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C-EnterNet 2007 Annual Report

...National Integrated Enteric Pathogen Surveillance Program

Canada

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C-EnterNet Annual Report
2007

...National Integrated Enteric Pathogen Surveillance Program

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Executive Summary

C-EnterNet is a multi-partner program facilitated by the Public Health Agency of Canada to detect changes in trends in human enteric disease and in levels of pathogen exposure from food, animal and water sources in Canada. The design is based on a sentinel site surveillance model first adopted in the United States by the Centers for Disease Control (FoodNet) in 1995, to reflect 10% of the population. The system involves enhanced epidemiological and microbiological surveillance of reportable human enteric diseases in selected communities. In addition, the active surveillance of pathogens in retail food, water and food animal operations is designed to be carried out within the same geographical areas. This C-EnterNet Annual Report presents the results from the surveillance data collected from its pilot sentinel site, the Regional Municipality of Waterloo, Ontario, during the year 2007.

A total of 477 human cases of 11 bacterial (6), viral (1) and parasitic (4) enteric diseases were reported to the local public health authority within the pilot sentinel site during 2007. Less than 1% (4) of the cases were outbreak-related, 30% (142) were travel-related and 69% (331) were classified as endemic. Endemic cases include those acquired locally or during travel within Canada. The four most frequently reported diseases (campylobacteriosis, salmonellosis, giardiasis, and amoebiasis) in Sentinel Site 1 in 2007 accounted for 83% of the endemic cases.

The enhanced, systematic and standardized follow-up by the public health inspectors allowed for the documentation of travel status for all cases. Travelling abroad appeared to be a major risk factor for reported acute enteric diseases. The travel-related proportion was higher for shigellosis (82%), amoebiasis (50%), giardiasis (39%) and cryptosporidiosis (37%). Conversely, cases of Hepatitis A appeared to be mainly acquired domestically in 2007. Based on subtyping results, several distinct patterns emerged among the travel-related cases, when compared to the endemic cases. For example, 36% of *Salmonella* Enteritidis infections were contracted abroad, while cases of S. Typhimurium and S. Heidelberg were primarily of domestic origin (36/39 and 5/5, respectively). The isolates from *Campylobacter* infections associated with travelling abroad were more frequently resistant to at least one of the eight antibiotics tested compared to the endemic strains (19/24 travel-related vs. 39/68 endemic cases).

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

Food animals are a natural reservoir for several pathogens that cause acute enteric diseases in humans. As observed in other years, these pathogens were found in the local dairy, swine, beef and broiler chicken operations sampled in 2007. A correlation between human strains and strains detected on the farms was occasionally observed. Pathogenic *Yersinia enterocolitica* were detected on four swine farms; pathogenic *Cryptosporidium* species were isolated on beef and dairy cattle farms; and *Salmonella* Enteritidis was detected on broiler chicken farms.

Untreated surface water continues to be a potential exposure route for several enteric pathogens in the pilot site. *Giardia* and *Cryptosporidium* occurred frequently in untreated surface water, and several *Salmonella* serotypes (e.g. Typhimurium, Heidelberg, Thompson), verotoxigenic *Escherichia coli* (VTEC), *C. jejuni* and *C. coli* were occasionally detected in the local watershed. However, even with the use of additional subtyping, strong correlations between the human strains isolated in the sentinel site and strains detected in the untreated surface water were rarely seen.

Pathogens capable of causing human enteric illness (*Campylobacter*, *Salmonella*, *Listeria*) were detected on the three raw meat commodities (pork, chicken and beef) that were sampled at retail emphasizing the need for proper handling and cooking of raw meat. Generally, raw chicken meat was more often contaminated than beef or pork. In the pork samples that were positive for *Yersinia*, the subtyping data showed that the strains were non-pathogenic. VTEC was detected in a small number of beef samples. Based on the quantitative Most Probable Number (MPN) method, the majority of positive samples had bacterial loads below the limit of detection (<0.3 MPN/g). In some cases, the subtyping results indicated that the subtypes found on the retail meat were similar to those that cause human illness. For example, among *Campylobacter* strains, MLST pattern 45 was most commonly detected in retail chicken samples (12 out of 51 isolates analyzed) and most commonly detected in endemic human cases (10 out of 50 isolates analyzed). Thirteen other chicken isolates exhibited an MLST pattern that had been detected among human cases. However, the MLST patterns in 26 of the 51 *Campylobacter* chicken isolates were not common to the MLST patterns from the human strains.

With two calendar years of data, temporal analyses were performed on the human cases, untreated surface water and retail meat data. It was found that endemic VTEC infections decreased in 2007 compared to 2006, whereas endemic salmonellosis increased. Travel-related campylobacteriosis and amoebiasis both increased in 2007. *Campylobacter* and *Yersinia* were more frequently isolated from untreated surface water in 2007 compared to 2006, whereas detection of *Salmonella* in untreated surface water decreased. The prevalences of *Campylobacter*, *Salmonella*, VTEC and *Listeria* on the retail pork, chicken or beef samples were similar between 2007 and 2006 on the retail pork, chicken or beef samples. The prevalence of *Yersinia* on pork chops increased from 2006 to 2007. Statistically-significant seasonal variations were detected in human endemic campylobacteriosis, salmonellosis, *E. coli* O157:H7 infections, giardiasis and cryptosporidiosis (all higher in the summer and campylobacteriosis was also higher in the fall), in the detection of *Yersinia* in untreated surface water (lower in the spring), and in the detection of *Campylobacter* in retail raw chicken meat (higher in the fall and lower in the winter).

Two years after its implementation in the pilot sentinel site, C-EnterNet's surveillance system provides unique information on the incidence of several enteric diseases in humans, as well as the presence and level of the same pathogens in a number of sources in the community. The system also has demonstrated its utility for the analysis of local temporal variations in pathogens (yearly trends, seasonal cycles) and the identification of important risk factors worth further evaluation. As a consequence, the system provides a clearer understanding of human enteric diseases and their evolution over time within the site, which is fundamental to public health surveillance. In addition, the intensive laboratory analyses combined with the systematic gathering of epidemiological data allows for the exploration of transmission pathways of enteric disease in one community. This relates to source attribution, the second objective of the C-EnterNet program. The use of molecular

subtyping has facilitated, in some cases, the identification of a potential link between the source/reservoir and the human cases at the population level. However, more data are needed to provide improved quantitative and reliable source attribution estimates for Canada. This can be achieved through the expansion of this program to five sites across Canada.

In light of recent outbreaks in Canada, collection of surveillance data on enteric illness and the capability to link human illness to exposure sources is fundamental to the understanding of the epidemiology of enteric disease. It is also important for disease detection, outbreak control, and epidemiological knowledge capacity for public health professionals. The results from the C-EnterNet surveillance system will be used for these purposes, and 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.

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1. Introduction

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

C-EnterNet is based on a sentinel surveillance model and is a leading-edge integrated 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, food safety and water safety. The first sentinel site – the Region of Waterloo, Ontario – is a community of approximately 500,000 residents, with a mix of urban and rural activities, and innovation in public health and water conservation. Four additional sites are planned to provide a nationally representative system encompassing approximately 10% of Canada's population.

C-EnterNet conducts continuous and episodic surveillance activities in four components: human, food, water, and food animals. For a description of the suite of pathogen testing see Appendix A. Continuous surveillance 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. Detailed descriptions of the C-EnterNet design, laboratory methods and the enteric disease case questionnaires, are available at our website (http://www.phac.gc.ca/c-enternet/index.html).

Because of its objectives, its scope and its comprehensive design, C-EnterNet surveillance activities generate a rich, multi-dimensional data set. The system focuses on eleven reportable infectious enteric diseases. The enhanced laboratory surveillance of the human cases and the active surveillance of the agriculture, water and food components generate comparable data by phenotypic (e.g. species, serotype, phagetype, antimicrobial susceptibility) and genotypic (e.g. PCR, flaA SVR, PFGE) methods for each enteric pathogen isolated. The enhanced epidemiological surveillance of each human case produces extensive data (e.g. demographic, risk factors such as travelling, exposure to animals and water). The agriculture and the retail food components include several commodities (dairy cattle, beef cattle, swine, and broiler chickens).

The format of the 2007 report has been slightly changed compared to previous annual reports. The report still begins with a summary of the infectious enteric disease cases in humans in Sentinel Site 1, summarizing the outbreak- and travel-related cases separately from the endemic cases (Chapter 2). Chapters 3 through 8 provide information on human cases and exposure source surveillance for 2007 by pathogen, as in previous years. These chapters provide detailed epidemiological and laboratory information from the human endemic cases and active surveillance results for the agriculture, retail food and water components.

This year, the report also includes a section describing the temporal variations observed in the human cases and among the potential exposures (Chapter 9). All observations and analyses dealing with trends (2007 vs. 2006) and seasonality are addressed in this section. Chapter 10 is also new this year, and presents results by exposure source rather than by pathogen and provides an integrated summary of all three surveillance years.

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

C-EnterNet's second objective is to address the issue of source attribution for cases of infectious gastroenteritis. There are a number of methods that are internationally recognized to address the complex task of source attribution, including: a) analysis of outbreak data; b) comparisons of pathogen profiles among sources and human cases; c) case control studies; d) risk assessments, and; e) expert opinion. Despite the pilot nature of the program, C-EnterNet has made significant progress in refining the Canadian approach to source attribution, even with the limited amount of data currently available. A retrospective analysis of international and Canadian foodborne outbreak data will be completed in early 2009.

The comparison of pathogen profiles between sources and human cases has already started for some pathogens, as reported in this document. In particular, the C-EnterNet program has piloted the application of a human salmonellosis attribution model that was developed in Denmark for the attribution of human salmonellosis cases to their sources.[1] The original mathematical model has been adapted to conform to the available Canadian data and promising preliminary results have been obtained. A number of issues related to data quality from the various sources, and the operation of the model have been identified during this pilot and need to be solved to ensure valid results. Since the first report, C-EnterNet has adapted the traditional case-control design, with a case-case approach, as detailed in this report. The C-EnterNet scientific team has written a study proposal for a survey of non-diseased residents in Sentinel Site 1 who could be matched with cases for a more traditional case-control study. Thanks to a strong partnerships with the Microbial Risk Modelling Unit within the Public Health Agency of Canada's Laboratory for Foodborne Zoonoses, the team has developed initial quantitative microbial risk assessments (QMRAs) for the transmission of *Salmonella* from retail meat, as well as the transmission of *Cryptosporidium* from recreational and drinking waters. C-EnterNet has also recently partnered with a Canadian Water Network funded project led by Dr. Pierre Payment at the Institut Armand-Frappier to develop and validate QMRAs for drinking water attribution of various pathogens. In 2008, C-EnterNet partnered on an expert elicitation project on food attribution with Dr. Juliana Ruzante, a post-doctoral fellow at the University of Guelph and Aamir Fazil, a senior risk analyst with the Public Health Agency of Canada's Laboratory for Foodborne Zoonoses. This project will seek opinions from Canadian food safety experts according to a methodology developed and applied in the US. In addition, international colleagues are being pursued to inform the Canadian modelling initiative. More data will be needed to provide quantitative and reliable source attribution estimates for Canada. Only through the expansion of this program to five sites across Canada will this be achieved.

1 Hald T, Vose D Wegener H C Koupeev T. A Bayesian Approach to Quantify the Contribution of Animal-Food Sources to Human Salmonellosis. Risk Analysis. 2004; 24, 255-269.

2. Human Case Summary

2.1 Overview of Human Cases

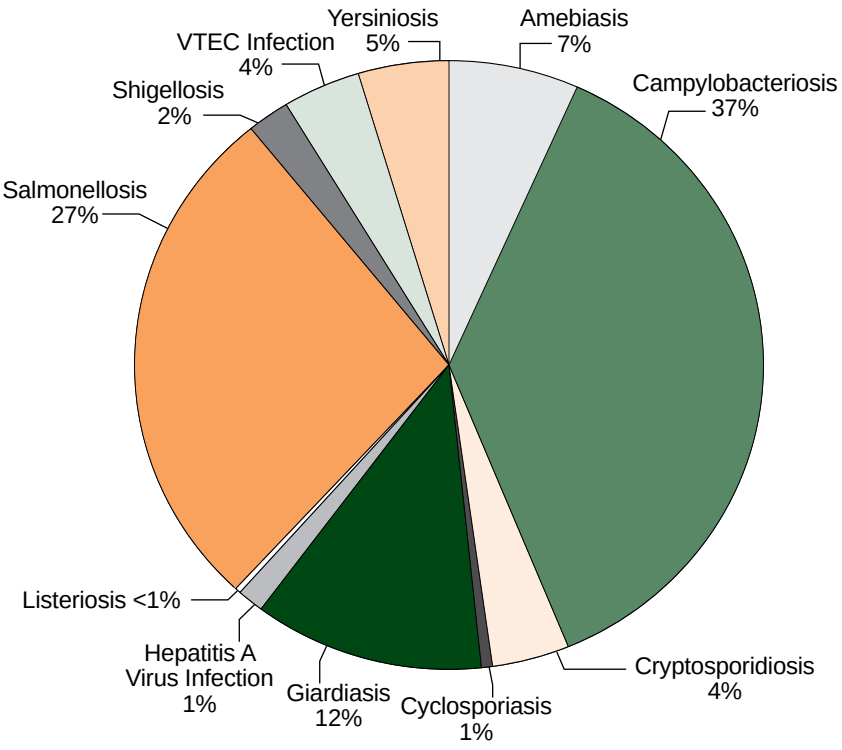
A total of 477 cases of 11 bacterial, viral and parasitic enteric diseases were reported to the local public health authorities within Sentinel Site 1 in 2007 (Table 2.1). The three most frequently reported diseases (salmonellosis, campylobacteriosis and giardiasis) accounted for 76% of those cases (Figure 2.1).

Information on potential exposures was obtained from 87% of the reported endemic cases (seven pathogens included) within the sentinel site in 2007 (Appendix B). Public health inspectors administered a standardized questionnaire to the cases or proxy respondents. Preliminary analyses of this information were used to determine case status (travel versus endemic) and compare exposures of endemic cases. Cases were classified as outbreak-related if the case could be linked to an identified outbreak through epidemiological or laboratory methodology. Travel-related cases were identified as those that had travelled outside of Canada in the relevant timeframe before onset of illness. Endemic cases are those that occur sporadically within the geographic area.

TABLE 2.1
Number of cases and incidence rates per 100,000 person-years of laboratory-confirmed enteric diseases in Sentinel Site 1 in 2007

Disease	Exposure Period	Number of Cases				Incidence Rate	
		Outbreak	Travel	Endemic	Total	Endemic	Total
Amoebiasis	2-4 weeks	0	16	16	**32**	3.22	**6.44**
Campylobacteriosis	10 days	0	46	131	**177**	26.36	**35.62**
Cryptosporidiosis	1-12 days	0	7	12	**19**	2.41	**3.82**
Cyclosporiasis	1 week	0	1	2	**3**	0.40	**0.60**
Giardiasis	26 days	1	22	33	**56**	6.64	**11.27**
Hepatitis A	15-50 days	0	0	7	**7**	1.41	**1.41**
Listeriosis	3-70 days	0	0	1	**1**	0.20	**0.20**
Salmonellosis	3 days	1	33	96	**130**	19.32	**26.16**
Shigellosis	1-10 or 8-14 days	0	9	2	**11**	0.40	**2.21**
Verotoxigenic *E. coli* (VTEC)	2-10 days	2	3	14	**19**	2.82	**3.82**
Yersiniosis	10 days	0	5	17	**22**	3.42	**4.43**
Total		**4**	**142**	**331**	**477**		

FIGURE 2.1
Relative proportions of enteric diseases reported in Sentinel Site 1 in 2007



2.2 Outbreak-related Cases

Four community-based enteric outbreaks occurred within the sentinel site in 2007. Two of the four outbreaks occurred in workplace settings, one in a community training centre and one occurred following a family event at a church. No causative agent was identified in any of the four community outbreaks.

Four outbreak-associated enteric cases were reported in the sentinel site this year. One case of *Giardia* was associated with an outbreak at a tree-planting camp in Northern Ontario, likely associated with the water source; one case of *E. coli* O157:H7 was associated with an outbreak at a home daycare in the sentinel site (the only positive isolation in the outbreak); an additional *E. coli* O157:H7 was associated with a family pig roast from a neighbouring health jurisdiction; and one case of *Salmonella* was associated with a provincial outbreak of *Salmonella* Typhimurium PT 108, in May 2007. In the previous year, there were four outbreak-associated cases, including two cases of *E. coli* O157:H7 and two cases of *Salmonella*.

In 2007, a total of 78 institutional enteric outbreaks were identified and investigated. Thirty-nine enteric outbreaks occurred in long-term care facilities (LTCF), 33 occurred in childcare centres (CCC) and six in residential facilities. A causative agent was identified in 7% of the Region of Waterloo institutional outbreaks. All of the LTCF and CCC outbreaks, where a causative agent was identified, were due to norovirus and rotavirus, respectively.

2.3 Travel-related Cases

Of the reported cases, 30% (142/477) were classified as travel-related (Table 2.1). Campylobacteriosis, salmonellosis and giardiasis were the three most common diseases, contributing to 71% of the travel-related cases (Table 2.2). Most of the cases had visited Mexico and the Caribbean region or Asia prior to acquiring their illness, a trend that possibly reflects travel preferences of the sentinel site population. Half of the travel-related *Salmonella* cases had been to Mexico and the Caribbean region (16/33). Of all travel-related cases *Campylobacter* was the most frequent cause of disease among travellers to Europe (13/18) and Mexico and the Caribbean (20/59).

TABLE 2.2
Travel-related cases in Sentinel Site 1 in 2007

Disease	Africa	Asia	Europe	Mexico & Caribbean	USA	Multiple Destinations & Others	Total
Amoebiasis	2	7	0	7	0	0	**16 (11%)**
Campylobacteriosis	3	5	13	20	3	2	**46 (32%)**
Cryptosporidiosis	3	1	0	2	1	0	**7 (5%)**
Cyclosporiasis	0	1	0	0	0	0	**1 (1%)**
Giardiasis	3	8	1	6	4	0	**22 (15%)**
Hepatitis A	0	0	0	0	0	0	**0**
Salmonellosis	4	8	3	16	1	1	**33 (23%)**
Shigellosis	1	6	0	2	0	0	**9 (6%)**
Verotoxigenic *E. coli*	0	0	1	2	0	0	**3 (2%)**
Yersiniosis	1	0	0	4	0	0	**5 (4%)**
Total	**17 (12%)**	**36 (25%)**	**18 (13%)**	**59 (42%)**	**9 (6%)**	**3 (2%)**	**142 (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. Reported national and provincial annual incidence rates for each pathogen include both endemic and travel cases from 2006, since the 2007 rates were not available at the time of publication. 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 public health department.

In each of the following chapters, because of limited analytical power, a 5% difference between cases and non-cases was chosen to identify potential risk factors. 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 applicable for certain age groups. 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.

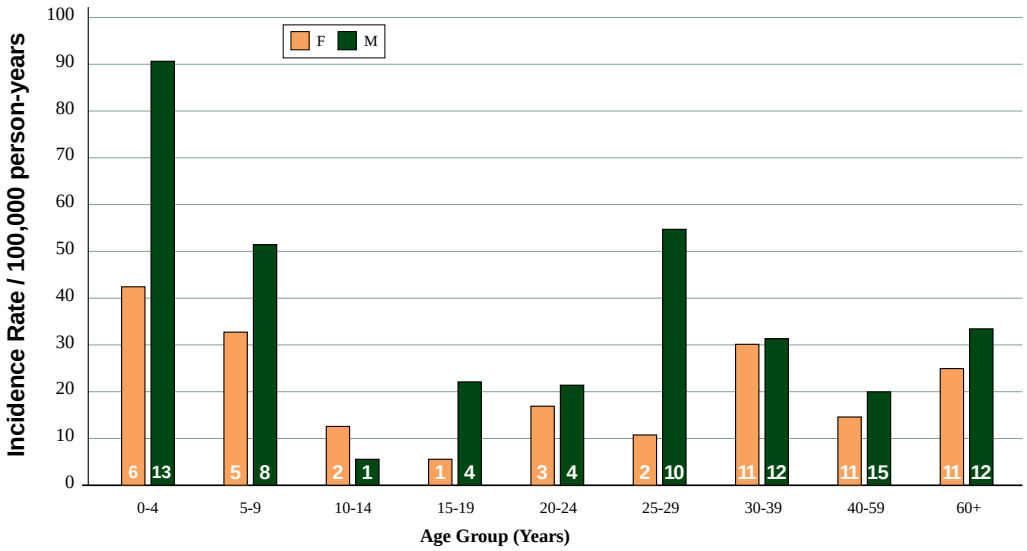
3. *Campylobacter*

3.1 Human Cases

In 2007, in Sentinel Site 1, there were a total of 177 (35.6/100,000 person-years) reported cases of *Campylobacter* infection. Of these 177 cases, 26% (46/177) were travel-related, and 74% (131) were classified as endemic (26.4/100,000 person-years), which is higher than in 2006 (Chapter 9). 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]

The age- and gender-specific endemic incidence rates were highest in males less than five years of age (Figure 3.1). A breakdown by gender shows that 52 cases were female (20.9/100,000 person-years) and 79 were male (31.9/100,000 person-years).

Figure 3.1
Incidence rates of endemic campylobacteriosis in Sentinel Site 1 by gender and age group in 2007



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

The vast majority (98%) of endemic campylobacteriosis cases were identified as *C. jejuni*, while *C. coli* and *C. upsaliensis* accounted for the remaining 2% (Table 3.1). The majority (36/68) of the *Campylobacter* strains from endemic cases that were tested for their antimicrobial susceptibility were resistant to tetracycline, whereas 29 were susceptible to all antimicrobials tested and a few were resistant to both nalidixic acid and ciprofloxacin only or in addition to tetracycline (Table 3.2). Among the 24 travel cases tested, five were susceptible to all antimicrobials tested and these five had travelled to Europe. Of the ten travel cases who were resistant to both nalidixic acid and ciprofloxacin, six traveled to the Americas, two traveled to Asia, and two traveled to Europe.

2 National Notifiable Disease representative (Carole Scott) 2007 [personal communication]. Note: 2006 numbers contain travel and endemic cases and are preliminary and subject to change.

TABLE 3.1
Campylobacter detection and speciation data from integrated surveillance activities in Sentinel Site 1 in 2007

	Human	Retail Food			Food Animals (Manure)				Untreated Surface Water	
	Endemic Cases	Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Grand River	
Detection		Pork chop	Skin-on breast	Ground beef	30 Farms	9 Farms	21 Farms	28 Farms	5 sample points on Grand River	
# tested	Unknown	187 [a]	187 [a]	187 [a]	120 [a]	36 [a]	80 [a]	112 [a]	134 [a]	118 [b]
# positive	131 [a]	3	55	1	12 (12 farms)	0 (0 farms)	10 (7 farms)	23 (11 farms)	24	108
% positive		2%	29%	1%	10%	0%	13%	21%	18%	92%
Subtyping										
# subtyped	130	3	55	1	12		10	23	28 [c]	
C. coli	1 1%	1 33%	7 13%		8 67%		4 40%	8 35%	2 (A,C)	
C. jejuni	128 98%	2 67%	48 87%	1 100%			6 60%	9 39%	9 (A,B, C, D)	
C. lari									17 (A, B, C, D)	
C. upsaliensis	1 1%									
Other					4 33%			6 26%		

[a] Culture-based method, [b] Molecular-based method (16SrRNA), [c] Multiple isolates in some samples.
Water Sampling Locations in Grand River Watershed: A- Canagagigue, B- Conestogo River, C- Upper Grand River, D- Grand River, near drinking water intake, E- Grand River, near one wastewater treatment plant effluent point.

TABLE 3.2
Antimicrobial susceptibility of *Campylobacter* strains isolated through the integrated surveillance activities in Sentinel Site 1 in 2007

	Human		Retail Food			Food Animals (Manure)				Untreated Surface Water
Resistance Pattern [a]	Endemic Cases	Travel-related Cases	Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Grand River
			Pork chop	Skin-on breast	Ground beef					5 sample points on Grand River
# tested	68	24	3	49	1	6	0	4	19	19
Susceptible	29	5	2	27				1	10	16
TET	36	7		18	1	2		3	4	
NAL CIP	2	3				2				2
TET NAL CIP	1	7		1						
CIP										1
NAL						1			3	
TET NAL									2	
NAL AZM ERY						1				
TET AZM ERY CLI			1	3						
NAL CIP AZM ERY CLI		1								
TET NAL CIP AZM ERY CLI GEN		1								

[a] The isolates were tested for their susceptibility to the following antimicrobials: AZM= azithromycin; CIP = ciprofloxacin; CLI= clindamycin; ERY= erythromycin; GEN= gentamicin; NAL= nalidixic acid; TET= tetracycline.

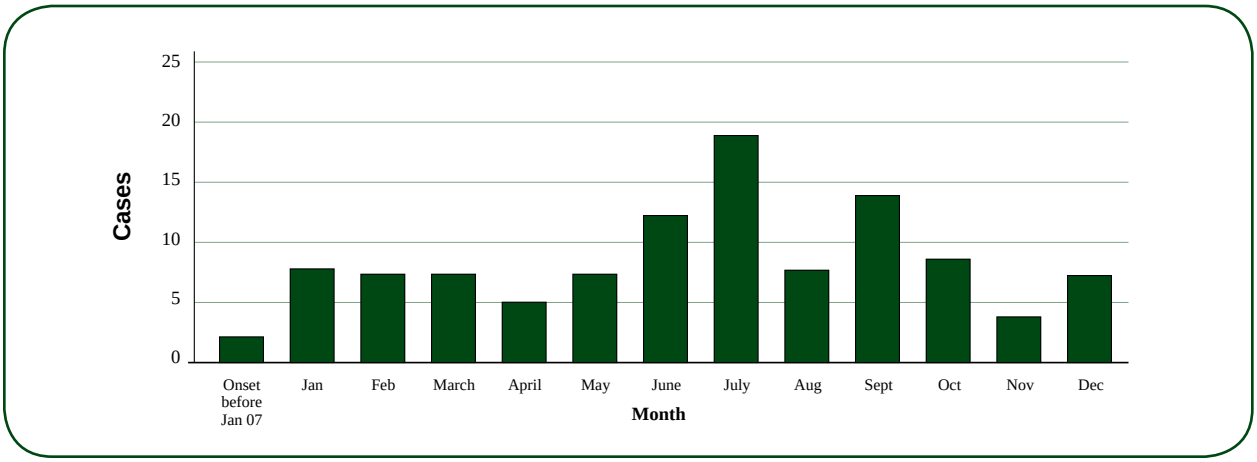
In collaboration with the PHAC National Microbiology Laboratory, various genotyping methods were used to characterize the isolates and identify human case clusters. No predominant strains were identified among the human *Campylobacter* isolates by any of the methods used, and the multi-locus sequence typing (MLST) results are presented in Table 3.3.

TABLE 3.3
Campylobacter subtyping data (MLST) from the integrated surveillance activities in Sentinel Site 1 in 2007 (values in brackets refer to 2006 and 2005 data for comparison)

	Human		Retail Food			Food Animals (Manure)				Untreated Surface Water
ST (Sequence Type)	Endemic Cases	Travel-related Cases	Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Grand River
			Pork chop	Skin-on breast	Ground beef					5 sample points on Grand River
# subtyped	50	13	3	51 (31)	1	6 (22)	0	7	8 (14)	(17)
45	10		1	12 (9)					(3)	(1)
982	7	2		1 (2)					(1)	
21	4			1 (2)	1					
922	4			1						
459	3					(1)		2	2 (1)	
1244	2	1								
267	2			1 (1)						
8	2									
508	2									
42	1			3 (1)					(3)	
52	1	1		1						
61	1									
441	1									
460	1			1 (3)						
806	1							2		
918	1	1								
929	1		1	1					(1)	
933	1									
3511	1									
3514	1									
3529	1									
3530	1									
3531	1									
137		1		1						
257		1								
353		1		1						
443		1								
1212		1		1						
2880		1								
3515		1								
3528		1								
1591			1							
50, 51, 222, 262, 352, 429, 457, 467, 535, 679, 766, 825, 829, 917, 939, 992, 1065, 1205, 1210, 1219, 1228, 1332, 1698, 1911, 2503, 3515, 3517, 3518, 3520				25 (13)						
132				1					(2)	
890, 900, 1096, 1097, 1105, 1115, 1172, 1185, 1417, 1573, 1631, 1946, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2878						6 (21)				
902, 2501, 2512									(3)	
1068								3	6	
996, 1243, 1257, 2524, 2525, 2526, 2527, 2528, 2530										(16)

As in the past, the incidence rate of endemic *Campylobacter* cases was statistically higher during the summer months (see Chapter 9), although the incidence in August 2007 was low (Figure 3.2).

FIGURE 3.2
Monthly distribution of endemic human *Campylobacter* cases in Sentinel Site 1 reported in 2007



Eighty-six percent (113/131) of the endemic *Campylobacter* cases provided potential exposure information for the ten days prior to onset of illness (Appendix B). Use of an in-home treatment system for drinking water (59%), attending a barbeque (25%), and drinking unpasteurized milk (7%) were reported more frequently in the *Campylobacter* cases than in other enteric cases. In contrast, the proportion of endemic *Campylobacter* cases that had contact with household pets was lower than for the non-*Campylobacter* cases (47 vs. 61%).

3.2 Exposure Surveillance

Retail

Campylobacter was isolated from 29% of the skin-on chicken breasts sampled, but more rarely from raw retail pork and beef (Table 3.1). Of the 59 raw meat samples positive for *Campylobacter*, 51 (86%) were *C. jejuni*. Of the *Campylobacter* isolates, 53 (90%) were found to be below the Most Probable Number detection limit (0.3 MPN/g) and six between the detection limit and ten MPN/g (Appendix C). Over half (29/53 tested) of the *Campylobacter* strains isolated from meat showed no resistance to the antimicrobials tested, while nearly half (22/53) were resistant to tetracycline and four isolates were multi-resistant (Table 3.2).

On-Farm

Campylobacter jejuni and *coli* were isolated from pooled manure samples from beef and dairy farms whereas only *C. coli* was isolated from swine farms (Table 3.1). *Campylobacter* was not isolated from the nine chicken farms sampled. Possible explanations include the timing, since this sampling occurred in cooler months (October, November and December)[3] or the low sample size.

3 Wagenaar, J.A., W. Jacobs-Reitsma, M. Hofshagen, and D. Newell. 2008. Poultry Colonization with *Campylobacter* and Its Control at the Primary Production Level, p. 667-678. *In* I. Nachamkin, C.M. Szymanski, M.J. Blaser (eds.), *Campylobacter*, 3rd Edition, ASM Press, Washington, D.C.

About one third of *Campylobacter* isolates isolated on the farms (11/29 tested) were fully susceptible to the antimicrobials tested. The remaining 18 were resistant mainly to tetracycline and/or nalidixic acid (Table 3.2).

Water

In 2007, using the culture technique, *Campylobacter* was detected in 18% of the untreated water samples, while 92% (108/118) were found positive by the molecular method (Table 3.1). The true level of *Campylobacter* is somewhere between these estimates. The molecular method may overestimate bacteria levels because it can also detect dead (non-viable) but intact cells. The culture method may underestimate bacteria levels because it cannot detect low numbers of organisms present in the sample matrix and non-culturable but viable cells (NCBV).

As in 2006, *C. lari* was the most frequent species detected in the untreated surface water, but *C. jejuni* and *C. coli* were also detected.

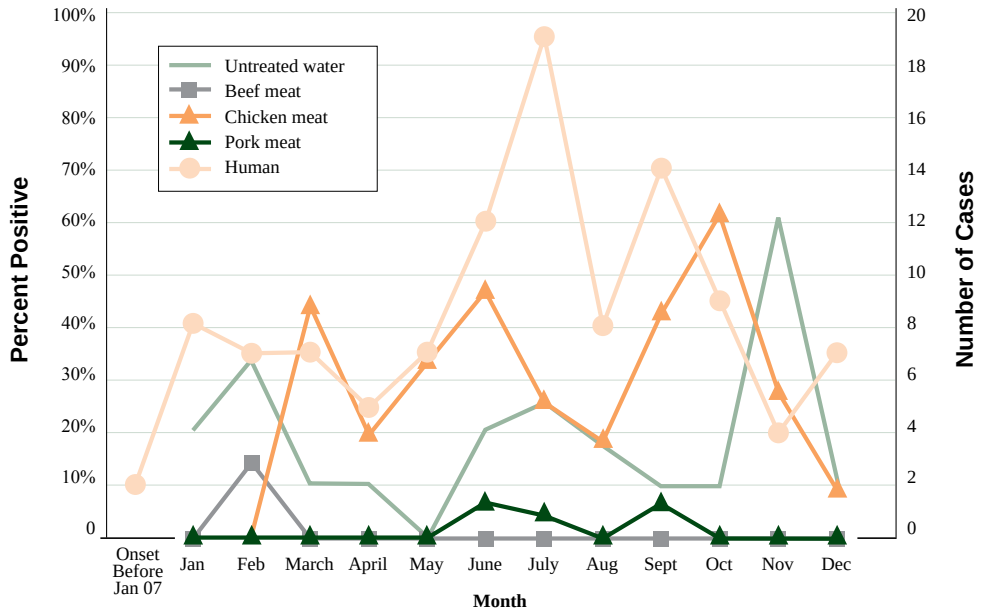
Very few (3/14) *Campylobacter* isolates detected in raw surface water were resistant to the antimicrobials tested, although ciprofloxacin resistance was detected in three of the 19 isolates (Table 3.2).

3.3 Summary of *Campylobacter* Results

- Campylobacteriosis is the most frequently reported enteric disease in Sentinel Site 1.
- The incidence of campylobacteriosis is higher during the summer months (Figure 3.2). Conversely, *Campylobacter* prevalence increases in certain exposure sources (chicken meat and surface water) during late fall and early winter (Figure 3.3).
- *C. jejuni* is the most common species associated with human campylobacteriosis.
- Raw chicken meat is commonly contaminated with *Campylobacter* (29%), although levels are low. Pork and beef are rarely contaminated with *Campylobacter*.
- *C. jejuni* and *C. coli* were detected in untreated surface water, in manure from swine, dairy, and beef farms, but not in manure from chicken farms. *C. lari* was the predominant species in water.
- Epidemiologically, consumption of unpasteurized milk appears to be a potential risk factor for *Campylobacter* infections in humans, especially in comparison to the general population (7% versus <1%, respectively)[4].
- *Campylobacter* isolated from human cases and from various exposure sources are spread across a wide range of genotypes with no strains specific to any component or commodity.
- *Campylobacter* isolated from humans and from exposure sources show some resistance to antimicrobials, especially to tetracyclines. Amongst the sources, less resistance was observed in water isolates compared to food animal isolates and retail food isolates.

4 Nesbitt A, Majowicz S, Finley R, Pollari F, Pintar K, Marshall B, Cook A, Sargeant J, Wilson J, Ribble C and Knowles L. Food consumption patterns in the Waterloo Region, Ontario, Canada: a cross-sectional telephone survey. BMC Public Health 2008, 8:370 (24 October 2008).

FIGURE 3.3
Temporal distribution of *Campylobacter* detected in human endemic cases, untreated surface water and retail meat samples in Sentinel Site 1 in 2007



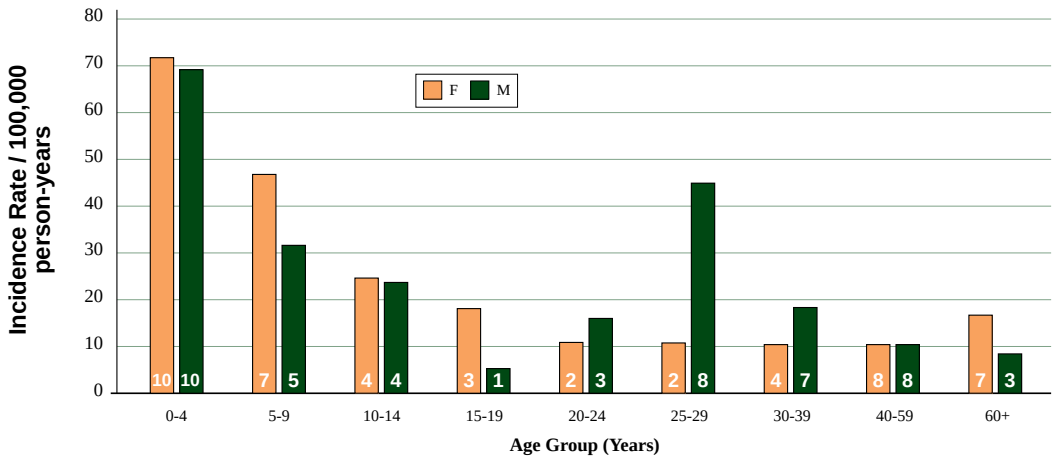
4. *Salmonella*

4.1 Human Cases

In 2007, in Sentinel Site 1, a total of 130 cases of salmonellosis were reported (26.2/100,000 person-years). Of these 130 cases, 25% (33) were travel-related, 0.8% (1) were outbreak-related and 74% (96) were classified as endemic (19.3/100,000 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.[5]

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

FIGURE 4.1
Incidence rates of endemic salmonellosis cases by gender and age group in Sentinel Site 1 in 2007



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

There were 27 different serotypes detected among the 96 endemic cases, for which the serotype was known. The top three serotypes, Typhimurium (36), Enteritidis (18), and Heidelberg (5), encompassed 62% of isolates that were serotyped (Table 4.1). Comparison of travel versus endemic *Salmonella* cases indicated that Typhimurium (36/39), Heidelberg (5/5), and Newport (2/2) serotypes were primarily of domestic origin, while over one third of the Enteriditis (10/28) cases were travel-related.

Potential exposure information for the three days prior to onset of illness was collected for 90% (86/96) of the reported endemic *Salmonella* infections (Appendix B). Few meaningful risk factors were identified from the case-case comparison; however, household pet exposure did appear to be a risk factor for *Salmonella* cases.

5 National Notifiable Disease representative (Carole Scott) 2007 [personal communication]. Note: 2006 numbers contain travel and endemic cases and are preliminary and subject to change.

4.2 Exposure Surveillance

Retail

Salmonella was commonly detected on raw skin-on chicken breasts but rarely found on raw pork chops and ground beef (Table 4.1). Only low levels of *Salmonella* were detected on the positive retail samples (Appendix C).

The three most frequent serotypes found on chicken meat included: Kentucky, Heidelberg and Hadar (Table 4.1). The top two serotypes found on pork chops were Typhimurium and Give, while the single beef isolate was Enteritidis PT13.

On-Farm

The prevalence of *Salmonella* in pooled manure samples from swine, beef and dairy farms in 2007 was 33%, 10%, and 13%, respectively (Table 4.1). Broiler chicken farm sampling was initiated late in the year (October). During the three months of sampling on broiler chicken farms, *Salmonella* was detected in 72% of the samples. Hadar (6), Heidelberg (5) and Kentucky (5) were the most common serotypes isolated on broiler chicken farms. On swine farms, Typhimurium (15) and Agona (7) were the most frequently isolated *Salmonella* serotypes (Table 4.1). The most frequently isolated *Salmonella* serotypes from dairy operations were Kentucky (6) and Typhimurium (3). On beef farms, Typhimurium (2), Kentucky (2) and Uganda (2) were the most frequently isolated *Salmonella* serotypes.

Water

The prevalence of *Salmonella* contamination in untreated surface water samples was lower for the culture-based method (10%) than the molecular method (35%) (Table 4.1). Of the 13 isolates cultured, *Salmonella* Thompson was the most frequently detected serotype. *Salmonella* was most frequently detected at sample site E (close to a waste water treatment effluent point on the Grand River) by both culture and molecular methods.

TABLE 4.1
Salmonella detection and serotyping data from the integrated surveillance activities in Sentinel Site 1 in 2007

	Human	Retail Food			Food Animals (Manure)				Untreated Surface Water	
		Pork	Chicken	Beef					Grand River	
	Endemic Cases	Pork chop	Skin-on breast	Ground beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	5 sample points on Grand River	
Detection									Culture	Molecular
# tested	Unknown	187 [a]	187 [a]	187 [a]	120 [a]	36 [a]	80 [a]	112 [a]	134 [a]	129 [b]
# positive	96 [a]	6	61	1	40	26	8	14	13	45
% positive		3%	33%	1%	33%	72%	10%	13%	10%	35%
Subtyping # subtyped	**95**	**6**	**61**	**1**	**40**	**26**	**8**	**14**	**13**	
Adelaide	2									
Agona	2				7			1		
Berta	1	1							1 (E)	
Bovismorbificans	1				1					
Brandenburg					1				1 (C)	
Branderup					3					
Cerro								2		
Derby					2					
Enteritidis	6									
Enteritidis PT 13	2		2	1	1	2				
Enteritidis PT4	1									
Enteritidis PT6	1									
Enteritidis PT6a	1									
Enteritidis PT8	4		1			1				
Enteritidis PT8a						1				
Enteritidis PT21	1									
Enteritidis PT911	1									
Enteritidis Atypical	1									
Give		2			1					
Group B	2									
Hadar	1		5		2	6				
Hartford	2									
Heidelberg	5		16			5				
I:4,5,12:b:-	1								2 (B, E)	
I:4,12:i:-						2				
I:ROUGH-O:-:-						1		2		
Infantis	3	1	1				1			
Javiana	2									
Kentucky	1		28			5	2	6	1 (D)	
London					1		1			
Mbandaka	1		1							
Newport	2									
Ohio	1				1					
Oranienberg	2									
Schwarzengrund	1				1					
Thompson	4		1			3			2 (B)	
Typhimurium	11								1 (A)	
Typhimurium DT104 [c]	2				4		1	2		
Typhimurium DT104a [c]					1					
Typhimurium 3	3									
Typhimurium 12	1									
Typhimurium 21	1									
Typhimurium 28 [c]					2					
Typhimurium 41 [c]	1									
Typhimurium 46					1					
Typhimurium 82	2									
Typhimurium 97	2									
Typhimurium U285	1									
Typhimurium U302 [c]		1			2		1	1		
Typhimurium U310	1									
Typhimurium UT1 [c]	1									
Typhimurium 108	9		1							
Typhimurium 110 [c]			1							
Typhimurium 120		1								
Typhimurium 151 [c]					1					
Typhimurium 194 [c]					2					
Typhimurium 208 [c]					2					
Typhimurium Untypable [c]	1									
Typhimurium Atypical			1							
Uganda	1						2			
Worthington					2					
Other [d]	6		3		2				5	

[a] Culture method. [b] Molecular method. [c] Includes var5-. [d] Serotypes that were identified once in a single component are listed below and are NOT listed in Table 4.1:

Human: Anatum, Choleraesuis, I:4,5,12-,I:4,5,12.6-, Java, Virchow. Chicken meat: Indiana, Kiambu, Tumodi. Swine operations: I:6,7,14:r:-, Krefeld. Untreated water: Alachua (C), I:6,7:-;enz15 6,7:-215 (E): I:ROUGH-O:z10:enz15 -:z10:z15 (E); I:10:-:1,5 10:-:5 (E), Kiambu (E).

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

Serotype ranking within each component

- most frequent serotype
- second most frequent serotype
- third most frequent serotype

TABLE 4.2
PFGE results for the most common *Salmonella* serotypes for all components, including human travel-related cases in Sentinel Site 1 in 2007 (values in brackets refer to 2006 and 2005 data for comparisons)

	Non-travel Cases [a]	Travel-related Cases	Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Grand River
			Pork chop	Skin-on breast	Ground beef					5 sample points on Grand River
Typhimurium										
# samples with PFGE result	24 (15)	1	2 (1)	3 (4)	0	16 (32)	0	2	3 (2)	1 (4)
STXAI.0001	2 (2)		(1)			4 (7)		2	3 (1)	(1)
STXAI.0006	1									
STXAI.0013						(1)				
STXAI.0027	(1)			(1)		3 (13)				
STXAI.0029						(4)				
STXAI.0044	(1)									
STXAI.0067	4									
STXAI.0098	(1)					(1)				
STXAI.0193	3									
STXAI.0195	(1)									(2)
STXAI.0203	(1)									
STXAI.0214						1 (1)				
STXAI.0233	(2)									
STXAI.0239	(1)									
STXAI.0243	1									1
STXAI.0269										(1)
STXAI.0270									(1)	
STXAI.0286			1			(1)				
STXAI.0312	8 (3)			2 (2)						
STXAI.0314			1							
STXAI.0339						(1)				
STXAI.0349	(1)									
STXAI.0361	(1)			(1)		(1)				
STXAI.0362						(1)				
STXAI.0364						3 (1)				
STXAI.0376	1									
STXAI.0406				1						
STXAI.0425	1	1								
STXAI.0434						2				
STXAI.0436						1				
STXAI.0440						1				
STXAI.0441						1				
STXAI.0444	1									
STXAI.0452	1									
STXAI.0479	1									

Enteritidis										
# samples with PFGE result	12 (14)	6 (19)	0	3 (5)	1	1	4	0	0	0
SENXAI.0001	2	3 (14)								
SENXAI.0002	(1)	(1)								
SENXAI.0003	4 (2)			1			2			
SENXAI.0004	2	1 (1)								
SENXAI.0008		2								
SENXAI.0009	1									
SENXAI.0038	3 (11)			2 (5)	1	1	2			
SENXAI.0079		(1)								
SENXAI.0093		(1)								
SENXAI.0123		(1)								

	Non-travel Cases [a]	Travel-related Cases	Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Grand River
			Pork chop	Skin-on breast	Ground beef					5 sample points on Grand River
Heidelberg										
# samples with PFGE result	3 (5)	0	0	16 (11)	0	0	5	0	0	0 (2)
SHEXAI.0001	1			8 (4)			5			(1)
SHEXAI.0006	(1)			(5)						(1)
SHEXAI.0009	(4)									
SHEXAI.0011	2			2 (1)						
SHEXAI.0015				(1)						
SHEXAI.0020				4						
SHEXAI.0187				1						
SHEXAI.0194				1						
Kentucky										
# samples with PFGE result	1	1	0 (1)	28 (26)	0	0	5	2	6 (12)	1 (5)
KenXAI.0005	1			7 (9)			2			
KenXAI.0012				2 (3)						
KenXAI.0013				15 (12)			3			
KenXAI.0016				(1)				2	6 (11)	1 (5)
KenXAI.0023			(1)							
KenXAI.0024				(1)						
KenXAI.0025									(1)	
KenXAI.0029				2						
KenXAI.0030										
KenXAI.0032				1						
KenXAI.0033				1						
KenXAI.0034		1								
Thompson										
# samples with PFGE result	3 (1)	2 (1)	0 (2)	1	0	0	3	0	0 (1)	2 (6)
STHXAI.0001							3		(1)	(2)
STHXAI.0002	1	1								1 (1)
STHXAI.0011		(1)								
STHXAI.0046	1			1						(3)
STHXAI.0056	1									
STHXAI.0060	(1)									
STHXAI.0062			(2)							

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

The PFGE patterns of *Salmonella* isolated by C-EnterNet during 2007 were compared to the PulseNet Canada National Databases, which contain clinical isolates uploaded by provincial public health labs between 2000 and 2008 during routine laboratory-based surveillance[6]. The C-EnterNet PFGE results described below refer to isolates from 2007 only. For comparison purposes, we have included PFGE results for isolates from 2005 and 2006, in parentheses, in Table 4.2.

The most frequently occurring PFGE patterns of *Salmonella* Typhimurium, Enteritidis, Heidelberg, Thompson, and Kentucky among human clinical isolates in the PulseNet Canada database were represented in C-EnterNet isolates.

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

There were 52 Typhimurium isolates with PFGE results representing 22 distinct patterns collected by C-EnterNet in 2007. Three of the PFGE patterns (STXAI.0001, STXAI.0243, STXAI.0312) were isolated from more than one source in 2007. Two represent the most common patterns in the PulseNet Canada database (STXAI.0001, STXAI.0312); however, pattern STXAI.0243 (isolate from a human case and from untreated surface water) is an uncommon pattern for Typhimurium (Table 4.2). The PFGE patterns STXAI.0027 and STXAI.0001 were most commonly identified in non-human sources and both were also found in human cases. Most of these were from pooled swine manure samples.

The 27 isolates of Enteritidis from C-EnterNet in 2007 comprised 6 distinct PFGE patterns, a lower diversity compared to Typhimurium and consistent with the overall diversity of PFGE patterns for Enteritidis in the PulseNet Canada database. Three patterns of Enteritidis were isolated from more than one category. The 12 endemic S. Enteritidis cases had 5 PFGE patterns, whereas the six travel-related ones were distributed among three patterns, two being identical to patterns identified in endemic cases (SENXAI.0001 and SENXAI.0004) (Table 4.2). The nine non-human isolates were distributed among two patterns, SENXAI.0003 and SENXAI.00038, which were also seen in endemic cases but not travel-related cases. The PFGE patterns SENXAI.0001, SENXAI.0038, SENXAI.0003, SENXAI.0008, found among C-EnterNet samples, represent the vast majority of Enteritidis isolates in PulseNet Canada.

Of the 24 isolates of *S.* Heidelberg that were isolated by C-EnterNet and characterized by PFGE in 2007; 5 distinct patterns were found. The PFGE pattern SHEXAI.0001, which was recovered in C-EnterNet retail chicken, broiler chicken manure, and from a human case, is the most frequently occurring PFGE pattern for Heidelberg in the PulseNet Canada database (over 40% of all cases). Similarly, SHEXAI.0011 was also recovered from both C-EnterNet retail chicken and from human cases; this pattern is the second most frequently occurring Heidelberg pattern in PulseNet Canada. Chicken retail isolates were distributed among four other patterns not seen in any other components.

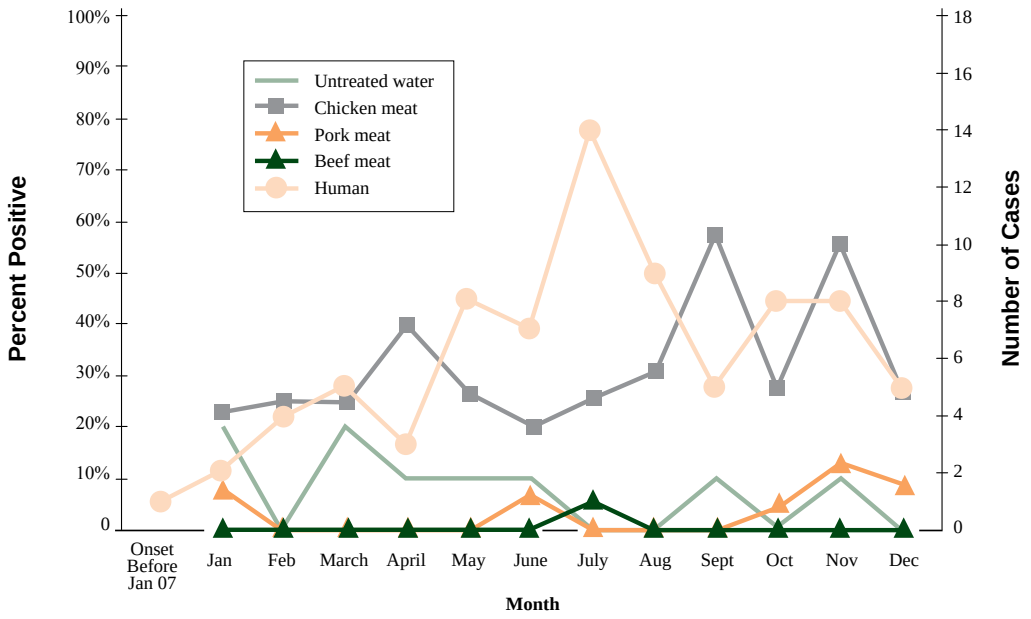
Seven of the *S.* Kentucky patterns were detected in the 28 retail chicken isolates, and two were predominant (KenXAI.0013 and KenXAI.0005). These two patterns were also detected in broiler chicken manure. KenXAI.0005 was the only *S.* Kentucky pattern isolated from an endemic case. KenXAI.0016 was detected on dairy cattle farms, beef farms and in untreated surface water samples. PFGE patterns from the few *S.* Thompson isolates in Sentinel Site 1 in 2007 were not specific to any particular pattern, but scattered across various ones. (Table 4.2). The majority of C-EnterNet *S.* Kentucky and *S.* Thompson samples comprised the most frequently occurring PFGE patterns in the PulseNet Canada database.

Generally, when looking at these five *Salmonella* serotypes, PFGE patterns associated with travel-related cases were rarely found in the sources tested (1/6) whereas patterns associated with endemic cases were more frequently found in the sources tested (9/22). Also, about half of the PFGE patterns associated with travel-related cases were also associated with endemic cases.

4.3 Seasonal Trends in Exposure Sources

There are no obvious seasonal trends in the *Salmonella* exposure sources evaluated in Sentinel Site 1 (Figure 4.2). Among human cases, there appears to be a seasonal increase in summer months, which matches trends observed in 2006.

FIGURE 4.2
Temporal distribution of *Salmonella* detected in human endemic cases, untreated surface water and retail meat samples in Sentinel Site 1 in 2007



4.4 Summary of *Salmonella* Results

- Typhimurium was the most commonly detected *Salmonella* serotype in human cases and on swine and beef farms, and the second most commonly detected serotype on dairy farms in Sentinel Site 1.
- *Salmonella* Enteritidis was the second most commonly detected serotype in human cases and the third most commonly detected serotype in broiler chicken manure. The only retail ground beef isolate identified was *S.* Enteritidis. A third of the *Salmonella* Enteritidis cases were travel-related.
- In Sentinel Site 1, the prevalence of *S.* Enteritidis phagetype 13 has decreased in 2007 from 2006 in human cases and retail chicken meat. However, it was detected in retail ground beef and on swine and broiler chicken farms in 2007. This pattern was identified whether you consider the phagetype (PT13) or the PFGE pattern (SENXAI.0038).
- *Salmonella* Heidelberg was the third most commonly detected serotype in human cases and the second most commonly detected serotype in retail chicken meat and on broiler chicken farms (tied for second with *S.* Kentucky). PFGE patterns identified in human cases this year (SHEXAI.0001 and SHEXAI.0011) are the most frequently occuring Heidelberg patterns in PulseNet Canada. These patterns were detected in retail chicken meat and SHEXAI.0001 was also found on broiler chicken farms in 2007.

- The most common serotype detected on broiler chicken farms was *S.* Hadar. All five *S.* Hadar isolates recovered from retail chicken had the same PFGE pattern (SHAXAI.0001). This PFGE pattern was also found on one swine and one broiler chicken farm in Sentinel Site 1. This PFGE pattern was not found in any of the human cases in Sentinel Site 1, but is a common pattern identified in human cases across Canada.
- *Salmonella* Kentucky was the most commonly detected serotype on retail chicken meat, manure from dairy cattle, and beef farms, and tied for second on manure from broiler chicken farms with *S.* Heidelberg. It was isolated in one endemic and one travel-related human case. The single endemic human case isolate (PFGE pattern KENXAI.0005) matched isolates recovered from retail chicken meat and broiler chicken farms in Sentinel Site 1.

5. Pathogenic *E. coli*

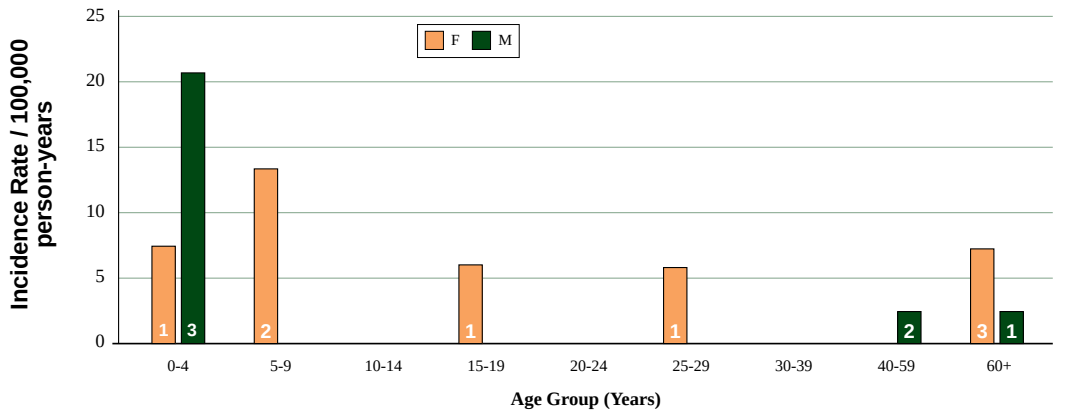
5.1 Human Cases

In 2007, in Sentinel Site 1, there were 19 reported cases of *E. coli* O157:H7 (3.8/100,000 person-years). Of those 19 cases, three were travel-related, two were outbreak-related and 14 were classified as endemic (2.8/100,000 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]

Endemic *E. coli* O157:H7 infections (14 cases) decreased in 2007 compared to infections in 2005 (26 cases from April-December) and 2006 (32 cases) [see Chapter 9].

The age- and gender-specific incidence rates among the 14 endemic cases were highest among children less than five years of age (Figure 5.1), a trend that has been consistent in previous years.

FIGURE 5.1
Incidence rates of endemic *E. coli* O157:H7 in Sentinel Site 1 by gender and age group in 2007



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

Exposure information for the ten days prior to the onset of illness was collected for 100% (14/14) of the reported endemic cases of *E. coli* O157:H7 (Appendix B). A higher number of *E. coli* O157:H7 cases was observed for the following exposures: use of municipal water source; drank untreated water; swam in a lake; ate undercooked food; attended a barbecue; ate in a restaurant; shopped at a butcher shop; lived on a farm; and on-farm animal contact with poultry. Travel within Canada and travel by car (within Canada or to US destinations) were reported more frequently among *E. coli* O157:H7 cases than other enteric cases. The Canadian travel destinations included camping or travel to Northern Ontario.

