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C-EnterNet 2005–2006 Annual Report

...National Integrated Enteric Pathogen Surveillance Program

Canada

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C-EnterNet Annual Report

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...National Integrated Enteric Pathogen Surveillance Program

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Executive Summary

C-EnterNet is a multi-partner initiative facilitated by the Public Health Agency of Canada and funded by Agriculture and Agri-Food Canada through the Agricultural Policy Framework initiative. It is designed to support activities that will reduce the burden of enteric (gastrointestinal) disease, by comprehensive sentinel site surveillance implemented through local public health units. Its core objectives are:

- To detect changes in trends in human enteric disease and in levels of pathogen exposure from food, animal and water sources in a defined population;
- To conduct source attribution (determine the proportion of human cases that are due to exposure via water, food and animals); and
- To improve the analysis, interpretation and reporting of laboratory and epidemiological data for public health, water and agri-food purposes.

C-EnterNet is designed to cover 5 or 6 sentinel sites across Canada with continuous and episodic surveillance activities for each of four components: humans, food, water, and food animals. Most of the planned surveillance activities have been implemented in the program's first (pilot) sentinel site – the Region of Waterloo, Ontario (Sentinel Site 1) – over the course of 2005. More specifically, C-EnterNet was able to generate site-specific incidences for reportable human enteric diseases and risk factor data for endemic cases. In addition, C-EnterNet began to collect pathogen data from most of the a *priori* important sources of exposure within the sentinel site's geographical area, including untreated surface water, stored and fresh manure from dairy and swine farms, and retail raw meat. This inaugural report provides results of the first 12 months of operation, from mid-2005 to mid-2006.

A total of 417 cases of 9 bacterial and parasitic enteric diseases were reported to the local public health authorities: 68% (282) of the cases were related to endemic causes, 21% (88) to travel, and 11% (47) to outbreaks. The three most frequently reported diseases were salmonellosis, campylobacteriosis and giardiasis, accounting for more than 80% of the endemic and the travel-related cases.

There were a total of 129 (26.7/100,000 person-years) reported cases of *Campylobacter* infection. Of these 129 cases, 19% (24) were travel-related and 81% (105) were classified as endemic (21.8/100,000 person-years). Most cases (69%) were reported between June and September 2005, and the majority (94%) were *C. jejuni* infections. For animal exposures, *Campylobacter* cases had higher exposure than the other cases for household pet contact with dogs (36.5%). Eating in a restaurant (37.8%) was high compared to the cases due to other pathogens. In parallel, *Campylobacter* was successfully isolated from swine (71% of pooled samples) and dairy farms (26% of pooled samples), raw chicken meat (37%) and untreated surface water (7%), but not from raw retail pork and beef. Swine and dairy cattle appeared to be reservoirs of *Campylobacter*, predominantly *C. coli* in the case of pigs. Raw chicken meat was a

potential source of transmission of foodborne *C. coli* and *C. jejuni* in households. The level of contamination in chicken meat was usually low (< 1 MPN/g), but sporadically could be higher; thus, retail chicken may be an important source of both *C. coli* and *C. jejuni* infections in humans if food is insufficiently cooked or improperly handled during preparation. Untreated surface water cannot be ignored as a potential exposure route for *Campylobacter*, although further subtyping data will be needed to clarify this point.

There were a total of 151 (31.3/100,000 person-years) reported cases of salmonellosis. Of these 151 cases, 22.5% (34) were related to travel, 26.5% (40) to outbreaks and 51% (77) were classified as endemic cases (16/100,000 person-years). Most endemic cases (61%) were reported from June to September 2005. Twenty-one serotypes were identified and the top three were *Typhimurium* (15), *Heidelberg* (10) and *Enteritidis* (6), which comprised 53% of serotyped isolates. For most animal exposures (both on-farm and while visiting farm animal areas), *Salmonella* cases had lower exposure than that reported from all infections except for household pet contact (53.6%), which was slightly elevated, and pet cats (18.8%). While eating undercooked food was not frequently reported (9.0%), it is interesting to note that those cases cited involved eating chicken dishes and omelettes. *Salmonella* was isolated from the swine (36% of pooled samples) and dairy (13% of pooled samples) farms, raw pork (2%), chicken (27%), beef (1%) and untreated surface water (13%). The number and types of serotypes identified varied with the sample source, making it difficult to attribute specific sources to human infections.

There were a total of 31 (6.4/100,000 person-years) reported cases of *E. coli* O157:H7. Of these 31 cases, none were travel-related, 7 were outbreak-related and 24 were classified as endemic (5.0/100,000 person-years). For *E. coli* O157:H7 cases, the proportion of cases that indicated a private well as a main water source was over twice as high as cases due to other pathogens. Higher proportions were also reported for other potential types of exposure, including: had eaten meat from a butcher shop, had swum in a pool, lived on a farm or in a rural setting, had visited farm animal areas, had shopped at a butcher shop, had eaten undercooked food (barbecued roast beef and steak tartar), had eaten meat from a private kill and had drunk unpasteurized milk. A low proportion had contact with a household pet. For on-farm animal exposures, cases of *E. coli* O157:H7 reported higher exposure to cattle, poultry, horses and cats than cases of other diseases. Verotoxigenic *E. coli* (VTEC) was detected in one pork sample and in no chicken or beef samples. Three swine manure and one dairy manure sample tested positive for *E. coli* O157. However, further testing determined that these were not the H7 strain. Verotoxigenic *E. coli* was also detected by molecular analyses in untreated surface water samples throughout the year. Swine and dairy cattle may be a reservoir of non-pathogenic *E. coli* O157, whereas untreated surface water is a possible source of VTEC. In addition, raw meat was rarely contaminated with pathogenic *E. coli*.

Eleven people (2.3/100,000 person-years) were reported with *Yersinia enterocolitica* infection. All cases were classified as endemic; over one-half were reported between July and September 2005. Seventeen of the pork chops tested were contaminated with *Yersinia*. However, following further subtyping, all were determined to be of non-pathogenic strains. Of the 117 swine manure samples tested, *Yersinia* was detected in 6%. Presently, subtyping results are available for 3 of the positive samples; all are of pathogenic strains.

No human listeriosis cases were reported. In raw retail meats, 7%, 23% and 28% of the pork, beef and chicken samples, respectively, were contaminated. Of the swine and dairy manure samples, 61% and 55% respectively, were positive for this bacteria. Following subtyping of the manure isolates, a much smaller proportion was confirmed to be *L. monocytogenes*. Retail subtyping results are pending.

There were a total of 54 (11.2/100,000 person-years) reported cases of giardiasis. Of these 54 cases, 31.5% (17) were travel-related and 69% (37) were classified as endemic (7.7/100,000 person-years). The giardiasis cases reported higher exposures for: swimming in a lake (33.3%), swimming in a pool (26.7%), visiting a farm animal area (25.8%), and drinking untreated water (24.1%). Of the meat samples tested using microscopy techniques, *Giardia* was detected on only one pork sample. Of the dairy and swine manure samples, 54% and 50%, respectively, tested positive for *Giardia*. Initial subtyping work has indicated that zoonotic assemblages are present (results pending). *Giardia* was detected in 100% of the untreated surface water samples.

A total of 12 (2.5/100,000 person-years) cases of cryptosporidiosis were reported. Of these 12 cases, 2 were travel-related and 10 were classified as endemic (2.1/100,000 person-years). High proportions were reported for swimming and visiting a farm animal area. No *Cryptosporidium* was detected in the retail raw meat samples, although it was found in pooled swine manure samples and in pooled dairy manure samples. Further subtyping on 17 of the swine manure samples indicated that they were *C. parvum*, the bovine genotype, which is considered to be zoonotic. *Cryptosporidium* was detected in 30 of 32 of the untreated surface water samples collected on Sentinel Site 1 (Grand River) during the first surveillance year.

Three cases of cyclosporiasis were reported: 1 was travel-related and 2 were classified as endemic. As *Cyclospora* is not considered to be endemic to Canada, no active surveillance for this parasite was performed at the food, agriculture and water sources.

There were a total of 20 (4.1/100,000 person-years) reported cases of amoebiasis. Of these 20 cases, 7 were travel-related and 13 were classified as endemic (2.7/100,000 person-years). As most *Entamoeba* infections in Canada are related to travel, immigration or person-to-person transmission, it was not assessed in the various exposure sources (food, agriculture and water samples).

In addition to the routine surveillance for enteric pathogens in the agri-food and water components, a number of episodic activities were performed that have direct relevance to attributing the level of risk and exposure to pathogens.

A food consumption survey (n = 2332) with a focus on the food safety perspective was conducted. This survey provided baseline levels of food and water consumption and food handling in the general population, as well as a comparison for risk factors from the case questionnaires.

A quantitative evaluation of pathogen load with enumeration was conducted on retail meat samples. In general, the bacterial pathogen loads were found to be below detectable levels on the majority of positive samples (*Campylobacter, Salmonella, Listeria* and *Yersinia*). For instance, the majority of chicken samples (85%) were found to have *Salmonella* levels below the enumeration detection limit, although 2 samples (6%) were found to have high levels of *Salmonella*

contamination (> 1100 MPN per gram). Thus, prevalence and concentration data are available for risk modelling.

A study was performed to quantify the influence of refrigerated storage on pathogen levels on raw chicken, for five-day and eight-day storage periods. Results exhibited no statistically significant differences for *Salmonella* and *Campylobacter* between the time of sample collection and the end of the two storage periods. Statistically significant differences were observed for *Listeria*, with lower counts at Day 0 than after storage, with the maximum mean difference being less than 0.6 log.

Additional work related to source attribution has been initiated. A multi-partner collaborative group is working on a conceptual framework for source attribution. Work has begun to analyze a large dataset of Canadian foodborne outbreaks for source attribution. Work to apply a quantitative method of source attribution to historical Canadian *Salmonella* data has been initiated. Additionally, linkages with other groups interested in source attribution and the burden of enteric diseases, both in Canada and internationally, have been established. Additional ways to analyze the C-EnterNet's rich data will be incorporated as the program matures (additional years, complete subtyping, etc.).

The results reported here will serve as a benchmark for the ongoing monitoring of trends in pathogen movement, behaviour, prevalence and impact in the first sentinel site and subsequent sites across Canada. As the surveillance system progresses, with the addition of more sentinel sites and the complete implementation of all the planned surveillance activities, more exhaustive and reliable information based on laboratory findings and epidemiological data will show trends in enteric disease occurrence and in exposure sources to inform and strengthen source attribution in Canada.

This report summarizes the findings from Canada's new integrated foodborne and waterborne disease surveillance system, which focuses on four major components. The results from this surveillance system show that the epidemiology of foodborne disease in a Canadian-based community is consistent with that observed for other developed countries; this is expected, given the increasing globalization of food distribution, technologies and practices. The full implementation of this surveillance system will enable Canada to monitor the effectiveness of interventions as they apply to our food and water systems, ensuring our ability to maintain Canada's safe food and water supply in the face of new and emerging challenges.

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1. Introduction

1.1 Background

C-EnterNet is a multi-partner initiative facilitated by the Public Health Agency of Canada. It is designed to support activities that will reduce the burden of enteric (gastrointestinal) disease, by comprehensive sentinel site surveillance implemented through local public health units.

C-EnterNet is funded primarily by Agriculture and Agri-Food Canada through the Agriculture Policy Framework. The Framework is a funding initiative that allocates resources to achieve the following objectives:

- Protecting human health by reducing exposure to hazards;
- Increasing consumer confidence in the safety and quality of food produced in Canada; and
- Reducing agricultural risks to the environment and providing benefits in terms of the health and supply of water, with key priority areas being nutrients, human pathogens, pesticides and water conservation.

The C-EnterNet model is based on the US Centers for Disease Control and Prevention (CDC) FoodNet sentinel site model – a leading-edge surveillance approach implemented to reduce the occurrence and impact of foodborne diseases in the United States. However, C-EnterNet's scientific mandate is broader, as it includes simultaneous and in-depth investigation of foodborne and waterborne diseases and exposure. This enhanced, community-based investigation is done through sentinel site surveillance. The selection of sentinel site locations is based on specific criteria. Such criteria ensure that cost efficiencies are achieved for sample collection and laboratory analyses, and that the resulting data may be generalized to communities across Canada. Each sentinel site is established in a unique partnership with local public health units, and includes a working network with the local water, agriculture and retail food sectors, as well as the provincial and federal institutions responsible for public health.

The core objectives of the C-EnterNet program are:

- To detect changes in trends in human enteric disease and in levels of pathogen exposure from food, animal and water sources in a defined population;
- To conduct source attribution (determine the proportion of human cases due to exposure via water, food and animals); and
- To improve the analysis, interpretation and reporting of laboratory and epidemiological data for public health, water and agri-food purposes.

As detailed in C-EnterNet's website (http://www.phac.gc.ca/c-enternet/index.html), the general design proposes 5 or 6 sentinel sites across Canada with continuous and episodic surveillance activities for each of four components: humans, food, water, and food animals. Continuous surveillance activities are continuously undertaken 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 results obtained from the continuous activities (e.g. inclusion of emerging pathogens, focus on specific exposure sources, focus on specific human subpopulations).

1.2 Status of C-EnterNet – July 2006

After one year of design and planning, C-EnterNet began operation in 2005 in its first (pilot) sentinel site – the Regional Municipality of Waterloo, Ontario. This community has approximately 470,000 residents, a mix of urban and rural activities, and demonstrated innovation in public health and water conservation (including a very useful database on the Grand River watershed).

C-EnterNet's close collaboration with front-line staff of Region of Waterloo Public Health forms the cornerstone of the larger partnership within the site. Most of the planned continuous surveillance activities and some sporadic activities in this area have been implemented over the course of 2005. Specifically, C-EnterNet was able to generate site-specific incidence and risk factor data on human reportable enteric diseases. In addition, C-EnterNet began to collect pathogen data from most of the *a priori* important sources of exposure within the sentinel site's geographic area, including untreated surface water, stored and fresh manure from dairy and swine farms, and retail raw meat (chicken breasts, pork chops and ground beef). The various surveillance activities were initiated at different dates in 2005 and 2006, with subsequent methodological adjustments as needed.

1.3 Scope of Report

This inaugural report provides the results from the first year of C-EnterNet's implementation, from mid-2005 to mid-2006. Readers should bear in mind that C-EnterNet is still in its pilot phase.

This document provides an overview of the reported human cases of enteric disease, including demographic and incidence results and risk factor information. Pathogen-specific sections cite the results gleaned from the human, agri-food and water surveillance activities and are followed by a summary section on source attribution. Please note that the source attribution results are preliminary; further extrapolation can only be made once C-EnterNet has been fully implemented across Canada, to cover several sentinel sites and several commodities, and once molecular subtyping methods and more quantitative data analysis are pursued in subsequent surveillance years. The next section provides additional results from sporadic surveillance activities and summarizes the relevant information in terms of risk for the human population. The final section provides information on the future activities of C-EnterNet.

Appendix A provides a detailed description of the Region of Waterloo. Appendix B presents the relevant details about the sampling and testing design used in this program. C-EnterNet is currently compiling a summary of laboratory methods which will be available in the near future. Appendix C presents the human endemic cases exposure data acquired from case questionnaires.

While the results published here only capture the first year of surveillance, they are intended to provide an introduction to the type of data that will eventually be collected in the fully implemented, national, integrated sentinel site surveillance program. Limitations inherent to the first year include low numbers of samples, incremental incorporation of various components and discontinuous sampling of some components. After this inaugural report, the plan is to release annual reports based on calendar years.

Because collaboration is one of C-EnterNet's key principles, readers are invited to provide any comments, suggestions or ideas to improve this report to the program lead, Dr. Frank Pollari by e-mail at frank_pollari@phac-aspc.gc.ca. This feedback will help the team prepare the 2006 C-EnterNet Annual Report (encompassing data from January to December 2006), which will be released in the spring of 2007.

The results reported herein will serve as a benchmark for the ongoing monitoring of trends in pathogen movement, behaviour, prevalence and impact in the first sentinel site and, upon expansion, subsequent sites across Canada. As the surveillance system progresses to encompass more sentinel sites and the complete implementation of all the planned surveillance activities, more exhaustive and reliable information based on laboratory findings and epidemiological data will show trends in enteric disease occurrence, in exposure sources, and inform and strengthen source attribution.

2. Human Case Summary

2.1 Overview of Human Cases

A total of 417 cases of 9 bacterial and parasitic enteric diseases were reported to the local public authorities within Sentinel Site 1 between June 2005 and May 2006 (Table 2.1). The three most frequently reported diseases (salmonellosis, campylobacteriosis and giardiasis) accounted for 80% of those cases.

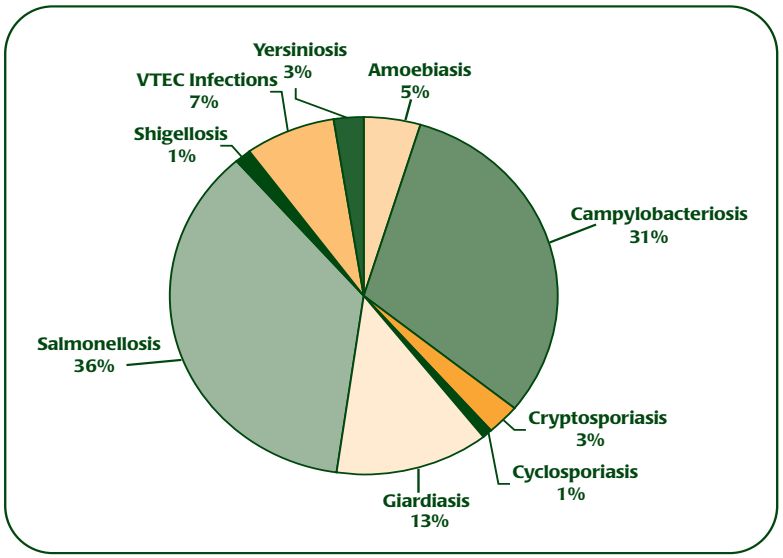
Information on potential exposure was obtained from 91.4% of the reported cases within the sentinel site during the first year of surveillance. Public health inspectors administered a standardized questionnaire to the cases or proxies. It is interesting to note, that these new standardized questionnaires were created by C-EnterNet and the Region of Waterloo Public Health, and are based on ones used at the CDC Food Net site at the Minnesota Department of Health. These questionnaires are designed to secure a higher quality of information that supports further epidemiological information. Preliminary analyses of this information were used to determine case status (travel versus endemic) and compare exposures (Appendix C); they will provide guidance for episodic activities in subsequent years.

It is important to note that the original integrated design includes the active surveillance of enteric viral diseases, but this was not achieved during the first year of the program. Sporadic viral enteric diseases are not reportable in the province of Ontario, therefore routine microbiological or epidemiological data were not available for incorporation in these analyses. However, C-EnterNet will incorporate viral diseases in the surveillance report in future years.

Table 2.1
Number of Cases and Incidence Rates per 100,000 Person-years of Laboratory-confirmed Enteric Diseases in Sentinel Site 1, June 2005 – May 2006

Disease	Number of Cases				Incidence Rate	
	Outbreak	Travel	Endemic	Total	Endemic	Total
Amoebiasis	0	7	13	**20**	2.7	**4.1**
Campylobacteriosis	0	24	105	**129**	21.8	**26.7**
Cryptosporiasis	0	2	10	**12**	2.1	**2.5**
Cyclosporiasis	0	1	2	**3**	0.4	**0.6**
Giardiasis	0	17	37	**54**	7.8	**11.2**
Salmonellosis	40	34	77	**151**	16.0	**31.3**
Shigellosis	0	3	3	**6**	0.6	**1.2**
Verotoxigenic *E. coli* (VTEC)	7	0	24	**31**	5.0	**6.4**
Yersiniosis	0	0	11	**11**	2.3	**2.2**
Total	47	88	282	417		

Figure 2.1
Relative Proportion of Enteric Diseases Reported in Sentinel Site 1
June 2005 – May 2006



For the first year of the program, denominator data (i.e. the total number of submitted stool specimens tested) were not available from all participating laboratories. These data were provided by the regional hospital's microbiology laboratory. It is C-EnterNet's goal to have complete denominator data for human cases for the second year and beyond.

Historically, numbers for enteric diseases showed an overall decline in Sentinel Site 1 from 1990 to 2004 (see Figures 2.2 and 2.3). A total of 8,351 cases of fifteen reportable enteric illnesses, including endemic, travel and outbreak cases, were reported from 1990 to 2004. *Campylobacter* spp., *Giardia and Salmonella* spp. accounted for over 80% of the enteric illness cases during that fifteen-year period. Those results are similar to the ones for June 2005 to May 2006.[1] Considering the 2005-06 data, the trends in enteric diseases were unchanged compared to earlier years, except for *Salmonella* and VTEC. Both of these infections showed sharp increases when compared to recent years.

1 Keegan V. Descriptive analysis of enteric illness in Waterloo, Ontario: 1990-2004. MSc thesis, University of Guelph, Guelph, ON; 2006.

Figure 2.2
Historical Data from Sentinel Site 1, 1990–2006, the Red Box Indicates Data Collected during the First Year of C-EnterNet Surveillance

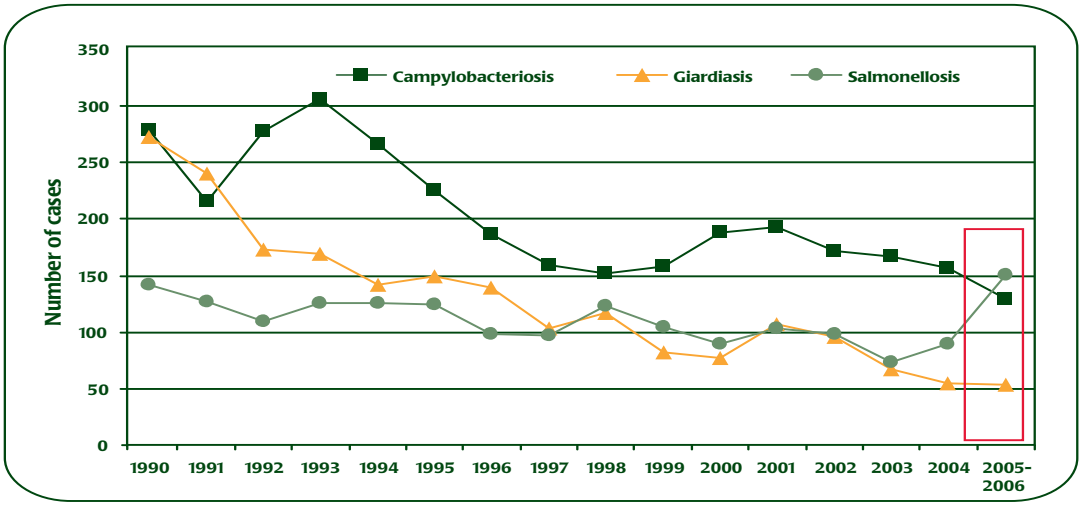
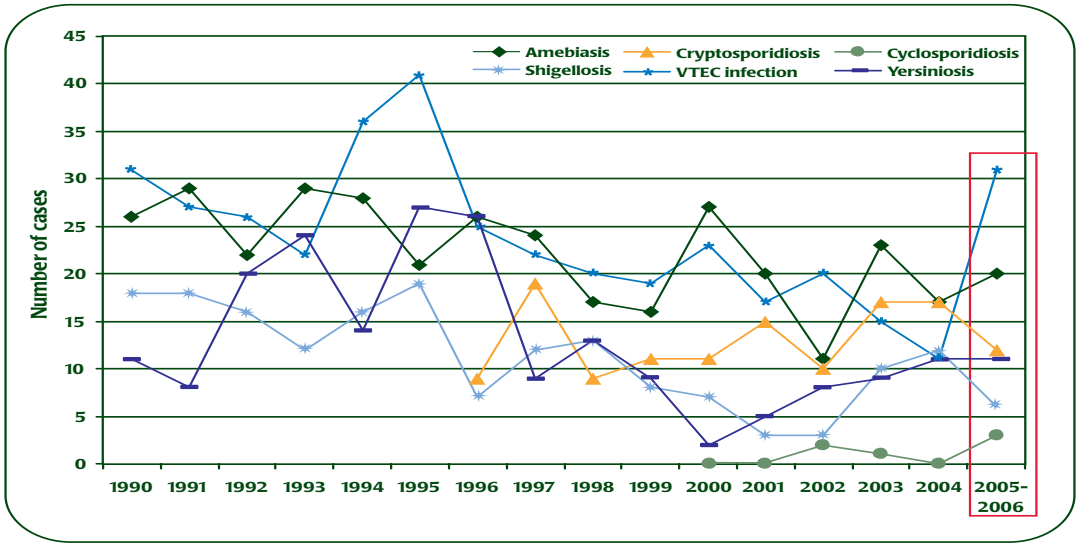


Figure 2.3
Historical Data from Sentinel Site 1, 1990–2006, the Red Box Indicates Data Collected during the First Year of C-EnterNet Surveillance



2.2 Outbreak-related Cases

There were two significant outbreaks identified within the sentinel site between June 2005 and May 2006 – one of *Salmonella* Enteritidis and the other of *E. coli* O157:H7. These outbreak cases contributed to the aforementioned trend deviations.

In the fall of 2005, a large outbreak of *Salmonella enterica*, serotype Enteritidis PT13 (SE PT13), was reported in Ontario, with 40 of the cases occurring in Sentinel Site 1, between November 11

and December 28. Of the 40 cases, 23 reported having consumed mung beans. The Ontario-wide outbreak of SE PT13 occurred from October 1 to December 14, 2005. A total of 552 laboratory-confirmed SE PT13 cases were identified during the outbreak period. Mung bean sprout consumption was reported by 247 cases (45%); the remaining cases had unknown exposure. Cases were 59% female (323/552), the median age was 31 years (range: 1–92), and 30 cases (5%) were hospitalized. Consumption of mung bean sprouts was a significant risk factor for SE PT13 infection (MOR = 14.0, 95% CI = 4.2–86.7); no other exposure was significant. The source of contamination was unknown. As a result of this outbreak, public health messaging in Canada changed to address cooking mung bean sprouts to reduce the risk of foodborne illness.

The second outbreak in Sentinel Site 1 was due to *E. coli* O157:H7 in a local daycare facility. Seven confirmed cases and 4 probable cases were identified. A federal field epidemiologist was deployed to assist in investigation of the outbreak, including the administration of a questionnaire and active case finding. No definitive source was identified. The key features of this outbreak included the possible role of an asymptomatic child in disease transmission, the lack of comprehensive provincial or federal guidelines specific to the management of *E. coli* O157:H7 in daycare facilities, a lack of parental understanding regarding symptoms of diarrhea, and the parents' inability to keep excluded children out of child care facilities.

2.3 Travel-related Cases

Of the reported cases, 88 (21%) were classified as travel-related (Table 2.1). No verotoxigenic *E. coli* or *Yersinia* infections were travel-related. Again, salmonellosis, campylobacteriosis and giardiasis were the three most common diseases, contributing 85% of the travel-related cases. Most of the cases had visited the Mexico/Caribbean region or Asia prior to acquiring their illness (Table 2.2), a trend which likely reflects travel preferences of Canadians. Unfortunately, calculations of country-specific relative risks were not possible. Most of the travel-related

Table 2.2
Travel-Related Cases in Sentinel Site 1, June 2005 – May 2006

Disease	Africa	Asia	Europe	Mexico/ Caribbean	USA	Multiple Destinations/ Others	Total
Amoebiasis	0	4	0	1	2	0	**7 (8.0%)**
Campylobacteriosis	4	7	5	5	2	1	**24 (27.3%)**
Cryptosporiasis	1	0	1	0	0	0	**2 (2.3%)**
Cyclosporiasis	0	0	0	1	0	0	**1 (1.1%)**
Giardiasis	0	9	1	3	2	2	**17 (19.3%)**
Salmonellosis	1	5	2	21	5	0	**34 (38.6%)**
Shigellosis	0	2	0	1	0	0	**3 (3.4%)**
Verotoxigenic *E. coli* infection	0	0	0	0	0	0	**0**
Yersiniosis	0	0	0	0	0	0	**0**
Total	6 (6.8%)	27 (30.7%)	9 (10.2%)	32 (36.4%)	11 (12.5%)	3 (3.4%)	88 (100%)

Salmonella cases, 21/34, had been to the Mexico/Caribbean region and most of these, 16/21, had S. Enteritidis (phage types 4, 4a, 1 and 1a). Of all the travel-related cases, 9/88 were associated with travel to Europe and 5 of these were campylobacteriosis cases.

2.4 Endemic Cases

The analyses presented in the rest of this report refer to the endemic cases. Because one of the C-EnterNet program's goals is to develop accurate estimates of source attribution for the Canadian population, it is important to capture only those cases that could be attributed to local sources, whether they be food, water or animals. While outbreak cases are also attributed to local sources of exposure, they represent unusual events. By excluding outbreak cases, more stable estimates of disease incidence are provided and attribution estimates will not be overly influenced by unusual events. It is important to also note that, while C-EnterNet is not actively monitoring pathogen exposure in other potential sources (such as pet animals), these risk factors are nonetheless explored through the human case follow-up questionnaire used at the local health unit.

In each of the following sections, potential exposures are noted when the proportion for the specific disease differs by more than 5% from the proportion of the other diseases combined. It should be noted that exposure information was pooled for all cases, including infants and young children, which are a vulnerable sub-population. Thus, the exposures reported here represent overall exposures for the general population, and are not necessarily valid for age-specific subgroups (e.g. children). Additionally, summarizing these endemic cases pools multiple sources of infection and tends to dilute the contribution of each individual source indicator (exposure). Please refer to the C-EnterNet website (http://www.phac-aspc.gc.ca/c-enternet/index.html) to see the complete list of exposures analyzed as well as the worksheet (questionnaire) used in Sentinel Site 1 for case follow-up investigations.

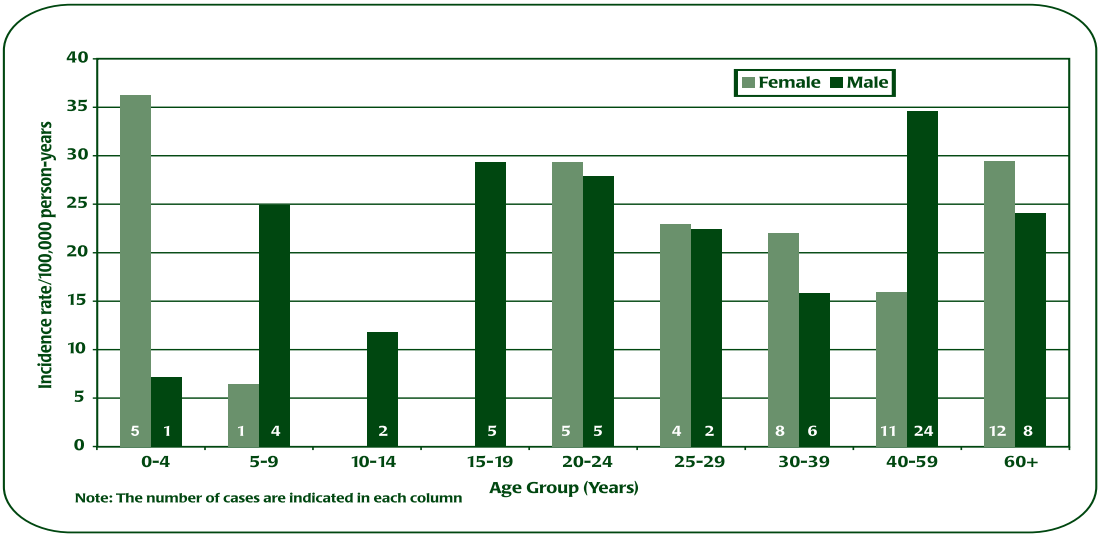
3. *Campylobacter*

3.1 Human Cases

From June 2005 to May 2006, in Sentinel Site 1, there were a total of 129 (26.7/100,000 person-years) reported cases of *Campylobacter* infection. Of these 129 cases, 19% (24) were travel-related and 81% (105) were classified as endemic (21.8/100,000 person-years). In comparison, the annual incidence rates for campylobacteriosis in 2005 in Canada and Ontario were 29.62/100,000 and 27.61/100,000, respectively.[2] Both of these rates are similar to the sentinel site's overall rate, but the large proportion of travel-related cases underscores the need to focus on endemic cases to establish the links between public health and domestic food and water safety issues.

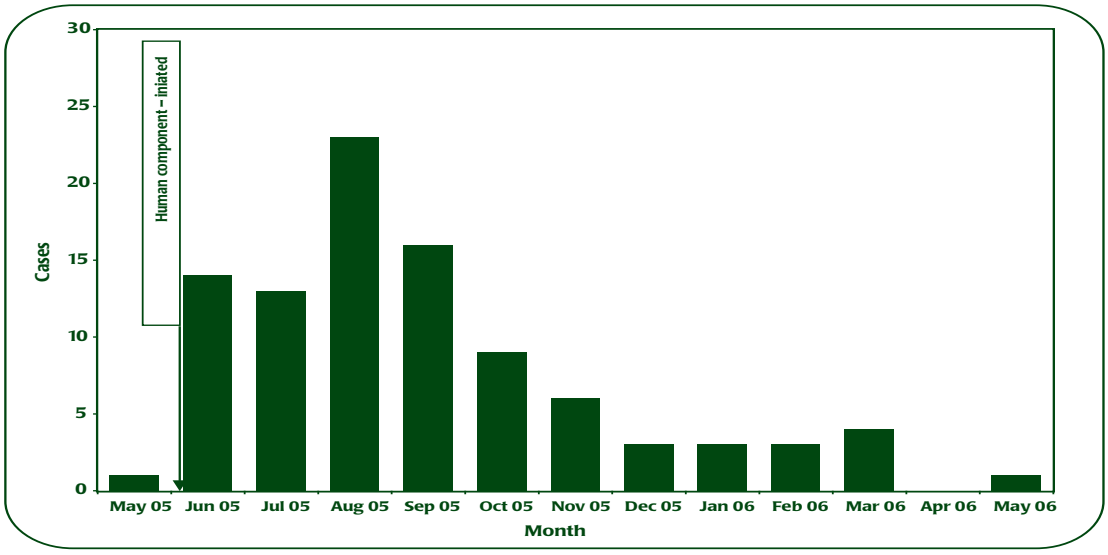
The age- and gender-specific endemic incidence rates were highest in females less than 5 years of age (Figure 3.1). A breakdown by gender shows that 46 cases were female (19.0/100,000) and 59 were male (24.6/100,000). The quartile age ranges were: 1.2 years (min.), 24 (Q1), 41 (median), 55 (Q3), 73 (max.). Most cases were reported between June and September 2005 (Figure 3.2) and most (94%) were *C. jejuni* infections (Table 3.1).

