*Epidemiol. Infect.* (2004), **132**, 607–617. 
DOI: 10.1017/S0950268804002353 Printed in the United Kingdom

# Magnitude and distribution of acute, self-reported gastrointestinal illness in a Canadian community

S. E. MAJOWICZ[1,2]*, K. DORÉ[1,2], J. A. FLINT[2], V. L. EDGE[1,2], S. READ[3], M. C. BUFFETT[4,5], S. McEWEN[1], W. B. McNAB[1,6], D. STACEY[7], P. SOCKETT[1,2] AND J. B. WILSON[1,2]

[1] *Department of Population Medicine, University of Guelph, Guelph, Ontario, Canada*
[2] *Foodborne, Waterborne and Zoonotic Infections Division, Health Canada, Guelph and Ottawa, Ontario, Canada*
[3] *Laboratory for Foodborne Zoonoses, Health Canada, Guelph, Ontario, Canada*
[4] *Social and Public Health Services Department, City of Hamilton, Hamilton, Ontario, Canada*
[5] *Faculty of Health Sciences, McMaster University, Hamilton, Ontario, Canada*
[6] *Innovation and Risk Management Branch, Ontario Ministry of Agriculture and Food, Guelph, Ontario, Canada*
[7] *Department of Computer and Information Science, University of Guelph, Guelph, Ontario, Canada*

(*Accepted 3 March 2004*)

## SUMMARY

To estimate the magnitude and distribution of self-reported, acute gastrointestinal illness in a Canadian-based population, we conducted a retrospective, cross-sectional telephone survey of approximately 3500 randomly selected residents of the city of Hamilton (Ontario, Canada) from February 2001 to February 2002. The observed monthly prevalence was 10% (95% CI 9·94–10·14) and the incidence rate was 1·3 (95% CI 1·1–1·4) episodes per person-year; this is within the range of estimates from other developed countries. The prevalence was higher in females and in those aged <10 years and 20–24 years. Overall, prevalence peaked in April and October, but a different temporal distribution was observed for those aged <10 years. Although these data were derived from one community, they demonstrate that the epidemiology of acute gastrointestinal illness in a Canadian-based population is similar to that reported for other developed countries.

## INTRODUCTION

Waterborne, foodborne and enteric diseases remain important public health issues around the world. Mortality associated with gastrointestinal illness in developing countries is high [1, 2] and although such illness in developed countries is characteristically self-limiting and mild, the associated morbidity and economic impact are significant [3–6]. Although there have been several studies internationally of acute gastrointestinal illness in the general population [3, 7–10], such studies in Canadians have been restricted to specific pathogens or subsets of the population, or have relied on passive surveillance information [11–17]. It is well recognized that under-reporting is a major limiting factor in passive surveillance, and representative population-based studies are one way to obtain more accurate estimates of the magnitude, burden, and distribution of a disease [18].

In 2000, Health Canada began developing the National Studies on Acute Gastrointestinal Illness (NSAGI) initiative, a multi-faceted project designed to address recognized gaps in the understanding of enteric disease in Canada. One of the components

* Address for correspondence: Ms. S. E. Majowicz, Health Canada, 160 Research Lane, Suite 206, Guelph, Ontario, Canada, N1G 5B2.

of NSAGI is a population-based survey aimed at describing self-reported, acute gastrointestinal illness in the population. In March 2002, Health Canada completed the first phase of the population survey in the city of Hamilton, Ontario, Canada. The objective of the study presented here was to estimate the magnitude and distribution of self-reported, acute gastrointestinal illness in this population.

## METHODS

### Study design

The study was a retrospective, cross-sectional telephone survey of randomly selected residents of Hamilton (Ontario, Canada), administered from February 2001 to February 2002. Hamilton has a diverse population of approximately 500 000, and is a large urban centre surrounded by suburban and rural areas.

Interviews were conducted by trained interviewers at the Centre for Evaluation of Medicines (St. Joseph's Hospital, Hamilton). Using a randomized list of residential telephone numbers, one individual from each household was randomly selected to participate by identifying the individual in the household with the next birthday. Initial contact with a household member was attempted up to five times, on different days and at different times of the day. Once a randomly selected individual at a given residential telephone number was identified, up to five attempts were made to contact that individual to complete the survey. Proxy respondents were used for all individuals aged $<12$ years, and for individuals aged 12–18 years, at the discretion of the parent or guardian. Surveys were administered in English.

The target sample size of 3434 interviews was calculated to detect a prevalence of 10% in a population of 500 000, with a 1% allowable error and a 95% confidence (Epi-Info, version 6.04). Interviews were conducted over 12 months, with an equal number completed each month.

The survey was developed by modifying existing, validated questionnaires [7–9] and was pre-tested by conducting mock interviews with a convenience sample of 21 individuals until no new changes were required to either the survey tool or the methodology. To identify those individuals with self-reported acute gastrointestinal illness, respondents were asked if they experienced any vomiting or diarrhoea in the 28 days prior to the interview, where diarrhoea was defined as loose stool or stool with abnormal liquidity. This case definition did not exclude individuals who reported causes other than gastrointestinal illness, such as vomiting possibly due to excess alcohol intake. A broad case definition was deliberately chosen to ensure high sensitivity and case capture. Additional questions explored secondary symptoms, severity of illness, medical history including chronic and non-infectious causes of gastrointestinal symptoms, number of days of school or work missed, health-care use, medications taken, and self-reported causes of illness. The study was approved by the Research Ethics Board of St. Joseph's Hospital and McMaster University (Hamilton, Ontario, Canada), and the Human Subjects Committee of the University of Guelph (Guelph, Ontario, Canada).