7 National Notifiable Disease representative (Carole Scott) 2007 [personal communication]. Note: 2006 numbers contain travel and endemic cases and are preliminary and subject to change.

5.2 Exposure Surveillance

TABLE 5.1
Verotoxigenic *E. coli* detection data from the integrated surveillance activities in Sentinel Site 1 in 2007

	Human	Retail Food			Food Animals (Manure)				Untreated Surface Water	
	Endemic Cases	Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Grand River	
Detection		Pork chop	Skin-on breast	Ground beef	30 Farms	9 Farms	21 Farms	28 Farms	5 sample points on Grand River	
# tested	Unknown	187 [a]	187 [a]	187 [a]	120 [a]	36 [a]	80 [a]	112 [a]	134 [a]	129 [b]
VTEC		0	0	2						
O 157 (non-H7)					2	1		5	1 (E)	
O 157:H7	14						7	6	2 (A)	35

[a] Culture method. [b] Molecular method.
Water Sampling Locations in Grand River Watershed: A- Canagagigue Creek, B- Conestogo River, C- Upper Grand River, D- Grand River, near drinking water treatment plant intake, E- Grand River, near one wastewater treatment plant effluent point.

Retail

Verotoxigenic *E. coli* (VTEC) was detected on 1% (2/187) of retail beef samples (Table 5.1). VTEC was not detected on retail pork (0/187) or chicken (0/187) samples.

On-Farm

E. coli O157:H7 was isolated from 9% (7/80) of the pooled manure samples collected from 21 beef operations and from 5% (6/112) of the pooled manure samples collected from 28 dairy operations (Table 5.1). Of the swine and broiler chicken pooled manure samples tested, none were positive for *E. coli* O157:H7.

Water

E. coli O157:H7 was detected by molecular analysis in 27% (35/129) of the untreated surface water samples. The culture-based method identified three (2%) O157 isolates; two of the three were positive for the H7 antigen (Table 5.1). As in previous years, the difference between culture and molecular results is partly attributed to the difficulty associated with culturing this organism from environmental water samples.

TABLE 5.2
PFGE results for *E. coli* O157:H7 for all components, including human travel-related cases in Sentinel Site 1 in 2007 (values in brackets refer to 2006 data for comparison)

	Human		Food Animals (Manure)		Untreated Surface Water
	Non-travel Cases	Travel-related Cases	Beef Cattle	Dairy Cattle	Grand River 5 sample points on Grand River
# of samples with PFGE results	10 (32) [a]	2 (1)	7 (0)	6 (16) [b]	1 (1) [b]
ECXAI.0001	(5)				
ECXAI.0002	1				
ECXAI.0006				(3)	
ECXAI.0007	(1)				
ECXAI.0008	(2)			1	1
ECXAI.0017	(3)				
ECXAI.0023				(1)	
ECXAI.0052	2	(1)			
ECXAI.0063	(1)				
ECXAI.0073			1		
ECXAI.0140			1		
ECXAI.0247	(1)				
ECXAI.0262	(9)				
ECXAI.0309	(1)				
ECXAI.0317				1	
ECXAI.0378				1	
ECXAI.0776			1		
ECXAI.0841	1				
ECXAI.1175	1			(1)	
ECXAI.1248	(1)				
ECXAI.1267			1	(1)	
ECXAI.1304				1	
ECXAI.1477	(1)				
ECXAI.1478	(1)				
ECXAI.1495	1				
ECXAI.1501	(1)				
ECXAI.1526	(1)				
ECXAI.1537	(1)				
ECXAI.1556					(4)
ECXAI.1557					(1)
ECXAI.1577	(2)				
ECXAI.1578	(1)				
ECXAI.1610	1				
ECXAI.1611				(3)	
ECXAI.1612				(3)	
ECXAI.1613				(2)	
ECXAI.1614				(1)	
ECXAI.1687				(6)	
ECXAI.1688				(1)	
ECXAI.1689				(1)	
ECXAI.1690				(4)	
ECXAI.1691				(1)	
ECXAI.1692				(2)	
ECXAI.1694	1			(2)	
ECXAI.1714		1			
ECXAI.1737	2				
ECXAI.1777		1			
ECXAI.1855				1	
ECXAI.1857				1	
ECXAI.1858			1		
ECXAI.1859			1		
ECXAI.1860			1		

[a] Non-travel includes endemic and outbreak cases. [b] Multiple isolates per positive sample in 2006 (i.e. 16 positive dairy manure samples yielded 32 isolates; 1 untreated water sample yielded 5 isolates).

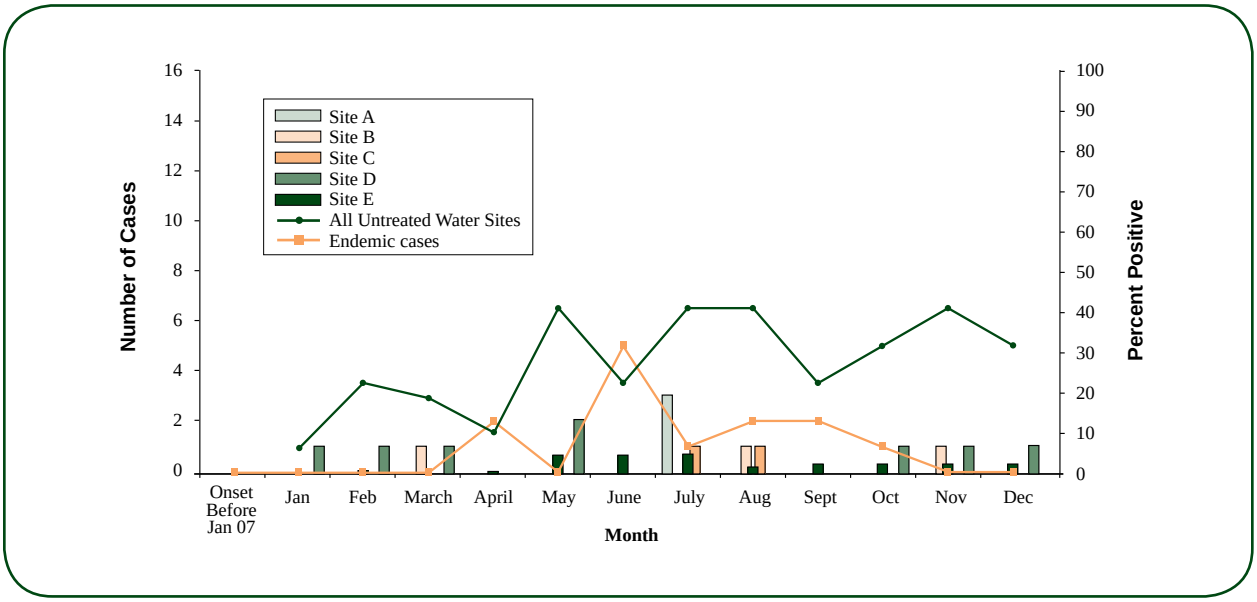
PFGE analysis of the 2007 *E. coli* O157:H7 isolates showed 26 isolates comprising 23 distinct PFGE patterns and little overlap between human cases and isolates from non-human sources (Table 5.2). The single exception was ECXAI.0008, isolated from untreated surface water as well as from dairy cattle. ECXAI.0008 is a fairly common pattern in the PulseNet Canada database (associated with ~11 human cases in 2007)[8]. Interestingly, the most frequently occurring PFGE pattern among human clinical isolates reported to PulseNet Canada, ECXAI.0001, was not recovered from any C-EnterNet samples in 2007. Half of the C-EnterNet isolates in 2007 had uncommon or rare patterns in the PulseNet Canada database; however, given the considerable diversity that *E. coli* O157:H7 shows by PFGE, this may not be surprising. When comparing three years of surveillance data, some overlap was found among PFGE patterns. Two PFGE patterns (ECXAI.1175 and ECXAI.1694) were detected in both dairy manure and endemic cases. PFGE pattern ECXAI.1267 was detected in manure from both dairy and beef farms.

5.3 Seasonal Trends in Exposure Sources

No endemic VTEC cases were reported between January and March or in November and December, and the highest number of cases was reported in June (Figure 5.2). A similar seasonal pattern was observed in 2006.

No obvious seasonal trends were observed in *E. coli* O157:H7 levels in exposure sources that were tested throughout the year (Figure 5.2).

FIGURE 5.2
Monthly distribution of *E. coli* O157:H7 cases and detection in untreated surface water samples in Sentinel Site 1 in 2007



8 PulseNet Canada, National Microbiology Laboratory, Public Health Agency of Canada (Celine Nadon) 2008 [personal communication].

5.4 Summary of Pathogenic *E. coli* Results

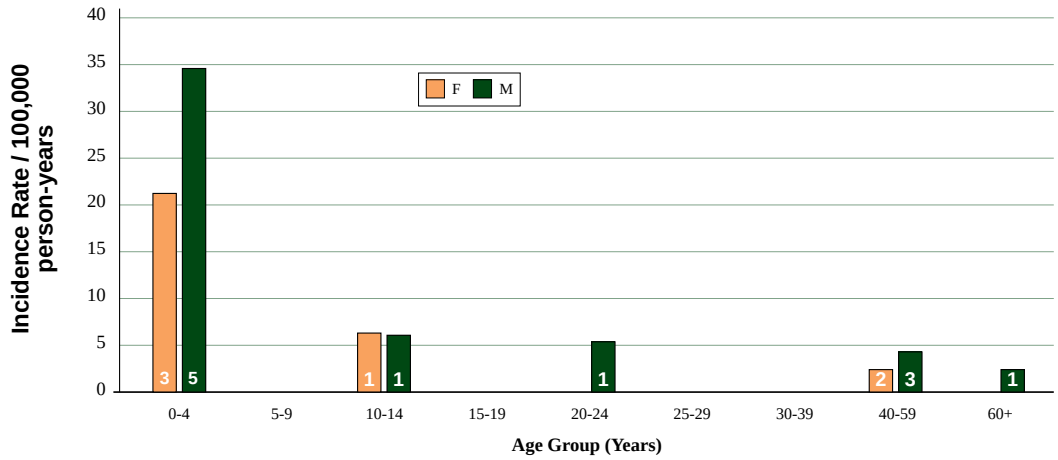
- Human endemic incidence rates of *E. coli* O157:H7 decreased in 2007 compared to 2006 (see Chapter 9).
- *E. coli* O157:H7 appears to be a domestically acquired infection as demonstrated by the low proportion of travel-related cases.
- As was previously observed in 2006, *E. coli* O157:H7 cases in 2007 were more likely to be urban residents. Conversely, in 2005, cases were more likely to be rural residents (Appendix B).
- As in previous years, PFGE subtyping of the human and non-human isolates from 2007 revealed no overlapping patterns, suggesting that different strains are circulating in these components. However, when reviewing data from multiple years, some overlap exists.

6. *Yersinia*

6.1 Human Cases

In 2007 in Sentinel Site 1, there were 22 reported cases of *Yersinia* infection (4.4/100,000 person-years). Of these 22 cases, 23% (5) were travel-related, and 77% (17) were classified as endemic (3.4/100,000 person-years). Currently, *Yersinia* is not a nationally notifiable disease, and so the annual national and provincial incidence rates are not available for comparison. The age-specific incidence rate from the 17 endemic cases was highest among children less than five years of age (Figure 6.1).

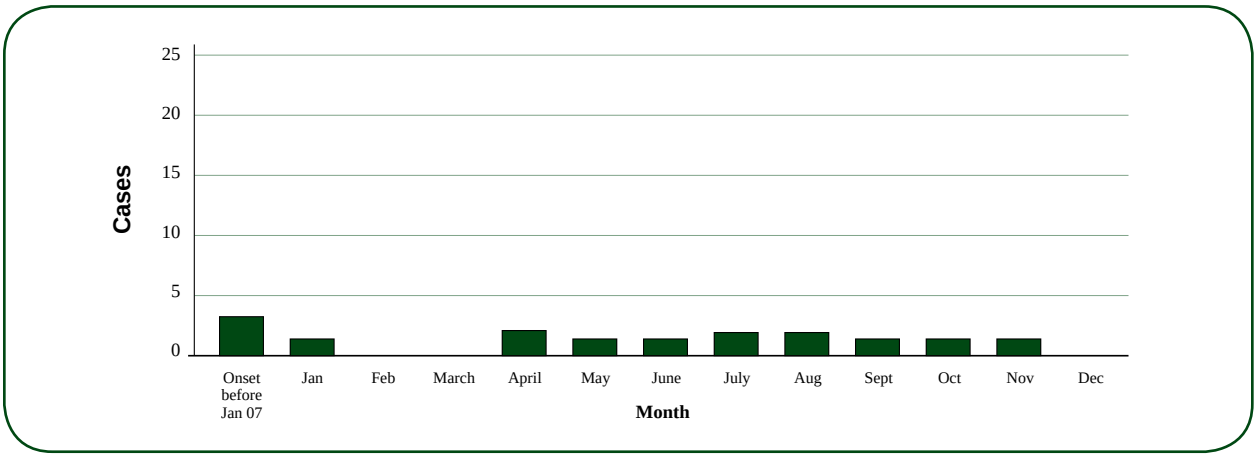
FIGURE 6.1
Incidence rates of endemic *Yersinia* infection by gender and age group in Sentinel Site 1 in 2007



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

Only 14 of the 16 *Yersinia enterocolitica* isolates from human cases were serotyped. Twelve of fourteen *Y. enterocolitica* were serotype O:3, one was serotyped as 1A O:6,30 and one was serotyped as 1a O:rough. In addition, there was one isolate classified as *Yersinia intermedia*. *Yersinia intermedia*, *Yersinia enterocolitica* 1A O:6,30 and 1a O:rough are considered non-pathogenic strains. The cases were uniformly spread over the year ranging from zero to three cases per month without obvious seasonal patterns (Figure 6.2) [see Chapter 9].

FIGURE 6.2
Monthly distribution of human *Yersinia* cases in Sentinel Site 1 reported in 2007



Potential exposure information for the seven days prior to the onset of illness was collected for 16/17 of the reported endemic yersiniosis cases (Appendix B). A higher number of reported yersiniosis cases were observed for the following exposures: attending a barbecue, and on-farm animal exposure to cats and dogs.

6.2 Exposure Surveillance

TABLE 6.1
***Yersinia* detection and speciation data from the integrated surveillance activities in Sentinel Site 1 in 2007**

	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	187 [a]	120 [a]	133 [a]	77 [b]
# positive	17 [a]	8	4 (4 farms)	53	45
% positive		4%	3%	40%	58%
Subtyping					
# subtyped	**15**	**6**	**4**	**42** [c]	
Y. aldovae - non-pathogenic				2 (C)	
Y. bercovieri - non-pathogenic				8 (B, D, E)	
Y. enterocolitica - pathogenic	12		4		
Y. enterocolitica - non-pathogenic	2	2		13 (A, B, C, D)	
Y. frederiksenii - non-pathogenic		3		20 (A, B, C, D, E)	
Y. intermedia - non-pathogenic	1	1		20 (A, B, C, D, E)	
Y. kristensenii - non-pathogenic				2 (D)	
Y. mollaretti - non-pathogenic				6 (D)	
Y. rohdei - non-pathogenic				1 (E)	

[a] Culture-based. [b] Molecular-based. [c] Multiple isolates were detected in more than one samples, 72 isolates in total. Water Sampling locations in Grand River Watershed: A- Canagagigue Creek, B- Conestogo River, C- Upper Grand River, D- Grand River, near drinking water intake, E- Grand River, near one wastewater treatment plant effluent point.

Retail

Yersinia was isolated from 4% (8/187) of the raw pork chops sampled (Table 6.1), all of which had levels of *Yersinia* below the MPN detection limit (Appendix C). In 2007, there was a statistically-significant decrease in the contamination rate of *Yersinia* on retail pork (see Chapter 9).

Five isolates were subtyped and found to be non-pathogenic subtypes (*Y. enterocolitica* serotypes O:7,8, O:Un-typeable, *Y. intermedia* and *Y. frederiksenii*).

On-Farm

Yersinia was isolated from 3% (4/120) of the pooled swine manure samples collected (Table 6.1). All four isolates were pathogenic *Y. enterocolitica* serotypes (O:3).

Water

Yersinia was isolated from 40% (53/133) of the untreated surface water samples by culture method, and 58% (45/77) by molecular method (Table 6.1), signalling a statistically significant increase in detection from 2006, when only 15% of samples were positive for *Yersinia* (see Chapter 9).

6.3 Summary of *Yersinia* Results

- *Yersinia* continues to be primarily a domestically acquired infection, as demonstrated by the low proportion of travel-related cases.
- Epidemiologically, contact with cats and dogs on a farm may be important risk factors for yersiniosis.
- 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, these strains were determined to be non-pathogenic.
- Three *Yersinia* strains (*Y. intermedia, Y. enterocolitica* 1A O:6,30 and 1a O:rough) that are considered non-pathogenic were isolated from three cases in 2007. It is unclear if these are the etiologic agents or incidental findings.

7. *Listeria*

7.1 Human Cases

Recognized human listeriosis is rare and is typically identified with severe, hospitalized cases among immunocompromised individuals. In 2007, in Sentinel Site 1, there was one reported endemic case of *Listeria monocytogenes* in August. An annual national incidence rate for listeriosis is not currently available. Health Canada's *Listeria* Reference Services, however, reports the incidence remains below 0.35 cases per year per 100,000 nationally.[9]

7.2 Exposure Surveillance

TABLE 7.1
***Listeria monocytogenes* detection data from the integrated surveillance activities in Sentinel Site 1 in 2007**

	Human	Retail Food			Food Animals (Manure)	
	Endemic Cases	Pork	Chicken	Beef	Broiler Chickens	Beef Cattle
Detection		Pork chop	Skin-on breast	Ground beef	9 Farms	21 Farms
# samples tested	Unknown	187 [a]	187 [a]	187 [a]	36 [a]	80 [a]
# positive	1 [a]	21	64	44	1	51
% positive		11%	34%	24%	3%	64%

[a] Culture method.

Retail

Listeria monocytogenes detection rates and MPN levels were similar to those observed in 2006 on retail meat (Table 7.1) [see Chapter 9]. Two raw chicken meat samples were found to have high levels (>1000MPN/g) of *Listeria monocytogenes* (Appendix C).

On-Farm

In 2007, manure samples were collected from broiler chicken and beef operations. Of the pooled broiler chicken and pooled beef manure samples, 3% (1/36) and 64% (51/80), respectively, tested positive for *Listeria monocytogenes* (Table 7.1).

In previous years, manure samples were only obtained from swine and dairy operations and the prevalence was found to be 3% and 9%, respectively.[10]

Subtype Comparisons

Listeria monocytogenes serotypes 1/2a, 1/2b and 4b were the 3 most frequently detected serotypes in the exposure sources tested and are reported to be the predominant serotypes in Canada causing human illness[11]. *Listeria monocytogenes* 4b was most frequently detected on dairy and beef farms while *Listeria monocytogenes* 1/2a and 1/2b were the two most frequently detected serotypes on retail meats (Table 7.2).