Figure 3.1
Incidence Rates of Endemic Campylobacteriosis in Sentinel Site 1 by Gender and Age Group, June 2005 – May 2006



2 Public Health Agency of Canada. National Notifiable Diseases On-Line. Posted at http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/top_list and updated by Carole Scott; 2006 [personal communication].

Figure 3.2
Temporal Distribution of Human *Campylobacter* Cases in Sentinel Site 1 during the First Year of Implementation



Ninety-two percent (97) of the endemic *Campylobacter* cases provided potential exposure information for the 10 days prior to onset of illness. Eating in a restaurant (37.8%) was more frequent than in cases of other diseases, while eating undercooked food was not commonly reported (7.4%). The types of undercooked foods reported were chicken, turkey, beef and Chinese. For exposure to animals, *Campylobacter* cases had a higher proportion of household pet contact with dogs (36.5%) than cases of other diseases.

Of the 274 individuals (for all reported enteric diseases) who provided information about their occupation, all (4/4) of those who reported they worked in agriculture or a slaughterhouse, were infected with *Campylobacter*.

3.2 Exposure Surveillance

Campylobacter were isolated from the three potential sources of exposure to enteric pathogens that were monitored at the community level (farms, raw meat and untreated surface water) [Table 3.1], although they were not detected in raw retail pork and beef. We must note, however, that the sampling of meat, water and on-farm manure was introduced in phases during this first year and some methodological adjustments were made during this period. Additionally, on-farm manure samples were collected three times a year rather than continuously. Therefore, the distribution of positive samples needs to be interpreted along with the sampling activities.

The positive raw chicken samples were further analyzed with the Most Probable Number (MPN) technique to count their bacterial load. Of the positive samples, 32/45 were found to be below the MPN detection limit, 10/45 were reported to be 0.35–0.92 MPN *Campylobacter*/g and 3/45 were reported to be 1.5–4.3 MPN *Campylobacter*/g.

The untreated surface water (i.e. before any treatment by the municipal water treatment plant) was tested within the sentinel site, using both culture and molecular methodologies. More samples were tested by molecular analysis, as this technique was initiated earlier than culture-based detection. The molecular method used is designed to quantitatively target 16S rRNA of *C. jejuni*, *C. coli* and *C. lari* (thermophilic species). More positive samples were found by the molecular approach than the culture method (Table 3.1).

Detection of *Campylobacter* in environmental (untreated surface water) samples by the culture method is limited by a number of factors, including both the low number of organisms present in the sample matrix and the fact that many of these cells will be sub-lethally damaged. These organisms may therefore not be detected by culture-based methods, and are often referred to as non-culturable but viable (NCBV). Although they cannot be detected by culture methods, they can still cause contamination and infection, resulting in human cases. Therefore, the true level of *Campylobacter* contamination in untreated surface water samples is likely somewhere between 8% and 57%, considering that some of the samples that test positive by molecular analysis could represent dead (non-viable) but intact cells.

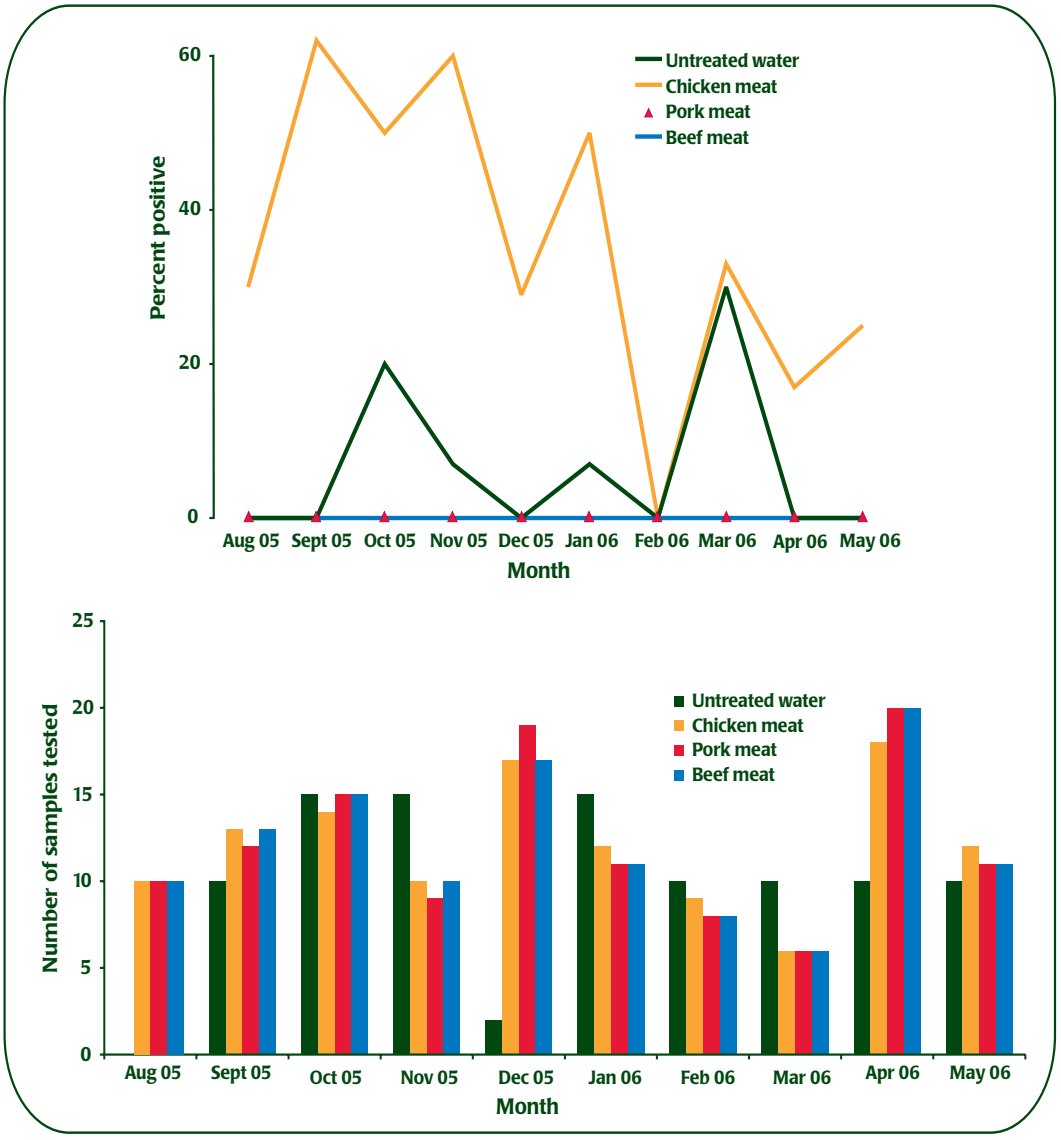
The observed limitations of traditional culture-based *Campylobacter* detection methods from all potential exposures will be examined in future episodic activities of the C-EnterNet surveillance program.

Table 3.1
Campylobacter Contamination Data for the Integrated Surveillance Activities in Sentinel Site 1 during the First Year

	Human	Retail Food			Food Animals (Manure)		Untreated Surface Water	
Sampling Initiated	Endemic Cases June 2005	Pork August 2005	Chicken August 2005	Beef August 2005	Swine March 2005	Dairy Cattle May 2006	Grand River August 2005	Grand River March 2005
Detection		Pork chop	Skin-on breast	Ground beef	(10 farms)	(7 farms)	5 sample points on Grand River	
# tested	Unknown	117*	117*	117*	159*	27*	97*	147**
# positive	105*	0	43	0	113	7	8	84
% positive		0%	37%	0%	71%	26%	8%	57%
Subtyping								
# subtyped	100	0	37	0	111	7	8	0
C. coli	2 2%		7		104 54%	2	2	
C. jejuni	98 98%		30		1 1%	2	3	
Other	0 0%		0		6 5%	3	0	
Missing data	0%						3	

* Culture method
** Molecular method

Figure 3.3
Temporal Distribution of Samples and *Campylobacter* Contamination for Untreated Surface Water and Raw Meat Samples in Sentinel Site 1, during the First Year



The temporal distribution of positive samples from the exposure sources showed no clear seasonal pattern (Figure 3.3), unlike the human cases (Figure 3.2). Positive samples of swine manure were found in every month of testing. The positive samples of untreated surface water were few and scattered over most months of sampling, with no clear clustering. More interestingly, raw chicken samples seemed to be more frequently positive from the fall of 2005 to early winter in 2006 (September 2005–January 2006). This apparent lack of a common seasonal pattern linking the human occurrence of *Campylobacter* infection and presence of the pathogen in the exposure sources will have to be further explored based on more complete surveillance data.

3.3 Source Attribution

Below are qualitative findings based on subtyping data from serotyping methodologies from the first year of data collection. More complete sampling and the inclusion of additional subtyping results will enhance future analyses.

- Swine and dairy cattle are reservoirs of *Campylobacter*, mainly *C. coli* in the case of pigs;
- Raw chicken meat is a potential source for the transmission of foodborne *C. coli* and *C. jejuni* in households, whereas raw pork and beef seem to be free of *Campylobacter*, based on these initial findings;
- The level of *Campylobacter* in fresh chicken meat is usually low (97.8% < 1 MPN/g), but was sporadically higher, indicating that retail chicken may be an important source of both *C. coli* and *C. jejuni* infections in humans if food is insufficiently cooked or improperly handled during food preparation; and
- Untreated surface water cannot be ignored as a potential exposure route for *Campylobacter* although further data are needed to clarify this point. The current municipal water treatment aims at eliminating this risk from drinking water. However, the natural recreational water might be the source for human waterborne campylobacteriosis.

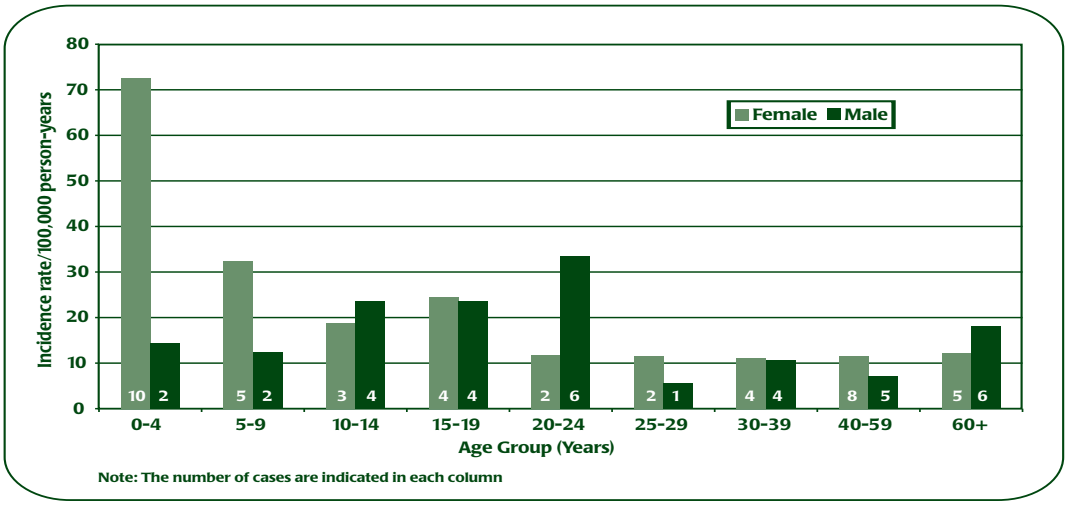
4. *Salmonella*

4.1 Human Cases

From June 2005 to May 2006, in Sentinel Site 1, a total of 151 (31.3/100,000 person-years) cases of salmonellosis were reported (Figure 4.1). Of these 151 cases, 22.5% (34) were travel- related, 26.5% (40) were outbreak-related and 51% (77) were classified as endemic (16.0/100,000 person-years). In comparison, the annual incidence rates for salmonellosis in 2005 in Canada and Ontario were 17.98/100,000 and 22.61/100,000, respectively.[3] This comparison emphasizes the need to focus on endemic cases to stabilize rates over years, especially when looking at smaller populations.

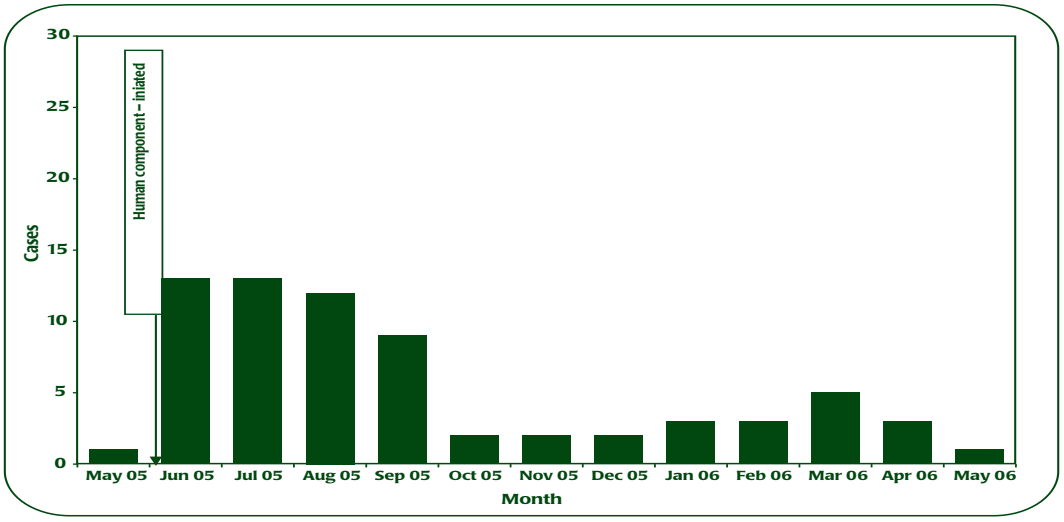
The age and gender-specific endemic incidence rates from the 77 endemic cases showed the highest rates in females less than five years of age (73/100,000), while among the male cases, the highest incidence rate (34/100,000) was observed among 20-24 year olds. The quartile age ranges were: 0.2 years (min.), 10 (Q1), 23 (median), 45 (Q3) and 84 (max.). Of those cases, 43 (17.7/100,000) were female and 34 (14.2/100,000) were male. Most cases (47/77; 61%) occurred from June to September 2005 (Figure 4.2). The 59 cases for which the serotype was known were spread over 21 serotype categories, of which the top three were Typhimurium (15 isolates), Heidelberg (10) and Enteritidis (6), encompassing 53% of isolates that were serotyped (Table 4.1).

Figure 4.1
Incidence Rates of Endemic Salmonellosis Cases by Gender and Age Group in Sentinel Site 1, June 2005 – May 2006



3 Public Health Agency of Canada. National Notifiable Diseases On-Line. Posted at http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/top_list and updated by Carole Scott; 2006 [personal communication].

Figure 4.2
Temporal Distribution of Human *Salmonella* Cases in Sentinel Site 1 Reported during the First Year of Implementation by Date of Onset



Potential exposure information for the 3 days prior to onset of illness was collected for 90% (69) of the reported endemic *Salmonella* infections. While eating undercooked food was not elevated (9.0%), it is interesting to note that the types of food were chicken dishes and omelette. For most animal exposures (both on-farm and while visiting farm animal areas), *Salmonella* infection cases had lower exposure than that reported from all infections except for household pet contact (53.6%), which was slightly elevated, and pet cats (18.8%).

4.2 Exposure Surveillance

Salmonella was isolated from the three potential sources of exposure to enteric pathogens that were monitored at the community level, including farms, raw meat and water (Table 4.1). Contamination in raw pork chops and ground beef was rare (< 2%). Compared to *Campylobacter*, the prevalence of *Salmonella* contamination in untreated surface water samples was fairly similar for both the culture-based and molecular approaches (13 and 17%, respectively). The molecular method used is specific to *Salmonella* species.

The sampling of retail meat, water and on-farm manure was introduced in phases during this first year and some adjustments were made where necessary. Additionally, on-farm manure samples were collected three times a year rather than continuously. Therefore, the distribution of positive samples must be interpreted along with the sampling activities. It is interesting to note an increase in the number of *Salmonella* isolates from untreated surface water samples in March and April 2006 (Figure 4.3). This pattern does not correlate with the human seasonal occurrence (Figure 4.2).