### Analysis

Data were analysed in Microsoft Excel 2000 (Microsoft Corporation, Redmond, WA, USA) and SAS version 8.01 (SAS Institute Inc., Cary, NC, USA). Individuals responding 'don't know/not sure' or 'refused' to any question were excluded from the analysis of that question. The Hamilton population from the 1996 Canadian Census, and the 2001 Canadian Census where available (Statistics Canada) were used to calculate expected population characteristics.

Differences between two proportions were tested using Fisher's exact test, and differences between medians were tested using the Median test in SAS [19]. The null hypothesis of no association between prevalence of disease and age group, cultural group, total household income level, and highest education level was tested using the $\chi^2$ test.

A geographical variable corresponding to the Statistics Canada urban/rural area classification was linked to each respondent via their reported residential postal code using a commercial database (Enhanced Postal Code Conversion File, Desktop Mapping Technologies, Inc., Markham, Ontario, Canada). Urban areas are defined by Statistics Canada as areas with a minimum population of 1000 persons and a population density of at least 400 persons/km$^2$; all other areas are defined as rural.

The primary outcome measure of monthly prevalence was defined as the number of respondents reporting acute gastrointestinal illness in the previous 28 days divided by the total number of respondents. Incidence rates and incidence proportions were calculated using the terminology and formulae outlined by Rothman and Greenland [20]; to summarize, the term incidence rate refers to an incidence density rate, and the term incidence proportion refers to a cumulative incidence rate. These measures were adjusted to account for the following: due to the wording of the questionnaire, respondents reporting a disease event during the 28-day observation period either (*a*) developed the illness event during the 28-day period and thus represented incident cases, or (*b*) developed the illness event prior to the 28-day observation period, were still ill at the start of the observation period, and thus represented existing cases which should be excluded from any incidence measures. The status of ill respondents was unknown with respect to when their disease event began relative to the 28-day observation period. Thus, the average duration of illness ($x$) was used to calculate the likely proportion of existing cases, under the assumption that cases occurred equally throughout the 28-day period, using the formula: $[x-1]/[28+(x-1)]$. Incidence measures were adjusted by subtracting this proportion from both the number of cases and the initial number at risk.

## RESULTS

### Response rate and representativeness of respondents

Of the 9543 individuals contacted to participate in this survey, 63·4% ($n=6047$) refused to participate, yielding a response rate of 36·6%. The demographic profiles of survey respondents and Hamilton residents (Table 1) show that overall, respondents were older than the Census population, had a higher total household income, were slightly more rural, had a higher education level, and were more likely to be female.

### Magnitude of illness

Of the 3496 respondents, 428 (12%) reported an illness that included vomiting or diarrhoea in the preceding 28 days. Of these 428, 77 (18%) stated their symptoms were due to a pre-existing condition such as Crohn's disease, irritable bowel syndrome, lactose intolerance and pregnancy that had been diagnosed by a doctor. Since the objective of the study was to describe acute gastrointestinal illness, these 77 respondents were included in the non-case group. Of the 351 cases of acute gastrointestinal illness, 132 (38%) reported more than one episode in the 28 days prior to the interview; for these respondents, the following results relate to their most recent experience of gastrointestinal illness.

The period prevalence of self-reported acute gastrointestinal illness in the 28-day period was 10·04% (95% CI 9·94–10·14). Fifty-one cases had vomiting or diarrhoea on the date of the interview, yielding a point prevalence of 1·46%. The unadjusted incidence rate was 1·4 (95% CI 1·2–1·5) episodes of self-reported, acute gastrointestinal illness per person-year, and the unadjusted annual incidence proportion was 0·75. The average duration of approximately 4 days was used to determine that the likely proportion of existing cases was 9·68%. Thus, the adjusted incidence rate was 1·3 (95% CI 1·1–1·4) episodes per person-year and the adjusted annual incidence proportion was 0·71.

### Distribution

The monthly prevalence of illness per demographic category is shown in Table 1. There were significantly more female cases than males ($P=0{\cdot}0241$). Overall, cases were significantly younger than non-cases, with median ages of 39 and 43 years respectively ($P=0{\cdot}0017$). The prevalence peaked in age groups 0–9 and 20–24 years. The prevalence was marginally higher for females than males aged 0–9 years ($P=0{\cdot}0637$; Fig. 1), and significantly higher for females than males aged 25–64 years ($P=0{\cdot}0082$).

Prevalence of illness (Fig. 2) involving only vomiting peaked in those aged 0–9 years, with a small increase in those aged 20–24 years. Prevalence of illness involving both vomiting and diarrhoea followed a similar pattern, with clear peaks in age groups 0–9 and 20–24 years. Prevalence of illness involving only diarrhoea peaked in age groups 0–9 and 20–24 years; an increase was also seen in those aged over 84 years.

Overall, prevalence was significantly associated with cultural group ($P=0{\cdot}0195$), marginally associated with total household income ($P=0{\cdot}0700$), and not associated with highest level of education attained ($P=0{\cdot}3442$, Table 1). The urban/rural distribution was not significantly different for cases *vs.* non-cases ($P=0{\cdot}2816$). The median number of people residing in the household was the same for cases and non-cases (median 2 people, $P=0{\cdot}4459$).

The prevalence by study month peaked in April and October (Fig. 3). For those aged 25 years and older, the 3-month moving average prevalence peaked in

Table 1. *Demographic comparison showing per cent of residents and survey respondents per category (except where noted) and monthly prevalence of acute, self-reported gastrointestinal illness per category, in the city of Hamilton, Ontario, Canada, February 2001 to February 2002*

| | Hamilton residents ($n$=490 268) | Survey respondents ($n$=3496) | Monthly prevalence (%) | 95% CI (%) |
|---|---|---|---|---|
| Sex | | | | |
| Male | 49 | 41 | 9* | (8–11) |
| Female | 51 | 59 | 12* | (10–13) |
| Age (years) | | | | |
| Mean | — | 43 | — | — |
| Median | 38 | 43 | — | — |
| 0–9 | 12 | 8 | 16* | (11–20) |
| 10–14 | 7 | 4 | 7 | (3–13) |
| 15–19 | 7 | 4 | 11 | (7–18) |
| 20–24 | 7 | 5 | 18* | (12–25) |
| 25–64 | 53 | 60 | 11 | (10–13) |
| 65–69 | 4 | 7 | 6* | (3–10) |
| 70–74 | 4 | 5 | 4* | (2–8) |
| 75–84 | 5 | 6 | 5 | (2–9) |
| >84 | 1 | 1 | 7 | (1–18) |
| Cultural group† | | | | |
| North American | — | 80 | 11* | (10–12) |
| European | — | 12 | 7* | (5–10) |
| African | — | 2 | 3 | (1–12) |
| Mediterranean | — | 2 | 7 | (2–16) |
| Asian | — | 3 | 4 | (1–11) |
| Native North American/Aboriginal | — | <1 | 22 | (6–48) |
| South American | — | <1 | 14 | (2–43) |
| Austral-asian | — | <1 | 11 | (1–33) |
| Total household income | | | | |
| <\$20 000 | 24 | 16 | 15* | (12–16) |
| >\$20 000 to <\$40 000 | 25 | 22 | 10 | (8–13) |
| >\$40 000 to <\$60 000 | 20 | 25 | 11 | (9–14) |
| >\$60 000 to <\$80 000 | 15 | 17 | 12 | (9–16) |
| >\$80 000 | 16 | 20 | 9 | (7–12) |
| Education‡ | | | | |
| No high school diploma | 35 | 20 | 9 | (7–11) |
| High school diploma | 28 | 41 | 11 | (9–13) |
| College or trade diploma | 26 | 18 | 10 | (8–13) |
| University, graduate, or professional degree | 11 | 21 | 9 | (7–12) |
| Location | | | | |
| Urban | 91 | 90 | 10 | (9–12) |
| Rural | 9 | 10 | 12 | (9–16) |
| Mean no. people in household | 2·6 | 2·68 | — | — |
| Median no. people in household | — | 2 | — | — |

* Proportion per category significantly different than all other categories combined ($P<0{\cdot}05$).

† Survey respondents reported with which cultural group they most identified. No comparable information was available from the Canadian Census.

‡ Answered for proxy if proxy respondent was used.

April and October, and for those aged 10–24 years, the prevalence peaked in April and November (Fig. 4). However, the temporal pattern was different for those <10 years, and showed no real trend.

**Symptoms and severity**

Of the 351 cases, 14% ($n$=50) experienced vomiting, 66% ($n$=231) diarrhoea, and 20% ($n$=70) both

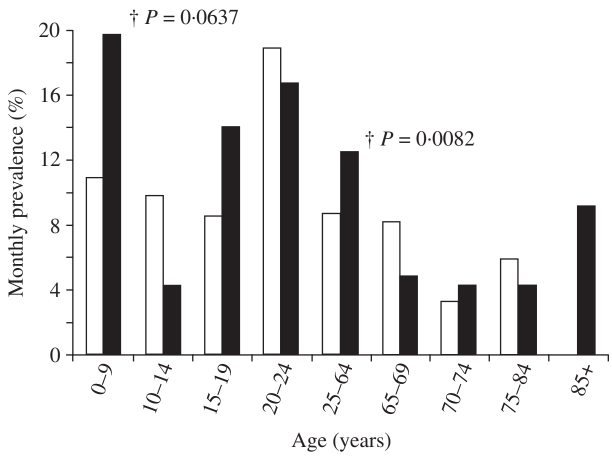


**Fig. 1.** Monthly prevalence of acute gastrointestinal illness, by age and sex, in the city of Hamilton, Ontario, Canada, February 2001 to February 2002 ($n=3496$). †$P<0{\cdot}10$ for the null hypothesis of no association between prevalence and sex, per age group. □, Males; ■, females.

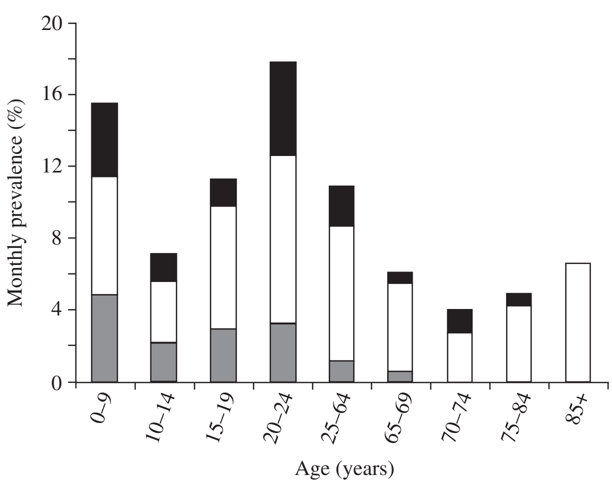


**Fig. 2.** Monthly prevalence of acute gastrointestinal illness, by age and primary symptom, in the city of Hamilton, Ontario, Canada, February 2001 to February 2002 ($n=3496$). ■, Vomiting and diarrhoea; □, diarrhoea only; ■, vomiting only.

vomiting and diarrhoea. For those respondents reporting diarrhoea ($n=301$), approximately 4% ($n=12$) reported blood in their stool, with half reporting 'just a little blood in the toilet or on the toilet paper', and half reporting 'some blood mixed in with the stool'. The most common secondary symptoms experienced were stomach cramps and abdominal pain, fever, and lethargy and extreme tiredness; secondary symptoms experienced and duration of illness are shown in Table 2. Overall, the mean and

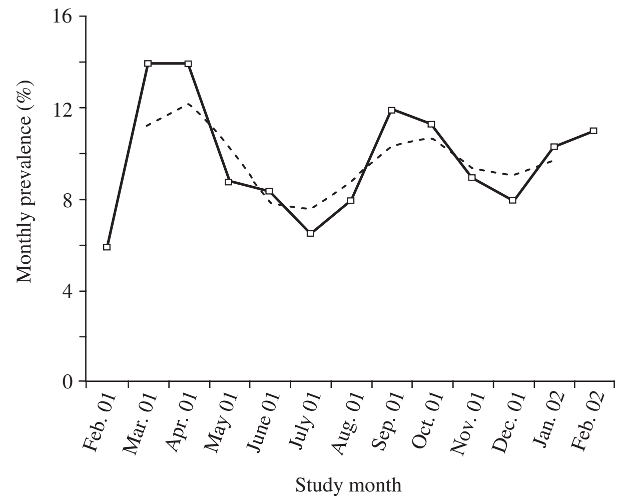


**Fig. 3.** Monthly prevalence (—□—) of acute gastrointestinal illness by study month, with 3-month moving average (-----), in the city of Hamilton, Ontario, Canada, February 2001 to February 2002 ($n=3496$).

median duration of illness were 4·23 days and 2 days respectively, and the duration ranged from 1 to 40 days. The case reporting the longest duration (40 days) was the only individual in the study whose illness was a culture-confirmed enteric infection (campylobacteriosis). Since names and other unique identifiers were not collected in this study, it was not possible to discern if this culture-confirmed case was reported through the routine reporting channels.

Cases were asked how severe their illness was on its worst day in terms of restricting their normal activities (Table 2). On average, cases with diarrhoea reported five loose stools on their worst day (range 1–24), and cases with vomiting reported vomiting three times on their worst day (range 1–24). Overall, respondents with vomiting as a part of their gastrointestinal illness reported more severe activity restrictions than those without. For those who reported their illness restricted their daily activities, the median number of days was 2 days (range $<1$–30, Table 2).

## Predisposing factors

Cases were asked whether they took medications with potential gastrointestinal consequences prior to their illness. Overall, 9% of cases took prescription antibiotics, 3% laxatives, 16% antacids, and 1% immunosuppressive agents in the previous 28 days. The proportion of cases who took laxatives was the same regardless of primary symptom. Prescription

Table 2. *Symptoms, duration, and severity of acute, self-reported gastrointestinal illness, by primary symptom, in the city of Hamilton, Ontario, Canada, February 2001 to February 2002 (n=351)*

| | All cases ($n=351$) | Vomiting only ($n=50$) | Diarrhoea only ($n=231$) | Both vomiting and diarrhoea ($n=70$) |
|---|---|---|---|---|
| Symptoms (per cent of cases) | | | | |
| Nausea | 55 | 80 | 39 | 90 |
| Stomach cramps/abdominal pain | 75 | 50 | 78 | 81 |
| Fever | 33 | 28 | 27 | 59 |
| Chills | 39 | 28 | 32 | 68 |
| Muscle or joint pain/stiffness | 41 | 25 | 40 | 53 |
| Headache | 48 | 47 | 44 | 62 |
| Excessive thirst | 37 | 29 | 35 | 47 |
| Lethargy/extreme tiredness | 67 | 66 | 63 | 83 |
| Sore throat/runny nose | 37 | 32 | 36 | 46 |
| Coughing/sneezing | 31 | 20 | 29 | 44 |
| Other | 4 | 2 | 5 | 1 |
| Duration | | | | |
| Mean duration of illness in days | 4·23 | 2·13 | 3·82 | 5 |
| Median duration of illness in days (range) | 2 (1–40) | 1 (1–15) | 2 (1–40) | 3 (1–37) |
| Median no. times vomiting in 24 h (range) | 3 (1–24) | 2 (1–24) | — | 3 (1–24) |
| Median no. loose stool in 24 h (range) | 5 (1–24) | — | 4 (1–24) | 6 (1–24) |
| Activity restrictions (per cent of cases) | | | | |
| Slightly unwell; able to do all activities | 33 | 27 | 43 | 6 |
| Quite unwell; able to do most activities | 36 | 20 | 31 | 15 |
| Restricted to the home; able to do limited activities | 25 | 31 | 17 | 45 |
| Restricted to the home; unable to do any activities | 15 | 22 | 8 | 34 |
| Hospitalized | 1 | — | 1 | — |
| Median no. of days restricted (range) | 2 (<1–30) | 1 (<1–30) | 2 (<1–28) | 3 (1–28) |

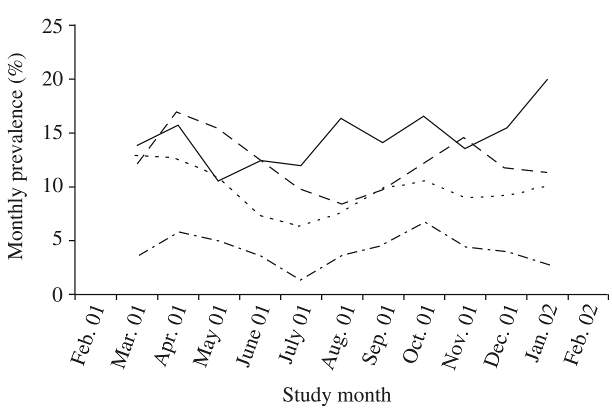


**Fig. 4.** Three-month moving average of monthly prevalence of acute gastrointestinal illness by study month and age group (in years), in the city of Hamilton, Ontario, Canada, February 2001 to February 2002 ($n=3496$). ——, 0–9 years age group; – – –, 10–24 years age group; - - - -, 25–69 years age group; - – - –, 70+ years age group.

antibiotics were taken mainly by age groups 0–9 years (17%), 10–14 years (10%), and ⩾75 years (17%). Antacids were taken mainly by those aged ⩾15 years.

Respondents were asked what they believed was the cause of their illness. The most common reason for illness reported, regardless of age group, was 'stomach flu/intestinal flu/caught a virus'. The second most common reason was 'food poisoning/contaminated food' for those aged 0–9 and 15–74 years, 'milk or lactose intolerance' for those aged 10–14 years, and 'overeating/fatty foods/spicy foods' for those over 74 years. The reason 'overindulgence of drugs or alcohol' was reported for 10% of those aged 15–24 years, and for 2% of those aged 25–74 years. Since these self-reported causes were not diagnosed or determined by a medical professional, they were not used to exclude individuals from the case group.

## DISCUSSION

The incidence rate observed in this study was 1·3 cases of self-reported acute gastrointestinal illness per person-year, and the average probability that an individual developed acute gastrointestinal illness during the year was 71%. Given the study area population of 490 268, the observed monthly prevalence of 10·04% translated into an estimated 49 223 (95% CI 48 733–49 713) cases per month in the city of Hamilton. Although most gastrointestinal illnesses are typically self-limiting and mild, by virtue of its magnitude this estimate represents a potentially significant health burden, especially in light of a recent finding by Helms et al. [21] that bacterial gastrointestinal infections are associated with an increased short-term risk of death, even after pre-existing illnesses are taken into account.

The magnitude of illness reported for this Canadian community is in the range of that reported for other developed countries (Table 3). Estimates of incidence of infectious intestinal disease obtained prospectively tend to be lower than those obtained retrospectively, as demonstrated by Wheeler et al. [9], who found a three-fold difference. This discrepancy is likely a function of recall, with respondents telescoping past illness events into the observation period [9, 29], resulting in overestimates of the true rate of disease. Thus, it is possible that retrospectively obtained rates like those observed here may overestimate the magnitude of illness, potentially by 2–3 times the value.

In the results presented here, the 77 respondents who reported their symptoms were due to a chronic condition were not excluded from the analysis, but were included as part of the denominator, since individuals who truly have chronic conditions are still a part of the population at risk to become cases of acute gastrointestinal illness. There is the potential that this introduces misclassification bias (if these cases are truly acute), but unfortunately it was impossible to determine the true status of these individuals given the study design used. The potential for misclassification exists, however, whether these cases are included (potential to underestimate the prevalence) or excluded (potential to under- or overestimate the prevalence). Thus, including these cases appeared less detrimental in terms of potential to bias results than excluding them.

Several options were considered for the 132 respondents who reported multiple episodes during the 28-day observation period, including (*a*) to consider the multiple episodes to be all part of one greater episode, (*b*) to consider them all as independent episodes, counting only the first episode, and (*c*) to consider them all as independent episodes, counting only the last episode. Given the study design, the third option was used as the most conservative approach, both to avoid any false inflation of either the number of episodes experienced or their duration, and to minimize the potential for recall bias by enumerating the last episode that occurred.

A review of the literature shows considerable variation in the case definitions used [2–4, 7–10, 24, 30, 31], potentially decreasing comparability across studies. Not only do the broader case definitions vary (Table 3), but definitions of specific symptoms within case definitions also vary. For example, diarrhoea is defined as any watery stool [27], two or more loose or liquid stools [24, 27], or three or more loose stools [3, 7, 8] in 24 h. The results presented here used a broad case definition of any vomiting or diarrhoea in the last 28 days, in the absence of any previously diagnosed non-infectious cause. A need for a common, validated case definition has been proposed to increase comparability and ensure greater reproducibility [30]. At the very least, it will be important to examine how different case definitions impact on case classification and the results obtained, especially given that differences in case definitions tend to be disregarded when comparing rates, as in Table 3 and elsewhere [2].

The population distribution of acute gastrointestinal illness observed in this study is similar to that in previously reported studies. In this study, females reported more gastrointestinal illness than males, which is consistent with other studies [23, 24, 32]. Here, a significantly higher rate was observed in women than men in the 25–64 years age group, and this is consistent with previous results from the United States which report more illness in women than men aged 20–40 years [10]. This higher rate has been attributed, in part, to a higher prevalence of functional gastrointestinal disorders in adult women than men [32]. More likely, given that the kitchen serves as a reservoir for many foodborne enteric pathogens [33], the higher rate observed may reflect a higher rate of exposure via food preparation.

An increased prevalence of illness was observed in two age groups. For children under 10 years old, this is consistent with one study from The Netherlands, which reported highest incidences in children and the elderly [24], and with other studies [3, 7, 8, 10, 14]. In the results presented here, the lack of an observed increased rate in the elderly may actually reflect a lower rate in this group, but may also be an artefact of the sampling method, since those with more severe illnesses requiring institutionalization were not

Table 3. *Published rates of gastrointestinal illness in developed countries, by data collection method*

| Country | Study period | Study design | Sample size* | Main components of case definition | Monthly prevalence (except where noted) | Incidence (per person-year) | Ref. |
|---|---|---|---|---|---|---|---|
| Retrospective data collection | | | | | | | |
| Wales | Jan.–Oct. 1992 | Population survey | 1557 individuals | D or V | 7·4% | — | [3] |
| England | 1993–1996 | Population survey | 9776 individuals | D | 6·5% | 0·55 | [9] |
| Multinational† | Oct.–Dec. 1996 | Population survey | 5581 urban adults | D or V | 4·8%‡ (V); 12·0%‡ (D) | — | [22, 23] |
| United States | July 1996–June 1997 | Population survey | 8624 individuals | D | 11% | 1·4 | [7] |
| Prospective data collection | | | | | | | |
| United States | 1965–1971 | Population survey | 850 households | D or V or N or upset stomach | — | 1·2 | [10] |
| Canada | Mar. 1988– June 1989 | Intervention trial | 307§ | D or V or N with abdominal cramps | — | 0·76 | [14] |
| The Netherlands | Mar.–July 1991 | Population survey | 2257 individuals | D or V with at least two additional symptoms | — | 0·63 | [24] |
| England | Oct. 1991–May 1992 | Population survey | 192 individuals | D or V | — | 0·99 | [25] |
| England | 1993–1996 | Population survey | 9776 individuals | D or V | — | 0·194 | [9] |
| Australia | Sep. 1997–Feb. 1999 | Intervention trial | 300§ | D or V or N with abdominal pain | — | 0·82 | [26] |
| Austria | Dec. 1997–May 1998 | Population survey | 6969 children aged 0–4 years | D or V | — | 0·47 | [27] |
| The Netherlands | Dec. 1998–Dec. 1999 | Population survey | 4860 individuals | D or V | — | 0·28 | [8] |
| United States | 1999 | Intervention trial | 39§ | D or V or N with abdominal cramps | — | 3·48 | [28] |

D, diarrhoea; V, vomiting; N, nausea.
* Randomly selected.
† Canada, Italy, Japan, The Netherlands, Switzerland, the United States, Denmark, Finland, Norway, Sweden.
‡ Three-month prevalence.
§ Control-group households.

captured by this survey. A potential explanation for the increased incidence in age group 20–24 years may be lifestyle changes, for example a 'second weaning' type phenomenon where individuals are, for the first time, the primary food preparer and either do not have training in, or are not attentive to, proper food safety, food preparation and hygiene practices.

The results presented here represent preliminary analyses of the association between population determinants and illness, and should not be used to infer causal associations. Unlike previously reported studies, where a higher incidence of gastroenteritis is found in people with a higher education level [7, 8], no initial association between prevalence and education was observed in this study. However, it is possible that true education effects may not have been detected in this univariate analysis. In Canada, income and health are positively associated [34, 35], and low socioeconomic status is associated with poor health despite the existence of universally insured health services [36]. In Australia, low social class is reported as a risk factor for gastrointestinal symptoms [37]. Here, we observed that prevalence was only marginally associated with total household income, and, as with education, it is possible that a true income effect was confounded. In fact, confounding in these results is probable; for example, poverty rates for the study area are known to be higher in women, immigrants and visible minorities, those without a secondary-school certificate, children, seniors, and those in urban areas [38]. Further analyses are needed to explore the complex nature of these relationships in order to examine how population determinants truly relate to disease status.

The temporal distribution of gastrointestinal illness is reported to be bimodal, with bacterial gastroenteritis tending to peak in the summer [16, 39] and viral gastroenteritis in the winter in temperate climates [16, 40, 41]. The results presented here were similar to those previously reported: a bimodal distribution was observed, with peaks in April and October. However, the distribution appeared different for those <10 years, and showed no real trend. This observation may reflect a lack of immunity to various enteric pathogens in children [42], or it may reflect age-specific differences in behaviours, for example a lack of personal hygiene in children, facilitating faecal–oral and person-to-person pathogen spread regardless of seasonal exposures or risks. The discrepancy in the age-specific temporal distributions should be explored in future studies. Furthermore, a future consideration when interpreting temporal patterns will be the impact of climate. As the body of literature examining the temporal and seasonal distribution of enteric diseases with respect to climate trends and events grows [41, 43, 44], it will be important to interpret temporal patterns in light of such results. Unfortunately, since this study collected data for one year and in one location, analysis of the effects of climate trends was not feasible.

Cases were asked to report what they thought caused their illness. Overconsumption of drugs or alcohol was reported for 10% of those aged 15–24 years, and 2% of those aged 25–74 years. If accepted as the true cause of illness, this would explain part of the peak seen in the 15–19 and 20–24 years age groups; however, reducing the incidence by 10% in these groups does not significantly diminish the peak in the age distribution. Interestingly, 17% of cases <10 years and >74 years took prescription antibiotics in the 28 days prior to their illness. Antimicrobial use for unrelated reasons increases the likelihood of infection upon exposure to a foodborne pathogen [45], and it is possible that prior antibiotic use may have precipitated some of the illnesses reported in these individuals. Unfortunately, relative risk measures were not calculated since antibiotic use in non-cases was not assessed by the survey.

Low response rate was the main limitation of this study, and is a limitation typical of such telephone surveys. Non-response in this survey probably related to the nature of the questionnaire, and the fact that the study area is a highly surveyed area, with numerous telephone health surveys conducted each year. Other similar studies report response rates ranging from 27 to 71% [7, 9, 25, 46, 47]. However, it is difficult to compare response rates between studies since they are often calculated differently and since many study-specific factors affect response, including the nature of the sampling method, number of call-backs, and pre-notification procedures [47]. As long as non-respondents are similar to respondents with respect to all potentially confounding characteristics, then non-response may limit selection bias. Since we did not have information on non-respondents, we could only compare respondents to the total Hamilton Census population.

In this study, respondents were older, had a higher total household income, were slightly more rural, and had a higher education level than the Census population. These differences were expected and resulted from the sampling strategy employed. Moreover, selection required a residential telephone number. Thus, the results of this study may not be valid for certain groups excluded from the sampling frame, such as the homeless, those without telephones, and those in long-term care institutions and in prison.

A potentially important source of bias in the estimates presented here was the administration of the survey in English only. However, of the 6047 people who did not participate, only 9% ($n=568$) did so due to language problems. Language would only be an important source of bias if the magnitude and distribution of acute gastrointestinal illness in these individuals were distinct from those who responded. Future surveys should attempt to address this by offering as many of the survey area's major languages as is feasible to avoid this potential source of bias.

This study provides the first Canadian population-based estimates of the magnitude and distribution of acute gastrointestinal illness in the general population. Acute gastrointestinal illness represented a potentially significant health burden in the study community, with higher rates observed in women, and those aged <10 years and between 20 and 24 years. Overall, the temporal distribution was bimodal, peaking in April and October. Although these data were derived from one community, they demonstrate that the epidemiology of acute gastrointestinal illness in a Canadian-based population corresponds closely to that reported from other developed countries. Unfortunately, the lack of an internationally accepted case definition makes comparisons between studies difficult, and further examination of symptom-based case definitions is needed to critically evaluate if and how the use of different definitions significantly impacts the results obtained.

## ACKNOWLEDGEMENTS

The authors thank the staff of the Department of Population Medicine (University of Guelph) and the Division of Enteric, Foodborne, and Waterborne Diseases (Health Canada) for pre-testing the survey, the staff of the Centre for Evaluation of Medicines (St. Joseph's Hospital, Hamilton) for their expert interviewing, and the residents of the city of Hamilton for their participation. This project was funded by Health Canada.

## REFERENCES

1. Bern C, Martines J, de Zoysa I, Glass RI. The magnitude of the global problem of diarrhoeal disease: a ten-year update. Bull World Health Organ 1992; **70**: 705–714.
2. Kosek M, Bern C, Guerrant RL. The global burden of diarrhoeal disease, as estimated from studies published between 1992 and 2000. Bull World Health Organ 2003; **81**: 197–203.
3. Palmer S, Houston H, Lervy B, Ribeiro D, Thomas P. Problems in the diagnosis of foodborne infection in general practice. Epidemiol Infect 1996; **117**: 479–484.
4. Mead PS, Slutsker L, Dietz V, et al. Food-related illness and death in the United States. Emerg Infect Dis 1999; **5**: 607–625.
5. Buzby JC, Roberts T. Economic costs and trade impacts of microbial foodborne illness. World Health Stat Q 1997; **50**: 57–66.
6. Todd ECD. Preliminary estimates of costs of foodborne disease in the United States. J Food Prot 1989; **52**: 595–601.
7. Herikstad H, Yang S, Van Gilder TJ, et al. A population-based estimate of the burden of diarrhoeal illness in the United States: FoodNet, 1996–7. Epidemiol Infect 2002; **129**: 9–17.
8. de Wit MAS, Koopmans MPG, Kortbeek LM, et al. Sensor, a population-based cohort study on gastroenteritidis in the Netherlands, incidence and etiology. Am J Epidemiol 2001; **154**: 666–674.
9. Wheeler JG, Sethi D, Cowden JM, et al. Study of infectious intestinal disease in England: rates in the community, presenting to general practice, and reported to national surveillance. Br Med J 1999; **318**: 1046–1050.
10. Monto AS, Koopman JS. The Tecumseh study. Am J Epidemiol 1980; **112**: 323–333.
11. Brunton J, Hinde D, Langston C, Gross R, Rowe B, Gurwith M. Enterotoxigenic *Escherichia coli* in central Canada. J Clin Microbiol 1980; **11**: 343–348.
12. Gyorkos T. Estimation of parasite prevalence based on submissions to provincial laboratories. Can J Public Health 1983; **74**: 281–284.
13. Gyorkos T, Meerovitch E, Prichard R. Estimates of intestinal parasite prevalence in 1984: report of a 5-year follow-up survey of provincial laboratories. Can J Public Health 1987; **78**: 185–187.
14. Payment P, Richardson L, Siemiatycki J, Dewar R, Edwardes M, Franco E. A randomized trial to evaluate the risk of gastrointestinal disease due to the consumption of drinking water meeting current microbiological standards. Am J Public Health 1991; **81**: 703–708.
15. Gurwith M, Wenman W, Hinde D, Feltham S, Greenberg H. A prospective study of rotavirus infection in infants and young children. J Infect Dis 1981; **144**: 218–224.
16. Gurwith MJ, Williams TW. Gastroenteritis in children: a two-year review in Manitoba. I. Etiology. J Infect Dis 1977; **136**: 239–247.

17. Wilson JB, Clarke RC, Renwick SA, et al. Vero cytotoxigenic *Escherichia coli* infection in dairy farm families. J Infect Dis 1996; **174**: 1021–1027.
18. Sethi D, Wheeler J, Rodrigues LC, Fox S, Roderick P. Investigation of under-ascertainment in epidemiological studies based in general practice. Int J Epidemiol 1999; **28**: 106–112.
19. SAS Institute, Inc. SAS/STAT user's guide, version 6, 4th edn. Cary, North Carolina: SAS Institute, Inc., 1989.
20. Rothman KJ, Greenland S, eds. Modern epidemiology, 2nd edn. Philadelphia, Pennsylvania: Lippincott-Raven Publishers, 1998.
21. Helms M, Vastrup P, Gerner-Smidt P, Molbak K. Short and long term mortality associated with foodborne bacterial gastrointestinal infections: registry based study. Br Med J 2003; **326**: 357–360.
22. Eggleston A, Farup C, Meier R. The Domestic/International Gastroenterology Surveillance Study (DIGEST): design, subjects and methods. Scand J Gastroenterol 1999; **34**: 9–14.
23. Stanghellini V. Three-month prevalence rates of gastrointestinal symptoms and the influence of demographic factors: results from the Domestic/International Gastroentorology Surveillance Study (DIGEST). Scand J Gastroenterol 1999; **34**: 20–28.
24. Hoogenboom-Verdegaal AMM, De Jong JC, During M, Hoogenveen R, Hoekstra JA. Community-based study of the incidence of gastrointestinal diseases in the Netherlands. Epidemiol Infect 1994; **112**: 481–487.
25. Roderick P, Wheeler J, Cowden J, et al. A pilot study of infectious intestinal disease in England. Epidemiol Infect 1995; **114**: 277–288.
26. Hellard ME, Sinclair MI, Forbes AB, Fairley CK. A randomized, blinded, controlled trial investigating the gastrointestinal health effects of drinking water quality. Environ Health Perspect 2001; **109**: 773–778.
27. Frühwirth M, Karmaus W, Moll-Schüler I, Brösl S, Mutz I. A prospective evaluation of community acquired gastroenteritis in paediatric practices: impact and disease burden of rotavirus infection. Arch Dis Child 2001; **84**: 393–397.
28. Colford JM, Rees JR, Wade TJ, et al. Participant blinding and gastrointestinal illness in a randomized, controlled trial of an in-home drinking water intervention. Emerg Infect Dis 2002; **8**: 29–36.
29. Scheaffer R, Mendenhall W, Ott L, eds. Elementary survey sampling, 5th edn. