Skin-on breast	Ground beef			5 sampling points on river	
Detection					30 Farms	45 Farms		
# tested	Unknown	140[a]	145[a]	139[a]	120[a]	179[a]	140[a]	140[b]
# positive	60[a]	4	43	1	33	20	28	24
% positive		3%	30%	1%	28%	11%	20%	17%
Subtyping								
# subtyped	**60**	**4**	**43**	**1**	**33**	**20**	**32[c]**	
Typhimurium[d,e]	**3**							
Typhimurium DT104[d]	**2**				**7 (4 farms)**	**1**	1	
Typhimurium DT104a[d]			1		**1**			
Typhimurium DT104b[d]	**1**				**1**			
Typhimurium 1[d]	**2**							
Typhimurium 2[d]	**1**							
Typhimurium 10	**1**							
Typhimurium 15[d]					**1**			
Typhimurium 41[d]							1	
Typhimurium 69[d]							1	
Typhimurium U302[d]					**3 (2 farms)**			
Typhimurium UT1[d]					**1**			
Typhimurium 108	**2**							
Typhimurium 120	**1**							
Typhimurium 151					**1**			
Typhimurium 169[d]			1					
Typhimurium 170	**1**							
Typhimurium 193[d]					**1**		**1**	
Typhimurium Untypable[d]	**1**					**1**		
Enteritidis	**2**							
Enteritidis PT13	**9**		**5**					
Enteritidis PT4a	**1**							
Enteritidis PT8	**2**							
Heidelberg	**4**		**6**				2	
Newport	3						2	
Branderup	2							
Oranienberg	2							
Senftenberg	2							
Untypable	2							
Agona	1				2 (2 farms)	**2 (1 farm)**		
Derby	1				**5 (3 farms)**			
Hadar	1		1			1		
Infantis	1		1		**4 (3 farms)**		1	
Saintpaul	1					1		
Schwarzengrund	1	**1**	2					
Tennessee	1				1			
Thompson	1	**2**				1	**5**	
I:4,5,12:b:-	1						2	
Brandenburg					2 (2 farms)		1	
Kentucky		**1**	**20**			**12 (6 farms)**	**5**	
Kiambu			2				2	
London					2 (2 farms)			
Orion var. 15+34+				1				
Other[f]	7		4		1	1	8	

[a]Culture method.
[b]Molecular method.
[c]Multiple serotypes were detected in more than one sample.
[d]Includes var 5-.
[e]Phagetype information not available.
[f]Serotypes that were identified once in a single component are listed below and are NOT listed in Table 4.1:
Human: SSP Diarizonae, Sandiego, Paratyphi A, Panama, Muenchen, Montevideo, Agoueve,
Chicken meat: Indiana, Mbanaka, I:4,5,12:i:-, I:8,20:i:-
Swine operations: Livingstone
Dairy cattle operations: I:6,14,18:-:-
Untreated water: Albany, Berta, Minnesota, Muenster, Uganda, Worthington, I:10:-:-, I:4, 12:i:-

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

Table 4.2
PFGE results for *S.* Typhimurium, *S.* Enteriditis, and *S.* Heidelberg for all components, including human travel-related cases in Sentinel Site 1 in 2005 (in parentheses) and 2006

	Human		Retail		Food Animals (Manure)		Untreated Surface Water
	Non-travel[a]	Travel	Pork	Chicken	Dairy Cattle	Swine	Grand River
Typhimurium							
# samples with PFGE results	14	0	1	4	2	31	4
STXAI.0001	2		(1)		1	5 (1)	1
STXAI.0013						1	
STXAI.0027	1			(1)		6 (7)	
STXAI.0029						2 (2)	
STXAI.0044	1						
STXAI.0098	1					(1)	
STXAI.0195	1						2
STXAI.0203	1						
STXAI.0214						(1)	
STXAI.0233	2						
STXAI.0239	1						
STXAI.0269							1
STXAI.0270					1		
STXAI.0286						1	
STXAI.0312	2			1 (1)			
STXAI.0339						(1)	
STXAI.0344	1						
STXAI.0349	1						
STXAI.0361				1		1	
STXAI.0362						(1)	
STXAI.0364						(1)	
Enteriditis							
# samples with PFGE results	14	18	0	5	0	0	0
SENXAI.0001		11 (2)					
SENXAI.0002	1	1					
SENXAI.0003	2						
SENXAI.0004		1					
SENXAI.0038	9 (2)			5			
SENXAI.0079		1					
SENXAI.0093		1					
SENXAI.0123		1					
Heidelberg							
# samples with PFGE results	4	0	0	11	0	1	2
SHEXAI.0001				1 (3)			1
SHEXAI.0005				(1)		(1)	
SHEXAI.0006	1			4 (1)			1
SHEXAI.0009	3						
SHEXAI.0015				1			

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

Five of the 21 *S.* Typhimurium PFGE patterns were isolated from more than one source. Of the Typhimurium isolates, PFGE pattern STXAI.0027 and pattern STXAI.0001 were the two most common from non-human sources and both were also found in human cases. Most of these were from pooled swine manure samples. Pattern STXAI.0001 is the most common pattern reported to PulseNet Canada[5] while STXAI.0027 is not commonly reported.

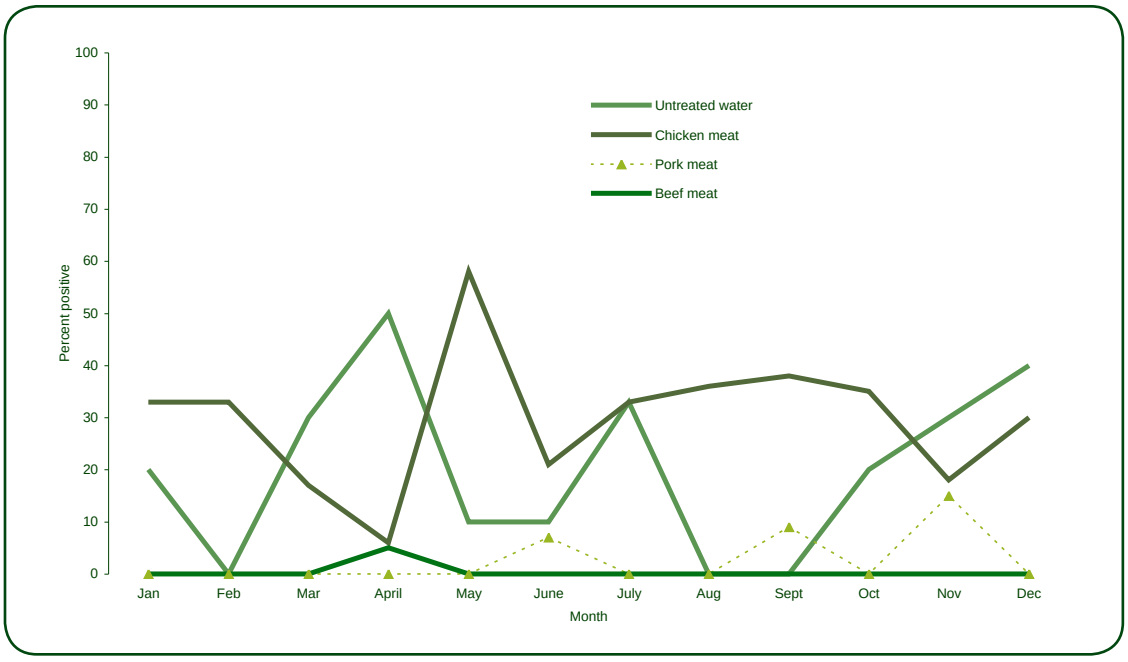
The majority of *S.* Enteritidis cases were travel-related. However, for the two most common PFGE patterns identified, SENXAI.0001 cases were all travel-related and SENXAI.0038 cases all were non-travel. These two PFGE patterns represent approximately 50% of all human S. Enteritidis cases reported in PulseNet Canada. The only 5 non-human *S.* Enteritidis isolates characterized by PFGE were also SENXAI.00038 and were from retail chicken.

Two of the *S.* Heidelberg PFGE patterns, SHEXAI.0006 and SHEXAI.0009, were isolated from human cases. Pattern SHEXAI.0006 was also identified from retail chicken but SHEXAI.0009 was not isolated from any non-human source despite it being the second most common PFGE pattern reported to PulseNet Canada. The majority of non-human isolates of *S.* Heidelberg were from retail chicken.

Seasonal Trends in Exposure Sources

There are no obvious seasonal trends in the exposure sources of *Salmonella* (Figure 4.3).

Figure 4.3
Temporal distribution of *Salmonella* detected in untreated surface water and retail meat samples in Sentinel Site 1 in 2006



[5]PulseNet Canada is the National Molecular Subtyping Network for Foodborne Disease Surveillance

4.3 Integrated Overview

- Typhimurium is the top *Salmonella* serotype in humans and on swine farms, and the second most frequent on dairy farms and in untreated surface water.

- No travel-associated cases of *S.* Typhimurium were reported within Sentinel Site 1. The two most frequent PFGE patterns detected in pooled swine manure samples were also detected in non-travel human cases (Table 4.2).

- *Salmonella* Enteritidis was the second most common serotype in human cases and third most common serotype in retail chicken samples. It was not identified in the other components. More than half of the *Salmonella* Enteritidis cases were travel associated with a specific predominant PFGE pattern. Of the 14 non-travel *Salmonella* Enteritidis cases that had phagetype and PFGE patterns determined, 11 were PT13 and had identical PFGE patterns (SENXAI.0038). This matches the phagetype and PFGE pattern in the 5 Enteritidis isolates found in chicken meat.

- *Salmonella* Heidelberg was the third most common serotype in human cases and the second most common serotype detected in chicken meat. The most frequent PFGE pattern (SHEXAI.0006) detected in chicken meat was also detected in a human endemic case.

- *Salmonella* Kentucky was the most common serotype among chicken meat, dairy cattle, and untreated surface water, but was not found in any human cases in the sentinel site.

- Although *Salmonella* was somewhat common on retail chicken meat, the majority of positive samples had low MPN levels (81% below detection limits) (Appendix B).

- Epidemiologically, reptiles appear to be a potential risk factor for *Salmonella* infections in humans. There was one case of *S.* Agoueve in an infant under 6 months of age. While no definitive source of the infection was identified, it was noted that the family owned 3 reptiles, which are a known risk factor for *S.* Agoueve infection.[6]

- Untreated surface water cannot be ignored as a potential exposure route for *Salmonella* since 13/32 isolates tested positive for serotypes also found in human cases. Therefore, natural recreational water might be a source for human waterborne salmonellosis.

[6]de Jong B, et al. Effect of Regulation and Education on Reptile-associated Salmonellosis. Emerging Infectious Disease 2005;11(3):398-403.

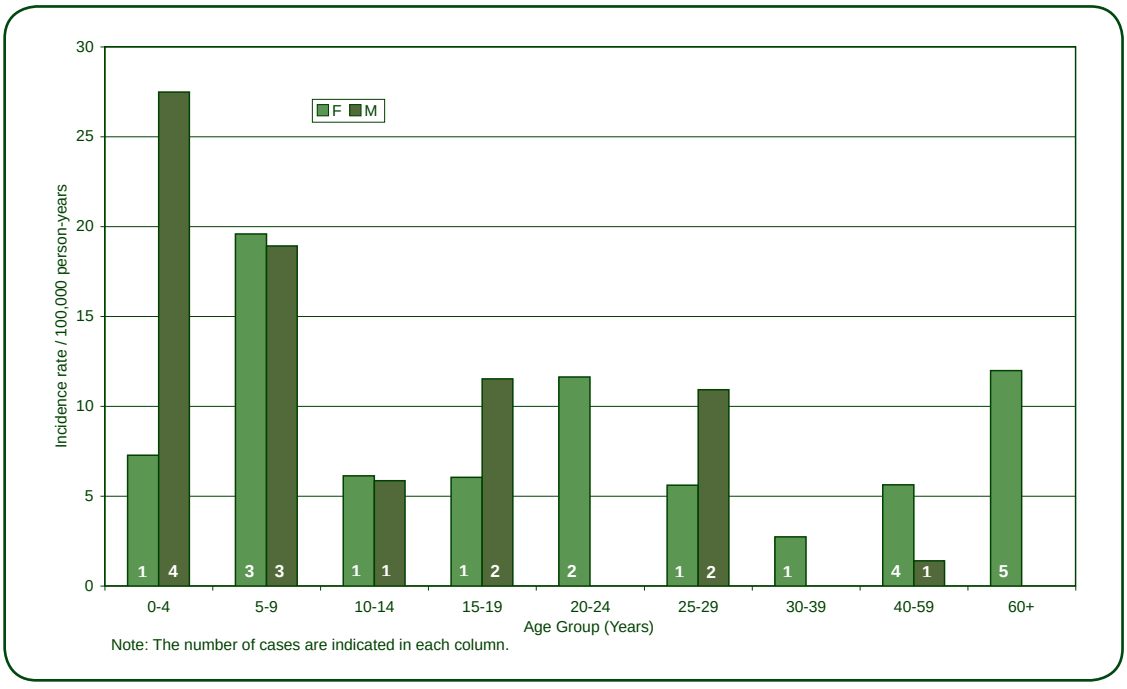
5. Pathogenic *E. coli*

5.1 Human Cases

In 2006, in Sentinel Site 1, there were a total of 35 reported cases of *E. coli* O157:H7 (7.3/100,000 person-years). Of those 35 cases, 1 was travel-related, 2 were outbreak-related and 32 were classified as endemic (6.6/100,000 person-years). In comparison, the annual incidence rates for *E. coli* O157:H7 in 2006 in Canada and Ontario were 2.9/100,000 and 2.3/100,000, respectively.[7]

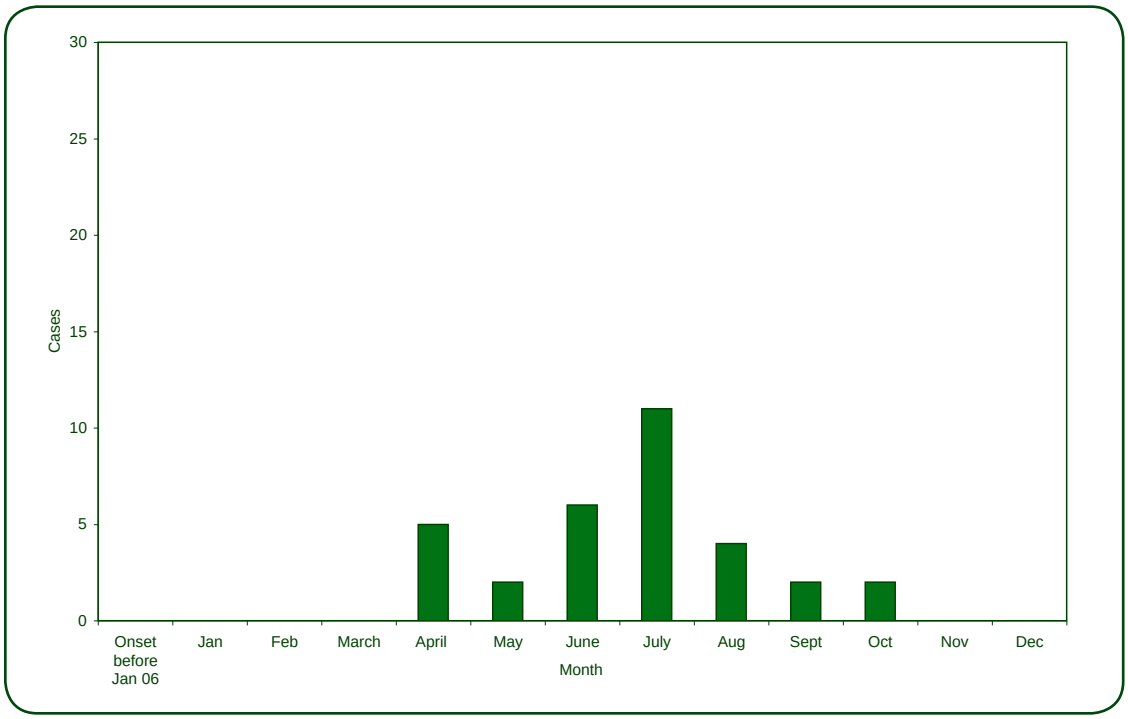
The age- and gender-specific incidence rates from the 32 endemic cases showed the highest rates in males less than 5 years of age (Figure 5.1). Nineteen cases were female (7.7/100,000) and 13 were male (5.3/100,000). The quartile age ranges were: 0.8 years (min.), 5.5 (Q1), 19.5 (median), 50.5 (Q3), 78 (max.). Only the O157:H7 subtype of verotoxigenic *E. coli* was reported (Table 5.1).

Figure 5.1
Incidence rates of endemic *E. coli* O157:H7 in Sentinel Site 1 by gender and age group in 2006



[7]Public Health Agency of Canada. Notifiable Diseases On-Line. Posted at http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/#top_list and updated by Carole Scott; 2007 [personal communication]. Note: 2006 numbers are preliminary and subject to change.

Figure 5.2
Monthly distribution of endemic human *E. coli* O157:H7 cases in Sentinel Site 1 in 2006



No endemic VTEC cases were reported between January and March or in November and December, and the highest number of cases was reported in July (Figure 5.2).

Exposure information for the 10 days prior to the onset of illness was collected for 97% (31/32) of the reported endemic cases of *E. coli* O157:H7 (Appendix A). The *E. coli* O157:H7 cases had higher reported proportions compared to the other enteric cases for the following exposures: use of municipal water source; swam in a lake; attended a barbecue; ate in a restaurant; ate meat from a butcher shop; shopped at a butcher shop; and contact with a household pet. The proportion of *E. coli* O157:H7 cases that indicated a private well as a main water source was lower than that of the other enteric cases.

E. coli O157:H7 Cluster

From April to July 2006 an increase in the number of *E. coli* O157:H7 cases was identified in the sentinel site. A cluster of four cases (April 14-19, 2006) was identified as having identical phagetypes (PT 14a) and PFGE patterns (ECXAI.0262). After administering a detailed questionnaire, there appeared to be no commonalities between the cases, except consumption of ground beef within the incubation period. In one of the 4 initial cases, an 11-year-old female reported consuming steak tartare. A potential common source of ground beef supplied by a local butcher was investigated; however, *E. coli* O157 was not detected. The supplier of the butcher was investigated, but could not be linked to any other cases by PFGE analysis. An additional 4 cases that shared the above phagetype and PFGE pattern were reported between May 15 and

June 22, 2006; however, no common source was identified. Monitoring continued throughout the remainder of the year with no further isolation of this *E. coli* O157:H7 subtype.

5.2 Exposure Surveillance

Table 5.1
Verotoxigenic *E. coli* detection data for the integrated surveillance activities in Sentinel Site 1 in 2006

	Human	Retail Food			Food Animals (Manure)		Untreated Surface Water	
	Endemic Cases	Pork	Chicken	Beef	Swine	Dairy Cattle	Grand River	
Detection		Pork chop	Skin-on breast	Ground beef	(30 farms)	(45 farms)	River	
# tested	Unknown	140[a]	145[a]	139[a]	120[a]	179[a]	120[a]	140[b]
VTEC		0	0	0				
O157 (non-H7)					8 (6 farms)	7 (7 farms)	1	
O157:H7	32				0	16 (13 farms)	1	35

[a]Culture method.
[b]Molecular method.

Retail

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

On-Farm

E. coli O157 was isolated from 7% (8/120) of the pooled manure samples collected from 30 swine operations, and from 13% (23/179) of the pooled manure samples collected from 45 dairy operations (Table 5.1). Further testing for the H7 antigen determined that 9% (16/179) of the pooled dairy cattle manure samples and none of the swine samples contained *E. coli* O157:H7 (pathogenic). The non-H7 *E. coli* O157 isolates tested negative for the shiga toxin genes.

Water

E. coli O157:H7 was detected by molecular analysis in 25% (35/140) of the untreated surface water samples. Culture-based methods identified two O157 isolates, one of which was also positive for the H7 antigen (Table 5.1). The low detection rate is potentially due to the difficulty associated with culturing this organism from environmental water samples (Appendix C).

Table 5.2
PFGE results for *E. coli* O157:H7 among all components, including human travel-related cases in Sentinel Site 1 in 2006

	Human		Food Animals (Manure)	Untreated Surface Water
	Endemic Cases	Travel	Dairy Cattle	Grand River
# of samples with PFGE results	30	1	16[a]	1[a]
ECXAI.0001	5			
ECXAI.0007	1			
ECXAI.0008	2			
ECXAI.0017	3			
ECXAI.0063	1			
ECXAI.0247	1			
ECXAI.0262	9			
ECXAI.0309	1			
ECXAI.1248	1			
ECXAI.1477	1			
ECXAI.1478	1			
ECXAI.1501	1			
ECXAI.1526	1			
ECXAI.1537	1			
ECXAI.1578	1			
ECXAI.0052		1		
ECXAI. 0006			3	
ECXA1.0023			1	
ECXA1.1175			1	
ECXA1.1267			1	
ECXAI.1611			3	
ECXAI.1612			3	
ECXAI.1613			2	
ECXAI.1614			1	
ECXA1.1687			6	
ECXA1.1688			1	
ECXA1.1689			1	
ECXA1.1690			4	
ECXA1.1691			1	
ECXA1.1692			2	
ECXA1.1694			2	
ECXAI.1556				4
ECXAI.1557				1

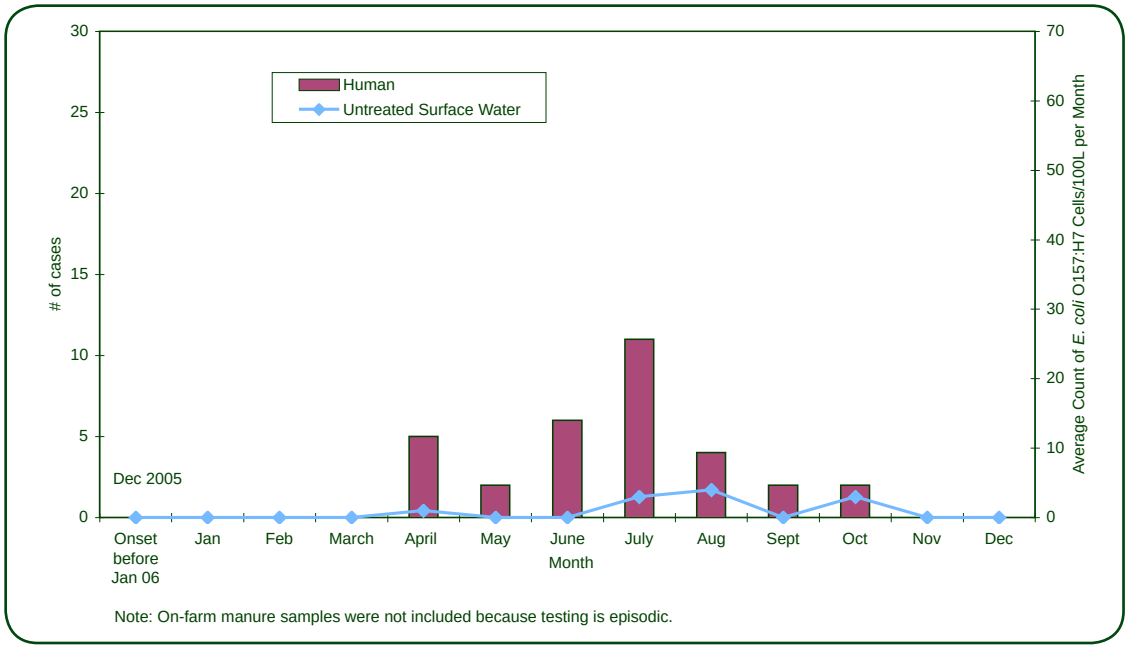
[a]Multiple isolates per positive sample (i.e. 16 positive dairy manure samples yielded 32 isolates; 1 untreated water sample yielded 5 isolates).

PFGE analysis of the *E. coli* O157:H7 isolates showed a high degree of diversity with distinct PFGE patterns and no overlap between human cases and isolates from non-human sources. Overall, the 48 *E. coli* O157:H7 isolates comprised 33 distinct patterns. Seven of the PFGE patterns isolated from human cases, which represented 71% of cases, were among the most common patterns reported to PulseNet Canada. In contrast, only three of the PFGE patterns from non-human isolates (representing 14% of the isolates from dairy cattle manure and untreated surface water) are commonly occurring PFGE patterns (ECXAI.0006, ECXAI.0023 and ECXAI.1175).

Seasonal Trends in Exposure Sources

Molecular analysis by quantitative PCR indicated that the highest levels of *E. coli* O157:H7 from untreated surface water samples were detected in July, August and October (Figure 5.3).

Figure 5.3
Monthly distribution of *E. coli* O157:H7 cases and average counts in untreated surface water samples in 2006



Note: On-farm manure samples were not included because testing is episodic.

5.3 Integrated Overview

- Human endemic incidence rates of *E. coli* O157:H7 are much higher in the sentinel site compared to the national and provincial rates. This higher rate is in part due to the cluster (see page 21) identified in the sentinel site; however, other factors contributing to this higher rate remain unknown and warrant further study.

- As demonstrated by the low proportion of travel-related cases, *E. coli* O157:H7 appears to be a domestically acquired infection.

- Based on the exposure information including well water use and lived on-farm, the *E. coli* O157:H7 cases in 2006 are more likely to be urban residents compared to the 2005 cases which were more likely to be rural residents.

- Pathogenic strains of *E. coli* were detected in pooled dairy manure samples and untreated surface water. However, PFGE subtyping revealed no identical patterns between the human and non-human isolates, suggesting that different strains are circulating in these components.

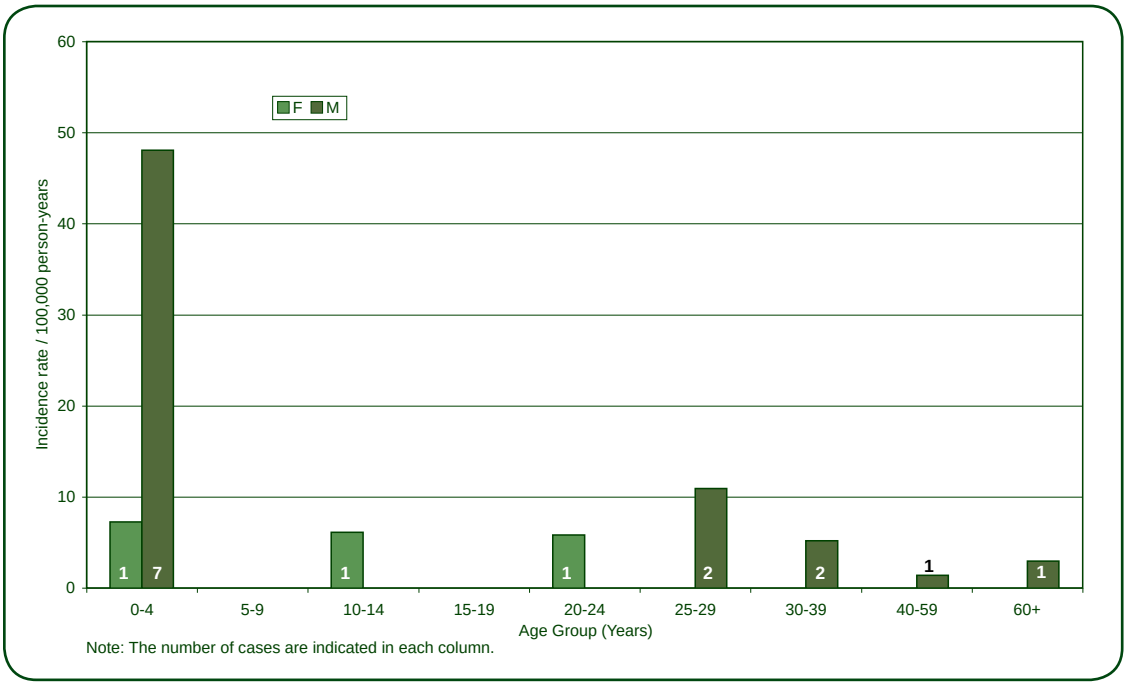
6. *Yersinia*

6.1 Human Cases

In 2006, in Sentinel Site 1, there were a total of 17 reported cases of *Yersinia enterocolitica* infection (3.5/100,000 person-years). Of these 17 cases, one was travel-related, and 16 were classified as endemic (3.3/100,000).

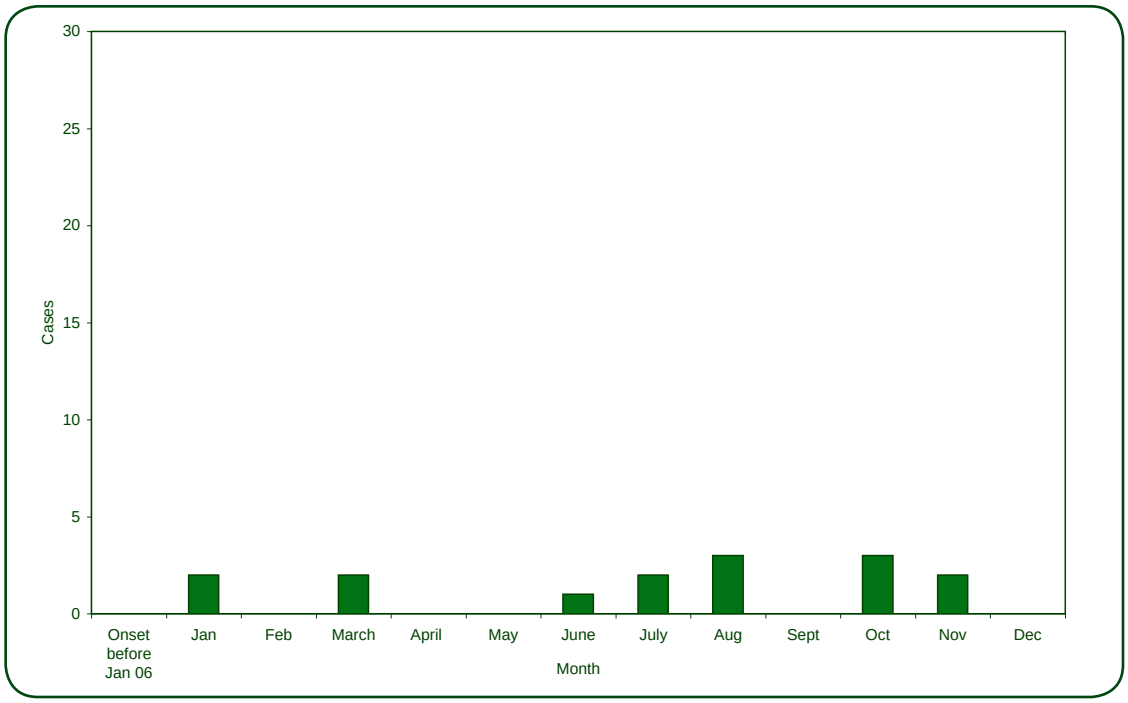
Currently, *Yersinia* is not a nationally notifiable disease[8], and so the annual incidence rate is not available for comparison. The age- and gender-specific incidence rates for the endemic cases showed the highest rate (48.1/100,000) in males less than 5 years of age (Figure 6.1). The quartile age ranges were: 0.6 years (min.), 1.1 (Q1), 6.5 (median), 30.5 (Q3), 63 (max.). Three cases were female and 13 were male.