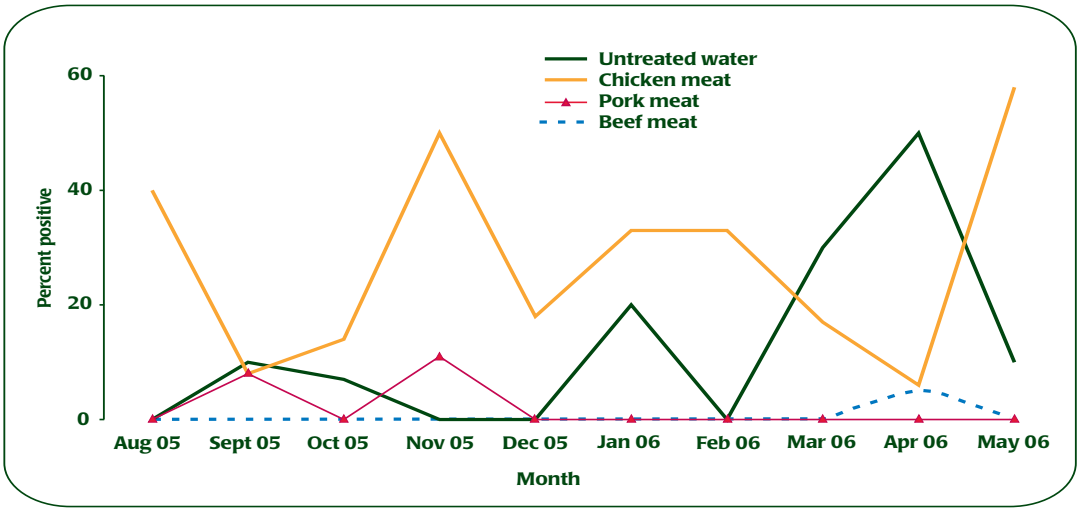
It is interesting to note that 8/15 of the serotypes isolated from untreated surface water had also been observed in human cases, though this does not indicate a direct correlation between exposure and illness (Table 4.1).

Table 4.1
Salmonella Contamination Data for the Integrated Surveillance Activities in Sentinel Site 1, during the First Year of Implementation

	Human	Retail Food			Food Animals (Manure)		Untreated Surface Water	
							Grand River	
Sampling Initiated	Endemic Cases June 2005	Pork August 2005	Chicken August 2005	Beef August 2005	Swine March 2005	Dairy Cattle May 2006	August 2005	March 2005
Detection		Pork chop	Skin-on breast	Ground beef	(10 farms)	(7 farms)	5 sample points on Grand River	
# tested	Unknown	117[1]	117[1]	117[1]	159[1]	30[1]	97[1]	147[2]
# positive	77[1]	2	31	1	57	4	14	25
% positive		2%	27%	1%	36%	13%	13%	17%
Subtyping # subtyped	**61**	**2**	**33**	**1**	**57**	**4**	**15[3]**	
Agona	2				4 (1 farm)		1	
Agoueve	1							
Albany							1	
Berta	1						3	
Branderup								
Brandenburg		1			1			
Derby					12 (1 farm)			
Enteritidis	4							
Enteritidis PT 13	1		3					
Enteritidis PT 4a	1							
Havana					3 (1 farm)			
Hadar	2		2					
Heidelberg	10		6					
Indiana	1		2					
Infantis	4		1		4 (2 farms)			
Kentucky	1		9			3	3	
Kiambu								
Litchfield	1							
London					2 (1 farm)			
Mbanaka					4 (1 farm)			
Minnesota							1	
Montevideo	1							
Muenchen	2							
Oranienberg	1							
Newport							1	
Saintpaul	3							
Schwarzengrund	2		2					
Senftenberg	1							
Stanley	1							
Tennessee	1							
Thompson	2						1	
Typhimurium[4,5]	14				5 (4 farms)			
Typhimurium DT 104[4]			1		17 (4 farms)		2	
Typhimurium DT 104a[4]		1	1					
Typhimurium PT 108[4]	1							
Typhimurium 15[4]					1			
Typhimurium U30[4]					1			
Typhimurium UT1[4]					1			
Typhimurium 169[4]			1					
Typhimurium 170[4]			1					
Typhimurium 193[4]							1	
Orion var. 15+34+								
I: 10:-:-							1	
I: 4,5, 12:I:-			2					
I: 8, 20:I:-			1					
I:6,7. 14:-:-					2 (2 farms)			
I:6,14, 18:-:-						1		
Untypable	2							

[1]Culture method , [2]Molecular method, [3]Two serotypes were detected in 1 sample, [4]Includes Var Copenhagen, [5]Phagetype information not available

Figure 4.3
Temporal Distribution of *Salmonella* Contamination for Untreated Surface Water and Raw Meat Sampled Monthly in Sentinel Site 1, during the First Year



For the first year of surveillance, the serotype results have been provided (and the top three identified in each component are listed in (Table 4.2). Further analyses (phagetype and PFGE) of positive samples were performed to discriminate likely sources. For example, *Salmonella* serotype Enteritidis was found in humans and all three sources tested, yet the PFGE of these strains were different, suggesting that there are no clear correlations between cases and exposures based on this dataset. It is interesting to note that *Salmonella* Typhimurium is in the top three serotypes in retail pork and chicken meat, swine manure, and untreated surface water. As well, *Salmonella* Heidelberg is in the top three serotypes for human and retail chicken meat.

4.3 Source Attribution

Below are qualitative findings based on subtyping data from serotyping methodologies from the first year of data collection. More complete sampling and the inclusion of additional subtyping results will enhance future analyses.

- Swine and dairy cattle are reservoirs of *Salmonella enterica*, with some serotypes found in human salmonellosis cases as well (e.g. Agona, Infantis, Kentucky, Typhimurium).

- Raw chicken meat is a potential source of transmission of foodborne *Salmonella enterica* in households (especially for Heidelberg, Enteritidis PT13, Kentucky, Infantis, Hadar and Indiana serotypes), whereas raw pork and beef seem rarely contaminated, based on these initial findings.

- The level of *Salmonella* in raw meat is usually low (99.5% < 1 MPN/g), but was sporadically higher for chicken, indicating that retail chicken may be an important source of human salmonellosis if food is insufficiently cooked or improperly handled during food preparation.

- Untreated surface water cannot be ignored as a potential exposure route for *Salmonella* (especially Agona, Berta, Kentucky, Thompson serotypes) although further data are needed to clarify this point. Current municipal water treatment aims at eliminating this risk from drinking water. However, natural recreational water might be a source for human waterborne salmonellosis.

- The serotype distribution across the water, agriculture and retail food components differ from the human cases, impeding a straightforward source attribution (Table 4-2). However, it is interesting to note that Typhimurium, the top human serotype, is also in the top three serotypes for retail pork and chicken meat, swine manure, and untreated surface water.

- Exotic pets can be also a source of salmonellosis. During the surveillance year, there was one case of *Salmonella enterica* serotype Agoueve. The case was a 3-month old infant, who was formula-fed. While no definitive source of the infection was identified by the local public health authorities during the case follow-up, it was noted that the family owned three exotic reptilian pets (a Gecko, a Bearded Dragon, and a Monitor), which are a previously documented risk factor for this type of *Salmonella* infection.[4]

Table 4.2:
Top Three *Salmonella Enterica* Serotypes Recovered from Each Source in Sentinel Site 1, during the First Year

Serotype Ranking	Human	Retail Food			Food Animals (Manure)		Untreated Surface Water
	Endemic Cases	Pork	Chicken	Beef	Swine	Dairy Cattle	Grand River
1	Typhimurium (14)	Brandenburg (1)	Kentucky (9)	Orion var. 15+34+ (1)	Typhimurium (25)	Kentucky (3)	Typhimurium (3)
2	Heidelberg (10)	Typhimurium (1)	Heidelberg (6)		Derby (12)	I:6,14,18:-:- (1)	Kentucky (3)
3	Enteritidis (4) Infantis (4)		Typhimurium (4)		Agona (4) Infantis (4 Mbanaka (4)		Berta (3)
Total # subtyped	75	2	33	1	57	4	15

4 de Jong B, et al. Effect of Regulation and Education on Reptile-associated Salmonellosis. Emerg Infect Dis; 2005.

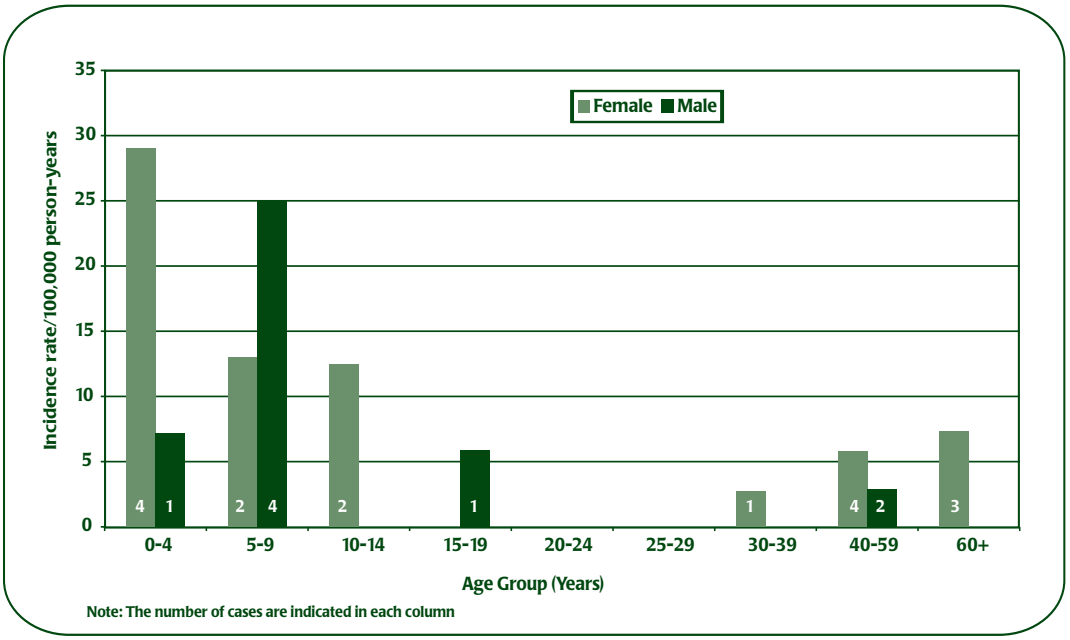
5. Pathogenic *E. coli*

5.1 Human Cases

Between June 2005 and May 2006, in Sentinel Site 1, there were a total of 31 (6.4/100,000 person-years) reported cases of *E. coli* O157:H7. Of those 31 cases, none were travel-related, 7 were outbreak-related and 24 were classified as endemic (5.0/100,000 person-years). In comparison, the annual incidence rates for *E. coli* O157:H7 in 2004 in Canada and Ontario were 3.4/100,000 and 2.5/100,000, respectively.[5]

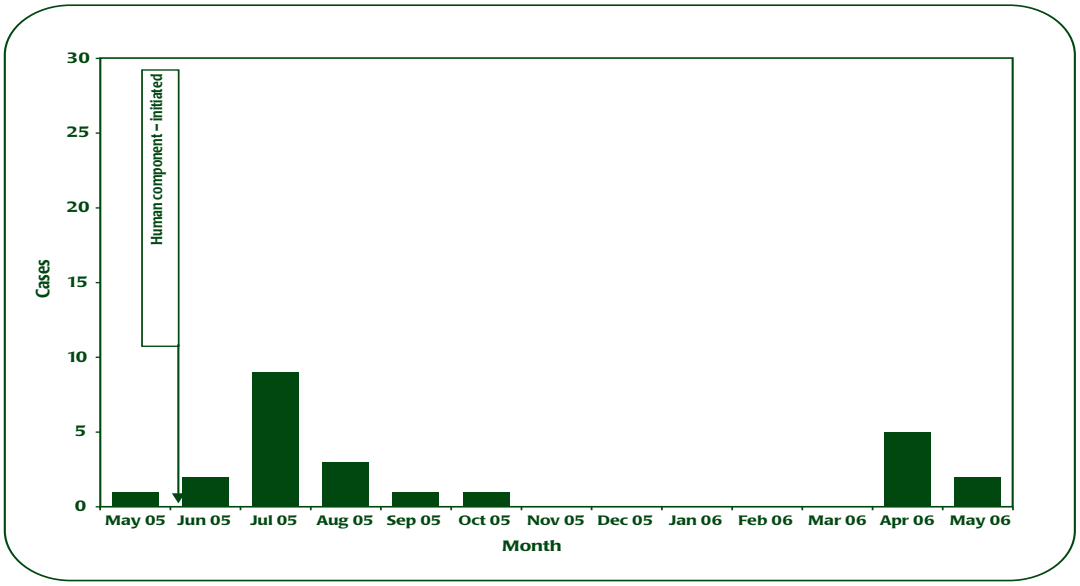
The age- and gender-specific incidence rates from the 31 endemic cases showed the highest rates in females less than 5 years of age (Figure 5.1). The quartile age ranges were: 0.8 years (min.), 5.5 (Q1), 11 (median), 54 (Q3), 78 (max.). Twenty cases were female (8.3/100,000) and 11 were male (4.6/100,000). Only the O157:H7 subtype of verotoxigenic *E. coli* was reported (Figure 5.1). No cases were reported between November 2005 and March 2006, and the highest number of cases was reported in July 2005 (Figure 5.2).

Figure 5.1
Incidence Rates of Endemic *E. coli* O157:H7 in Sentinel Site 1 by Gender and Age Group, June 2005 – May 2006



5 Public Health Agency of Canada, 2006. Notifiable Diseases On-line. Posted at http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/top_list and updated by Carole Scott; 2006 [personal communication].

Figure 5.2:
Temporal Distribution of Human VTEC Cases in Sentinel Site 1 Reported during the First Year, by Date of Onset



Exposure information for the 10 days prior to the onset of illness was collected for 23 of the reported endemic cases of *E. coli* O157:H7 during the first year of surveillance. None of the endemic cases reported any association with daycare centres. For *E. coli* O157:H7 cases, the proportion of cases that indicated a private well as a main water source was over twice as high as cases due to other pathogens. Higher proportions were also reported for other potential exposures, including: ate meat from a butcher shop; swam in a pool; lived on a farm or in a rural area; visited a farm animal area; shopped at a butcher shop; ate undercooked food (barbecued roast beef or steak tartar); ate meat from a private kill; and drank unpasteurized milk. A low proportion had contact with a household pet. For on-farm animal exposure, *E. coli* O157:H7 cases reported higher rates of exposure to cattle, poultry, horses and cats than cases of other diseases.

5.2 Exposure Surveillance

Table 5.1
***E. coli* Detection Data for the Integrated Surveillance Activities in Sentinel Site 1, during the First Year**

	Human	Retail Food			Food Animals (Manure)		Untreated Surface Water	
							Grand River	
Sampling Initiated	Endemic Cases June 2005	Pork August 2005	Chicken August 2005	Beef August 2005	Swine March 2005	Dairy Cattle May 2006	February 2005	March 2005
Detection		Pork chop	Skin-on breast	Ground beef	(10 farms)	(7 farms)	5 sample points on Grand River	
# tested		117*	117*	117*	159*	5*	25*	147**
VTEC		1	0	0				
0157:H7	24						1	36
0157					3	1		

* Culture method
** Molecular method

Verotoxigenic *E. coli* was detected on 1 pork sample and no chicken or beef samples. Three swine manure samples and 1 dairy cattle manure sample tested positive for *E. coli* O157; however, further testing determined that these were not of the H7 strain.

VTEC was also detected by molecular analysis in the untreated surface water samples throughout the year, and once the culture-based analyses had been initiated, in 1 sample among 25 during the spring of 2006, illustrating the difficulty associated with culturing this organism in environmental matrices.

5.3 Source Attribution

Below are qualitative findings based on subtyping data from serotyping methodologies from the first year of data collection. More complete sampling and the inclusion of additional subtyping results will enhance future analyses.

- Swine and dairy cattle may be a reservoir of non-pathogenic *E. coli* O157.
- Raw meat is rarely contaminated with pathogenic *E. coli*.
- Untreated surface water is a potential source of human infection with pathogenic *E. coli*, primarily through recreational water activities.

6. *Yersinia*

6.1 Human Cases

From June 2005 to May 2006, in Sentinel Site 1, there were a total of 11 (2.3/100,000 person-years) reported cases of *Yersinia enterocolitica* infection. Of these 11 cases, all were classified as endemic.

Currently, *Yersinia* is not a nationally notifiable disease, and so the annual incidence rate is not available for comparison. The age- and gender-specific incidence rates for the endemic cases showed the highest rates in males less than 5 years of age (Figure 6.1). The quartile ranges were: 0.8 years (min.), 4.0 (Q1), 13 (median), 29 (Q3), 31 (max.). Five cases were female and 6 were male. Over one-half of the cases were reported between July and September 2005 (Figure 6.2).