9 Personal communications. Listeria Research Laboratory and Listeriosis Reference Service, Food Directorate, Bureau of Microbial Hazards
10 Government of Canada. Canadian National Enteric Pathogen Surveillance System (C-EnterNet) 2006. Guelph, ON: Public Health Agency of Canada, 2007.
11 Listeria Research Laboratory and Listeriosis Reference Service, Food Directorate, Bureau of Microbial Hazards

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

	Human	Retail Meat			Farm Animals (Manure)				
Serotype	Endemic Cases	Pork Chop	Skin-on Chicken Breast	Ground Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Total
# serotyped	1	41	128	96	4	1	51	15	337
1/2a	1	6 (11)	45 (41)	18 (23)	(1)	1	24 (14 farms)	(2) (2 farms)	173
1/2b		7 (5)	6 (21)	27 (25)	(3) (2 farms)		8 (4 farms)	(4) (4 farms)	106
1/2c		7 (3)	4	1 (2)					17
3a		1	1 (1)						3
3b			3 (2)						5
4a							4 (2 farms)		4
4b		(1)	2 (2)				12 (8 farms)	(5) (4 farms)	22
4c							3 (2 farms)	(4) (3 farms)	7

In comparing PFGE patterns from farm manure and retail meat samples, no significant overlap was observed (Table 7.3). For example, the most common pattern isolated from retail ground beef (LMAAI.0223) was not detected on any beef farms, while the most common pattern on beef farms (LMAAI.0093) was detected on only one retail beef sample. PFGE patterns LMAAI.0093 and LMAAI.0223 have been infrequently associated with human illness.

TABLE 7.3
Listeria monocytogenes PFGE data from the integrated surveillance activities in Sentinel Site 1 in 2007 (values in brackets refer to 2006 and 2005 data for comparisons)

	Human	Retail Meat			Farm Animals (Manure)					
PFGE Pattern	Endemic Cases	Pork	Chicken	Beef	Swine	Broiler Chickens	Beef Cattle	Dairy Cattle	Non-human Total	Top ten human ranking
		Pork chop	Skin-on breast	Ground beef	30 Farms	9 Farms	21 Farms	28 Farms		
# subtyped		41	128	96	4	1	51	15	336	
LMAAI.0001	1	2 (1)	9 (8)	3 (1)					24	1
LMAAI.0003		(1)	(1)	(1)					3	2
LMAAI.0007							2 (1 farm)		2	
LMAAI.0013		3 (5)	12 (11)	7 (14)					52	10
LMAAI.0014		(1)							1	6
LMAAI.0017							1		1	3
LMAAI.0024		(1)		3 (1)					5	5
LMAAI.0028			5	(1)					6	
LMAAI.0049			(2)	(1)			2		5	
LMAAI.0074			1 (2)				2 (2 farms)	(1)	6	
LMAAI.0090							1	(1)	2	
LMAAI.0093				(1)			11 (8 farms)		12	
LMAAI.0097			8 (1)						9	
LMAAI.0126			2 (1)	2 (1)			3 (2 farms)		9	
LMAAI.0147		2							2	
LMAAI.0204							6	(5) (4 farms)	11	
LMAAI.0223		5 (4)	1 (1)	22 (21)					54	
LMAAI.0256		1		(1)					2	
LMAAI.0266							5 (3 farms)		5	
LMAAI.0333							1	(1)	2	
LMAAI.0360			1 (1)						2	
LMAAI.0377			2 (1)						3	
LMAAI.0378		1 (4)		1 (1)					7	
LMAAI.0383			2						2	
LMAAI.0384		1		(1)					2	
LMAAI.0402			4 (6)						10	
LMAAI.0432					(2) (1 farm)				2	
LMAAI.0454			2 (1)						3	
LMAAI.0465			(7)						7	
LMAAI.0467			(2)	1					3	
LMAAI.0472			1 (1)						2	
LMAAI.0498			(2)						2	
LMAAI.0531			(2)						2	
Other patterns [a]		6 (3)	9 (16)	5 (7)	(2)		11	(4)	63	
No PFGE designation			2 (1)			1	6 (4 farms)	(3) (2 farms)	13	

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

7.3 Summary of *Listeria monocytogenes* Results

- In general, the prevalence of *Listeria monocytogenes* on retail meat was higher than the prevalence in on-farm manure samples, with the exception of the beef operations. Literature supports this finding, which suggests that abattoirs and meat processing environments may be an important source of *Listeria monocytogenes*[12].
- No seasonal trend in the retail meat contamination was detected.
- *Listeria monocytogenes* serotype data correlate with PFGE results. For example, of the 52 isolates with the LMAAI.0013 pattern, 51 were serotype 1/2a and of the 54 isolates with the LMAAI.0223 pattern, 52 were serotype 1/2b.
- Of the three most common PFGE patterns found on retail meat and farms in Sentinel Site 1, two (LMAAI.0001 and LMAAI.0013) are ranked among the top ten patterns associated with human illness in Canada (Table 7.3).
- The most common PFGE pattern (LMAAI.0223) detected on retail ground beef and retail pork chops is rarely associated with human illness in Canada (Table 7.3).

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

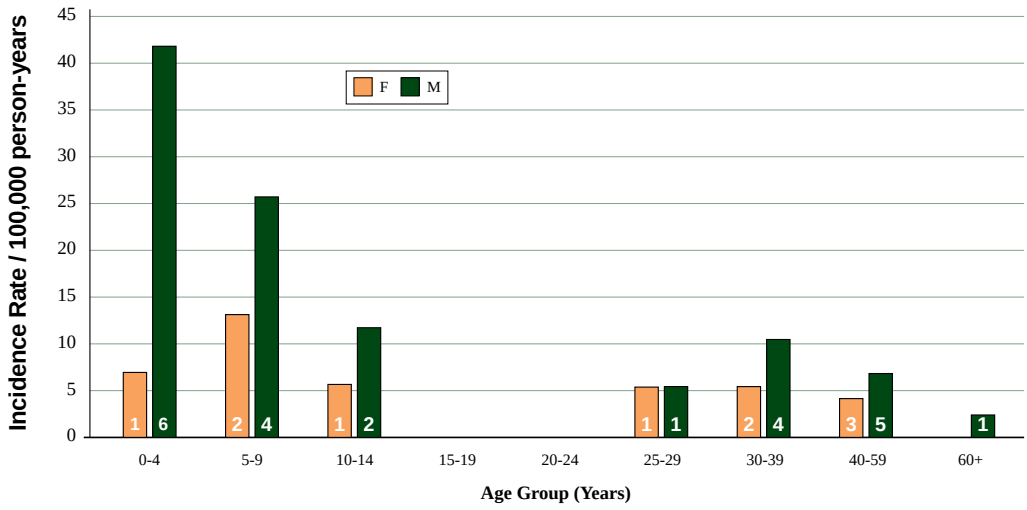
8. Parasites

8.1 Giardiasis

In 2007, in Sentinel Site 1, there were 56 reported cases of giardiasis (11.3/100,000 person-years). Of these 56 cases, 22 (39%) were travel-related, one was related to an outbreak, and 33 (59%) were classified as endemic (6.6/100,000 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.[13]

Of the endemic cases, ten were female (4.0/100,000) and 23 were male (9.3/100,000), indicating a higher incidence rate among males (Figure 8.1). No cases were reported among individuals in the 15-19 and 20-24 age groups.

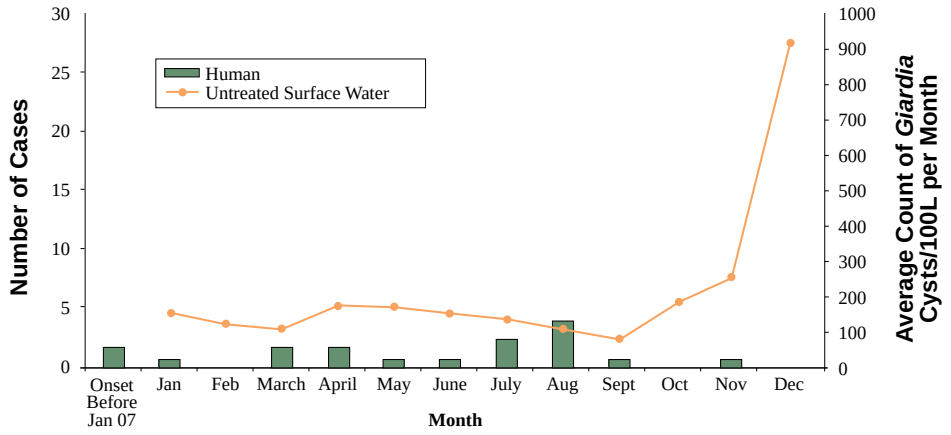
FIGURE 8.1
Incidence rates of endemic giardiasis cases by gender and age group in Sentinel Site 1 in 2007



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

13 National Notifiable Disease representative (Carole Scott) 2007 [personal communication]. Note: 2006 numbers contain travel and endemic cases and are preliminary and subject to change.

FIGURE 8.2
Monthly distribution of *Giardia* cases and detection in untreated surface water sampled in Sentinel Site 1 in 2007



Note: Retail and on-farm manure samples were not included because parasite testing is episodic.

The number of cases per month varied from none to five with the most number of cases observed in July and in August (Figure 8.2).

Potential exposure information for the 25 days prior to the onset of illness was available for 25/33 (76%) of the endemic cases (Appendix B). Higher numbers of reported *Giardia* cases were observed for the following exposures: using a private well, swimming in a pool, eating at a restaurant, eating meat from a butcher shop, eating meat from private kill, shopping at a butcher shop, contact with households pets, living on a farm or in a rural area, visiting a farm animal area (horses), and on-farm exposure to cattle and horses.

TABLE 8.1
***Giardia* detection and subtyping data from the integrated surveillance activities in Sentinel Site 1 in 2007**

	Human	Food Animals (Manure)		Untreated Surface Water
	Endemic Cases	Broiler Chickens	Beef Cattle	Grand River
		9 Farms	21 Farms	5 sample points on Grand River
Microscopic Results				
# tested # positive	Unknown 33	33 0	76 52	40 40 (A, B, C, D, E)
% positive		0%	68%	100%
PCR Results				
# tested # positive		33 1	76 52	
% positive		3%	68%	
Sequencing Results				
# samples with sequencing results	0	1	48	0
Assemblage B		1		
Assemblage E			48	

Note: **Zoonotic Assemblages:** Assemblage B-humans, cattle, pigs, dogs, beavers, seals. **Non-zoonotic Assemblages:** Assemblage E- cattle, sheep, pigs.

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

Exposure Surveillance

On-Farm

Using microscopy techniques, 68% of the pooled beef manure and 0% of the pooled broiler chicken manure samples, respectively, tested positive for *Giardia* (Table 8.1). Using PCR methods, 68% and 3% of the pooled beef and pooled broiler chicken manure samples, respectively, were positive for *Giardia*. Correlations between the microscopy and PCR results were not always observed, although overall proportions were similar for the beef samples. Assemblage E, a non-zoonotic assemblage, was the only assemblage detected in the beef manure. Conversely, the one positive broiler chicken manure sample was identified as Assemblage B, a zoonotic strain.

Water

Giardia was detected in 100% 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 the river from October to December (Figure 8.2).

Summary of Giardiasis Results

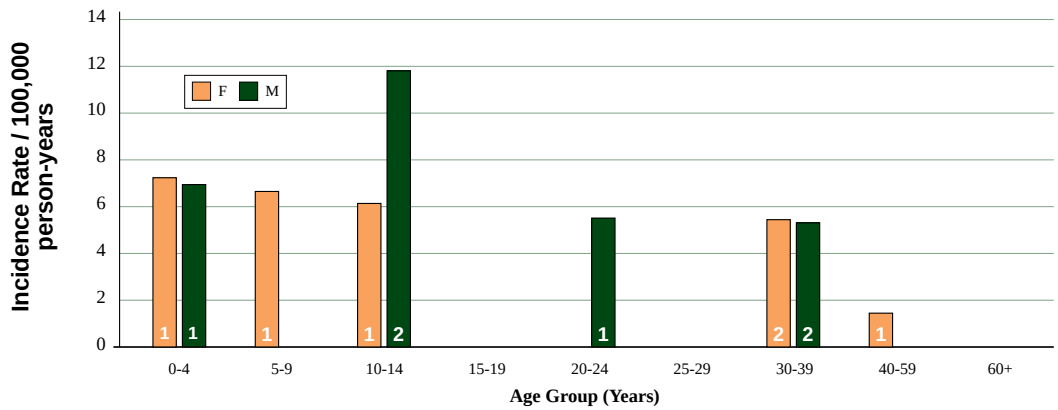
- Epidemiologically, using a private well, swimming in a pool, eating at a restaurant, eating meat from a butcher shop, eating meat from private kill, shopping at a butcher shop, contact with household pets, living on a farm or in a rural area, visiting a farm animal area (horses), and on-farm exposure to cattle and horses appear to be important risk factors for endemic giardiasis.
- *Giardia* Assemblage B, which is pathogenic to humans, was only found in one pooled broiler chicken manure sample. Similar molecular subtyping methods on positive human and water samples are needed to inform source attribution estimates. Subtyping of positive water samples commenced in 2008.
- In the sentinel site, *Giardia* appears to be endemic in untreated surface water.

8.2 Cryptosporidiosis

In 2007, in Sentinel Site 1, there were a total of 19 reported cases of cryptosporidiosis (3.8/100,000 person-years). Of these 19 cases, seven were travel-related and 12 were classified as endemic (2.4/100,000 person-years). 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.[14] Of the endemic cases, six were female (2.4/100,000) and six were male (2.4/100,000) (Figure 8.3).

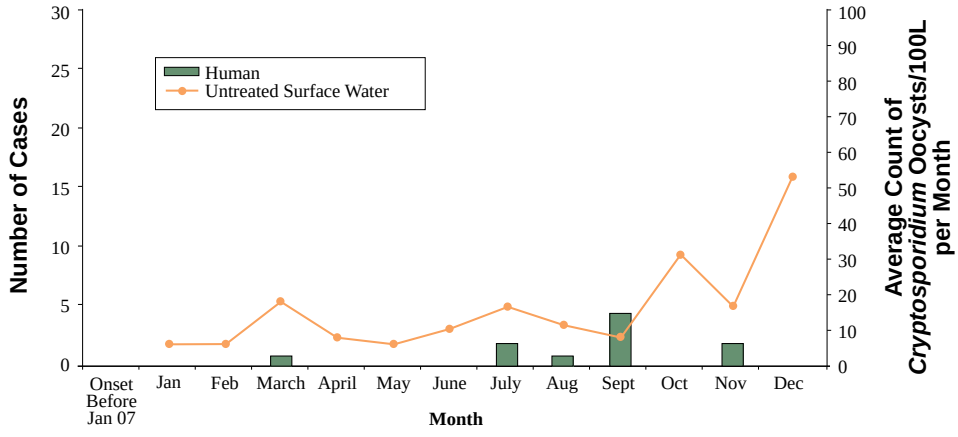
14 National Notifiable Disease representative (Carole Scott) 2007 [personal communication]. Note: 2006 numbers contain travel and endemic cases and are preliminary and subject to change.

FIGURE 8.3
Incidence rates of endemic cryptosporidiosis cases by gender and age group in Sentinel Site 1 in 2007



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

FIGURE 8.4
Monthly distribution of *Cryptosporidium* cases and detection in untreated surface water sampled in Sentinel Site 1 in 2007



Note: Retail and on-farm manure samples were not included because parasite testing is episodic.

The onset of the endemic cryptosporidiosis cases occurred in March, July, August, September and November (Figure 8.4).

Potential exposure information for the 12 days prior to the onset of illness was available for 11 of the 12 cases (Appendix B). Higher numbers of reported *Cryptosporidium* cases were observed for the following exposures: using a private well, swimming, ate meat from a private kill, contact with households pets (dog and reptile), living on a farm or in a rural area, visiting a farm animal area (cat, cattle, horses), and on-farm exposure to pigs.

TABLE 8.2
***Cryptosporidium* detection and subtyping data from the integrated surveillance activities in Sentinel Site 1 in 2007**

	Human	Animals (Manure)		Untreated Surface Water
	Endemic Cases	Broiler Chickens	Beef Cattle	Grand River
		9 Farms	21 Farms	5 sample points on Grand River
Microscopic Results				
# tested # positive	Unknown 12	33 0	76 22	40 35 (A, B, C, D, E)
% positive		0%	29%	88%
PCR Results				
# tested # positive		33 0	76 20	
% positive		0%	26%	
Sequencing Results				
# samples sequenced	0	0	18	26 (multiple genotypes per sample)
C. andersoni [a]			17	13
C. cervine [a]				1
C. parvum (bovine genotype) [a]			1	2
C. hominis [a, b]				3
C. muskrat genotype I				2
C. muskrat genotype II				1
Other				4

[a] Known to be pathogenic to humans. [b] Only found in humans.

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

Exposure Surveillance

On-Farm

Using microscopy techniques, 29% and 0% of the pooled beef and broiler chicken manure samples, respectively, tested positive for *Cryptosporidium* (Table 8.2). Using PCR methods, 26% and 0% of the pooled beef and broiler chicken manure samples, respectively, were positive for *Cryptosporidium*. *C. andersoni* was the most common subtype detected in the beef samples, and one sample was positive for the *C. parvum* bovine genotype.

Water

Cryptosporidium was detected in 88% of untreated surface water samples, indicating a high prevalence of this potential pathogen in the watershed (Table 8.2). Further subtyping determined that *C. andersoni* was the most common genotype, supporting trends observed in previous sampling years. It should be noted that *C. andersoni*, while not commonly associated with human infections, has recently been reported in some immunocompetent cases[15 16], suggesting that it may be mildly infectious.

The two most common human pathogenic strains, *C. hominis* and *C. parvum* (the bovine genotype), were detected in 5 of the 25 samples tested. More than one genotype was detected in some of the samples. The average concentration of *Cryptosporidium* oocysts in untreated surface water peaked in December (Figure 8.4).

15 Leoni F, et al. Genetic analysis of Cryptosporidium from 2414 humans with diarrhoea in England between 1985 and 2000. J Med Micro. 2006;55:703-707

16 Morse TD, et al. Incidence of cryptosporidiosis species in paediatric patients in Malawi. Epidemiol Infect. 2007;135:1307-1315

Summary of Cryptosporidiosis Results

- Epidemiologically, using a private well, swimming, contact with household pets (dog), living on a farm or in a rural area, visiting a farm animal area (cat, cattle, horses), and on-farm exposure to pigs appear to be important risk factors for endemic cryptosporidiosis in Sentinel Site 1.
- 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. andersoni* was the most common subtype identified in beef cattle manure and in untreated surface water.
- *C. hominis*, which is host-specific to humans, was detected in untreated surface water and this illustrates a human source, although prevalence is low.
- *C. parvum*, also frequently associated with human infection, was detected in untreated surface water and in pooled beef cattle manure.
- Untreated surface water samples contained other *Cryptosporidium* sp. strains potentially pathogenic to humans (*C. cervine*).

8.3 Cyclosporiasis

One travel-related and two endemic cases (0.4/100,000 person-years) were reported in Sentinel Site 1 in 2007, compared to none in 2006.