Figure 6.1
Incidence rates of endemic *Yersinia* infection by gender and age group in Sentinel Site 1 in 2006



[8]Center 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 6.2
Monthly distribution of endemic human *Yersinia* cases in Sentinel Site 1 reported in 2006



All of the *Yersinia enterocolitica* isolates from human cases that were serotyped were serotype O:3. The majority of endemic *Yersinia* cases were reported between June and August (Figure 6.2).

Potential exposure information for the 7 days prior to the onset of illness was collected for 15/16 of the reported endemic yersiniosis cases (Appendix A). The following proportions were high for the yersiniosis cases compared to the other enteric cases: drinking untreated water, swimming in a lake, drinking unpasteurized milk, eating in a restaurant, contact with dogs (household pets, visited farm animal and on-farm animal), living in a rural area, and on-farm animal exposure (cattle, pigs and horses).

6.2 Exposure Surveillance

Table 6.1
***Yersinia* detection and speciation data for the integrated surveillance activities in Sentinel Site 1 in 2006**

	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	140[a]	120[a]	105[a]
# positive	16[a]	18	10 (9 farms)	15
% positive		13%	8%	14%
Subtyping				
# subtyped	15	16	10	15
Y. aldovae				3
Y. bercovieri				1
Y. enterocolitica- pathogenic	15		9	
Y. enterocolitica- non-pathogenic		15	1	
Y. frederiksenii- non-pathogenic		1		2
Y. intermedia- non-pathogenic				8

[a]Culture-based.

Retail

Yersinia was isolated from 13% (18/140) of the raw pork chops sampled (Table 6.1), of which 94% (17/18) had levels of *Yersinia* below the MPN detection limit. Only one sample had detectable levels (0.3-10 MPN/g) (Appendix B).

All strains were considered to be non-pathogenic (*Y. enterocolitica* serotypes O:5, O:36, O:41,42, O:41,43, O:6,30 and *Y. frederiksenii*).

Farm

Yersinia was isolated from 8% (10/120) of the pooled swine manure samples collected (Table 6.1). One non-pathogenic *Y. enterocolitica* serotype (O:6,30) and nine pathogenic *Y. enterocolitica* serotypes (O:3) were identified.

Water

Yersinia was isolated from 14% (15/105) of the untreated surface water samples (Table 6.1). All *Yersinia* serotypes identified were non-pathogenic (*Y. intermedia*, *Y. aldovae*, *Y. bercovieri*, *Y. frederiksenii*).

6.3 Integrated Overview

- Epidemiologically, contact with dogs and living on a farm or rural area may be important risk factors for yersiniosis.

- As demonstrated by the low proportion of travel-related cases, *Yersinia* appears to be a domestically acquired infection.

- Pathogenic *Yersinia enterocolitica* serotype O:3 was identified in human cases, as well as in pooled swine manure samples.

- Although *Yersinia* was detected on retail pork samples and in untreated surface water samples, all strains were determined to be non-pathogenic strains. This might be related to the difficulty associated with detecting *Yersinia* in the environment, and continues to be investigated.

7. *Listeria*

7.1 Human Cases

Human listeriosis is rare and is typically identified in severe, hospitalized cases. No human cases were reported in Sentinel Site 1 in 2006. *Listeria monocytogenes* was removed from the national notifiable disease list as of 2000[9], therefore an annual national incidence rate is not available.

7.2 Exposure Surveillance

Table 7.1
***Listeria monocytogenes* detection data for the integrated surveillance activities in Sentinel Site 1 in 2006**

	Retail Food			Food Animals (Manure)	
	Pork	Chicken	Beef	Swine	Dairy Cattle
Detection	Pork chop	Skin-on breast	Ground beef	10 Farms	45 Farms
# tested	140[a]	145[a]	139[a]	40[a]	175[a]
# positive	12	46	33	1	15
% positive	9%	32%	24%	3%	9%

[a]Culture method.

Retail

Listeria monocytogenes was detected on 9% (12/140), 32% (46/145) and 24% (33/139) of the raw retail pork, chicken and beef samples, respectively (Table 7.1).

Listeria monocytogenes was found below the MPN detection limit in 67%, 65% and 73% of the positive raw retail pork, chicken and beef samples, respectively (Appendix B). One pork chop and one ground beef sample were found to have high levels (>1000MPN/g) of *Listeria monocytogenes.*

Farm

Of the pooled swine and pooled dairy cattle manure samples, 3% (1/40) and 9% (15/175), respectively, tested positive for *Listeria monocytogenes* (Table 7.1).

7.3 Integrated Overview

- There are higher prevalences of *Listeria monocytogenes* on retail meat than in on-farm manure samples.

[9]Center 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

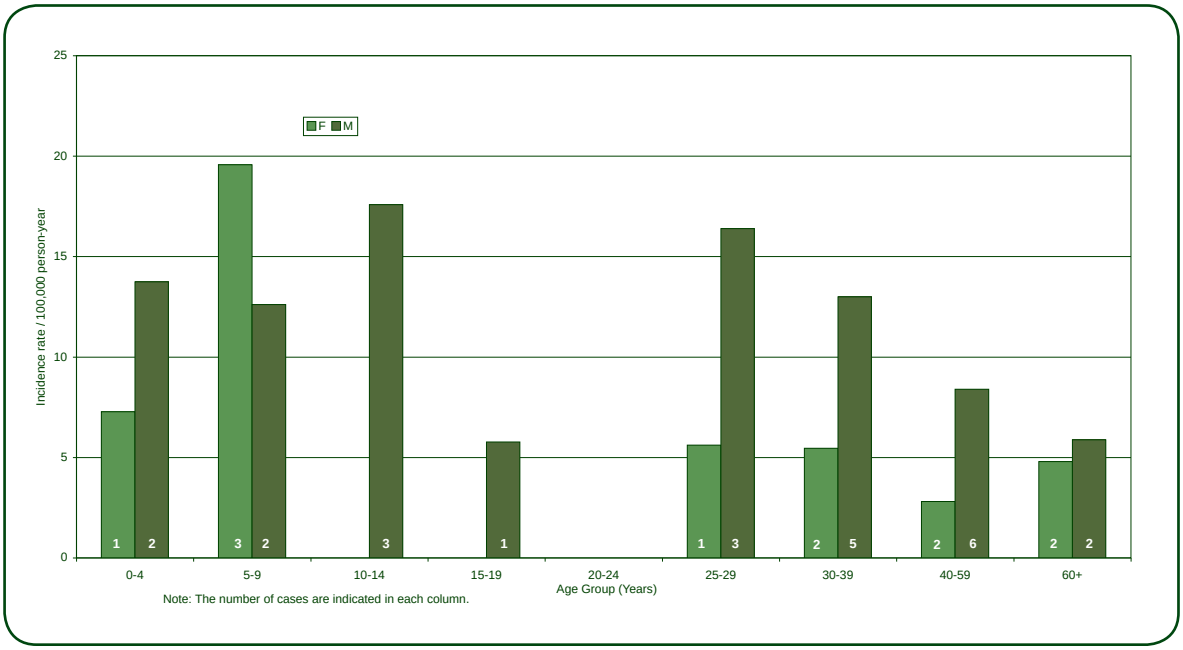
8. Parasites

8.1 Giardiasis

In 2006, in Sentinel Site 1, there were a total of 67 reported cases of giardiasis (13.9/100,000 person-years). Of these 67 cases, 48% (32) were travel-related and 52% (35) were classified as endemic (7.3/100,000 person-years). In comparison, the annual incidence rates for giardiasis in 2006 in Canada and Ontario were 11.1/100,000 and 9.7/100,000, respectively.[10]

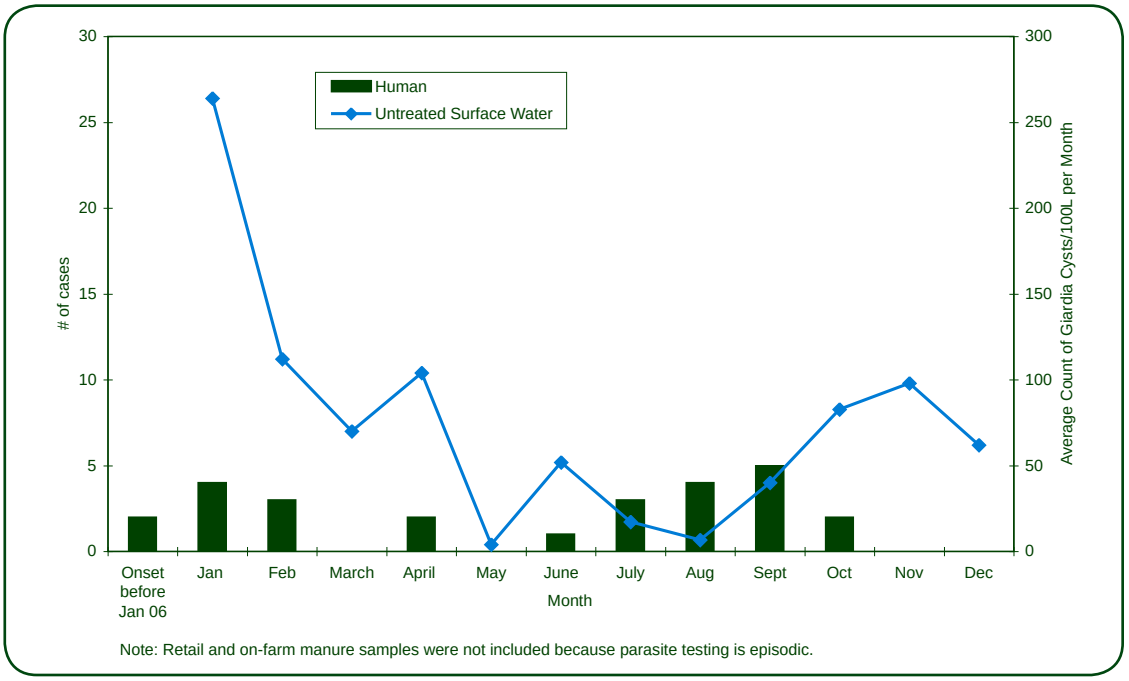
Of the endemic cases, 11 were female (4.5/100,000) and 24 were male (9.8/100,000), indicating a higher incidence rate among males (Figure 8.1). No cases were reported among individuals in the 20-24 age group. The quartile age ranges were: 1 year (min.), 10 (Q1), 34 (median), 43 (Q3) and 83 (max.).

