ABSTRACT

Cases of giardiasis in Ontario were described using notifiable disease data from the Ontario Ministry of Health for the years 1990-1998 inclusive. The mean annual age- and sex-adjusted incidence rate was 25.77 cases per 100,000 population for the 25,289 cases reported. Children under five years of age had the highest incidence of disease. Males had a higher mean annual incidence in all age groups. Four deaths occurred among cases. The most frequently reported symptoms were loose stools or watery diarrhea (50.1%). A seasonal pattern was noted, peaking in late summer and early autumn. The most frequently reported probable risk settings were the home (40.1%) and travel (39.1%). The study findings suggest that a high proportion of cases occur in urban areas and spatial analysis showed the highest incidence around Lake Huron and Georgian Bay. Unfiltered water and person-to-person contact are believed to be important sources of infection.

ABRÉGÉ

Les cas de giardiasis de la province de l'Ontario ont été décrits à partir du fichier des maladies à déclaration obligatoire du ministère de la Santé de cette province pour les années 1990 à 1998 inclusivement. Le taux moyen standardisé selon le sexe et l'âge, calculé pour les 25 289 cas déclarés, était de 25,77 cas pour 100 000 habitants. Les enfants de moins de cinq ans avaient le plus haut taux d'incidence de la maladie. Les mâles présentaient un taux d'incidence moyen annuel supérieur dans tous les groupes d'âge. Quatre décès ont été rapportés parmi les cas. Les symptômes les plus fréquemment déclarés étaient les selles liquides ou la diarrhée aqueuse (50,1 %). Nous avons remarqué une tendance saisonnière avec un sommet en fin d'été et en début d'automne. Les cadres de risque le plus souvent déclarés étaient la maison (40,1 %) et les voyages (39,1 %). Les résultats de cette étude suggèrent qu'une proportion élevée des cas se produisent en milieu urbain, et que l'eau non filtrée et les contacts personnels constituent d'importantes sources d'infection. Une analyse spatiale révèle que les taux d'incidence les plus élevés se situaient autour du lac Huron de la baie Georgienne.

A Descriptive Analysis of Giardiasis Cases Reported in Ontario, 1990-1998

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Giardia is the most commonly reported human intestinal parasite in Ontario, and affects millions worldwide.^{1,2} Giardiasis was the third leading reported enteric disease in Canada and Ontario in 1998, after campylobacteriosis and salmonellosis.^{3,4} Drinking unfiltered water, direct fecal-oral transmission, or ingestion of contaminated food are the most probable sources of infection.¹ The microbial quality of Canadian drinking water has been questioned since the Walkerton, Ontario outbreak of 2000, when municipal water was contaminated with *Escherichia coli* O157:H7 and *Campylobacter* spp. following heavy spring rains.⁵ Canadian waterborne giardiasis outbreaks involving municipal water systems using only chlorination treatment have been reported in 100 Mile House, British Columbia,^{6,7} Edmonton, Alberta^{8,9} and Botwood/Peterborough, Newfoundland.¹⁰ Although infection is usually asymptomatic, manifestations may include abdominal cramps, bloating, frequent loose and/or pale greasy stools, fatigue, weight loss, chronic diarrhea, fever, rash and joint manifestations.^{11,12} It is important to identify groups at increased risk of infection because of the serious nature of symptoms and the pres-

ence of *Giardia* may indicate other pathogens in the water supply.

Routine analyses of surveillance data are useful to identify high risk groups using the geographic distribution of cases to target disease-control resources. Potential risk factors can be identified by examining the relationship between the spatial distribution of disease incidence and reported exposures. This study is part of a larger project to investigate water quality in Ontario. Its purpose is to describe the demographic, temporal and spatial distributions, and reported risk factors and symptoms of giardiasis in Ontario during the years 1990-1998 inclusive using notifiable disease data.

MATERIALS AND METHODS

Data sources

The study's database consisted of all records of giardiasis cases reported to the Ontario Ministry of Health between January 1990 and December 1998 through the Reportable Disease Information System (RDIS). RDIS defines a case of giardiasis as an individual with clinically compatible signs and symptoms with either a) demonstration of trophozoites or cysts in stool or small bowel specimens, or b) an epidemiologic link to two or more laboratory-confirmed cases. Twelve fields were examined for each case (Table I).

For each case, the reported residential postal code was linked to geographic areas used in the 1996 Census of Population for Canada and to latitude/longitude co-ordinates using a commercial database (Enhanced Postal Code File, Desktop Mapping Technologies, Inc., Markham, Ontario). This associated each case to a census division and an urban/rural designation.

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Statistics Canada defines "urban" as an area with a minimum population of 1,000 and a population density of at least 400 per square kilometre. All other areas are considered rural.

The 1991 Canadian census population formed the reference population for the standardization of rates and the Ontario population from the 1996 Canadian census was used to calculate expected population proportions. Annual population estimates calculated by Statistics Canada were used to calculate factor-specific rates.

Data quality evaluation

Data completeness and internal consistency were assessed.^{13,14} Implausible values, "unknown", and "other" were replaced with "unspecified". Percentages of missing and unspecified values were calculated for each field. Duplication was checked by comparing the date of birth, episode date, sex and postal code of each case.

Descriptive analysis

Provincial age- and sex-adjusted rates (per 100,000) were calculated for each year using the direct standardization method.¹⁵ Data were aggregated by 5-year age groups, and annual age- and sex-adjusted rates were calculated for each census division using population estimates. Calculation of rates and descriptive analyses were performed using ArcView GIS 3.1 (Environmental Systems Research Institute, Incorporated) and Microsoft Excel 97 (Microsoft Corporation). The binomial test with exact p-values was used to test the differences between observed and expected proportions. Differences between medians were tested by the Mann-Whitney-Wilcoxon test.¹⁶

RESULTS

Data quality evaluation

Over the study period, 25,289 giardiasis cases were identified in RDIS. Reporting case information by the Health Units to Ontario Ministry of Health is mandatory for 9 of the 12 fields examined. Table I shows the percentage of missing or unspecified values for each field. There was no duplication of cases.

TABLE I
Number and Percent of Missing or Unspecified Values by Field* for All Cases of Giardiasis Reported in Ontario, 1990-1998 (n=25,289)

RDIS Field	Number Missing	Number Unspecified	Percent Missing or Unspecified
Responsible Health Unit	0	0	0
Episode Date	0	0	0
Disease	0	0	0
Date of Birth	87	2	0.3
Gender	32	9	0.2
Organism/Agent	26	0	0.1
Postal Code	710	0	2.8
Outbreak Associated	906	1135	8.1
Risk Setting	2799	9318	47.9
Symptoms	13,864	1141	59.3
Probable Source	2117	14,825	67.0
Hospitalization	18,305	226	73.3

* Fields in bold are mandatory for submission to the Ontario Ministry of Health

Descriptive analysis

The Ontario provincial mean annual age- and sex-adjusted incidence of giardiasis was 25.8 cases per 100,000 population, for the study period. Figure 1 shows the mean annual age- and sex-adjusted giardiasis incidence rates per 100,000 population for Ontario's 49 census divisions. Areas of highest incidence were around Lake Huron and Georgian Bay, including Manitoulin District, Bruce County, Parry Sound, Nipissing District and Victoria County. Overall, 3,353 cases (13.9%) were classified as rural, which was significantly lower

than expected (17%) based on the Ontario population ($p < 0.01$; 95% CI 0.13, 0.14). The proportion of males among urban cases was 54.7%, significantly greater than the expected 49.3% ($p < 0.01$) based on the Ontario population. The proportion of males among rural cases was 52.1%, again, significantly greater than the expected 49.3% ($p < 0.01$).

Reported cases under 5 and over 59 years of age represented 20.9% and 5.5% of cases, respectively (Figure 2). Children under the age of 5 years had the highest mean annual incidence for both males and

Figure 2. Mean Annual Age- and Sex-Specific Incidence Rates of Giardiasis Reported in Ontario, 1990-1998 (n = 25,186).

and 53.5% were over 25 years of age. Four deaths (0.02%), ranging in age from 54 to 80 years, were reported among cases.