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

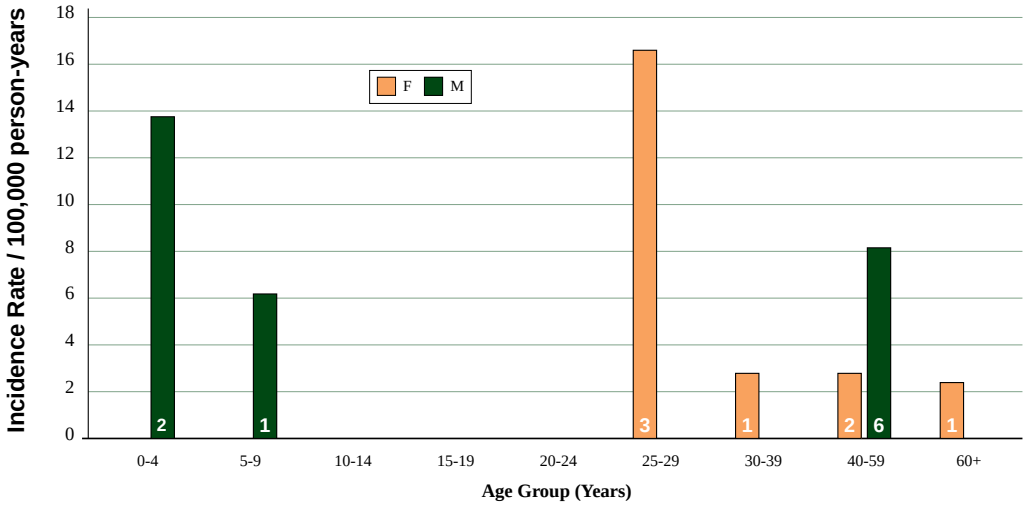
8.4 Amoebiasis

In 2007, in Sentinel Site 1, there were a total of 32 reported cases of amoebiasis (6.4/100,000 person-years). Of these 32 cases, 16 were travel-related and 16 were classified as endemic (3.2/100,000 person-years). Of the endemic cases, seven were female (2.8/100,000) and nine were male (3.6/100,000) (Figure 8.5).

Amoebiasis was removed from national surveillance as of January 2000[17]; therefore, comparative incidence data cannot be provided for Canada.

17 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 2007



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

Potential exposure information for the seven days prior to the onset of illness was available for 13 of the 16 cases (Appendix B). Higher numbers of reported amoebiasis cases were observed for the following exposures: using municipal water, eating in a restaurant, and visiting a farm animal area (horses).

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

9. Temporal Variations

This chapter, new to the 2007 Annual Report, highlights the changes over time in human enteric disease incidence and pathogen occurrence among the exposure sources included in the C-EnterNet surveillance program. Identifying temporal trends or seasonal and other cyclical variations over time is an important component of health surveillance. It allows for the interpretation of the current state of health in the context of historical background. It also allows for the forecasting of future trends of enteric disease and the related consequences in the absence of relevant interventions or policy changes.

9.1 Trends in Enteric Disease Annual Incidence

From 1990 to 2007, the total number of reported cases of enteric diseases showed an overall decline in Sentinel Site 1, whereas the total number was higher for the last three years compared to the years 2003 or 2004 (Figure 9.1). The disease-specific annual incidence rates exhibited the same overall decline with some variations (Figures 9.1 & 9.2).

Since the implementation of the C-EnterNet program in Sentinel Site 1 in June 2005, the standardization of the data collection for all reported enteric disease cases allowed for the comparison of disease-specific incidence rates for outbreak-related, international travel-related, and endemic (i.e. sporadic and domestic) cases separately for the last two calendar years (Table 9.1).

Among the endemic cases, one case of listeriosis and two cases of cyclosporiasis were reported in 2007, while none were reported in 2006. Endemic VTEC infections decreased significantly from 2006 to 2007 ($p<0.05$), whereas endemic salmonellosis significantly increased ($p<0.05$).

Among the travel-related cases, the incidence of campylobacteriosis and amoebiasis significantly increased from 2006 to 2007 ($p<0.05$). One case of travel-related cyclosporiasis was reported in 2007, while none were reported in 2006. There were no travel-related Hepatitis A cases in 2007, while in 2006, eight were reported.

Overall, the total incidence rates of campylobacteriosis, giardiasis and VTEC infections have decreased in 2007 compared to the average historical levels observed in Sentinel Site 1. The incidence rate of salmonellosis in 2007 is consistent with average historical levels. The yersiniosis incidence rate appears to be increasing compared to the average rate observed over the past eighteen-year period.

FIGURE 9.1
Temporal trends of the three most frequent enteric diseases, and total bacterial, viral and parasitic enteric diseases from Sentinel Site 1, between 1990 and 2007

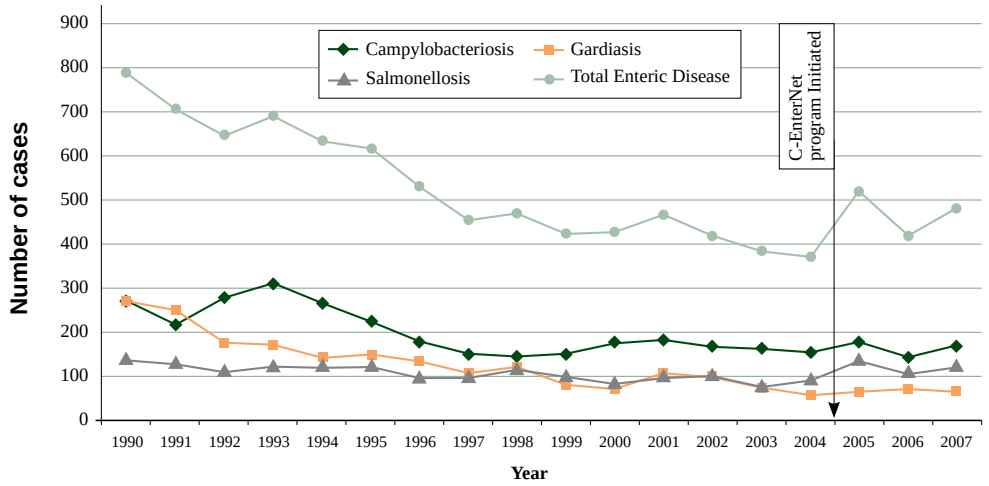


FIGURE 9.2
Temporal trends of seven enteric diseases from Sentinel Site 1, between 1990 and 2007

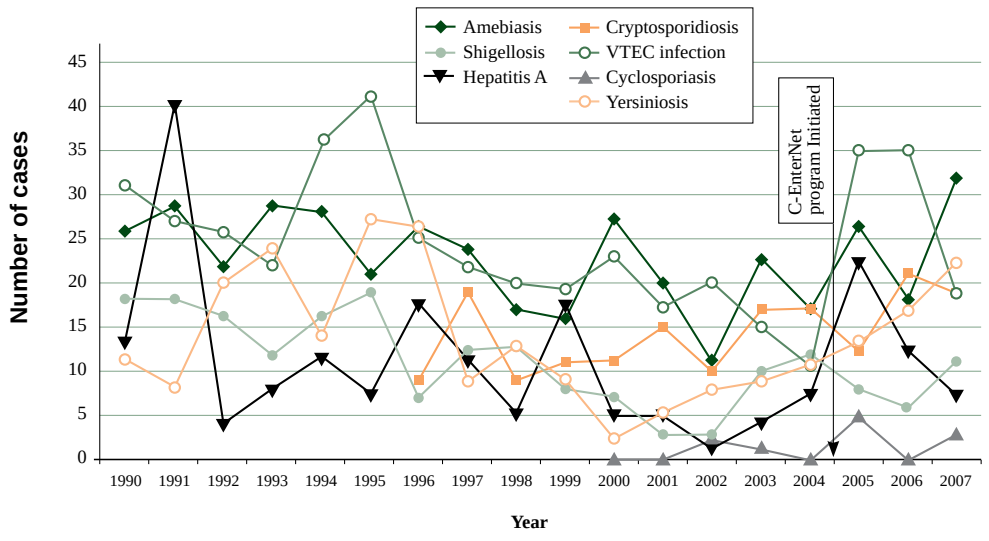


TABLE 9.1
Disease-specific annual incidence rates in Sentinel Site 1 in 2007 compared to 2006 and historical averages

		2007		2006		Historical
		# of Cases	Incidence Rate	# of Cases	Incidence Rate	Average Incidence Rate (1990-2004)†
TOTAL	Endemic	331		285		
	Travel	142		131		
	Outbreak	4		4		
AMOEBIASIS	Total		6.4		3.7	5.4
	Endemic	16	3.2	12	2.4	
	Travel	16	3.2	6	1.2	
CAMPYLOBACTERIOSIS	Total		35.8		27.2	49.7
	Endemic	131	26.4	108	22.0	
	Travel	46	9.3	26	5.3	
CRYPTOSPORIDIOSIS	Total		3.8		4.3	3.0
	Endemic	12	2.4	15	3.1	
	Travel	7	1.4	6	1.2	
CYCLOSPORIASIS	Total		0.6		0.0	0.7
	Endemic	2	0.4	0	0.0	
	Travel	1	0.2	0	0.0	
GIARDIASIS	Total		10.3		13.6	31.9
	Endemic	33	5.6	35	7.1	
	Travel	22	4.4	32	6.5	
	Outbreak	1	0.2	0	0.0	
HEPATITIS A	Total		1.4		2.4	2.7
	Endemic	7	1.4	4	0.8	
	Travel	0	0.0	8	1.6	
LISTERIOSIS	Total		0.2		0.0	0.2
	Endemic	1	0.2	0	0.0	
	Travel	0	0.0	0	0.0	
SALMONELLOSIS	Total		26.2		22.4	26.0
	Endemic	96	19.3	60	12.2	
	Travel	33	6.6	48	9.8	
	Outbreak	1	0.2	2	0.4	
SHIGELLOSIS	Total		2.2		1.2	2.8
	Endemic	2	0.4	3	0.6	
	Travel	9	1.8	3	0.6	
VEROTOXIGENIC *E. COLI* (VTEC)	Total		3.8		7.1	5.9
	Endemic	14	2.8	32	6.5	
	Travel	3	0.6	1	0.2	
	Outbreak	2	0.4	2	0.4	
YERSINIOSIS	Total		4.4		3.5	3.1
	Endemic	17	3.4	16	3.3	
	Travel	5	1.0	1	0.2	

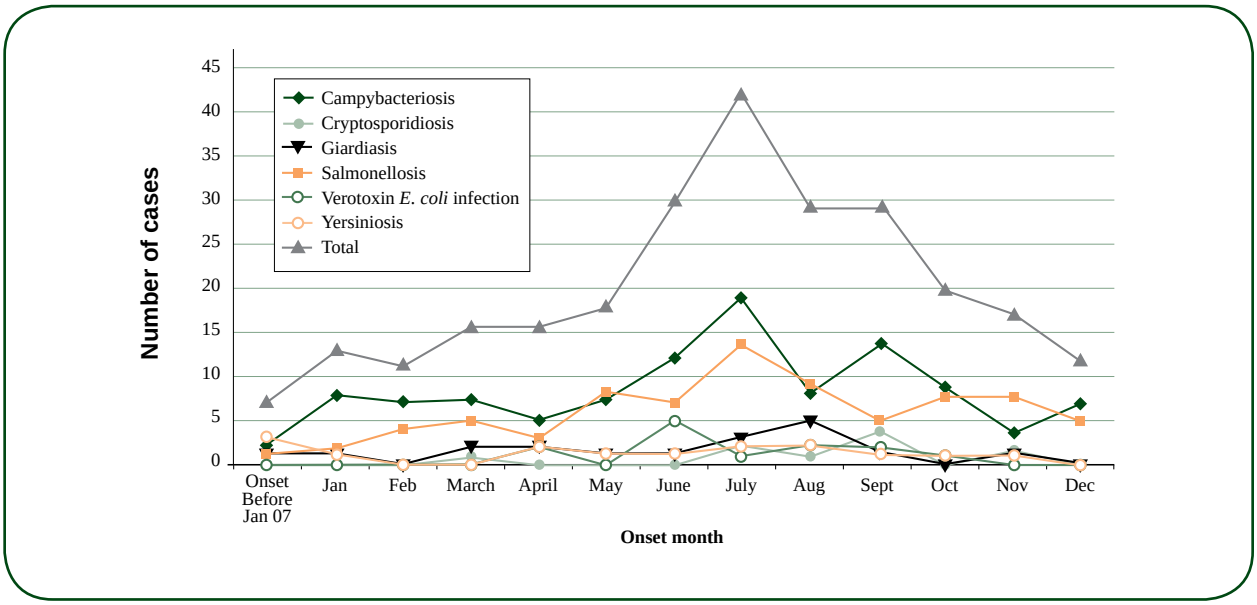
Cells shaded in orange represent signifiant changes from 2006 to 2007 (Mid-P Exact Test alpha=0.05)

† Keegan et al. 2008. Epidemiology of enteric disease in C-EnterNet's Pilot Site, Waterloo Region, Ontario, 1990-2004. Canadian Journal of Infectious Diseases and Medical Microbiology. In press.

9.2 Enteric Disease Monthly Incidence

Because of the systematic and standardized follow-up of each case of enteric disease reported in Sentinel Site 1 in 2007, the onset date is known for 260 of the 331 (79%) endemic cases. The monthly total number of cases increased from January to July and then decreased, with a plateau observed between August and September (Figure 9.3).

FIGURE 9.3
Monthly distribution of onset dates for endemic cases reported in Sentinel Site 1 in 2007 for selected enteric diseases

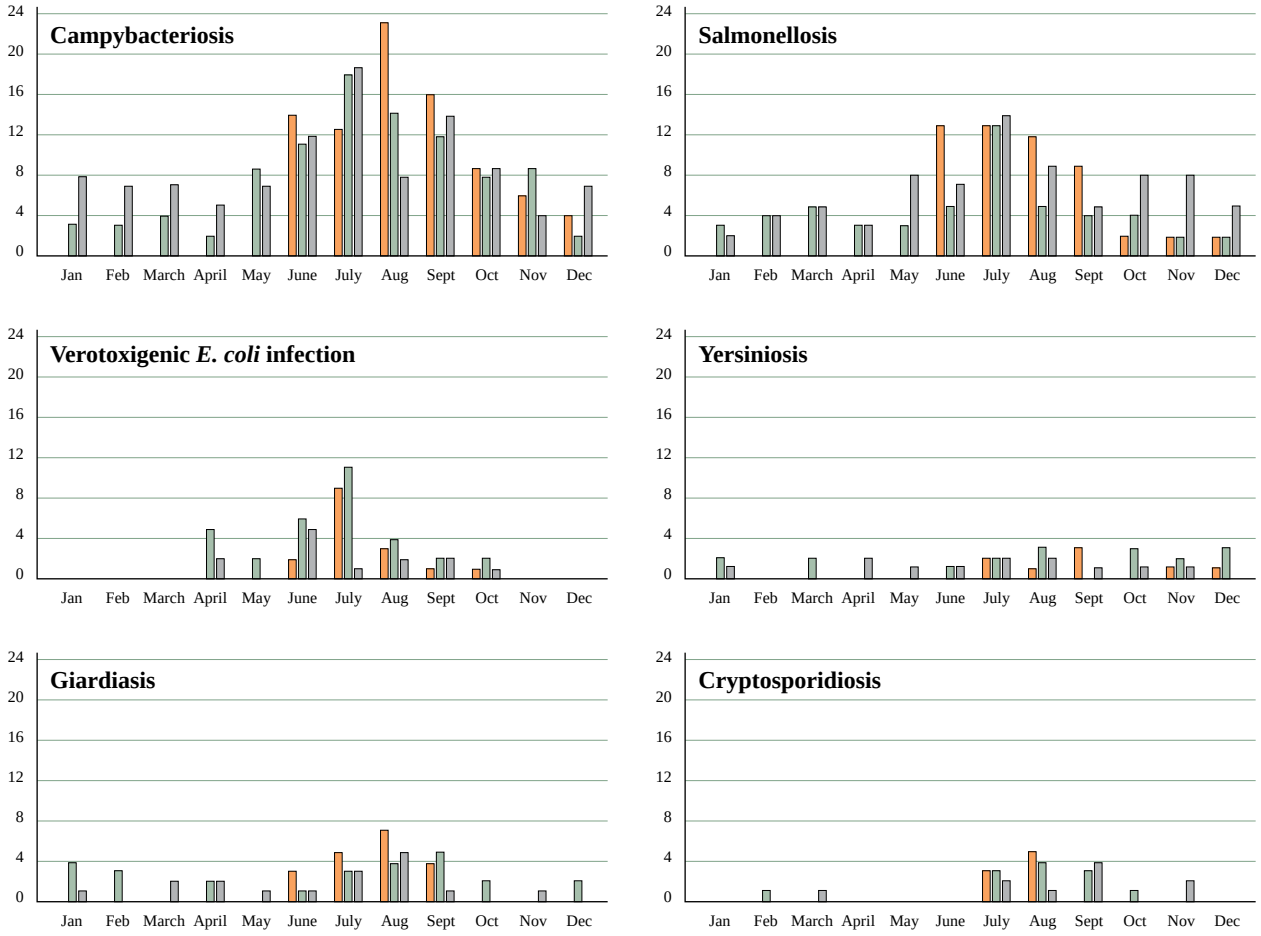


To further explore the seasonal peak in incidence for six of the most common enteric diseases, the disease-specific monthly numbers of cases were plotted by month using all data collected since the implementation of C-EnterNet in Sentinel Site 1 on June 1st 2005 (Figure 9.4). These figures show a seasonal cycle of disease occurrence with more cases during the June to September period from 2005 through 2007 for all six diseases, except for yersiniosis.

To statistically evaluate the significance of this seasonal cycle, a Poisson regression analysis was undertaken for each disease separately. The number of cases by month (based on the onset date) was the dependent variable and the year (2006 and 2007) and season[18] were the two independent variables. Because of low numbers, the summer quarter was compared to the three other quarters combined for *E. coli* O157:H7 infections, yersiniosis, giardiasis and cryptosporidiosis. The results illustrated that campylobacteriosis was higher in the summer and the fall; salmonellosis was higher in 2007 and higher during the summer; infection by *E. coli* O157:H7 was lower in 2007 and higher in summer compared to the rest of the year; and giardiasis and cryptosporidiosis were higher during the summer quarter compared to the rest of the year.

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

FIGURE 9.4
Monthly distribution of onset dates for endemic cases reported in Sentinel Site 1 in 2005 (orange), 2006 (green) and 2007 (gray) for selected enteric diseases



9.3 Trends in Exposure Sources

On-Farm Component

C-EnterNet's agricultural component samples manure from 30 farms for each of the four commodities (beef, dairy, swine and broiler chickens) in the sentinel site. The implementation was sequential beginning with swine (2005), dairy (2006), beef (February 2007) and broiler chicken farms (October 2007). A summary of the C-EnterNet sampling and laboratory methods are available on our website (http://www.phac.gc.ca/c-enternet/index.html).

Temporal analysis of the on-farm data is limited by the small number of farms sampled (30 farms per commodity) and by within-farm clustering. Nevertheless, the results in 2006 and in 2007 at the farm and sample levels for swine and dairy are similar, with the exception of *Yersinia* (Table 9.2).

TABLE 9.2
Pathogen detection from manure on local farms in Sentinel Site 1 in 2006 and 2007

Sample prevalence	2007				2006	
	Swine	Broiler Chickens	Beef	Dairy	Swine	Dairy
	120 samples	36 samples	80 samples	112 samples	120 samples	179 samples
Campylobacter	10% (12)	0%	13% (10)	21% (23)	13% (15)	25% (44)
Salmonella	33% (40)	72% (26)	10% (8)	13% (14)	28% (33)	11% (20)
E. coli O157:H7	0%	0%	9% (7)	5% (6)	0%	9% (16)
Yersinia spp	3% (4)	Not tested	Not tested	Not tested	8% (10)	Not tested
Listeria monocytogenes	Not tested	3% (1)	64% (51)	Not tested	1% (1)	8% (15)

Farm prevalence	2007				2006	
	Swine	Broiler Chickens	Beef	Dairy	Swine	Dairy
	30 farms	9 farms	21 farms	28 farms	30 farms	45 farms
Campylobacter	40% (12)	0%	33% (7)	40% (11)	40% (12)	60% (27)
Salmonella	60% (18)	89% (8)	14% (3)	21% (6)	60% (18)	22% (10)
E. coli O157:H7	0%	0%	24% (5)	21% (6)	0%	29% (13)
Yersinia spp	13% (4)	Not tested	Not tested	Not tested	30% (9)	Not tested
Listeria monocytogenes	Not tested	11% (1)	90% (19)	Not tested	3% (1)	33% (12)

Water Component

Since 2005, five sites along the Grand River have been sampled for the water surveillance component to understand the dynamics of pathogen levels in the environment and the potential transmission of enteric pathogens from both point and non-point sources within the watershed. A summary of the C-EnterNet sampling and laboratory methods are available on our website (http://www.phac.gc.ca/c-enternet/index.html).

Campylobacter and *Yersinia* prevalence (by culture) increased in 2007 while *Salmonella* prevalence (by culture) decreased (Table 9.3). Pathogenic *E. coli* detection (by both culture and molecular methods) in river samples continues to be low, and it is still unclear if this is due to low levels or methodology (or a combination of both). While detection of *Yersinia* increased in 2007, to date no human pathogenic strains of *Y. enterocolitica* have been detected in the river. *Cryptosporidium* and *Giardia* are consistently being detected at all five sample points in the river.

TABLE 9.3
Pathogen detection in untreated surface water in Sentinel Site 1 in 2006 and 2007

	2007						2006					
Culture Method	**All Sites**	**A**	**B**	**C**	**D**	**E**	**All Sites**	**A**	**B**	**C**	**D**	**E**
Campylobacter	18% (24/134)	22% (6/27)	12% (3/26)	37% (10/27)	19% (5/27)	0% (0/27)	9% (13/140)	18% (5/28)	4% (1/28)	14% (4/28)	11% (3/28)	0% (0/28)
Salmonella	10% (13/134)	4% (1/27)	8% (2/26)	7% (2/27)	4% (1/27)	26% (7/27)	20% (28/140)	21% (6/28)	21% (6/28)	18% (5/28)	29% (8/28)	11% (3/28)
E. coli O157:H7	2% (3/134)	7% (2/27)	0% (0/26)	0% (0/27)	0% (0/27)	4% (1/27)	1% (1/124)	0% (0/24)	0% (0/24)	4% (1/24)	0% (0/24)	0% (0/24)
Yersinia spp	40% (53/133)	37% (10/26)	39% (10/26)	56% (15/27)	30% (8/27)	41% (11/27)	14% (15/105)	19% (4/21)	19% (4/21)	14% (3/21)	10% (2/21)	10% (2/21)
Cryptosporidium [a]	88% (35/40)	100% (3/3)	100% (3/3)	67% (2/3)	80% (22/26)	100% (5/5)	94% (33/35)	—	—	100% (3/3)	93% (27/29)	100% (3/3)
Giardia	100% (40/40)	100% (3/3)	100% (3/3)	100% (2/2)	100% (27/27)	100% (5/5)	94% (33/35)	—	—	67% (2/3)	93% (28/29)	100% (3/3)

	2007						2006					
Molecular Method	**All Sites**	**A**	**B**	**C**	**D**	**E**	**All Sites**	**A**	**B**	**C**	**D**	**E**
Campylobacter	92% (108/118)	92% (22/24)	87% (20/23)	92% (22/24)	96% (23/24)	87% (20/23)	56% (78/140)	75% (21/28)	32% (9/28)	71% (20/28)	43% (12/28)	57% (16/28)
Salmonella	35% (45/129)	19% (5/26)	40% (10/25)	27% (7/26)	35% (9/26)	54% (14/26)	17% (24/140)	18% (5/28)	18% (5/28)	7% (2/28)	14% (4/28)	29% (8/28)
E. coli O157:H7	27% (35/129)	12% (3/26)	12% (3/25)	8% (2/26)	30% (8/26)	73% (19/26)	25% (35/140)	32% (9/28)	7% (2/28)	11% (3/28)	14% (4/28)	61% (17/28)
Yersinia spp	59% (46/78)	69% (11/16)	47% (7/15)	69% (11/16)	86% (12/14)	29% (5/17)	39% (54/140)	50% (14/28)	25% (7/28)	50% (14/28)	25% (7/28)	43% (12/28)

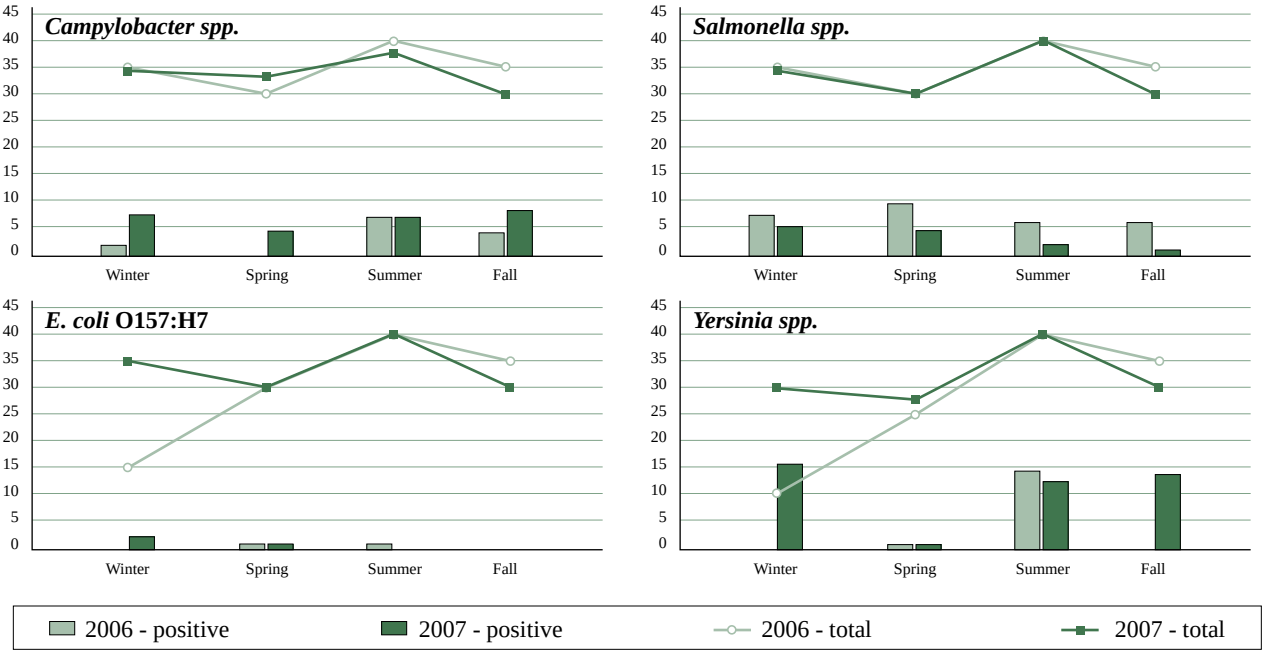
Cells shaded in orange represent signifiant changes from 2006 to 2007 (Mid-P Exact Test alpha=0.05)

[a] Microscopy method.

A- Canagagigue Creek. B- Conestogo River. C- Upper Grand River. D- Grand River, near drinking water intake. E- Grand River, near one wastewater treatment plant effluent point.

Figure 9.5 shows the quarterly distribution of positive and total samples of raw surface water in 2006 and 2007 for selected pathogens. To statistically test the hypothesis of any yearly or quarterly variations, the probability of being a positive water sample was modelled through a logistic regression for each pathogen separately. To evaluate temporal changes, the year (2006 and 2007), seasons[19] and the sample sites were included as independent variables. Repetition within the sample sites was introduced into the model to correspond with the sampling schemes.

FIGURE 9.5
Quarterly distribution of positive and total raw surface water samples tested by culture method in Sentinel Site 1 in 2006 and 2007 for selected enteric pathogens



The culture-based detection results illustrate a statistically significant lower detection of *Yersinia spp*. in the spring but no differences between quarters for *Campylobacter spp.* and *Salmonella spp.* (Figure 9.5). A statistically significant difference between 2006 and 2007 was found for *Campylobacter spp.* (higher in 2007), *Salmonella spp.* (lower in 2007) and *Yersinia spp.* (higher in 2007), as was previously shown (Table 9.3). There were no statistically significant differences between the sample sites at the $p<0.05$ level. Because of the small number of *E. coli* positive samples, only the year effect could be tested and was not significant.

Retail Component

Since mid-2005, C-EnterNet has systematically sampled fresh raw pork chops, chicken breasts and ground beef from randomly selected grocery stores within the sentinel site on a weekly basis. A summary of the C-EnterNet sampling and laboratory methods are available on our website (http://www.phac.gc.ca/c-enternet/index.html).

In 2007, the levels of pathogen contamination on raw retail meat were similar to that observed in 2006, with the exception of a decrease in *Yersinia* contamination on pork (Table 9.4). Verotoxigenic *E. coli* was detected in two ground beef samples in 2007, whereas it was not detected in 2006 in retail meat.

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

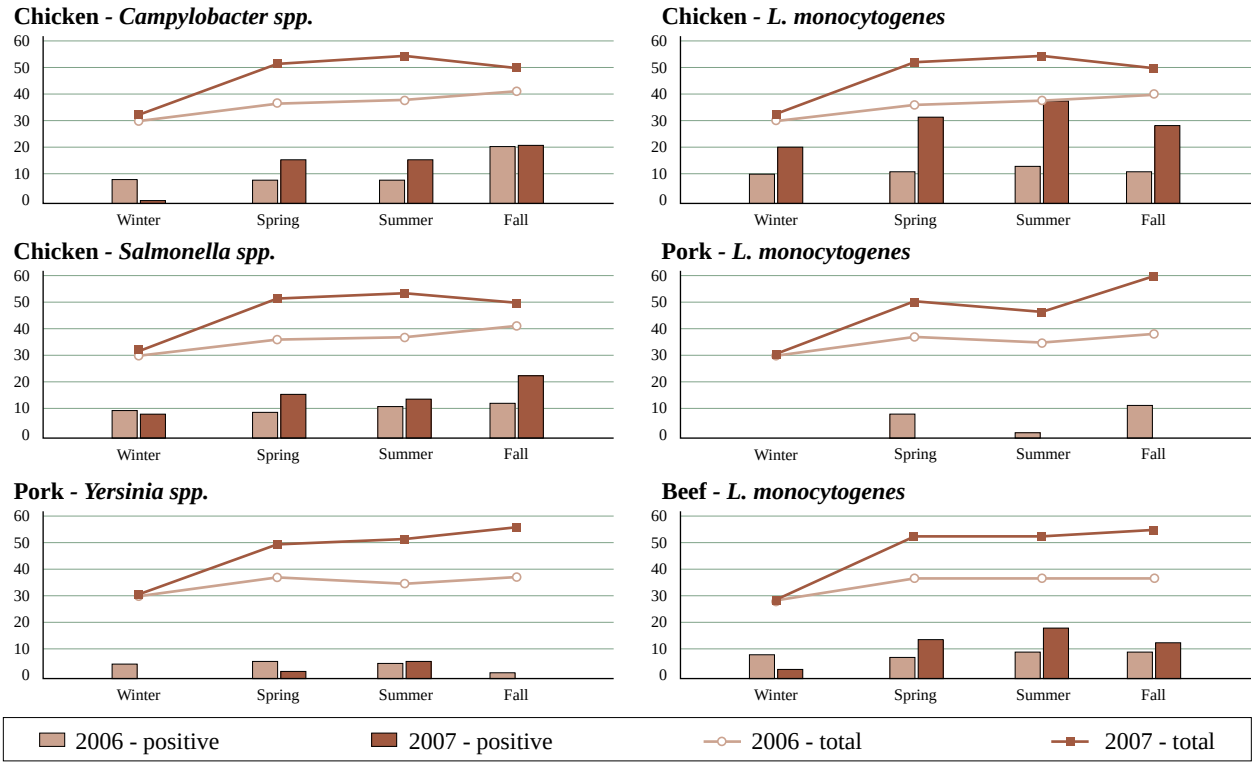
TABLE 9.4
Pathogen detection in raw retail meat in Sentinel Site 1 during 2006 and 2007

	2007			2006		
	Pork n= 187	Chicken n= 187	Beef n= 187	Pork n= 140	Chicken n= 145	Beef n= 139
Campylobacter	2% (3)	29% (55)	1% (1)	0%	31% (45)	0%
Salmonella	3% (6)	33% (61)	1% (1)	3% (4)	30% (43)	1% (1)
VTEC	0%	0%	1% (2)	0%	0%	0%
Yersinia spp	5% (9)	Not tested	Not tested	13% (18)	Not tested	Not tested
Listeria monocytogenes	11% (21)	35% (64)	24% (44)	9% (12)	32% (46)	24% (33)

Note: Cells shaded in orange represent signifiant changes from 2006 to 2007 (Mid-P Exact Test alpha=0.05)

Figure 9.6 illustrates the quarterly distribution of positive and total samples of raw retail meat contamination levels in 2006 and 2007. To statistically test the hypothesis of yearly or quarterly variations, the probability of being a positive meat sample was modelled with a logistic regression for each pathogen and for each kind of meat separately. The year (2006 and 2007) and season[20] were the independent variables. The type of store (big vs. small), the kind of package (pre-packaged vs. packaged at the counter) and type of meat inspection (federal vs. unknown) were included as covariates. In addition, re-sampling within the same store was considered a repetition and was set as such in the statistical algorithm. In retail pork, *Yersinia* prevalence was statistically lower in 2007 ($p<0.05$). In retail chicken, there was a quarterly significant increase in *Campylobacter* during the fall and a decrease in the winter compared to spring or summer.

FIGURE 9.6
Quarterly distribution of positive and total raw retail meat samples tested in Sentinel Site 1 in 2006 and 2007 for selected enteric pathogens



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

10. Exposure Sources

The Exposure Sources chapter, which is new for the 2007 Annual Report, summarizes the results presented in the disease-specific chapters by the main potential exposure sources monitored by C-EnterNet in the sentinel site: agriculture, surface water, and retail food. This section is a preliminary step forward towards source attribution. The data presented in this chapter include 2005, 2006 and 2007 surveillance years. Detailed descriptions of C-EnterNet's sampling and laboratory methods are available on our website (http://www.phac.gc.ca/c-enternet/index.html).

10.1 Agriculture

Swine Operations

Pathogenic strains of *Campylobacter* spp., *Salmonella enterica*, *Yersinia* spp., *Listeria* spp., *Giardia* spp. and *Cryptosporidium* spp. were found on swine farms in the sentinel site (Table 10.1). *Campylobacter* spp. was recovered from 36% (131/359) of the samples. *C. coli* was the most frequent species recovered, in 90% of swine samples (118/131), but was infrequently associated with human cases (2%) (Table 10.2). Of the 28 *Campylobacter* isolates from swine that were subtyped, only one had an MLST pattern (ST 459) that matched a human case (see Table 3.3 in Chapter 3.). *Salmonella* spp. were recovered from 31% (113) of the samples; Typhimurium (including var. 5-) was the most common serotype found in both swine and humans (Table 10.2). Twenty-seven of the Typhimurium isolates (including var. 5-) had PFGE patterns that have been identified in human cases (see Table 4.2 in Chapter 4). Eighty-one percent of the isolated *Yersinia* strains were considered pathogenic to humans (Table 10.2). Twenty-five percent of the *Cryptosporidium* strains and almost half of the *Giardia* strains were zoonotic.

Dairy Operations

Pathogenic strains of *Campylobacter* spp., *Salmonella enterica*, *Giardia* spp. and *Cryptosporidium* spp. and VTEC were found on dairy farms in the sentinel site (Table 10.1). *Campylobacter* spp. were recovered from 23% (67/291) of the samples. *C. jejuni* was the most frequently recovered species 47% (32/67) and most frequently associated with human campylobacteriosis (Table 10.2). Eleven of the 22 *Campylobacter* isolates detected in dairy cattle manure were matched by MLST pattern with isolates from human cases (see Table 3.3 in Chapter 3). Twenty-four percent of the dairy cattle manure samples were positive for *Salmonella*. *Salmonella* Kentucky was the most frequent serotype detected, but was infrequently associated with human illness (Table 10.2). *E. coli* O157:H7 was isolated from 8% (22/291) of the dairy manure samples. Four of these twenty-two isolates matched PFGE patterns identified in human cases (see Table 5.2 in Chapter 5).

Beef Operations

Pathogenic strains of *Campylobacter* spp., *Salmonella enterica*, *Listeria* spp., VTEC, and *Cryptosporidium* spp. were found on beef farms in the sentinel site (Table 10.1). *Campylobacter* spp. were recovered from 13% (10/80) of the samples. Similar to results from dairy farms, *C. jejuni* was the most frequent species recovered (Table 10.2). Four of the seven *Campylobacter* isolates that were subtyped had MLST patterns that matched human *Campylobacter* isolates (see Table 3.3 in Chapter 3). Pathogenic *E. coli* O157:H7 was detected in 9% of the beef manure samples, although their PFGE patterns did not match any human cases from the sentinel site (see Table 5.2 in Chapter 5).

Listeria monocytogenes was most commonly isolated in the beef manure samples (64% compared to other manure types) (Table 10.1). The two most common *Listeria monocytogenes* serotypes isolated in beef manure samples (1/2a and 4b) are considered important serotypes among human cases (see Table 7.2 in Chapter 7). Although pathogenic strains of *Cryptosporidium* were identified in 23% of samples, only non-pathogenic *Giardia* strains were identified (Table 10.1).

Broiler Chicken Operations

Pathogenic strains of *Salmonella enterica*, *Listeria* spp.,VTEC and *Giardia* spp. were found on poultry farms in the sentinel site (Table 10.1). Two common *Salmonella* serotypes detected in broiler chicken manure, Enteritidis and Heidelberg, were also commonly associated with human illness (Table 10.2). The PFGE patterns of these broiler chicken manure isolates matched human PFGE patterns (see Table 4.2 in Chapter 4). S. Heidelberg was only detected on chicken farms whereas the serotype Enteritidis was also detected on swine farms. Two other common *Salmonella* serotypes in broiler chicken manure Hadar and Kentucky, were only occasionally associated with human illness (Table 10.2).

These results illustrate that the local food animal farms are reservoirs of important pathogens known to cause human enteric illnesses. Contact with food animals or their environment may lead to unintentional human infections and occasionally to disease.

TABLE 10.1
Pathogen prevalence in livestock farms in Sentinel Site 1 between 2005 and 2007

Pathogen	Swine n= 359	Broiler Chickens n= 36	Beef n= 80	Dairy n= 291
Campylobacter spp	131 (36%)	0	10 (13%)	67 (23%)
Cryptosporidium spp (PCR test)	31/122 (25%) [c]	0 [c]	17/72 (23%) [c]	20/187 (11%) [c]
Giardia spp (PCR test)	56/122 (46%) [c]	1 (3%) [c]	0 [c]	21/187 (11%) [c]
Listeria monocytogenes	4/122 (3%)	1 (3%)	51 (64%)	15/179 (8%)
Salmonella enterica	113 (31%)	26 (72%)	8 (10%)	34 (12%)
Verotoxigenic E. coli (VTEC)	12 (3%) [a]	1 (3%) [a]	7 (9%) [b]	12 (4%) [a], 22 (8%) [b]
Yersinia spp	21 (6%)	NT	NT	NT

[a] O 157 non H7. [b] O157:H7. [c] Zoonotic strains (*C. andersoni, C. cervine, C. parvum* (bovine genotype), *C. hominis, C. suis, Giarda* assemblages A & B). NT=non tested.

TABLE 10.2
Pathogen species and serotypes in positive samples from livestock farms and in human endemic cases in Sentinel Site 1 between 2005 and 2007

Pathogen species or serotypes	Swine	Broiler Chickens	Beef	Dairy	Human endemic cases
Campylobacter spp	n= 131	n= 0	n= 10	n= 67	n= 325
C. jejuni			6 (60%)	32 (47%)	315 (97%)
C. coli	118 (90%)		4 (40%)	14 (21%)	5 (2%)
C. upsaliensis					1 (0.3%)
C. lari					1 (0.3%)
Other	13 (10%)			21 (31%)	2 (1%)
Salmonella enterica	n= 113	n= 26	n= 8	n= 34	n= 199
Typhimurium (including var 5-)	47 (42%)		2 (25%)	5 (15%)	62 (31%)
Enteritidis	1 (1%)	4 (15%)			34 (17%)
Heidelberg		5 (19%)			19 (10%)
Thompson		3 (12%)		1 (3%)	7 (4%)
Infantis	6 (5%)		1 (12%)		8 (4%)
Adelaide					2 (1%)
Agona	12 (11%)			3 (9%)	5 (3%)
Hadar		6 (23%)			3 (2%)
Hartford					2 (1%)
Javiana					2 (1%)
Kentucky		5 (19%)	2 (25%)	18 (53%)	2 (1%)
Newport					5 (3%)
Derby	14 (12%)				1 (1%)
Oranienberg					4 (2%)
Other serotypes	33 (29%)	3 (12%)	3 (38%)	7 (21%)	43 (22%)
Yersinia	n= 21	NT	NT	NT	n= 41
Y. enterocolitica - pathogenic	17 (81%) [a]				39 (95%)
Y. enterocolitica - non-pathogenic	4 (19%)				1 (2%)
Y. intermedia - non-pathogenic					1 (2%)

[a] 16 bioserotype 4/0:3, 1 bioserotype 1B/O:8. NT=non tested.

10.2 Surface Water

Campylobacter spp., *Cryptosporidium* spp., *Giardia* spp., *S. enterica*, VTEC and *Yersinia* spp. were detected in untreated surface water (Table 10.3). The recovery rate was always lower for the culture-based methods compared to the molecular-based methods, which was expected (see Appendix C in C-EnterNet 2006 Annual Report). The species distribution for *Campylobacter* and *Yersinia* illustrates that a majority of isolates from the surface water samples were either non-pathogenic to humans or not amongst the most frequent ones detected in the human clinical samples (Table 10.4). However, there was some overlap between isolates recovered in the watershed and those recovered from the other potential reservoirs and from the human cases. For example, of the 17 *Campylobacter jejuni* isolates recovered from the Grand River watershed in 2006, only one matched the MLST pattern of an isolate detected by other surveillance efforts (found on local dairy farms, on retail chicken and pork meat, and in human clinical samples) (see Table 3.3 in Chapter 3). Among the *Salmonella* isolates recovered from the Grand River watershed in 2007, the most common serotype was Thompson, which has been detected on local chicken farms, retail chicken meat, and among the human clinical samples (see Table 4.1 in Chapter 4). Based on additional molecular typing, three Typhimurium isolates matched PFGE patterns of isolates recovered from human samples, while one matched a PFGE pattern recovered from dairy, beef and swine farms, as well as human clinical samples (see Table 4.2 in Chapter 4). Pathogenic strains of *Yersinia* were never detected in the river

water, although in 2007 there were two clinical samples in the community that were positive for *Y. intermedia*, and *Y. enterocolitica* 1A, traditionally considered to be non-pathogenic. One of the most common *Cryptosporidium* genotypes detected in the river water was *C. andersoni*. This genotype was also the most frequently detected genotype on local beef farms (see Table 8.2 in Chapter 8).

TABLE 10.3
Contamination of raw surface water in Sentinel Site 1 in 2005, 2006 and 2007

Pathogen	Culture based method	Molecular based method
Entamoeba spp	NT	NT
Campylobacter spp	13%	69%
Cryptosporidium spp [a]	90%	NT
Cyclospora spp	NT	NT
Giardia spp	97%	NT
Hepatitis A virus	NT	NT
Listeria monocytogenes	NT	NT
Salmonella enterica	14%	24%
Shigella spp	NT	NT
Verotoxigenic *E. coli* (VTEC)	2% [b,c]	26% [d]
Yersinia spp	29% [b]	45% [b]

[a] Microscopic detection. [b] VTEC (*by culture*) and *Yersinia* (*by culture or molecular method*) were not tested for in 2005, thus proportions reflect 2006 and 2007 data.
[c] Two isolates O157:H7 and three isolates O157 non H7. [d] All O157:H7. NT = non tested.

The monthly average parasite counts detected in the surface water samples exhibit important seasonal variations (see Chapter 8, Sections 8.1 and 8.2), implying that the water contamination is dynamic. These dynamics and the transmission of enteric pathogens from both point and non-point sources within the watershed could be further explored.

The surface water in Sentinel Site 1 is not pristine and contamination may come from three main sources: the human population, the local farming activities (i.e. cattle grazing and manure spreading on land) and wildlife, from both upstream and local sources.

TABLE 10.4
Pathogen species and serotypes in positive samples from untreated surface water and in human endemic cases in Sentinel Site 1 in 2005, 2006 and 2007

Pathogen species or serotypes	Water	Human endemic cases
Campylobacter	n=40	n=325
C. jejuni	33%	96.9%
C. coli	9%	1.5%
C. upsaliensis	0%	0.3%
C. lari	61%	0.3%
Not typed		0.9%
Cryptosporidium	n=64	n=36
C. andersoni [a]	66%	NT
C. baileyi	5%	NT
C. cervine [a]	8%	NT
C. parvum (bovine genotype) [a]	5%	NT
C. hominis [a,b]	9%	NT
C. muskrat genotype I	5%	NT
C. muskrat genotype II	3%	NT
Other	14%	NT

Pathogen species or serotypes	Water	Human endemic cases
Salmonella enterica	n=48	n=199
Typhimurium	10%	28.7%
Enteritidis		15.7%
Heidelberg	4%	8.8%
Thompson	17%	3.2%
Infantis	2%	3.7%
Adelaide		0.9%
Agona	2%	2.3%
Hartford		0.9%
Javiana		0.9%
Kentucky	13%	0.9%
Newport	6%	2.3%
Oranienberg		1.9%
Other serotypes	46%	21.8%
Not typed		7.9%
Yersinia [c]	n=97	n=33
Y. aldovae - non-pathogenic	6%	
Y. bercovieri - non-pathogenic	9%	
Y. enterocolitica - pathogenic	0%	95%
Y. enterocolitica - non-pathogenic	13%	2%
Y. frederiksenii - non-pathogenic	23%	
Y. intermedia - non-pathogenic	29%	2%
Y. kristensenli - non-pathogenic	2%	
Y. mollaretti - non-pathogenic	6%	
Y. rohdei - non-pathogenic	1%	

[a] Zoonotic strain. [b] Anthroponotic strain. [c] *Yersinia* was not tested in 2005 in water, thus proportions reflect 2006 and 2007 data.

10.3 Retail Food

Retail Pork

Pathogenic strains of *Campylobacter* spp., *Salmonella enterica*, VTEC, and *Listeria* spp., were found on raw retail pork chops, although at relatively low levels (Table 10.5). Of the *Salmonella* serotypes detected, 25% were Typhimurium (including var. 5-), the most common *Salmonella* serotype associated with human illness (Table 10.6). Thirty-four percent (14/41) of the *Listeria monocytogenes* isolates subtyped matched PFGE patterns that are among the top ten patterns associated with human illness in Canada (see Table 7.3 in Chapter 7). Although *Yersinia* spp. were detected, further subtyping determined that the strains were not pathogenic to humans (Table 10.6).

Retail Chicken

Pathogenic strains of *Campylobacter* spp., *Salmonella enterica*, and *Listeria* spp., were consistently detected on raw retail chicken samples (Table 10.5). Of the retail meats tested, the highest prevalence of *Campylobacter* (33%), was observed on chicken and *C. jejuni* was the most commonly identified species (Table 10.6). Forty-three of the 82 *Campylobacter* isolates subtyped by MLST had patterns that matched human *Campylobacter* cases (see Table 3.3 in Chapter 3). Although the most frequent *Salmonella* serotype (Kentucky) was not frequently associated with human illness, the second most common serotype (Heidelberg) was identified in 10% of human endemic salmonellosis cases in the sentinel site (Table 10.6). Nineteen of the 27 S. Heidelberg isolates matched PFGE patterns with human cases (See Table 4.2 in Section 4). One third of the retail chicken samples were positive for *Listeria monocytogenes*. Thirty-two percent (41/128) of the subtyped isolates had PFGE patterns that are among the top ten patterns associated with human illness in Canada (see Table 7.3 in Chapter 7).

Retail Beef

Pathogenic strains of *Campylobacter* spp., *Salmonella enterica*, and VTEC were found in retail ground beef although at relatively low levels (Table 10.5). *Listeria monocytogenes* was found at moderate levels and 31% (30/96) of the isolates that were subtyped had PFGE patterns that are among the top ten patterns associated with human illness in Canada (see Table 7.3 in Chapter 7).

Retail pork, chicken and beef meats are potential sources of human enteric pathogens. However, more data are required to characterize and formally assess the potential risk of the foodborne transmission of enteric pathogens and to quantify the significance of each type of meat for its public health impact.

No attempts were made to compare the data from the agriculture component to the retail meat data, since a small, although unknown, proportion of meat eaten in Sentinel Site 1 originates from animals raised in the area.

TABLE 10.5
Contamination of raw retail meat in Sentinel Site 1 between 2005 and 2007

Pathogen	Pork n= 388	Chicken n= 392	Beef n= 387
Campylobacter spp	3 (1%)	129 (33%)	1 (<1%)
Listeria monocytogenes	40 (10%)	126 (32%)	90 (23%)
Salmonella enterica	12 (3%)	119 (30%)	2 (<1%)
Verotoxigenic E. coli (VTEC)	1 (<1%)	0	2 (<1%)
Yersinia spp	33 (9%)	NT	NT

NT=non tested. Note: After testing the first 61 samples, some laboratory methodology changes were adopted. The first 61 samples were therefore not used to develop the prevalence estimates presented in Table 10.5. The actual bacterial load was generally low on all retail meats sampled (Appendix B).

TABLE 10.6
Pathogen species and serotypes detected in raw retail meat and in human endemic cases in Sentinel Site 1 in 2007

Pathogen species or serotypes	Pork	Chicken	Beef	Human endemic cases
Campylobacter	n=3	n=131	n=1	n=322
C. jejuni	2 (67%)	115 (88%)	1 (100%)	315 (97%)
C. coli	1 (33%)	16 (12%)		5 (2%)
C. upsaliensis				1 (0.3%)
C. lari				1 (0.3%)
Salmonella enterica	n=12	n=121	n=2	n=199
Typhimurium	3 (25%)	7 (6%)		62 (31%)
Enteritidis		8 (7%)	1 (50%)	34 (17%)
Heidelberg		27 (22%)		19 (10%)
Thompson	2 (17%)	1 (<1%)		7 (4%)
Infantis	1 (8%)	2 (2%)		8 (4%)
Adelaide				2 (1%)
Agona				5 (3%)
Hartford				2 (1%)
Javiana				2 (1%)
Kentucky	1 (8%)	54 (45%)		2 (1%)
Newport				5 (3%)
Oranienberg				4 (2%)
Hadar		8 (7%)		3 (2%)
Orion			1 (50%)	
Other serotypes	5 (42%)	14 (12%)		44 (22%)
Yersinia	n=31	NT	NT	n=41
Y. enterocolitica - pathogenic	0			39 (95%)
Y. enterocolitica - non-pathogenic	21 (68%)			1 (2%)
Y. frederiksenii - non-pathogenic	7 (23%)			
Y. intermedia - non-pathogenic	3 (10%)			1 (2%)

NT=non tested. Note: subtyping results include all samples.

TABLE A
Laboratory testing performed on all isolates from exposure sources and human cases in Sentinel Site 1 in 2007

Component	Sample Type	Isolation/ Speciation OR Microscopic identification	Enumeration (MPN)	Serotyping	Phagetyping	Ribotyping	AMR	PFGE	Genotyping	MLST &/or fla A
RETAIL	Skin-on chicken breasts Ground beef Pork shops	**Continuous:** *Salmonella* *Campylobacter* *Yersinia* (pork only) *Listeria* VTEC	*Salmonella,* *Campylobacter,* *Yersinia,* *Listeria*	*Salmonella* *Listeria* *Yersinia*	*Salmonella*	*Listeria*		*Salmonella* *Listeria*		*Campylobacter*
FARMS	Fresh and stored pooled manure (dairy, beef, swine, broiler chickens)	**Continuous:** *Salmonella* *Campylobacter* *Yersinia* (swine) *E. coli* O157:H7 **Episodic (broiler chickens & beef):** *Listeria* *Giardia* *Cryptosporidium*		*Salmonella* *Listeria* *Yersinia*	*Salmonella*	*Listeria*		*Salmonella* *E. coli* O157:H7 *Listeria*	*Giardia* *Cryptosporidium*	*Campylobacter*
WATER	Raw surface water	*Salmonella* *Campylobacter* *Yersinia* *E. coli* O157:H7 *Giardia* *Cryptosporidium*		*Salmonella* *Yersinia*	*Salmonella*			*Salmonella* *E. coli* O157:H7	*Giardia* *Cryptosporidium*	*Campylobacter*
HUMAN	Human stool samples	*Salmonella* *Campylobacter* *Yersinia* *E. coli* O157:H7 *Cryptosporidium* *Giardia* *Shigella* *Listeria*		*Salmonella* *Listeria* *Yersinia*	*Salmonella*		*Salmonella* *Campylobacter*	*Salmonella* *E. coli* O157:H7		*Campylobacter*

APPENDIX B: Questionnaire Results

TABLE B

The percentage of human endemic cases with exposure data in Sentinel Site 1 in 2007, 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															
	Campylobacteriosis		Salmonellosis		*E. coli* O157:H7		Yersiniosis		Giardiasis		Cyptosporidiosis		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]	131		96		14		17		33		12		16		319
Number with exposure data	113	165	86	192	14	264	16	262	25	253	11	267	13	265	278
Proportion with exposure data	86		90		100		94		76		92		81		87
Exposure Information															
Private well - main water source	12	14	14	14	14	13	6	14	21	13	25	13	6	14	14
Municipal - main water source	59	47	55	51	63	52	46	52	23	56	27	53	70	51	52
Drank untreated water	7	3	1	7	14	4	0	5	9	5	0	5	0	5	5
Swam	19	21	17	22	14	20	13	20	44	18	30	20	15	20	20
in a lake	5	5	5	5	14	5	0	5	6	5	8	5	0	5	5
in a pool	9	10	6	11	0	10	12	10	24	8	8	10	13	10	10
in a river	2	0	0	1	0	1	0	1	0	1	0	1	0	1	1
Drank unpasteurized milk	7	2	3	5	0	4	0	4	3	4	0	4	0	4	4
Ate undercooked food	11	9	12	9	21	9	0	10	4	10	0	10	0	10	10
Attended a barbecue	25	19	17	23	29	21	29	21	15	22	10	22	23	21	21
Ate in a restaurant	23	26	23	26	36	24	24	25	33	24	17	25	31	24	25
Ate meat from butcher shop	8	6	3	8	0	7	6	7	18	5	8	7	0	7	7
Ate meat from private kill	3	3	0	5	0	3	0	3	15	2	8	3	0	3	3
Shopped at butcher shop	12	9	5	13	23	10	6	11	21	10	10	11	7	11	11
Contact with household pet	47	61	64	51	43	56	53	55	61	55	80	54	58	55	55
cats	16	18	21	16	14	18	18	17	12	18	17	17	19	17	17
dogs	28	34	33	31	29	31	29	32	33	31	50	31	31	31	31
reptile	1	5	6	2	0	4	6	3	6	3	8	3	0	4	4
Visited farm animal areas	10	9	5	11	0	10	0	10	17	9	30	9	23	9	9
cats	1	1	0	1	0	1	0	1	0	1	10	0	0	1	1
dogs	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
horses	0	2	0	2	0	1	0	1	4	1	10	1	8	1	1
cattle	2	1	0	2	0	2	0	2	0	2	20	1	0	2	2
Lived on a farm/rural	10	14	8	14	21	12	7	13	35	10	30	12	0	13	12
On-farm animal exposures															
cats	1	1	0	1	0	1	7	0	0	1	0	1	0	1	1
dogs	3	1	0	3	0	2	7	2	4	2	0	2	0	2	2
horses	1	1	0	2	0	1	0	1	9	0	0	1	0	1	1
cattle	5	1	0	4	0	3	0	3	9	2	0	3	0	3	3
pigs	1	2	1	2	0	2	0	2	4	1	10	1	0	2	2
poultry	3	1	1	2	7	2	0	2	0	2	0	2	0	2	2
sheep	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Note: Potential exposures are highlighted in orange when the percentage for the specific disease is at least 5% greater than the exposure for the other enteric diseases combined.
[a] Does not include Cyclosporiasis, Hepatitis A, Listeriosis, or Shigellosis.
[b] Non-cases include all other enteric cases with exposure information.

APPENDIX C: Enumeration Results

TABLE C
Enumeration results for retail meat samples collected within Sentinel Site 1 in 2007

	# 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	187	3	3				
Chicken	187	55	49	6			
Beef	187	1	1				
Salmonella							
Pork	187	6	5	1			
Chicken	187	61	52	7	2		
Beef	187	1	1				
Listeria							
Pork	187	21	14	5	2		
Chicken	187	64	48	11	3		2
Beef	187	44	37	7			
Yersinia							
Pork	187	8	8				

Summary of MPN technique

Primary isolation was initiated on each meat package purchased by removing a representative 50-gram portion from each sample and stomaching it for two minutes in a 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 by primary isolation. For *Salmonella*, *L. monocytogenes* and *Yersinia spp.*, 50 mL of the stomached rinsate 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 4ºC for MPN analyses if the primary isolation results were positive. The three-tube MPN series was prepared for each of the pathogens tested, by transferring 10 mL of the sample enrichment broth into three tubes containing 9 mL of broth, 1mL of the sample homogenate into three tubes containing 9 mL of broth, 1 mL of a 10^{-1} dilution into three tubes containing 9 mL of broth, and 1 mL of a 10^{-2} dilution into three 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).

A majority of the samples had levels below the MPN detection limit. These samples most likely represent a lower public health 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 for a positive enumeration result.

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