Figure 8.1
Incidence rates of endemic giardiasis cases by gender and age group in Sentinel Site 1 in 2006



[10]Public Health Agency of Canada. Notifiable Diseases On-Line. Posted at http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/#top_list and updated by Carole Scott; 2007 [personal communication]. Note: 2006 numbers are preliminary and subject to change.

Figure 8.2
Monthly distribution of endemic *Giardia* cases and average cyst count in untreated surface water sampled in 2006



The majority of endemic giardiasis cases were reported between June and October, although a spike was observed in January and February (Figure 8.2).

Potential exposure information for the 25 days prior to the onset of illness was available for 33/35 of the cases (Appendix A). The *Giardia* cases had higher reported proportions compared to the other enteric cases for the following exposures: using a private well, drinking untreated water, swimming in a pool, drinking unpasteurized milk, eating meat from a butcher shop and visiting a farm animal area (horses).

Table 8.1
***Giardia* detection and subtyping data for the integrated surveillance activities in Sentinel Site 1 in 2006**

	Human	Retail Food			Animals (Manure)		Untreated Surface Water
	Endemic Cases	Pork	Chicken	Beef	Swine	Dairy Cattle	Grand River
Microscopic Results							
# tested	Unknown	52	52	52	40	179	35
# positive	35	1	0	0	18	73	32
% positive		2%	0%	0%	45%	41%	91%
PCR Results							
# tested		52	52	52	40	179	
# positive		20	15	12	21	54	
% positive		38%	29%	23%	53%	30%	
Sequencing results							
# samples with sequencing results		19	10	10	6	26[a]	
Assemblage A						2	
Assemblage B		19	10	9	5	16	
Assemblage E				1	1	9	

[a]One sample contained both Assemblage B and Assemblage E.

Note: **Zoonotic Assemblages**

Assemblage A- humans, cattle, pigs, sheep, horses, cats, dogs, beavers, seals

Assemblage B- humans, cattle, pigs, dogs, beavers, seals

Non-zoonotic Assemblages

Assemblage E- cattle, sheep, pigs

Exposure Surveillance

Retail

Of the meat samples tested using microscopy techniques, *Giardia* was detected on a single pork sample (Table 8.1). PCR techniques were also applied with 38% (20/52), 29% (15/52), and 23% (12/52) of the pork, chicken and beef samples, respectively, testing positive for *Giardia*. DNA sequencing was performed on a subset of the positive samples and the most frequent pathogenic sequence found was Assemblage B for all retail meat samples. An explanation for the different recovery rates using culture or molecular methods can be found in Appendix C.

Farm

Using microscopy techniques, 45% (18/40) and 41% (73/179) of the pooled swine manure and pooled dairy cattle manure samples, respectively, tested positive for *Giardia* (Table 8.1). Using PCR methods, 53% (21/40) and 30% (54/179) of the pooled swine and pooled dairy manure samples, respectively, were positive for *Giardia*. DNA sequencing revealed that Assemblage B was the most frequent sequence found in both swine and dairy cattle manure. An explanation for the different recovery rates using culture or molecular methods can be found in Appendix C.

Water

Giardia was detected in 32/35 of the untreated surface water samples collected bi-weekly throughout the year in Sentinel Site 1 (Table 8.1), indicating a high prevalence of this potential pathogen. Further molecular subtyping was not performed on these samples. The average concentration of *Giardia* cysts was highest in January, gradually decreasing until July, at which point levels increased again from August to October, illustrating a bi-modal trend (Figure 8.2).

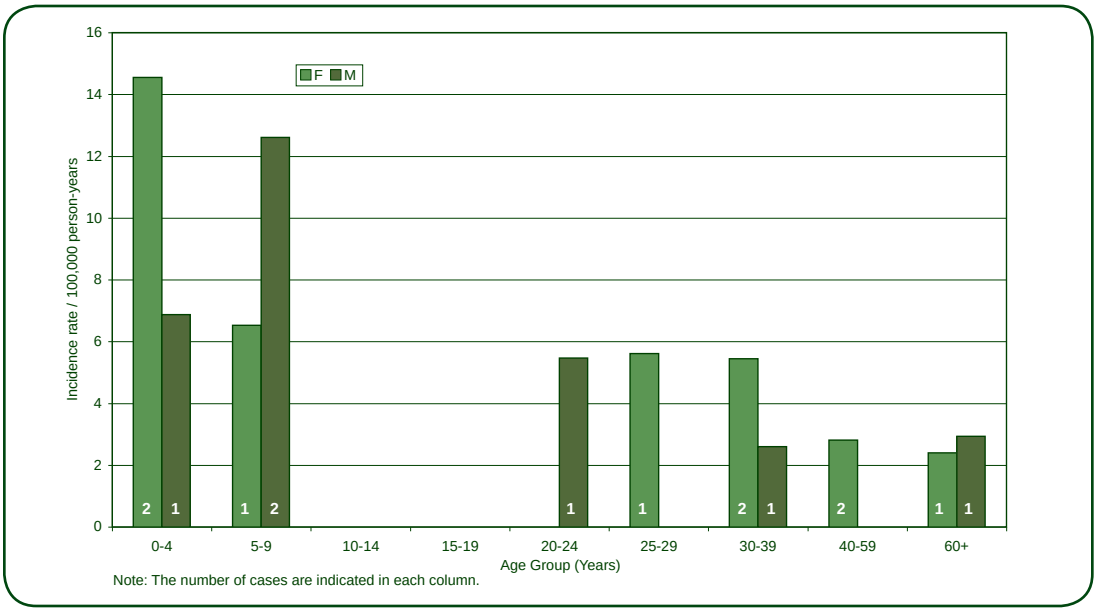
Integrated Overview

- Epidemiologically, non-municipal drinking water, swimming in a pool, and visiting a farm animal area appear to be important risk factors for endemic giardiasis.
- *Giardia* Assemblage B, which is pathogenic to humans, was the predominant subtype found on retail pork, chicken and beef, and in pooled swine and pooled dairy manure samples using molecular techniques. Similar molecular subtyping methods on positive human and water samples are needed to inform source attribution.
- In the sentinel site, *Giardia* appears to be endemic in untreated surface water. In the early part of the year, there appears to be a correlation between human endemic cases and the average concentration of *Giardia* cysts in the untreated surface water (Figure 8.2).

8.2 Cryptosporidiosis

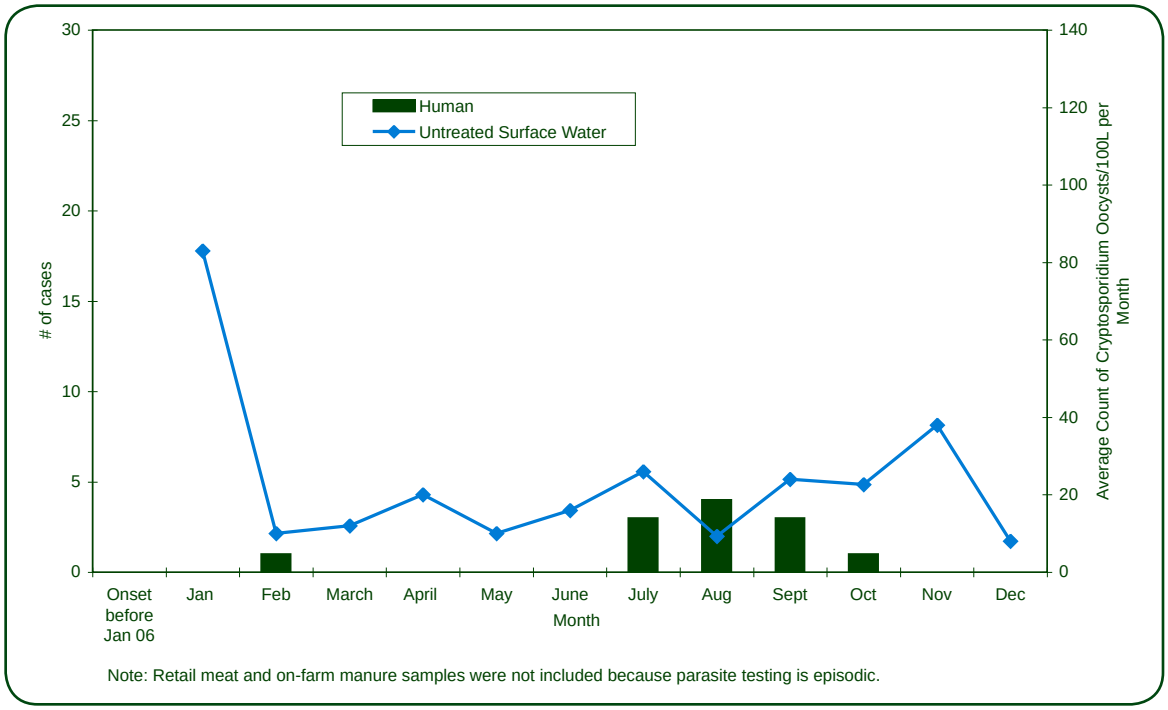
In 2006, in Sentinel Site 1, there were a total of 21 reported cases of cryptosporidiosis (4.4/100,000 person-years). Of these 21 cases, 6 were travel-related and 15 were classified as endemic (3.1/100,000 person-years) (Figure 8.3). In comparison, the annual incidence rates for cryptosporidiosis in 2006 in Canada and Ontario were 2.0/100,000 and 2.5/100,000, respectively.[11] Of the endemic cases, 9 were female (3.6/100,000) and 6 were male (2.4/100,000). The quartile age ranges were: 1 year (min.), 6 (Q1), 25 (median), 40 (Q3) and 87 (max.).