Figure 6.1
Incidence Rates of Endemic *Yersinia* Infection by Gender and Age Group in Sentinel Site 1, June 2005 – May 2006

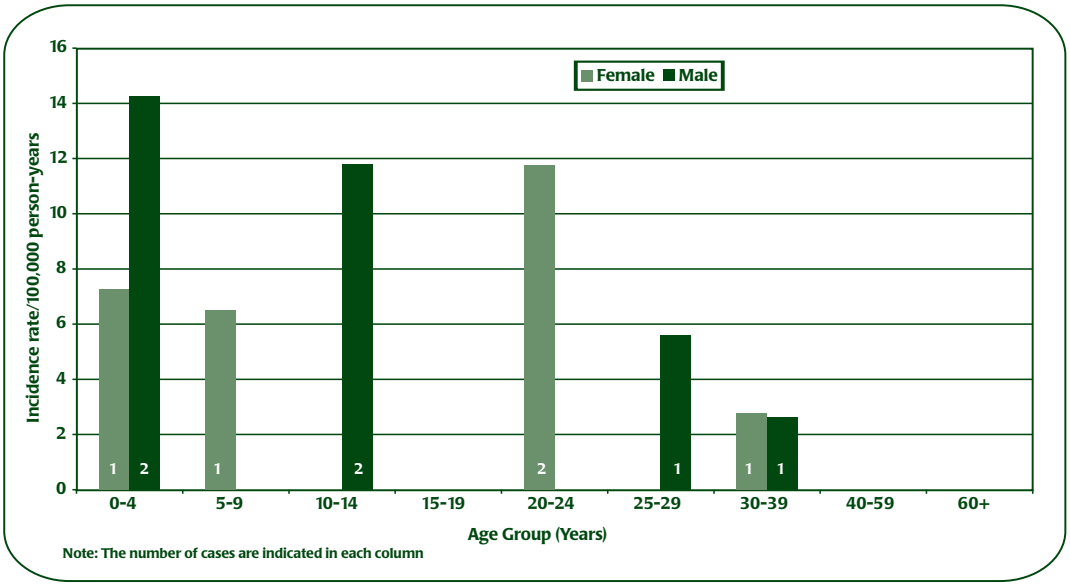
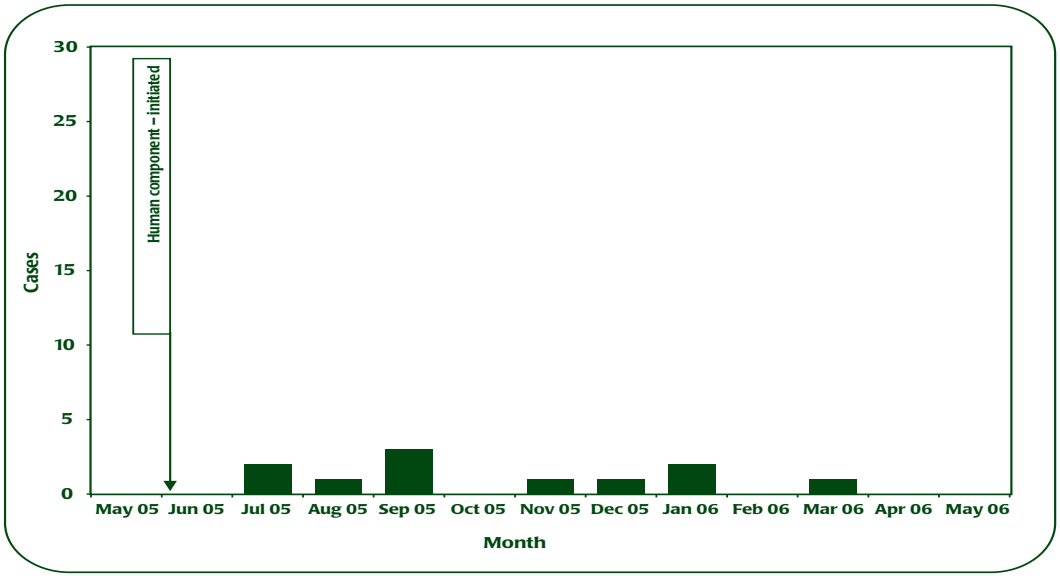


Figure 6.2:
Temporal Distribution of Human *Yersinia* Cases in Sentinel Site 1 Reported during the First Year, by Date of Onset



Potential exposure information for the 7 days prior to the onset of illness was collected for all 11 of the reported endemic yersiniosis cases. The following proportions were high for the yersiniosis cases compared to other diseases: contact with household pets, attending a barbecue, swimming in a lake, eating meat from a butcher shop, eating undercooked food (chicken and pork roast) and using a private well. The only case that reported exposure to farm animals had been on a pig farm.

6.2 Exposure Surveillance

Table 6.1
***Yersinia* Detection Data for the Integrated Surveillance Activities in Sentinel Site 1, during the First Year**

	Human	Retail Food	Food Animals (Manure)
Sampling Initiated	Endemic Cases June 2005	Pork August 2005	Swine March 2005
Detection		Pork chop	(10 farms)
# tested	Unknown	117*	117*
# positive	11	17	7
% positive		15%	6%
Subtyping			
# subtyped	11	8	3
enterocolitica - pathogenic	11	0	3
enterocolitica - non-pathogenic		3	
frederiksenii - non-pathogenic		3	
intermedia - non-pathogenic		2	

* Culture based

Retail raw pork and swine manure were tested for *Yersinia* using conventional culture-based methods (Table 6.1). Seventeen (15%) of the pork chops were contaminated with *Yersinia*; however, following further subtyping, all strains found were considered to be non-pathogenic (*Y. enterocolitica* serotypes O:5 and O:41, 43, *Y. intermedia, Y. frederiksenii*). Of the 117 swine manure samples tested, *Yersinia* was detected in 6% (7) of the samples. Presently, subtyping results are available for 3 of the positive samples – all were of pathogenic strains.

6.3 Source Attribution

Below are qualitative findings based on subtyping data from serotyping methodologies from the first year of data collection. More complete sampling and the inclusion of additional subtyping results will enhance future analyses.

- Swine operations may be a reservoir of pathogenic strains of *Yersinia enterocolitica*.
- Retail pork does not seem to be a common source of pathogenic *Yersinia* strains.
- Water contamination with pathogenic *Yersinia* will need to be further explored to better assess source attribution related to yersiniosis.

7. *Listeria*

7.1 Human Cases

Human listeriosis is rare; it is primarily identified with severe hospitalized cases. No human cases were reported in Sentinel Site 1 during its first year.

Listeria monocytogenes has been removed from the national notifiable disease list as of January 2000, and so the annual national incidence rate is not available.

7.2 Exposure Surveillance

Table 7.1
***Listeria* Detection Data for the Integrated Surveillance Activities in Sentinel Site 1, during the First Year**

	Retail Food			Food Animals (Manure)	
Sampling Initiated	Pork August 2005	Chicken August 2005	Beef August 2005	Swine March 2005	Dairy Cattle May 2006
Detection	**Pork chop**	**Skin-on breast**	**Ground beef**	**(10 farms)**	**(7 farms)**
# tested	117	117	117*	122	27
# positive	8	33	27	74	15
% positive	7%	28%	23%	61%	55%
Subtyping					
# subtyped	0	0	0	74	15
monocytogenes				4 (5%)	2
innocua				64 (87%)	13
welshimeri				4 (5%)	
grayi				2 (3%)	

Using conventional culture-based techniques for *Listeria monocytogenes* detection, 7%, 23% and 28% of the raw retail pork, beef and chicken samples, respectively, were contaminated. Of the swine and dairy cattle manure samples, 61% and 55%, respectively, tested positive for *Listeria* species. Following subtyping of the manure isolates, a much smaller proportion was confirmed to be *L. monocytogenes*. Subtyping results for raw retail meat samples are pending.

7.3 Source Attribution

Qualitative findings based on subtyping data from serotyping methodologies from the first year of data collection are inconclusive. More complete sampling and the inclusion of additional subtyping results will enhance future analyses.

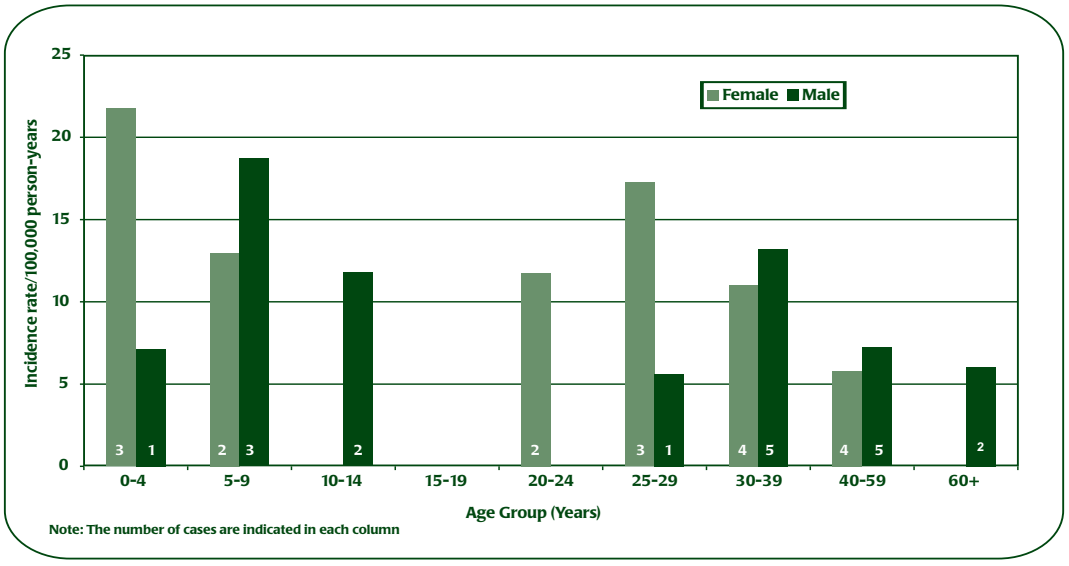
8. Parasites

8.1 Giardiasis

From June 2005 to May 2006, in Sentinel Site 1, there were a total of 54 (11.2/100,000 person-years) reported cases of giardiasis. Of these 54 cases, 31.5% (17) were travel-related and 69% (37) were classified as endemic (7.7/100,000 person-years). In comparison, the annual incidence rates for giardiasis in 2004 in Canada and Ontario were 13.1/100,000 and 12.7/100,000, respectively.[6]

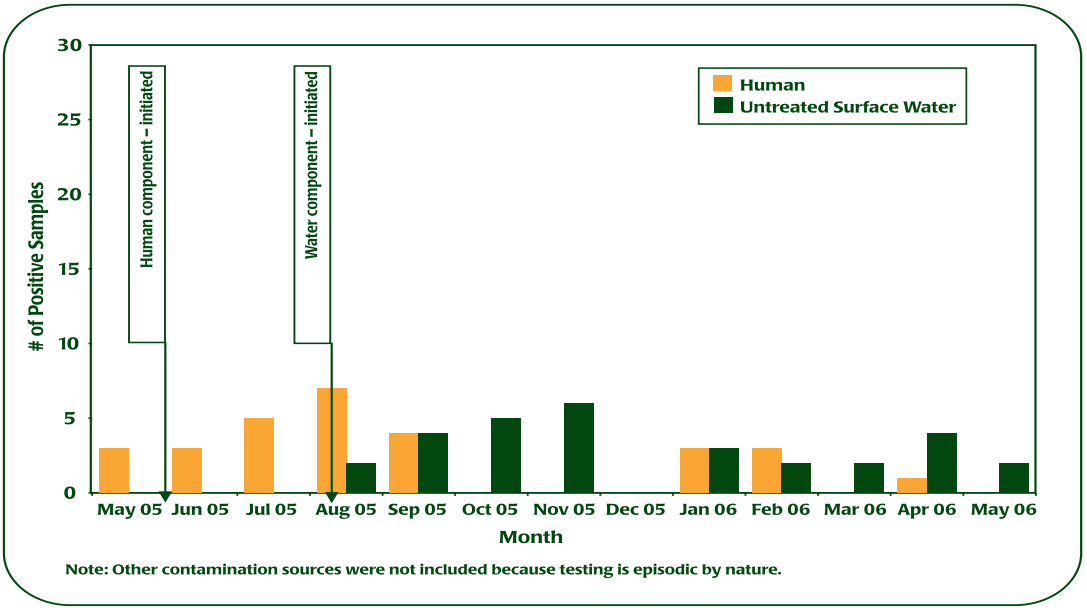
Of the endemic cases, 18 were female (7.4/100,000) and 19 were male (7.9/100,000), illustrating fairly similar overall incidence rates for both genders. The quartile age ranges were: 1 year (min.), 10 (Q1), 31 (median), 41 (Q3) and 73 (max.).

Figure 8.1
Incidence Rates of Endemic Giardiasis Cases by Gender and Age Group in Sentinel Site 1, June 2005 – May 2006



6 Public Health Agency of Canada. Notifiable Diseases On-Line. Posted at http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/top_list and updated by Carole Scott; 2006 [personal communication].

Figure 8.2
Temporal Distribution of *Giardia* Infection Among Humans and Contamination in Untreated Surface Water in Sentinel Site 1, Reported during the First Year, by Date of Onset



At this stage, it is too early in the implementation of this surveillance system to comment on temporal or seasonal trends. The analysis of a second year of data will help to inform what might be seasonal variations or trends in human cases of giardiasis and contamination in untreated surface water (Figure 8.2).

Potential exposure information for the 25 days prior to the onset of illness was available for 31 of the cases. The following high proportions were reported: swimming in a lake, 33.3%; swimming in a pool, 26.7%; visiting a farm animal area, 25.8% (3 for dogs, 2 for pigs, 1 for horses and 1 for cows); and drinking untreated water, 24.1%. No cases reported having eaten undercooked food.

Table 8.1
***Giardia* Contamination Data for the Integrated Surveillance Activities in Sentinel Site 1, during the First Year of Implementation**

	Human	Retail Food			Food Animals (Manure)		Untreated Surface Water
Sampling Initiated	Endemic Cases June 2005	Pork Jan-Apr 2005	Chicken Jan-Apr 2005	Beef Jan-Apr 2005	Swine Sept 2005	Dairy Cattle June 2006	Grand River August 2005
Microscopic Results							
# tested		25	25	25	122	26	31
# positive	37	1	0	0	61	14	31

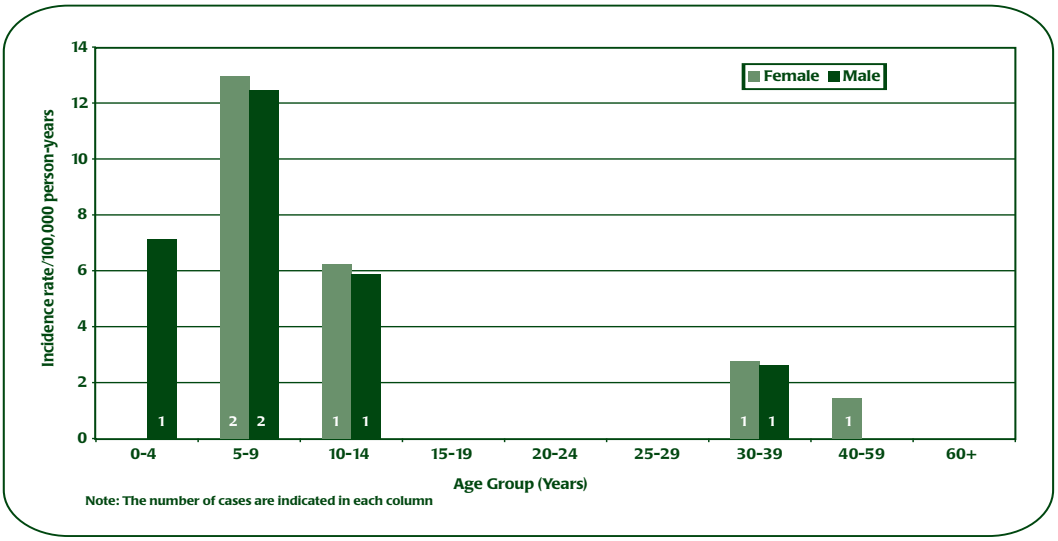
Of the meat samples tested using microscopy techniques, *Giardia* was detected on only one pork sample. Respectively, 54% and 50% of the dairy cattle manure and swine manure samples tested positive for *Giardia*. Although full results are pending, initial subtyping work has indicated that zoonotic assemblages are present.

Giardia was detected in 100% of the untreated surface water samples collected in Sentinel Site 1 (Grand River), indicating a high prevalence of this potential pathogen, despite the relatively poor recovery rate of the detection method that was used (US EPA Method 1623). Further molecular subtyping was not performed on these samples but could merit consideration for future surveillance years, to determine potential sources of contamination in the river.

8.2 Cryptosporidiosis

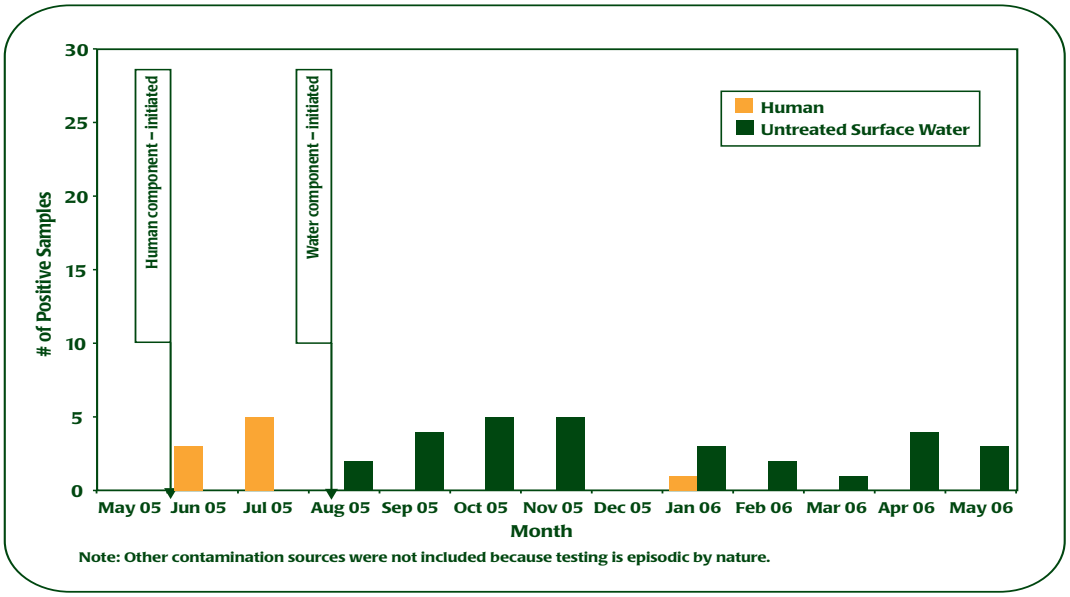
From June 2005 to May 2006, in Sentinel Site 1, there were a total of 12 (2.5/100,000 person-years) reported cases of cryptosporidiosis. Of these 12 cases, 2 were travel-related and 10 were classified as endemic (2.1/100,000 person-years). Of the endemic cases, 5 were female (2.1/100,000) and 5 were male (2.1/100,000). The quartile age ranges were: 3 years (min.), 5 (Q1), 10 (median), 31(Q3) and 48 (max.). In comparison, the annual incidence rates for cryptosporidiosis in 2004 in Canada and Ontario were 1.9/100,000 and 2.4/100,000, respectively.[7]

Figure 8.3
Incidence Rates of Endemic Cryptosporidiosis Cases by Gender and Age group in Sentinel Site 1, June 2005 – May 2006



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

Figure 8.4
Temporal Distribution of *Cryptosporidium* Infection Among Humans and Contamination in Untreated Surface Water in Sentinel Site 1 Reported during the First Year, by Date of Onset



It is too early in the implementation of this surveillance system to comment on temporal or seasonal trends. The analysis of a second year of data will help to inform what might be seasonal variations or trends in the human cases of cryptosporidiosis and contamination in the untreated surface water (Figure 8.4).