RDIS defines "risk setting" as the place/environment in which the client may have acquired the infection. The most frequently reported risk settings (Table III) were the home (40.1%), travel (39.1%), camping (5.6%), school (3.7%) and day care (3.4%).

The most often reported probable sources of infection (how the client most likely acquired the infection) (Table IV) were water (62.1%), person-to-person transmission (26.5%) and food (10.2%). Of the 5,182 records reporting water as the probable source, untreated water was implicated in 324 cases (6.2%), well water in 288 cases (5.6%) and bottled water in 6 cases (0.1%). Association with an outbreak was reported for 493 (1.9%) cases but only 343 cases specified a source: water (162 cases, 47.2%), person-to-person (146 cases, 42.6%), food (14 cases, 4.1%), and animal contact (1 case, 0.3%).

The number of cases occurring between July and October inclusive (40.3%) was significantly higher than expected (33.0%) assuming no seasonal variation ($p=0.01$; 95% CI 0.40, 0.41). During the study period, August had the largest number of cases reported, followed by September. The total number of cases per month for the study period is shown in Figure 3.

A least squares analysis showed the incidence of infection decreased by 1.94 cases per 100,000 per year during the study ($p<0.01$). Figure 4 shows a declining incidence over time from 1991 to 1998.

DISCUSSION

This study confirms that giardiasis is a significant disease in Ontario, however, the incidence appears to have been declining since 1991 (Figure 4). Of the 9 mandatory reporting fields in RDIS, 7 had less than 3% of data missing. Outbreak association information was missing 8% of the time. The risk setting, missing 48% of the time, is a subjective investigator estimation of the possible setting for *Giardia* contact. The significance of some findings must be carefully weighed due to the subjective assignment of some criteria. Further stud-

TABLE II
Frequency Distribution of Reported Symptoms Associated with Giardiasis Cases Reported in Ontario, 1990-1998 (n=15,828, up to three symptoms were allowed per case)

Symptom	Number	Percent
Loose Stools	5736	36.2
Cramps	2241	14.2
Watery Diarrhea	2186	13.8
Abdominal Pain	2091	13.2
Nausea and/or Vomiting	1478	9.3
Fever	446	2.8
Weight Loss	410	2.6
Fatigue	315	2.0
Bloody Diarrhea	247	1.6
Malaise	223	1.4
Anorexia	112	0.7
Other	343	2.1

TABLE III
Frequency Distribution of Reported Risk Settings for Giardiasis Cases Reported in Ontario, 1990-1998 (n=13,158)

Risk Setting	Number	Percent
Home	5279	40.1
Travel	5142	39.1
Camping	733	5.6
School	486	3.7
Day Care	443	3.4
Workplace	404	3.1
Other	671	5.1

TABLE IV
Frequency Distribution of Reported Probable Sources of Infection for Giardiasis Cases Reported in Ontario, 1990-1998 (n=8,347)

Probable Source	Number	Percent
Water	5182	62.1
Person-to-person	2211	26.5
Food	854	10.2
Animal Contact	74	0.9
Sexual Contact	26	0.3

324 cases (1.3%) under 12 months and 1,876 cases (7.4%) under 24 months of age.

The proportion of male cases observed (54.2%) was significantly higher than expected (49.3%) based on the Ontario population ($p<0.01$; 95% CI 0.54, 0.55). Males had a higher mean annual incidence than females for all age groups (Figure 2). Cases reporting male homosexual activity (n=107) represented 8.1% of male cases in the 15 to 59 age groups for whom there was a specific source of infection reported. The median age of these individuals was 34 years (range 19-51 years).

The most frequently reported symptoms were loose stools (36.2%), cramps (14.2%) and watery diarrhea (13.8%) (Table II). Of the 25,289 cases examined, 310 (1.2%) were hospitalized as in-patients. Of those hospitalized, 27.8% were under 5 years of age, 17.7% between 5 and 25 years of age

females (82.7 cases and 71.9 cases per 100,000, respectively). There were 65 reported cases (0.3%) under 6 months,

ies are necessary to identify specific risk factors.

Reported incidence rates are probably substantial underestimates of the actual incidence of giardiasis in Ontario due to under-reporting and asymptomatic infection.^{1,17} If, like *Salmonella*, the reporting rates are 1-5% of the actual number of cases,¹⁸ there may be as many as 297,927 *Giardia* cases annually in Ontario. True incidence of *Giardia* infection and morbidity in Ontario is impossible to calculate due to the absence of routine testing, non-specific symptoms and poor sensitivity of laboratory diagnostic techniques.^{7,19}

Differences noted in disease incidence among Ontario's 49 census divisions may be due to environmental factors (Figure 1). Overall, the greatest proportion of cases were in urban areas but spatial analysis demonstrated the highest incidence rates were around Lake Huron and Georgian Bay. The increased rates in these rural areas may represent increased child contact with young farm animals, contaminated well water or increased use of recreational water sources compared to urban residents. Increased awareness, reporting and access to health services in urban areas may account for larger numbers of cases reported in those areas.

The observed age distribution (Figure 1) is typical of an organism spread via the fecal-oral route.^{7,20,21} The large proportion of cases under the age of 5 likely results from person-to-person contact and from lack of immunity. Elevated rates of infection were observed for both sexes in the 20-39 year age group.

The higher infection rate for male children is unexplained but has been noted in studies of *Giardia* and *Campylobacter*.²⁰ Males had higher incidence rates in all age groups. Being male may be a surrogate measure for an unidentified host- or environment-related risk factor.

The frequency of reported symptoms (Table II) was consistent with the literature.^{1,7}

The home was the most frequently reported risk setting. Risks at home could include contaminated water, person-to-person contact or a common exposure to an unidentified source. Travel was reported for 39.1% of cases with risk settings recorded. Analysis shows camping and day

Figure 3. Mean Number of Cases of Giardiasis in Ontario Reported by Month, 1990-1998 (n = 25,238).

Figure 4. Number of Cases and Incidence per 100,000, of Giardiasis in Ontario by Year, 1990-1998 (25,289).

care situations appear to be less important risk settings for giardiasis in Ontario.

Probable sources of infection identified in Ontario reflect those known for giardiasis in North America.^{20,22} Although water was the most frequently reported probable source of infection (62.1%), it was impossible to determine the specific water source from the data. Person-to-person transmission was reported in 26.5% of cases. A study of verocytotoxigenic *E. coli* cases reported person-to-person contact as the second most common source of infection.¹³ Oro-anal sexual contact is an important identified risk factor for giardia-

sis.²³ Homosexual activity was reported for 8.1% of male cases 15-59 years of age for whom the specific source of infection was listed as person-to-person. Food was identified as the probable source of infection in 10.2% of cases reporting a specific source.

There was a statistically significant seasonal pattern in reported giardiasis cases in Ontario (Figure 3) agreeing with other studies.^{7,24} This could result from increased use of recreational water or increased contact with infected small children during summer holidays.^{19,21}

Differential reporting, differences in methods of data collection among Health

Units, missing values, and reporting of known risk factors, may have been sources of potential bias in this study.

The results of this study suggest that the incidence of giardiasis is comparable to that for salmonellosis in Ontario and the incidence rate appears to be declining. GIS demonstrated that areas with the highest incidence of infection were around Lake Huron and Georgian Bay. There is increased risk of giardiasis among males, those under 5 years of age, and urban residents. A seasonal pattern of infection was observed, peaking in mid-summer and early fall. The sources of *Giardia* infection most often identified were contaminated water and person-to-person transmission. This study is the first to use spatial analysis to report the distribution of giardiasis in Ontario and is a precursor to the demonstration of the usefulness of GIS to clarify the importance of water as a risk factor for giardiasis as well as other enteric infections.

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