Figure 8.3
Incidence rates of endemic *Cryptosporidium* cases by gender and age group in Sentinel Site 1 in 2006



[11]Public Health Agency of Canada. Notifiable Diseases On-Line. Posted at http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/#top_list and updated by Carole Scott; 2007 [personal communication]. Note: 2006 numbers are preliminary and subject to change.

Figure 8.4
Monthly distribution of endemic *Cryptosporidium* cases and average occyst count in untreated surface water sampled in 2006



Nearly all (11/12 with reported onset dates) of the endemic cryptosporidiosis cases occurred between July and October (Figure 8.4).

Potential exposure information for the 12 days prior to the onset of illness was available for 12/15 of the cases (Appendix A). The *Cryptosporidium* cases had higher reported proportions compared to the other enteric cases for the following exposures: swimming in a lake or pool; eating in a restaurant; contact with household cats and dogs; and visiting a farm animal area. There was also a high proportion of cryptosporidiosis cases living on a farm or in a rural area compared to other enteric cases. For on-farm animal exposure, cryptosporidiosis cases reported higher rates of exposure to dogs, cats, poultry, pigs, horses, cattle, and sheep.

Table 8.2
***Cryptosporidium* detection and subtyping data for the integrated surveillance activities in Sentinel Site 1 in 2006**

	Human	Retail Food			Animals (Manure)		Untreated Surface Water
	Endemic Cases	Pork	Chicken	Beef	Swine	Dairy Cattle	Grand River
Microscopic Results							
# tested	Unknown	52	52	52	40	179	35
# positive	15	0	0	1	17	14	33
% positive		0%	0%	2%	43%	9%	94%
PCR Results							
# tested		52	52	52	40	179	
# positive		2	2	5	11	40	
% positive		4%	4%	19%	28%	22%	
Sequencing results							
# samples sequenced	0	1	2	4	11	14[a]	25 (multiple genotypes per sample)
C. andersoni[d]						3	21
C. baileyi[d]							2
C. cervine[d]							1
C. parvum (bovine genotype)[b]		1	2	4	4	10	1
C. hominis[b,c]							3
C. sp. pig genotype: II[b]					6		
C. fox genotype (W24 cluster)							1
C. suis[b]					1		
C. muskrat genotype I							1
C. muskrat genotype II							2
C. skunk genotype (W13 cluster)							1
C. bovis						1	
C. sp. deer-like[b]						1	
other							1

[a]One dairy sample contained both *C.* bovis and *C.* sp. Deer-like strains.
[b]Pathogenic to humans.
[c]Only found in humans.
[d]Rarely reported with human infection.

Exposure Surveillance

Retail

Of the meat samples tested using microscopy techniques, *Cryptosporidium* was detected on a single beef sample (Table 8.2). PCR techniques were also applied with 4% (2/52), 4% (2/52), and 19% (5/52) of the pork, chicken and beef samples, respectively, testing positive for *Cryptosporidium*. DNA sequencing was performed on a subset of the positive samples and the only sequence found was *C. parvum* bovine genotype, which is pathogenic to humans. An explanation for the different recovery rates using culture or molecular methods can be found in Appendix C.

Farm

Using microscopy techniques, 43% (17/40) and 9% (14/179) of the pooled swine manure and pooled dairy cattle manure samples, respectively, tested positive for *Cryptosporidium* (Table 8.2). Using PCR methods, 28% (11/40) and 22% (40/179) of the pooled swine and pooled dairy cattle manure samples, respectively, were positive for *Cryptosporidium*. Pig genotype II was the most frequently identified subtype from pooled swine manure samples, while in the pooled dairy cattle manure samples, the most common subtype was the *C. parvum* bovine genotype. A comparison between molecular and non-molecular detection methods is described in Appendix C.

Water

Cryptosporidium was detected in 33/35 of untreated surface water samples, indicating a high prevalence of this potential pathogen (Table 8.2). Further subtyping determined that *C. andersoni* was the most common genotype detected in the water samples. The two most common human pathogenic strains, *C. hominis* and *C. parvum* (the bovine genotype), were also detected in the 25 samples tested. Note that more than one genotype was detected in some of the samples. The average concentration of *Cryptosporidium* oocysts in untreated surface water peaked in January and July, and dropped to levels below 40 oocyst/100L for the remainder of the year (Figure 8.4).

Integrated Overview

- The 2006 incidence rate of human *Cryptosporidium* infection in the sentinel site is elevated from previous years and is approximately twice as high as the national and provincial rates. Factors contributing to this higher rate are unknown at the present time.

- Epidemiologically, eating in a restaurant, recreational water use, living on and visiting a farm appear to be important risk factors for endemic cryptosporidiosis.

- 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 zoonotic and highly infectious in humans, was detected in untreated surface water.

- *C. parvum,* which is zoonotic and also highly infectious in humans, was detected in untreated surface water, pooled swine and pooled dairy cattle manure, and was the only subtype detected in retail pork, chicken and beef.

- Untreated surface water samples contained other *Cryptosporidium* strains that could be pathogenic to humans (*C. andersoni, C. baileyi, C. cervine*), although the strains are typically associated with low infection (and specific to the immuno-compromised) proportion of the community).

- *C. parvum* was the most common subtype identified in retail meat and dairy cattle manure, and was the second most common subtype in pooled swine manure. Athough genetic sequencing was not performed on C-EnterNet human *Cryptosporidium* isolates, a recent publication reported on the sequencing of 11 *Cryptosporidium* isolates from Ontario human sporadic cases as follows: 6 isolates were *C. parvum,* 4 were *C. hominis,* and 1 was *C. cervine*.[12]

[12]Trotz-Williams LA, Martin DS, Gatei W, Cama V, Peregrine AS, Martin SW, Nydam DV, Jamieson F, Xiao L. Genotype and subtype analyses of *Cryptosporidium* isolates from dairy calves and humans in Ontario. Parasitol Res 2006;99:346-352.

- Pig genotype II was the most common strain found in swine manure, however, pathogenicity to humans is unknown.

8.3 Cyclosporiasis

In 2006, in Sentinel Site 1, there were no reported human cases of cyclosporiasis.

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.

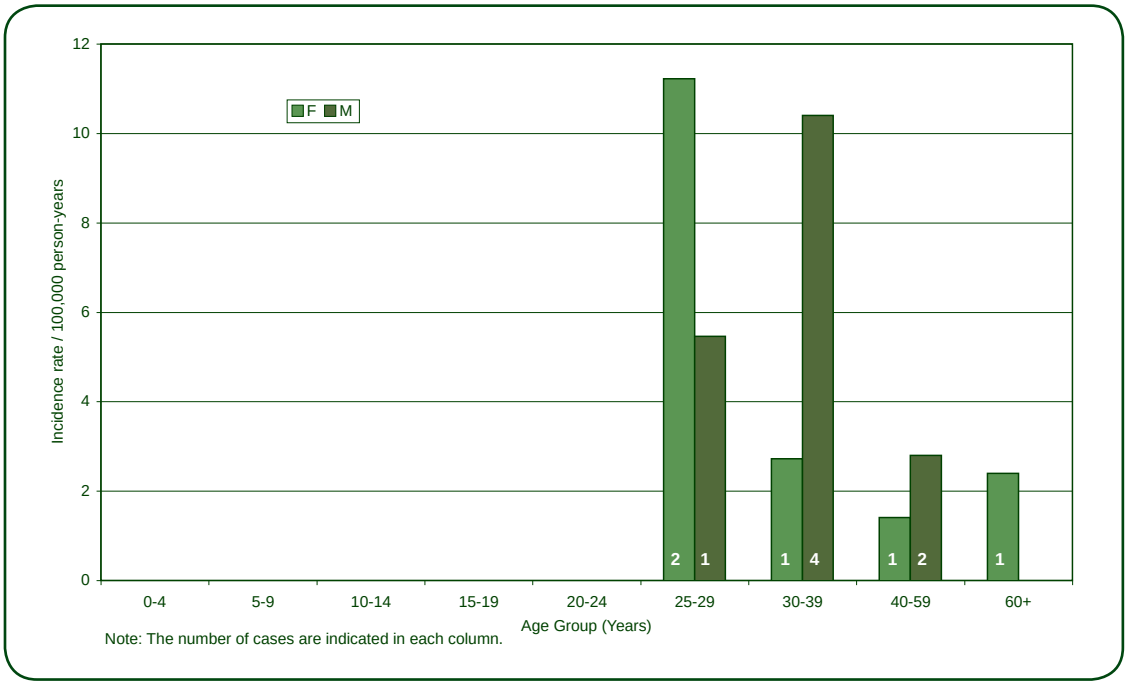
8.4 Amoebiasis

In 2006, in Sentinel Site 1, there were a total of 18 reported cases of amoebiasis (3.7/100,000 person-years). Of these 18 cases, 6 were travel-related and 12 were classified as endemic (2.5/100,000 person-years). Of the endemic cases, 5 were female (2.0/100,000) and 7 were male (2.9/100,000) (Figure 8.5). The quartile age ranges were: 25 years (min.), 30 (Q1), 36.5 (median), 44 (Q3) and 71 (max.).

Amoebiasis was removed from national surveillance as of January 2000[13]; therefore, comparative incidence data cannot be provided for Canada.

[13]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 2006



Potential exposure information for the 7 days prior to the onset of illness was available for 11/12 of the cases (Appendix A). The following risk factors were more common among the amoebiasis cases compared to other enteric cases: using municipal water, eating undercooked food, and contact with household cats.

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).

9. Episodic Activities

In addition to continuous surveillance for enteric pathogens, a number of episodic activities were performed in 2006.

9.1 Retail Meat Purchasing Trends

A food consumption survey (n=2,332) that focused on food safety was conducted in the Sentinel Site between November 2005 and March 2006.[14] The survey provides baseline data on food and water consumption and information about food handling in the general population.

The survey also included questions that addressed grocery-shopping practices and retail meat purchases, which were asked from the person who was most familiar with these practices in their household. Results of this survey have been used to inform the choice of commodities monitored in the C-EnterNet program. Based on location of meat purchases reported by survey respondents (Table 9.1), random selection of two large chain stores and one small store for retail food sampling by C-EnterNet was justified. Risk factor information collected from 91% (253/278) of the endemic cases of enteric illness reported in Sentinel Site 1 during 2006 showed similar findings: the week before their illness, 97% of cases had shopped for food from the supermarket, 14% had shopped at the butcher shop, 10% had shopped at the farmer's market, and 5% had purchased food from a farm. Overall, these findings support the choice of location for retail meat sampling for C-EnterNet.

Table 9.1
Proportion of meat purchased, by grocery location, as reported by survey respondents in the Waterloo Region, Ontario, Canada, November 2005 - March 2006

Location	Total %	95% CI
Chain grocery store	76.2	(74.4, 77.9)
Farmer's market	7.4	(6.4, 8.6)
Butcher shop	6.2	(5.2, 7.2)
Independent grocery store	3.6	(2.8, 4.4)
Don't purchase meat	1.9	(1.4, 2.5)
Delicatessen	0.4	(0.2, 0.7)
Home delivery / Internet purchase	0.1	(0.03, 0.4)
Other	8.2	(7.1, 9.4)

[14]Nesbitt, A. Food Consumption Patterns, Home Food Safety Practices, and Gastrointestinal Health in a Canadian Community. MSc. Thesis, University of Guelph, Guelph, ON; 2006.

The retail component of C-EnterNet consists of weekly sampling of fresh ground beef, pork chops, and chicken breast (with skin on), as these meats represented the three most consumed meat commodities. However, results from the food consumption survey indicated that the majority (87%) of chicken breast being consumed by residents within Sentinel Site 1 was skinless chicken breasts (Table 9.2). As a result, an episodic study that involved sampling fresh skinless chicken breast is currently underway. The objective of this study is to determine whether there is a statistically significant difference in pathogen levels on skinless versus skin-on chicken breasts.

Table 9.2
Total percentage of respondents purchasing food items in the past seven days, Waterloo Region, Ontario, Canada, November 2005 - March 2006

Food Item	Total %	95% CI
Beef	51.1	(48.9, 53.2)
Ground beef [a]	70.1	(67.3, 72.9)
Extra lean [b]	28.4	(25.1, 31.7)
Lean [b]	47.9	(44.2, 51.5)
Medium [b]	19.4	(16.5, 22.3)
Regular [b]	4.4	(2.9, 5.9)
Average amount of ground beef purchased in pounds	3.03 lbs	(2.8, 3.2)
Chicken	59.6	(57.4, 61.7)
Chicken breast [c]	70.0	(67.4, 72.6)
Skin on [d]	13.1	(10.8, 15.3)
Skin off [d]	87.0	(84.7, 89.2)
Average number of chicken breasts purchased	5.9	(5.6, 6.2)
Pork	41.9	(39.7, 44.0)
Pork chops [e]	49.4	(46.1, 52.8)
Average number of pork chops purchased	5.3	(5.0, 5.6)

[a]Among respondents that reported purchasing beef in the past 7 days.
[b]Among respondents that reported purchasing ground beef in the past 7 days.
[c]Among respondents that reported purchasing chicken in the past 7 days.
[d]Among respondents that reported purchasing chicken breast in the past 7 days.
[e]Among respondents that reported purchasing pork in the past 7 days.

9.2 Comparison of Travel-associated vs. Non-travel Cases of Enteric Disease

In order to better understand exposure risks of enteric pathogens associated with food, animals and water within Sentinel Site 1, an analysis was conducted of cases of enteric disease specifically evaluating the influence of travel as a risk factor. Working with the Foodborne, Waterborne and Zoonotic Infections Division, Public Health Agency of Canada, comparisons were made between travel-associated cases (international travelers only) and non-travel cases of enteric illness (endemic and outbreak cases). Travel-associated cases of enteric illness were defined as having an incubation period for their illness contained entirely within the period in which they traveled; or having an incubation period that overlapped the travel period, but

was not entirely contained within the travel period. All analyses were conducted using the C-EnterNet database for June 2005 to December 2006. Thirty-one percent of cases (131/420) were classified as travel-associated.

In general, differences in the type of pathogenic organism seemed to be dependent on travel destination among the travel-associated cases. Many *Salmonella* cases, 30/64, had been to Mexico or the Caribbean region; the majority of Hepatitis A (7/9) and amoebiasis cases (7/9) reported travelling to Asia; and *Giardia* cases were most commonly associated with travel to Asia, Mexico and the Caribbean region.

Both travel and non-travel groups showed high proportions of *Campylobacter*, *Giardia* and *Salmonella* cases, which is consistent with the provincial and national trends. Fifty-nine non-travel cases of verotoxigenic *E. coli* compared to one travel-associated case demonstrates that *E. coli* O157:H7 remains primarily a domestically acquired pathogen.

Overall, 12% of the travel-associated cases and 17% of non-travel cases were hospitalized. Of the travel-associated cases, the highest rate of hospitalization occurred among those travelling to Africa and Asia.

Travellers to Mexico and the Caribbean region were more likely to stay at a resort accommodation than those that travelled to Asia. Travel by many of the cases to Asia may have involved immigrants visiting friends and relatives, which likely represent different risks of exposures compared to holiday resorts.

These new analyses on travel-related exposure, based on the richness of the C-EnterNet data set, have increased clarity on the issue of travel as a risk factor and will influence future studies and program planning.

9.3 Norovirus and Rotavirus in On-farm and Retail Meat Samples

Study Description

In collaboration with the Bureau of Microbial Hazards of Health Canada, a research study was performed to determine the occurrence of norovirus and rotavirus in retail meat and pooled manure samples from swine and dairy operations within Sentinel Site 1.[15] One hundred and twenty-two samples were collected from ten swine farms visited twice in 2005 and again in 2006. In 2006, from May to October, 45 dairy operations were sampled once resulting in 179 samples. On each farm visit, one pooled sample from the manure storage pit and 3 pooled fresh pen samples from animals in 3 different age groups or stages of production were collected. In 2006, 156 raw meat samples were collected from retail grocery stores between January and March, or July and November.

[15]Mattison, K., Shukla, A., Cook, A., Pollari, F., Friendship, R., Kelton, D., Bidawid, S. & Farber, J. M. Human noroviruses in swine and cattle. In press. Emerging Infectious Diseases, 13(8), (2007).

Table 9.3
Norovirus detection data for the integrated surveillance activities in Sentinel Site 1 in 2006

Norovirus	Retail Food			Animals (Manure)	
	Pork	Chicken	Beef	Swine	Dairy Cattle
Molecular Results				10 farms	45 farms
# samples tested	52	52	52	122	179
# positive	1	0	0	30	3
% positive	2%	0%	0%	25%	2%
subtypes					
Human GII.4-like norovirus	1			4 (4 farms)	2
Bovine GIII.2 norovirus					1
Swine norovirus GII.11				6[a]	
Swine norovirus GII.18				22[a]	

[a]Two samples contained both swine GII.11 and swine GII.28 strains.
Note: 5 samples were positive for Swine sapovirus GIII.

Using molecular methods (Appendix C), a human GII.4-like norovirus was detected in the pooled swine, pooled dairy cattle manure and one pork chop. This virus had sequences of the region B primer set that are identical to the GII.4 human strain, but other regions were not identical to the human strain. It is unclear whether this human GII.4-like norovirus is infectious to humans. It is also unclear whether this is a recombination of a swine or bovine strain with the human virus strain or a newly identified strain. All human GII.4-like sequences were found in pooled fresh pen samples (not stored manure), decreasing the likelihood of a human waste source. Human GII.4-like norovirus and the GII.18 norovirus were detected from the same farms on the same sampling dates providing an opportunity for recombination and the generation of a new viral strain. Direct human exposure could have been the source of the GII.4-like norovirus infection in pigs.

Table 9.4
Rotavirus detection data for the integrated surveillance activities in Sentinel Site 1 in 2006

Rotavirus	Retail Food			Animals (Manure)	
	Pork	Chicken	Beef	Swine	Dairy Cattle
Molecular Results				10 farms	45 farms
# samples tested	52	52	52	122	179
# positive	5	10	13	21	7
% positive	10%	19%	25%	17%	1%
Subtypes					
Group A rotavirus G1	5	10	13	21	7

Note: 1 porcine enterovirus type 10 group III and 1 porcine enterovirus type 9 group III were also identified.

Using molecular methods (Appendix C), rotaviruses were found in all types of meat and manure tested (Table 9.4). All rotaviruses detected were the Group A rotavirus G1 strain, which is capable of causing human illness. This strain is ubiquitous, but originates from a mammalian gastro-intestinal tract source. Although sampling was not continuous throughout the year, 26/28 positive retail meat samples were detected in January and February, which corresponds to the winter peak observed for human infections in national surveillance data. Rotavirus infections are very common in children under 5 years of age but not common in adults. The presence of pathogenic norovirus or rotavirus on retail meat may pose a risk of infection to the consumer. It should be noted that these viruses are destroyed by proper cooking practices.

9.4 Towards Understanding Food Flows In The Region Of Waterloo

Given today's complex system of the distribution of food animals and their products, it is difficult to determine the source of the retail meat that is purchased and tested from Sentinel Site 1. In 2004, a food flow analysis study conducted by the Region of Waterloo Public Health focused on tracking the flow of food into and out of the sentinel site. The study was done to determine the percentage of food that is consumed in the Waterloo Region that was grown, raised and/or processed in the Region.[16] The food items selected for the study reflected current consumer food expenditure patterns and were representative of foods that are currently grown in the Region.