Potential exposure information for the 12 days prior to the onset of illness was available for 75% (9) of the cases. High proportions were reported for: swimming, (in lake, pool or river); and visiting a farm animal area, (3 for cats, 2 for cows, 1 for dogs and 1 for horses). No cases reported having eaten undercooked food.

Cryptosporidium was not detected in the retail raw meat samples (n = 75) by microscopy identification techniques; however, it was detected in 44% of the pooled swine manure samples and 19% of the pooled dairy cattle manure samples. Further subtyping on 17 of the swine manure samples indicated that the organism was *C. parvum*, the bovine genotype, which is considered to be zoonotic. (It is one of two *Cryptosporidium* species that cause the majority of zoonotic infections in humans.)

Cryptosporidium was detected in 30/32 of untreated surface water samples collected in Sentinel Site 1 (Grand River) during the first surveillance year, indicating a high prevalence of this potential pathogen, despite the relatively poor recovery rate of the detection method that was used (US EPA Method 1623). Further subtyping of a small number of these positive samples (samples still being processed) detected a variety of genotypes (Table 8.2). It must be noted that these data are still very preliminary and only based on 3 samples. It is interesting to note that more than one genotype has been detected in some of the samples.

Table 8.2
***Cryptosporidium* Contamination Data for the Integrated Surveillance Activities in Sentinel Site 1, during the First Year**

	Human	Retail Food			Food Animals (Manure)		Untreated Surface Water
Sampling Initiated	Endemic Cases June 2005	Pork Jan-Apr 2005	Chicken Jan-Apr 2005	Beef Jan-Apr 2005	Swine Sept 2005	Dairy Cattle June 2006	Grand River August 2005
Microscopic Results							
# tested		25	25	25	122	26	31
# positive	10	0	0	0	54	5	30
% positive		0%	0%	0%	44%	19%	94%
Molecular Results							
# samples sub-typed					17		3 (multiple genotypes per sample)
C. muris calf genotype (C. andersonii)							2
C. baileyii							**1**
C. cervine							4
C. ferret-like genotype							1
C. parvum (bovine genotype) *pathogenic					17		
C. hominis *pathogenic							

8.3 Cyclosporiasis

From June 2005 to May 2006, in Sentinel Site 1, there were a total of 3 reported cases of cyclosporiasis. Of these 3 cases, 1 was travel-related and 2 were classified as endemic. The two endemic cases were both female. In comparison, in 2004, 94 cases of cyclosporiasis were reported in Ontario. (Note: The sentinel site accounts for slightly less than 5% of the province's population.)

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

Cyclospora outbreaks in North America have been linked with various food items that currently are not included in the C-EnterNet sampling program, such as raspberries, fresh basil, mesclun lettuce and various types of fresh produce.[8] Since the spring of 1996 numerous outbreaks of diarrheal illness due to infection with *Cyclospora* have been reported in Canada and the United States, and epidemiological and traceback studies have clearly implicated fresh Guatemalan

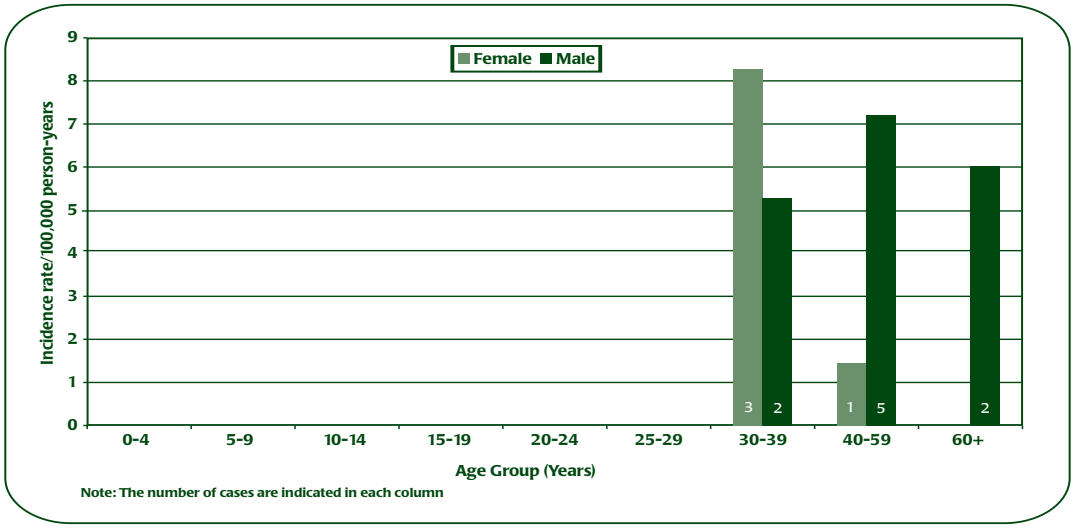
8 Sivapalasingam S, Friedman CR, Cohen L, Tauxe RV. Fresh produce: A growing cause of outbreaks of foodborne illness in the United States, 1973 through 1997. J Food Prot 2004;67(10):2342-53.

raspberries as the source of most of these outbreaks. Cases of *Cyclospora* infection unrelated to travel outside of Canada or the United States may be associated with a new outbreak.

8.4 Amoebiasis

From June 2005 to May 2006, in Sentinel Site 1, there were a total of 20 (4.1/100,000 person-years) reported cases of amoebiasis. Of these 20 cases, 7 were travel-related and 13 were classified as endemic (2.7/100,000 person-years). Of the endemic cases, 4 were female (1.7/100,000) and 9 were male (3.7/100,000) (Figure 8.5). The quartile age ranges were: 32 years (min.), 34 (Q1), 42 (median), 55(Q3) and 73 (max.).

Figure 8.5
Incidence Rates of Endemic Amoebiasis Cases by Gender and Age Group in Sentinel Site 1, June 2005 – May 2006



In 2000, amoebiasis was removed from the list of national surveillance targets; therefore, comparative incidence data cannot be provided for Canada (PHAC, 2006), although in 2004, 655 cases were reported in Ontario.

Potential exposure information for the 7 days prior to the onset of illness was available for 9 of the cases. The proportion of amoebiasis cases reporting they had swum in a lake was high compared to the proportion of cases of all enteric diseases covered by C-EnterNet.

Entamoeba is a human intestinal pathogen, although it can also infect dogs. It was not assessed in the various exposure sources (food, agriculture and water).

9. Getting Closer to Source Attribution

9.1 Risks Related to Food, Animals and Water

This report summarizes the first year of surveillance data obtained from the various components in the first sentinel site. This information is essential to help achieve C-EnterNet's objectives of source attribution and determination of pathogen levels for comparison with future findings and determination of trends. Although the attributable levels of risk from exposure to enteric pathogens from food, animals and water are not yet quantified, this first year of data provides a more precise look into the potential exposure routes for zoonotic pathogens that may contribute to both sporadic and outbreak cases of enteric illness.

Additional years of data and integration will help to further characterize the exposure routes for source attribution and to capture trends over time. Subtyping data will be particularly useful to determine the likely sources of the strains detected.

In addition to continuous surveillance for enteric pathogens in the public health, agri-food and water components of C-EnterNet, a number of episodic activities were performed between June 2005 and May 2006, some of which have direct relevance to attributing the level of risk and exposure to pathogens.

9.2 Episodic Activities to Inform Source Attribution in Year 1

9.2.1 Food Consumption Survey

A food consumption survey (n = 2332) focused on the food safety perspective was performed between November 2005 and March 2006 in Sentinel Site 1.[9] This survey provides baseline data on food consumption and information about food handling in the healthy population.

The survey found that 51.1%, 59.6% and 41.9% of the respondents had bought raw beef, chicken and pork, respectively, in the 7 days prior to the interview. Additionally, among the respondents who had bought those meats, 70.1%, 70.0% and 49.4% purchased ground beef, chicken breasts and pork chops, respectively. Further, 78.4%, 91.7% and 60.1% reported having eaten beef, chicken and pork, respectively, in the previous 7 days. These findings support the choice of the commodities monitored in the C-EnterNet program.

Of the survey respondents, 77.7% reported having eaten foods prepared outside the home (at least one meal or snack) in the previous 7 days. Comparatively, the overall rate for people eating food prepared outside the home in the relevant exposure period (before the onset of illness) was 55.4% for all the reported cases of endemic disease (46.8% for salmonellosis) captured through C-EnterNet surveillance. However, for the cases associated with the *Salmonella* Enteritidis (mung

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

beans) outbreak, the rate was 68.6%. While 0.7% of the survey respondents reporting having drunk unpasteurized milk in the 7 days prior to the interview, the percentages increase to 4.0% of the endemic cases (8.7% for VTEC and 1.5% for salmonellosis).

Results from the survey and the case questionnaires provide a sense of the most frequent and least frequent exposures and potential transmission pathways. As the surveillance database is compiled, these frequencies can be used to compare with expected frequencies in the population, other pathogen exposures, and different time frames to help identify sources as well as clusters of cases.

9.2.2 Drinking Water Consumption Survey

As a sub-component of the food consumption survey, a drinking water consumption survey (n = 2332) was performed between November 2005 and March 2006 in Sentinel Site 1. Some basic water use data for the sentinel site population were collected; they will be summarized in an upcoming peer-reviewed publication. Preliminary data indicate that:

- 91% of respondents (n = 2332) reported that they were served by the municipal water supply, while 7% of respondents reported that they used a private well.
- 57% of respondents reported that they used some form of home treatment device.
- Survey respondents reported that, of the water they consumed on a daily basis, 40.3% was bottled. However, it should also be noted that this value was not normally distributed; approximately 51% of respondents reported that they did not consume any bottled water, while 34% of respondents reported that 100% of their daily water intake was bottled. These data will be further described in future publications.
- Survey respondents reported that the mean daily volume of water consumed was 1.39 L. However, since the data on volume consumed were not normally distributed, further analysis will be performed and presented in future publications.

In comparison to the drinking water consumption survey, the following risk factor information, collected from 91% (258/282) of the endemic cases of enteric illness reported in Sentinel Site 1 between June 2005 and May 2006, indicate that:

- During the specified period prior to the onset of illness, 10% (27/258) of cases reported that their main source of drinking water was a private well, 62% (161/258) that it was the municipal water supply, and 26% (66/258) that it was bottled water.
- 64% (158/246) reported that they did not use a home water treatment device, while 33% (82/246) reported that they did and 2% (6/1246) were unsure.
- Of the 82 cases that reported using a home treatment device, 57% (47/82) used a filter jug, 26% (21/82) used a tap filter, 13% (11/82) used a reverse osmosis unit, and 1% (1/82) used a ultraviolet (UV) disinfection unit.

9.2.3 Private Well Water as a Risk

Private wells were not included in the sampling design of the C-EnterNet program for a number of reasons, including access to the wells for sampling, cost, and difficulty in determining the potential risk of exposure due to the potential for enhanced immunity of private well users to their own well water.

However, during November 2005 and February 2006, C-EnterNet participated in a survey of private well owners in Sentinel Site 1 with public health unit staff.[10] During the study, 549 nitrate and 425 bacteriological (basic *E. coli* and coliform) water sampling bottles were delivered to private well owners and water samples were collected the following day. Despite the design of the sampling program (no cost to owners, direct sample delivery, and collection to each residence), the participation rate was quite low (less than 50%). A follow-up telephone survey was conducted with both study participants and non-participants to identify the main barriers to private well water sampling that were encountered by the study sample population.

The results of this study provided evidence that the drinking water quality of private wells (both chemical and microbial) can be quite variable. In addition, the study demonstrated that both inconvenience and lack of time are key barriers to routine private well water sampling. These results highlight the importance of private well water sampling and the need to consider these barriers in the development of public health programs.

9.2.4 Pathogen Enumeration Study on Retail Meat

The retail component of C-EnterNet has been designed to document the presence or absence of pathogens in retail meat, and if present, to quantify the microbial load. This comprehensive approach provides valuable data for risk assessment. Specifically, the prevalence and concentration data can be incorporated into a risk model to predict the likelihood of enteric illness within the first sentinel site.

Enumeration results were obtained using a most probable number (MPN) 3-tube method which was sensitive to 0.3 MPN per gram of sample. The MPN table used for these analyses was obtained from the US Food and Drug Administration's *Bacteriological Analytical Manual*.

In general, the pathogen loads were found to be below the enumeration method detectable levels on the majority of positive samples for all pathogens (Table 9.1). It should be mentioned that although the primary advantage of the MPN enumeration method, when compared to direct plating, is a lower pathogen detection limit, it involves a higher level of uncertainty and is more labour intensive.

10 Hexemer A, Pintar K, Bird T, Zentner S, Garcia H, Pollari F. An Investigation of Bacteriological and Chemical Water Quality and the Barriers to Private Well Water Sampling in a Southwestern Ontario Community. [Unpublished manuscript.] 2006.

Table 9.1
Enumeration Results for Retail Meat Samples Collected within Sentinel Site 1, during the First Year of Implementation

	# Samples Tested for Presence/ Absence	# Positive Samples by Presence/ Absence	Reported as MPN/g of sample													
			Below Detection (< 0.3)	0,30	0,36	0,61	0,74	0,92	1,50	2,30	3,80	4,30	11,00	15,00	23,00	43,00	> 1100
Campylobacter																	
Pork	137	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chicken	138	45	32	–	8	–	1	1	1		1	1	–	–	–	–	–
Beef	137	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Salmonella																	
Pork	137	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chicken	138	33	28	–	2	–	–	1	–	–	–	–	–	–	–	–	2
Beef	137	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Listeria																	
Pork	137	10	6	–	2	–	–	–	–	2	–	–	–	–	–	–	–
Chicken	138	37	26	1	–	–	–	2	4	1	2	–	–	1	–	–	–
Beef	137	34	24	–	2	–	–	1	3	1	–	1	–	–	1	1	–
Yersinia																	
Pork	137	16	14	–	–	1	–	–	–	–	–	–	1	–	–	–	–
Chicken	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Beef	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note: Further subtyping of the *Listeria* and *Yersinia* isolates indicated the detection of non-pathogenic strains.

Specifically, results show that *Salmonella* was only detected on 1 beef sample and 2 pork samples, and all three were subsequently found to be below the MPN method detection limit. The majority of chicken samples (85%) were found to have *Salmonella* levels below the detection limit, although 2 samples (6%) were found to have high levels of contamination (> 1100 MPN/g). These two isolates were further tested and found to be of the following serotypes: Schwarzengrund, and I:4,5,12:i:-.

Of the 45 chicken samples analyzed for *Campylobacter* contamination load, 32 (71%) were found to be below the detection limit. In addition, 10 samples were found to have moderate levels of *Campylobacter* per gram. None of the pork or beef samples tested were positive for *Campylobacter*, therefore no further MPN analyses were performed.

Listeria monocytogenes was found on a number of the raw pork, chicken and beef samples, but following MPN analysis, determined to be below the detection limit in 60%, 70% and 71% of those samples, respectively.

9.2.5 Pathogen Levels During Refrigerated Storage: A Short Study

Finally, during the spring of 2005, an episodic study was performed to inform the design of the retail surveillance component of C-EnterNet. The objective of this study was to quantify the influence of refrigerated storage on pathogen levels on raw chicken, after 5-day and 8-day storage periods, for three pathogens: *Salmonella* Typhimurium, *Campylobacter jejuni* and *Listeria monocytogenes*. Results exhibited no significant differences for *Salmonella* and *Campylobacter* between the initial, spiked pathogen load (104-105 CFU/g) and the load at the end of the two storage periods. However, statistically significant differences were observed for *Listeria*; counts at Day 0 were lower than counts after 5 and 8 days of refrigerated storage (the maximum mean difference was less than 0.6 log). These findings suggest that a two-stage approach (keeping the chicken at 4°C for 8 days, waiting for the initial presence/absence results before initiating the MPN analyses) could overestimate the level of *Listeria* on chicken at the time of purchase. By processing the samples presumed to be positive for MPN count after 5 days of refrigerated storage, this difference will be reduced. In the case of retail chicken, these findings support the decision to perform a two-stage analysis for *Salmonella* and *Campylobacter* to reduce costs. In addition, this study provides direction for future sampling or surveillance programs that include enumeration of *Listeria* for retail food.[11]

9.3 Source Attribution Activities

A great deal of effort has gone into building the required infrastructure to implement the continuous and episodic surveillance activities and to compile the various data over the last two years. The initial analysis and interpretation of these comprehensive data has been undertaken. Beginning with the most basic analysis, C-EnterNet gradually moves to more in-depth examination for trend detection and for source attribution.