Of particular interest to C-EnterNet was the proportion of meat consumed by residents that originated from within the sentinel site (i.e. Region of Waterloo), within Ontario, within Canada, and from outside Canada. The food flow analysis study indicated that, in general, the amount of Waterloo Region content found in meat products was low, due to processors sourcing their meat products from multiple regions of the province and Canada (Table 9.5). For example, fresh ground beef and pork chops available in supermarkets within the sentinel site had a very low degree (<10%) of content from the Waterloo Region and a low to moderate degree (10-30%) of Ontario content (Table 9.5). Similarly, fresh chicken breasts had a low degree (<10%) of content from the Region, but had a moderate to high degree (60-80%) of Ontario content.[16]

Table 9.5
Amount of regional, provincial and Canadian content in meat available for purchase in the Sentinel Site

Source	Beef	Poultry	Pork
Region of Waterloo	1% to 10%	1% to 10%	1% to 10%
Ontario	10% to 30%	60% to 80%	10% to 30%
Other Provinces	60% to 80% from Alberta	Unknown	50% to 70% from Quebec and others

Based on the report, which consulted processors and industry, a very low proportion (1%) of poultry is imported into Canada, while beef (20%) and pork (<50%) are more commonly imported. Import data obtained from Industry Canada's Strategis indicated that the primary source for imported beef, poultry and pork in Ontario in 2006 was the United States.[16] Outside North America, the highest contributor was New Zealand for beef, Brazil for poultry, and Chile for pork (Table 9.6).[17]

[16]HCA (Harry Cummings and Associates), Region of Waterloo Food Flow Analysis Study. Waterloo, ON: ROWPH, 2005.
[17]Industry Canada, *Strategis*. Ottawa, ON, 2005. http://strategis.ic.gc.ca/sc_mrkti/tdst/engdoc/tr_homep.html

Table 9.6
Proportion of beef, poultry and pork imported into Ontario in 2006, by country of origin

	Beef	Poultry	Pork
United States	89.50%	90.20%	96.80%
New Zealand	5.30%	-	-
Australia	2.50%	-	-
Brazil	1.40%	7.10%	-
Thailand	-	2.70%	-
Chile	-	< 1%	2.00%

The results of the food flow analysis and import data provide a better understanding of where food comes from that is consumed within the sentinel site. It appears that the retail meat that is purchased and tested from the sentinel site is largely sourced domestically, with a small percentage of imported beef, poultry and pork. This information will inform the integration of results from the C-EnterNet components and to inform food safety policy. Further investigation of food sources and flow are required to expand our understanding of the complex food system within the sentinel site.

Table A.1
The percentage of human endemic cases with exposure data, and comparison of the percentage exposed for each disease with the percentage exposed for the other diseases combined for a selected subset of exposures

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]	108		60		32		16		35		15		12		278
Number with exposure data	94	159	57	196	31	222	15	238	33	220	12	241	11	242	253
Proportion with exposure data	87.0		95.0		96.9		93.8		94.3		80.0		91.7		91.0
Exposure Information															
Private well - main water source	21.3	13.8	9.1	18.6	9.7	17.5	13.3	16.7	30.3	14.5	8.3	16.9	9.1	16.9	16.5
Municipal - main water source	67.0	68.8	65.5	68.8	77.4	66.8	60.0	68.6	60.6	69.2	66.7	68.2	90.9	67.1	68.1
Drank untreated water	9.8	9.0	3.6	10.9	10.0	9.2	14.3	9.0	15.6	8.4	8.3	9.4	10.0	9.3	9.3
Swam	21.3	23.4	8.9	26.5	29.0	21.7	40.0	21.5	30.3	21.5	50.0	21.3	0.0	23.5	22.6
in a lake	8.7	10.3	3.6	11.5	16.1	8.8	20.0	9.1	9.4	9.8	27.3	8.9	0.0	10.0	9.7
in a pool	8.7	11.6	5.4	12.0	12.9	10.2	13.3	10.3	18.8	9.3	27.3	9.8	0.0	10.9	10.5
in a river	0.0	3.2	0.0	2.6	3.2	1.9	0.0	2.2	6.3	1.4	9.1	1.7	0.0	2.1	2.0
Drank unpasteurized milk	8.5	6.0	0.0	8.9	6.7	7.0	13.3	6.6	13.8	6.1	0.0	7.3	0.0	7.2	7.0
Ate undercooked food	8.6	8.8	7.7	9.0	10.0	8.5	13.3	8.4	3.3	9.5	0.0	9.1	25.0	8.2	8.7
Attended a barbecue	29.0	27.8	16.7	31.6	51.6	24.9	28.6	28.3	29.0	28.2	18.2	28.8	25.0	28.4	28.3
Ate in a restaurant	39.3	31.0	20.0	38.1	41.9	33.0	40.0	33.8	31.0	34.7	50.0	33.5	14.3	34.8	34.2
Ate meat from butcher shop	9.2	14.1	1.9	15.4	35.5	8.8	14.3	12.2	21.4	11.1	9.1	12.4	0.0	12.8	12.3
Ate meat from private kill	5.8	2.7	0.0	5.0	0.0	4.4	14.3	3.2	3.6	3.9	9.1	3.6	0.0	4.0	3.8
Shopped at butcher shop	13.2	14.5	6.1	16.0	25.8	12.2	13.3	14.0	17.9	13.5	27.3	13.3	0.0	14.5	14.0
Contact with household pet	57.5	53.9	51.8	56.2	66.7	53.6	73.3	54.0	31.3	58.7	58.3	55.0	55.6	55.2	55.2
cats	20.4	26.9	25.0	24.4	26.7	24.2	26.7	24.4	21.9	24.9	33.3	24.1	44.4	23.8	24.5
dogs	41.9	32.3	26.8	38.5	33.3	36.2	60.0	34.3	15.6	38.9	50.0	35.2	37.5	35.8	35.9
reptile	1.1	3.2	7.1	1.0	0.0	2.8	0.0	2.6	0.0	2.8	0.0	2.5	0.0	2.5	2.4

Continued on page 46

Table A.1
The percentage of human endemic cases with exposure data, and comparison of the percentage exposed for each disease with the percentage exposed for the other diseases combined for a selected subset of exposures

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]	108		60		32		16		35		15		12		278
Number with exposure data	94	159	57	196	31	222	15	238	33	220	12	241	11	242	253
Proportion with exposure data	87.0		95.0		96.9		93.8		94.3		80.0		91.7		91.0
Exposure Information															
Visited farm animal areas	11.8	9.0	1.8	12.4	12.9	9.6	7.1	10.2	15.2	9.3	16.7	9.7	11.1	10.0	10.0
cats	0.0	0.6	0.0	0.5	0.0	0.5	0.0	0.4	0.0	0.5	8.3	0.0	0.0	0.4	0.4
dogs	2.2	1.3	0.0	2.1	0.0	1.8	7.1	1.3	3.0	1.4	0.0	1.7	0.0	1.7	1.6
horses	2.2	3.9	0.0	4.1	3.2	3.2	0.0	3.4	9.1	2.3	8.3	3.0	11.1	2.9	3.2
cattle	2.2	3.2	0.0	3.6	6.5	2.3	0.0	3.0	3.0	2.8	8.3	2.5	11.1	2.5	2.8
Lived on a farm/rural	20.2	16.0	12.7	19.0	6.5	19.2	26.7	17.0	15.6	17.9	41.7	16.4	11.1	17.8	17.6
On-farm animal exposures															
cats	6.4	2.6	1.8	4.6	0.0	4.6	6.7	3.8	0.0	4.6	16.7	3.4	0.0	4.2	4.0
dogs	5.3	5.8	1.8	6.7	3.2	5.9	20.0	4.7	0.0	6.4	33.3	4.2	0.0	5.8	5.6
horses	5.3	3.9	1.8	5.1	0.0	5.0	13.3	3.8	0.0	5.1	16.7	3.8	11.1	4.2	4.4
cattle	10.6	6.4	3.6	9.2	3.2	8.7	20.0	7.2	3.1	8.7	16.7	7.6	11.1	7.9	8.0
pigs	4.3	3.9	3.6	4.1	0.0	4.6	13.3	3.4	0.0	4.6	16.7	3.4	0.0	4.2	4.0
poultry	3.2	3.9	3.6	3.6	0.0	4.1	6.7	3.4	0.0	4.1	16.7	2.9	11.1	3.3	3.6
sheep	0.0	1.9	0.0	1.5	0.0	1.4	6.7	0.9	0.0	1.4	16.7	0.4	0.0	1.2	1.2

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, Shigellosis or Hepatitis A.

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

Appendix B: Enumeration Results

Table B.1
Enumeration results for retail meat samples collected within Sentinel Site 1 in 2006

	# 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	140	0					
Chicken	145	45	30	14	1		
Beef	139	0					
Salmonella							
Pork	140	4	4				
Chicken	145	43	35	6	2		
Beef	139	1	1				
Listeria							
Pork	140	12	8	3			1
Chicken	145	46	30	9	4	3	
Beef	139	33	24	6	2		1
Yersinia							
Pork	140	18	17	1			

Summary of MPN technique

Primary isolation was initiated on each meat sample that was purchased in 2006, by removing a 50-gram representative portion from each sample and homogenizing it (in a stomacher) for 2 minutes with selective enrichment media specific for each pathogen. The Most Probable Number (MPN) method, which estimates the number of bacteria per gram of sample, was performed on meat samples that tested positive with primary isolation. For *Salmonella*, *L. monocytogenes* and *Yersinia spp.* 50 mL of the stomached rinsate to be used in the MPN procedure was stored at refrigeration temperature until the results of the primary isolation were known. For *Campylobacter spp.*, 50 g of meat was stored under microaerophilic conditions at 4 ºC until the results of the primary isolation were known. The three-tube MPN series was prepared for each of the pathogens tested, by transferring 10 mL of the sample enrichment broth into 3 tubes containing 9 mL of broth, 1mL of the sample homogenate into 3 tubes containing 9 mL of broth, 1 mL of a 10^1 dilution into 3 tubes containing 9 mL of broth, and 1 mL of a 10^2 dilution into 3 tubes containing 9 mL of broth. This method is sensitive to 0.3 MPN per gram of sample. The MPN table used for these analyses was obtained from the FDA Bacteriological Analytical Manual (http://www.cfsan.fda.gov/~ebam/bam-toc.html).

Following quantitative assessment by the MPN method, a majority of the samples exhibited levels below the detection limit of this test. These samples most likely represent a lower risk since the level of these organisms were sufficient for detection following growth in enrichment culture, but not high enough (<0.3 MPN/g) without enrichment culture for a positive enumeration result.

Appendix C: Molecular versus Non-molecular Detection Methods

Molecular detection methods for bacteria, parasites and viruses are based on the detection of genetic material specific to the organism of interest. In general, molecular testing has a greater sensitivity because it involves amplification of genetic material and will yield a positive result for both viable and non-viable organisms as long as genetic material is present. Traditional culture-based methods for bacteria and viruses rely on the presence of viable intact organisms for detection. Traditional microscopy techniques for parasite detection can detect both viable and non-viable organisms; however, the lack of an enrichment step results in a lower likelihood of detection. As a result, molecular methods may overestimate recovery rates, while traditional methods may underestimate them. This continues to be an area of great interest for microbiologists and epidemiologists, and continues to be investigated in coordination with the C-EnterNet survaillance activities.