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11 Pintar K, Cook A, Pollari F, Ravel A, Lee S, Odumeru J. Quantitative Effect of Refrigerated Storage Time on the Enumeration of Campylobacter, Listeria and Salmonella on Artificially Inoculated Raw Chicken Meat. Journal of Food Protection. [In press Aug 2006.]

The work related to source attribution has been initiated in respect of various other activities:

- Assembling a multi-partner collaboration to determine the meaning, terminology and methodologies regarding source attribution to provide a conceptual framework to tackle this issue, as such a framework is currently lacking;

- Initiating analysis of a large dataset on foodborne outbreaks that occurred in Canada between 1973 and 2006, for the sole purpose of source attribution;

- Working with collaborators to apply a quantitative method of source attribution on historical Canadian *Salmonella* data. This method, developed by epidemiologists at the Danish Institute for Food and Veterinary Research, compares the distribution of the *Salmonella* serotypes across the human patients and the various potential sources; and

- Linking with other groups interested in source attribution and the burden of enteric diseases in Canada and internationally to strengthen future information exchange and collaboration.

Additional ways to analyze the C-EnterNet program's rich data generated by its various continuous and episodic surveillance activities will be utilized as the program matures (more years, complete subtyping, etc.). The goal is to provide the most value-added information for all stakeholders involved in public health prevention, food safety and water safety.

10. Moving Forward

As this new, integrated enteric disease surveillance system develops from the pilot phase to the second year of operations, it will continue to enhance and strengthen its planned continuous surveillance activities and targeted research initiatives. Looking ahead to 2006–2007 and beyond, surveillance activities for all components of C-EnterNet – human reportable enteric diseases, untreated surface water, manure from farms and retail raw meat – will be in full operation in the pilot sentinel site. For the on-farm manure surveillance component, this includes expansion to poultry and beef operations to ensure that all commodities will be represented.

With the addition of more sentinel sites and the complete implementation of all the planned surveillance activities, more exhaustive and reliable information based on laboratory findings and epidemiological data will show trends in enteric disease occurrence and in exposure sources as well as inform and strengthen source attribution.

The C-EnterNet scientific team will continue to work with the medical diagnostic laboratories – private, hospital and public – to ensure that all positive isolations of reportable enteric pathogens, from each of the sentinel sites, are directed into the system for timely reporting and subtyping. An important goal for the year ahead is to acquire accurate denominator data (i.e. the total number of stool specimens tested by the participating laboratories) for human endemic cases. Another important goal is to incorporate subtyping of parasites, specifically *Giardia* and *Cryptosporidium*, even though sampling methodology is a challenging limitation. As well, because currently a very low proportion of enteric specimens are tested for viruses in Canada, a further goal is to increase the identification of viruses.

The risk factor analysis carried out indicated that *Salmonella* infection cases had a higher rate of exposure to household pets than those of the other reported bacterial infections. This finding warrants further investigation in the future, possibly through an episodic research initiative.

The basic design of surveillance for enteric pathogens in water will continue. In the future, there may be opportunities to further investigate issues like private well water as a risk, or to conduct quantitative microbial risk assessments that incorporate the detailed data gathered on untreated surface water, and optimize methodology.

Molecular detection methods offer the potential to improve the detection of various organisms in the environment. During the first year of surveillance in the exposure sources, both culture and molecular methods were used for all bacterial water analyses. The most significant weakness of the molecular method is the potential detection of intact but dead cells, which would result in a false-positive result. However, the percent of samples that are considered “positive” could be considered the upper estimate of the likely contamination level, while the culture-based results could be considered the lower estimate.

Because a core objective of C-EnterNet surveillance is to further subtype isolates detected in humans, food, water and agriculture, emphasis is placed on culture-based detection (to ensure that isolates are collected for further analyses). However, parallel molecular analyses of all water samples will continue until 2007, to further enrich the data collected. Molecular analyses of farm and retail food samples are currently being performed for parasite and virus detection, but as of yet the dataset is not complete and was therefore not included in this report of initial results.

There are several opportunities for potential expansion of the retail and on-farm components of C-EnterNet. For example, the addition of products such as fresh fruits and vegetables, ready-to-eat meats or other raw meat products (e.g. turkey) will provide additional information on the potential exposure of consumers to foodborne pathogens.

For C-EnterNet, it has been a challenging and exciting journey from the concept stage (late 2003) to the launch of the initial pilot sentinel site (June 2005) and the collection and analysis of data (2006). Along the way numerous local, provincial and national stakeholders in food safety, water safety, public health and agri-food production have rallied to make this program possible. As we share the first year of results from Sentinel Site 1, we realize that we face many more challenges ahead – including the expansion of our surveillance activities, the maintenance of activities already in place, and a continued search for sustainable funding. The C-EnterNet scientific team is committed to moving ahead, encouraged by the successes achieved to date.

Appendix A: Profile of Sentinel Site 1 – The Region of Waterloo, Ontario

Waterloo Region is a dynamic, prosperous community located in Southern Ontario in the centre of the triangle formed by three Great Lakes: Lake Ontario, Lake Erie and Lake Huron. Established in 1973, the Region is comprised of three urban municipalities – Cambridge, Kitchener and Waterloo, and four rural townships – North Dumfries, Wellesley, Wilmot and Woolwich. Its glacial plains form some of the best agricultural land in the province, and the Grand River and its tributaries link the communities together in a common watershed.

A distinctive aspect of Waterloo Region is its organic road patterns, which provide scenic roads (formed as a result of original surveys not using a conventional grid system). The Region of Waterloo has over 1400 farms and 225,800 acres of farmland. Most of the farmland (80%) is used for crop production, which supports a large and diverse livestock and poultry sector (Region of Waterloo Food Flow Analysis Study, 2005). It is home to the famous St. Jacobs Farmers' Market, with over 600 vendors, one of Canada's largest agricultural markets.

With a combined population of over 480,000, and a geographic area of 1,382 km2, Waterloo Region is one of the fastest-growing areas in Ontario. It is now the 10th largest census metropolitan area in Canada and the 5th largest in Ontario. The Region's population growth rate between 1996 and 2001 was 8%; almost double the Canadian average, with the largest number of residents in the 30–39 year age group.

Waterloo is a contemporary, liveable community with its natural features, ethnic diversity, vibrant countryside and rural communities, world-class educational institutions and thriving technology sector. Two of Canada's top-ranked universities, the University of Waterloo and Wilfred Laurier University, and the top-ranked college in Ontario, Conestoga College, are located there. The Region is a centre for advanced manufacturing and technical innovation. Over the past 20 years, it has established a niche in the areas of automotive parts assembly and production, insurance and financial services, agri-food technology, and advanced manufacturing and research. More recently, the Region has developed into a world-renowned, high-technology industrial centre. The University of Waterloo's research in the fields of computer science and mathematics, and the advent of businesses such as Research in Motion– (creator of the Blackberry communications device), has helped the Region acquire a critical mass of innovation that attracts new enterprise.

The Grand River defines Waterloo and is a source of pride for Canada, as evidenced by its 1994 designation as a Canadian Heritage River; it was the first river in a highly settled area to receive this status from the Canadian Heritage Rivers Board. As well, Waterloo Region is home to the head office of the progressive Grand River Conservation Authority, which works directly with partners to facilitate watershed planning and the protection of natural areas and biodiversity (Grand River Conservation Authority, 2006).

The Region's settlement pattern and immigration trends have contributed to its ethnic diversity. According to the 1996 Census, it is home to more than 60 identified linguistic groups, including large numbers of French, Chinese, German, Polish, Portuguese, Romanian, Spanish and Vietnamese. German traditions and festivals, such as Oktoberfest, are popular. The Mennonite population, particularly the Old Order Mennonites located in the north and west areas of the region, are a very unique cultural community which exists within the area and which continues to retain the religion, customs, and lifestyle of their 19th century forefathers.[12]

12 Region of Waterloo website; 2006. Available at: http://www.region.waterloo.on.ca/web/region.nsf

Appendix B: Sampling Methodology

Exposure Source And Pathogen Focus

Infectious enteric diseases are caused by a broad spectrum of pathogens that can reach the human population from multiple sources (people, food, water and animal reservoirs). Therefore, Canadian surveillance of these diseases must be comprehensive. Requirements include the investigation of all viral, bacterial and parasitic transmission routes, in addition to systematized, active data collection, high-quality laboratory analysis and effective communication of results. Increased volume and quality of epidemiological data, with enhanced methodology, will provide new insights, through source attribution, into the risks presented by the various pathogen exposure routes in Canada. This will ultimately enable C-EnterNet to provide accurate evaluation of existing policies and inform the development of new food and water safety programs and policies in Canada.

The pathogens C-EnterNet has chosen to focus on are those that are commonly known to have the greatest potential to cause enteric diseases in Canadians, with particularly severe consequences for the youngest, oldest and immune-compromised portions of the population (Table B.1).

Table B.1
Overview of Pathogen Testing within Sentinel Site 1, during the First Year of Implementation

	Type of samples			
Pathogen	**Human**	**Water**	**Agriculture**	**Retail Food**
Salmonella	Y	Y	Y	Y
E. coli (VTEC)	Y†	Y	Y†	Y
Campylobacter	Y	Y	Y	Y
Yersinia	Y	Y	Y*	Y*
Listeria	Y		Y	Y
Shigella	Y			
Vibrio	Y			
Cryptosporidium	Y	Y	Y	Y
Cyclospora	Y	Y		
Giardia	Y	Y	Y	Y
Norovirus	Y			
Rotavirus	Y			

* Yersinia was only tested in swine manure (agriculture) and raw pork samples.
† *E. coli* O157:H7 was only tested among human cases and in agriculture samples during the first year of implementation.

In addition to testing for the presence of enteric pathogens in the human population and three main sources of exposure, C-EnterNet dedicated a significant portion of its resources towards further subtyping the bacterial and protozoan isolates, to better understand the potential links between source and infection. Table B.2 provides a summary of the subtyping that was performed during the first year of implementation in Sentinel Site 1. These activities are coordinated through a number of partnerships with private and public diagnostic laboratories at the municipal, provincial and federal levels, as well as a number of key academic partners. The current subtyping list will change over subsequent surveillance years, as new methodologies emerge and refinement of existing methodologies is incorporated into standard laboratory practices.

Table B.2
Detailed Information on Subtyping that is Currently being Performed on all Isolates Identified from the Various Sources of Exposure and Human Cases of Enteric Illness in Sentinel Site 1

	Serotyping/ Phage-Typing	Speciation	Antimicrobial Resistance Testing	PFGE	Genotyping	MLST and/or fla A
Human	*Salmonella*	*Campylobacter* *Yersinia*	*Salmonella* *Campylobacter*	*E. coli O157:H7* *Salmonella* *Campylobacter*		*Campylobacter*
Retail Food	*Salmonella*	*Campylobacter* *Yersinia*	*Salmonella* *Campylobacter* *Yersinia*	*Salmonella* *Listeria* Campylobacter	*Giardia* *Cryptosporidium*	*Campylobacter*
Agriculture	*Salmonella*	*Campylobacter* *Yersinia*	*Salmonella* *Campylobacter* *Yersinia*	*Salmonella* *Listeria* *E. coli O157:H7* *Campylobacter*	*Giardia* *Cryptosporidium*	*Campylobacter*
Water	*Salmonella*	*Campylobacter*	*Salmonella* *Campylobacter*	*Salmonella* *E. coli O157:H7* *Campylobacter*	*Cryptosporidium*	*Campylobacter*

Sampling Timeline

Due to the complex nature of the program activities, the components were initiated in a staggered approach in 2005, thus the sampling started at different dates for the retail foods, human epidemiological data, agri-food and water components. This is noted in the subsections of the report, particularly with respect to the portrayal of temporal distributions of pathogen prevalence in the various sources.

In addition, for the retail component, an initial 63 retail meat samples that were collected between June and August 2005 were examined to optimize the efficiency of sample collection and laboratory practices (including sample size and methods). Results from this initial sampling were therefore excluded from bacterial prevalence calculations (due to sample preparation changes), but not from subtyping or enumeration investigations (because the isolates that were recovered from these samples still provided useful information). While the laboratory changes would likely have affected the number of samples from which bacteria were isolated, these changes were unlikely to have systematically altered the proportion of isolate subtypes or the numbers found on the sample, since the selective media were unchanged.

Human Cases

C-EnterNet's human enteric samples are selected through the existing passive surveillance system in Ontario. C-EnterNet works with the provincial public health laboratory, three private laboratories and the regional hospital laboratory that serve Sentinel Site 1, to ensure that the positive isolations of reportable enteric pathogens that have been initially identified, are sent on in the laboratory system for subtyping.

In addition, C-EnterNet works with the laboratories to ensure that *Campylobacter* isolations are sent for subtyping to the Public Health Agency of Canada's National Microbiology Laboratory in Winnipeg.

An improved standard questionnaire for sporadic enteric disease cases was among the first new epidemiological tools to result from C-EnterNet's partnership with the local public health unit at its pilot sentinel site in the Region of Waterloo, Ontario. The questionnaire, based on the one used at the CDC Food Net site at the Minnesota Department of Health, is designed to secure a higher quality of information that supports further epidemiological investigation

A passive surveillance system is based on the following: a patient with an acute gastrointestinal illness must consult a physician; the physician must request a stool specimen; and the patient must comply in providing a specimen. Then the specimen must be transported to the laboratory and test positive for an enteric pathogen that is reportable in the province. For the case to be captured by the public health services, the laboratory must report the positive isolation to a local health authority directly, or via a physician, who will then report the case to the province, and the province to the national level. The provincial laboratory arm requires the front-line laboratory to forward the isolate (or in some cases the data without the isolate) to the provincial laboratory. Following additional testing of the isolate, the provincial laboratory then reports the result to the national enteric surveillance program. The provincial laboratory's strength rests in the additional microbiological or molecular characterization of the pathogen implicated in the infection. The front-line laboratory receiving the stool specimens is pivotal in deciding if a case is included or excluded in either arm of the national surveillance system.[13]

Retail Food

To characterize the exposure of consumers to bacterial pathogens in the food supply, C-EnterNet focuses its active core sampling program on fresh raw meat available for purchase in grocery stores within Sentinel Site 1. Assessment of raw meat at the retail level is recognized as an effective method to monitor consumer exposure, given that the micro-organisms that colonize the gastrointestinal tract of food animals may contaminate food products during slaughter and handling. Furthermore, it has been documented that improper cooking and cross-contamination commonly occur during food preparation in the homes, increasing the risk that pathogens in raw meat pose to consumers.

13 Flint J. Report of the 2001 Canadian Laboratory Study. National Studies on Acute Gastrointestinal Illness, Division of Enteric, Foodborne and Waterborne Diseases, PPHB, Health Canada; July 2002.

C-EnterNet developed a systematic program for retail food sampling and analysis with trained field staff. Each week, throughout the year, two large chain stores and one small store are randomly selected from a census of retail food outlets in the sentinel site's territory. Single samples of fresh ground beef, pork chops and chicken breast (with skin on) are purchased from each store (they represent the three most consumed meat commodities). Information collected at the time of sample purchase includes: cut of meat, store size, and the presence of a federal inspection stamp. Unfortunately, C-EnterNet is unable to determine the origin of these samples (provincially/federally inspected abattoirs or imported), since this information is not indicated on the product at the retail store. The samples are submitted to a laboratory for primary isolation and the isolates obtained are forwarded to additional laboratories for further subtyping (Table B.2). Pathogen counts are obtained from those samples that were positive at primary isolation.

The retail component of C-EnterNet was designed to document the presence or absence of pathogens in retail meat, as well as to quantify the microbial load, in collaboration with the Ontario Ministry of Agriculture, Food and Rural Affairs. This comprehensive approach provides valuable data for microbial food safety risk assessments. Specifically, these prevalence and concentration data can be incorporated into a risk model to predict the likelihood of enteric illness within the first sentinel site. Some of the enumeration data are provided in each summary section of the report, and an overview of the findings is provided in Section 9 of this report.

Agriculture

Given that agri-food production provides potential reservoirs of some human enteric pathogens, C-EnterNet developed a program for active sampling of manure at farms in Sentinel Site 1 during the first year of implementation. The primary objective of C-EnterNet's on-farm activities is two-fold. First and foremost, it attempts to capture the characteristics of pathogens found in the fresh and stored food-animal manure, which may eventually reach the sentinel site watershed following manure-spreading activities. Second, these activities allow for the development of a library of pathogens from agri-food operations that may become food contaminants through the farm-to-fork continuum. However, given the wide and complex distribution of agri-food products, the likelihood of food produced within the sentinel site being consumed by consumers also within the sentinel site is unknown. C-EnterNet is currently conducting active sampling on swine and dairy operations within Sentinel Site 1 during three sampling periods each year (spring, late summer and late fall) and is in the process of developing a poultry and beef sampling program for 2007.

Swine Sampling

Through an existing on-farm surveillance program developed and coordinated by the University of Guelph and the Ontario Veterinary College, C-EnterNet's agriculture sampling program initially focused on swine farms in Sentinel Site 1 (April 2005). Use of an existing program avoided duplication and ensured greater cost efficiency as C-EnterNet strives to build a long-term, sustainable enteric disease surveillance system for Canada. Pathogen surveillance was conducted at farms selected from a census of swine farms within the sentinel site's geographical area. A third party conducted the sampling of (a) fresh, pooled manure, representing a variety of animal

age groups, and (b) stored manure; samples were collected from 10 farms three times per year (in the spring, summer and late fall). All of the samples were analyzed for specific pathogens known to cause enteric disease in humans, as described in Table B.1.

Dairy Sampling

Manure sampling from dairy farms began in June 2006 in partnership with researchers at the Ontario Veterinary College and will continue into the late fall of 2006. Due to the high number of dairy operations in the sentinel site, 45 operations were randomly selected to be sampled once in 2006. Sampling activities within an operation match the swine-sampling program, including the collection of fresh and stored manure samples.

Water

Beginning in March 2005, bi-weekly sampling occurred at five locations within Sentinel Site 1 (Grand River). Samples were analyzed for the following parameters:

- thermophilic ("heat-loving") *Campylobacter,*
- *Salmonella* species,
- *E. coli* O157:H7,
- generic *E. coli,*
- nitrate,
- ammonia,
- temperature, and
- turbidity (cloudiness).

Sampling was initiated in March 2005 for molecular-based analyses (results included in this report). Culture-based analyses started in August 2005; the delay was due to method and laboratory development period during the summer of 2005.

In August 2005, monthly *Cryptosporidium* and *Giardia* sampling was also initiated for subsequent analysis by US EPA Method 1623 and genotyping. Some of these data (such as the genotyping) are still being analyzed presently and are not included in this report, but will be included in the 2006 Annual Report.

During the summer of 2006, sampling for *Yersinia* was initiated. The associated data will be included in subsequent reports.

Table C.1
The Proportion (in percent) of Human Endemic Cases with Exposure Data, and the Comparison of the Proportion Exposed for Each Disease with the Proportion Exposed for the Other Diseases Combined for a Selected Subset of Exposures

Case Information															
	Campylobacterosis		Salmonellosis		*E. coli* O157:H7		Yersiniosis		Giardiasis		Cryptosporidiosis		Amoebiasis		All
	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases
Total number endemic cases*	105		77		24		11		37		10		13		277
Number with exposure data	97	161	69	189	23	235	11	247	31	227	9	249	9	249	258
Proportion with exposure data	92.4		89.6		95.8		100		83.8		90.0		69.2		93.1
Exposure Information															
Private well - main water source	14.4	11.8	10.1	13.8	26.1	11.5	18.2	12.6	9.7	13.2	11.1	12.9	0.0	13.3	12.8
Municipal - main water source	72.2	74.5	76.8	72.5	73.9	73.6	72.7	73.7	74.2	73.6	66.7	73.9	66.7	73.9	73.6
Drank untreated water	9.4	9.5	5.9	10.8	4.2	10.0	10.0	9.4	24.1	7.6	11.1	9.4	11.1	9.4	9.5
Swam	22.9	32.1	17.1	33.0	37.5	27.8	27.3	28.7	48.4	26.0	77.8	26.9	33.3	28.5	28.7
in a lake	8.4	19.6	8.8	17.8	13.0	15.6	27.3	14.9	33.3	13.0	44.4	14.3	33.3	14.8	15.4
in a pool	10.5	14.6	7.4	15.1	30.4	11.3	0.0	13.6	26.7	11.2	22.2	12.7	0.0	13.5	13.0
in a river	1.0	0.6	0.0	1.1	0.0	0.9	0.0	0.8	0.0	0.9	11.1	0.4	0.0	0.8	0.8
Drank unpasteurized milk	4.2	3.9	1.5	5.0	8.7	3.6	9.1	3.8	3.7	4.1	0.0	4.2	12.5	3.8	4.0
Ate undercooked food	7.4	7.7	9.0	7.1	12.5	7.1	18.2	7.1	0.0	8.6	0.0	7.9	11.1	7.5	7.6
Attended a barbecue	30.5	27.0	22.1	30.7	37.5	27.4	40.0	27.9	22.6	29.2	33.3	28.2	22.2	28.6	28.3
Ate in a restaurant	37.8	29.8	27.4	34.8	39.1	32.0	27.3	33.0	34.8	32.5	25.0	33.0	14.3	33.3	32.7
Ate meat from butcher shop	7.4	8.0	2.9	9.7	31.8	5.4	20.0	7.2	4.0	8.2	0.0	8.0	0.0	8.0	7.8
Ate meat from private kill	2.1	2.0	0.0	2.8	9.1	1.4	0.0	2.1	0.0	2.3	0.0	2.1	12.5	1.7	2.0
Shopped at butcher shop	5.3	5.9	3.0	6.6	13.0	4.9	9.1	5.5	6.9	5.5	12.5	5.4	0.0	5.8	5.7

Continued on page 48

Table C.1
The Proportion (in percent) of Human Endemic Cases with Exposure Data, and the Comparison of the Proportion Exposed for Each Disease with the Proportion Exposed for the Other Diseases Combined for a Selected Subset of Exposures (continued)

Case Information															
	Campylobacterosis		Salmonellosis		*E. coli* O157:H7		Yersiniosis		Giardiasis		Cryptosporidiosis		Amoebiasis		All
	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases
Total number endemic cases*	105		77		24		11		37		10		13		277
Number with exposure data	97	161	69	189	23	235	11	247	31	227	9	249	9	249	258
Proportion with exposure data	92.4		89.6		95.8		100		83.8		90.0		69.2		93.1
Exposure Information															
Contact with household pet	55.2	49.1	53.6	50.5	39.1	52.6	63.6	50.8	46.7	52.0	33.3	52.0	22.2	52.4	51.4
cats	15.6	13.2	18.8	12.4	17.4	13.8	9.1	14.3	10.0	14.7	0.0	14.6	0.0	14.6	14.1
dogs	36.5	20.8	20.3	29.0	8.7	28.5	18.2	27.0	30.0	26.2	11.1	27.2	0.0	27.6	26.7
Visited farm animal areas	13.7	13.1	5.8	16.1	20.8	12.6	0.0	13.9	25.8	11.6	33.3	12.6	11.1	13.4	13.3
cats	0.0	1.2	0.0	1.1	0.0	0.9	0.0	0.8	0.0	0.9	22.2	0.0	0.0	0.8	0.8
dogs	2.1	3.1	1.5	3.2	0.0	3.0	0.0	2.9	9.7	1.8	11.1	2.4	0.0	2.9	2.8
horses	0.0	3.1	0.0	2.7	12.5	0.9	0.0	2.0	3.2	1.8	11.1	1.6	0.0	2.0	2.0
cattle	3.2	3.8	1.5	4.3	8.3	3.0	0.0	3.7	3.2	3.6	22.2	2.9	0.0	3.7	3.5
pigs	1.1	1.3	0.0	1.6	0,0	1.3	0.0	1.2	6.5	0.5	0.0	1.2	0.0	1.2	1.2
poultry	4.3	1.2	1.5	2.7	4.2	2.2	2.5	0.0	2.7	0.0	0.0	2.4	0.0	2.4	2.4
Lived on a farm/rural	13.8	14.9	15.9	14.0	25.0	13.4	18.2	14.3	9.7	15.2	11.1	14.6	11.1	14.6	14.5
On-farm animal exposures															
cats	1.1	1.2	0.0	1.6	8.3	0.4	0.0	1.2	0.0	1.3	0.0	1.2	0.0	1.2	1.2
dogs	3.2	3.1	1.5	3.8	4.2	3.0	9.1	2.9	6.5	2.7	0.0	3.3	0.0	3.3	3.1
horses	0.0	1.9	0.0	1.6	8.3	0.4	9.1	0.8	0.0	1.3	0.0	1.2	0.0	1.2	1.2
cattle	4.3	3.7	1.5	4.8	16.7	2.6	0.0	4.1	0.0	4.5	0.0	4.1	11.1	3.7	3.9
pigs	2.1	3.1	4.4	2.2	4.2	2.6	9.1	2.5	0.0	3.1	0.0	2.9	0.0	2.9	2.8
poultry	2.1	2.5	1.5	2.7	12.5	1.3	0.0	2.5	0.0	2.7	0.0	2.4	0.0	2.4	2.4

* Does not include *Cyclospora* or *Shigella*.

Abbreviations Used

CI	confidence interval
MLST	multilocus sequence typing
MOR	matched odds ratio
MPN	most probable number
NCBV	Non-culturable but viable (cell)
PCR	polymerase chain reaction
PFGE	Pulse Field Gel Electrophoresis
rRNA	ribosomal RNA
US EPA	United States Environmental Protection Agency
VTEC	verotoxigenic *E. coli*

Glossary

Amoebiasis

A disease caused by the protozoan parasite *Entamoeba histolytica*. It is most common in people who live in developing countries with poor sanitary conditions and in people who have traveled to developing countries. People exposed to this parasite may experience mild or severe symptoms or no symptoms at all. The mild form of amoebiasis results in nausea, diarrhea, weight loss, abdominal tenderness and occasional fever. Symptoms usually occur within 2 to 4 weeks of exposure.

Antimicrobial resistance testing

A procedure used to determine whether a micro-organism is resistant to chemical or biological agents that kill or inhibit its growth.

Campylobacteriosis

A disease caused by bacteria of the genus *Campylobacter*. *Campylobacter* is one of the most common bacterial causes of diarrheal illness in Canada. This pathogen is rarely recognized in large outbreaks and most cases are apparently sporadic. Symptoms include diarrhea, cramping, abdominal pain, and fever within 2 to 5 days after exposure to the organism; however, in some cases there are no symptoms. Illness typically lasts 1 week.

Cryptosporidiosis

A diarrheal disease caused by microscopic parasites of the genus *Cryptosporidium*. Once an animal or person is infected, the parasite lives in the intestine and passes in the stool. "Crypto" has become recognized as one of the most common causes of waterborne disease in humans. The most common symptom of cryptosporidiosis, watery diarrhea, generally begins 2 to 10 days (7 days on average) after infection with the parasite. Symptoms usually last about 1 to 2 weeks.

Cyclosporiasis

A disease caused by a unicellular parasite. The incubation period between exposure and the onset of symptoms is about 1 week. *Cyclospora* infects the small intestine and typically causes watery diarrhea, with frequent, sometimes explosive, stools. Outbreaks linked to contaminated water, as well as various types of fresh produce, have been reported in recent years. Cyclosporiasis is currently believed not to be endemic in Canada.

***E. coli* O157:H7**

One of hundreds of strains of the bacterium *Escherichia coli*. Severe illness is linked to the presence of Shigatoxins (or verocytotoxins) and infection often results in bloody diarrhea and abdominal cramps; usually little or no fever is present. In its severest form, infection can lead to haemolytic uremic syndrome (HUS), kidney failure, and possibly death,

particularly in the very young and elderly. The incubation period is 2 to 5 days. Infection with *E. coli* O157:H7 is an important problem in North America and internationally. Most illness has been associated with eating undercooked, contaminated ground beef. Person-to-person contact in families and childcare centres is also an important mode of transmission. Infection can also occur after drinking raw milk and after swimming in or drinking contaminated water.

Endemic cases

Reportable gastrointestinal disease cases that occur sporadically in a given geographic area. For the purposes of this report, endemic cases are defined as those not associated with travel outside of Canada nor with an identified outbreak.

Enteric disease (illness)

Enteric disease, or illness, refers to gastrointestinal illnesses that result from ingesting bacteria, viruses or other parasitic micro-organisms, for example *Salmonella* or *Giardia*, which may be traced back to food, water, animals or an infected person. In humans, these micro-organisms can cause symptoms ranging from a few days of vomiting and/or diarrhea to severe chronic conditions or death.

fla A typing

A genotyping technique that uses DNA sequences of the fla A gene (a gene that codes for protein of bacterial flagella).

Genotyping

A process of determining the subtype of an organism with a biological assay of the genetic material, using processes such as a PCR (polymerase chain reaction) and DNA sequencing.

***Giardia* Assemblages (genotypes)**

Variants of *Giardia lamblia* which are differentiated by DNA sequences and host specificity.

Giardiasis

A diarrheal illness caused by a one-celled, microscopic parasite, *Giardia lamblia*. This parasite lives in the intestine of people and animals and is passed in the stool. Giardiasis occurs worldwide, and children are infected more often than adults. Symptoms include diarrhea, a loose, mucous pale greasy stool, stomach cramps, bloating, severe gas, weight loss, fatigue and dehydration. The incubation period is most commonly 7 to 10 days. Symptoms usually last 2 to 6 weeks, but occasionally become chronic. *Giardia* infection has become recognized as one of the most common causes of waterborne disease (found in both drinking and recreational water) in humans in North America.

Incidence rate

The speed at which new cases of disease occur in a population. The numerator is the number of new cases of disease occurring in a given period; the denominator is the person-time at risk. In this report, rates are expressed per 100,000 person-years.

Listeriosis

A serious infection caused by eating food contaminated with the bacterium *Listeria monocytogenes*. The disease affects primarily pregnant women, newborns, and adults with weakened immune systems. Symptoms include fever, muscle aches, and sometimes, gastrointestinal symptoms such as nausea or diarrhea. The incubation period is variable with estimated median incubation of three weeks.

Multilocus sequence typing (MLST)

A method of subtyping micro-organisms using internal fragments of multiple (usually seven) housekeeping genes.

Non-viable cell

A cell that is irreversibly metabolically inactive.

Non-culturable but viable (NCBV) cell

A cell that is potentially metabolically active but will not grow on routine laboratory media. Such cells may be stressed or dying. NCBV cells of pathogens may still cause infection and disease.

Outbreak-related case

A case (person) in the population, identified as having a particular reportable infectious disease that is linked to an identified outbreak through epidemiological or laboratory methodology.

Pulse field gel electrophoresis (PFGE)

A method of subtyping used to discriminate among strains based on electrophoretic separation of DNA molecules in an agarose gel.

Phagetyping

A standardized method of identifying bacterial strains by the determination of their susceptibility to a range of bacteriophages (viruses that attack bacteria).

Salmonellosis

A food-borne infection caused by *Salmonella* bacteria. It is one of the main causes of food-borne illness worldwide. Symptoms usually appear 6 to 72 hours after exposure, though 12 to 36 hours is most common. Typical symptoms include the sudden onset of cramps accompanied by diarrhea, nausea, fever, chills, headache and vomiting. The illness can last from several days to several weeks. Most people are ill for 4 to 7 days and recover without treatment.

Sentinel site

An area or subpopulation that is monitored. Sentinel sites are an alternative to monitoring entire populations. For C-EnterNet, a sentinel site is defined as a Canadian community that is serviced by at least one public health unit and that constitutes a local network, enabling coordinated investigation into potential sources and reservoirs of enteric pathogens.

Sentinel surveillance

Surveillance systems involving a limited number of selected reporting sites from which the information collected may be extrapolated to the general population. A concentration of resources in the defined sites produces a rich source of information, resulting in more accurate final estimates than those normally available from broader national surveillance programs.

Serotyping

A method used to identify subtypes of bacteria based on serological methods that detect the presence of specific cellular and flagellar antigens.

Shigellosis

A disease caused by a group of bacteria called *Shigella*. The *Shigella* bacteria are passed from one infected person to the next, and infection can result in diarrhea (often bloody), fever, and stomach cramps. Shigellosis usually resolves in 5 to 7 days. Infection with certain strains of *Shigella* bacteria, such as *Shigella flexneri*, can lead to chronic arthritis, known as Reiter's syndrome, only among people who are genetically predisposed to it.

Source attribution

The process of determining what proportion of a particular disease (e.g. salmonellosis) is acquired from a given source (e.g. chicken) and through a given pathway (e.g. food, water, person-to-person transmission).

Speciation

The identification of culturable bacteria to the genus and species level.

Surveillance

The process of ongoing systematic collection, orderly consolidation and evaluation of pertinent data with prompt dissemination of the results to those who need to know, particularly those who are in a position to take action (World Health Organization, 1968). Surveillance can be passive, in which case the health agency receives reports from physicians, laboratories and other institutions as mandated by provincial law; or active, which involves regularly and pro-actively collecting samples or eliciting reports.

Travel-related cases

Cases of reportable gastrointestinal disease in people who indicate that they have traveled outside of Canada in the relevant timeframe before onset of illness. The relevant timeframe, determined on a disease-specific basis, relates to the known time lapse between exposure and onset (i.e. the incubation period).

VTEC

Verocytotoxin-producing *Escherichia coli* (also known as verotoxigenic *E. coli*). VTEC infections are a major public health concern, causing severe illnesses such as hemorrhagic colitis and hemolytic uremic syndrome (HUS). *E. coli* O157:H7 is one subtype of *E. coli* that produces verocytotoxin, and thus is one subtype of VTEC.

Yersiniosis

An infectious disease caused by a bacterium of the genus *Yersinia*, with most human illness caused by one species, *Y. enterocolitica*. *Y. enterocolitica* occurs most often in young children. Common symptoms in children are fever, abdominal pain and diarrhea, which is often bloody. Symptoms typically develop 4 to 7 days after exposure and may last 1 to 3 weeks or longer. Infection is most often acquired by eating contaminated food, especially raw or undercooked pork products. Drinking contaminated unpasteurized milk or untreated surface water can also transmit the infection.

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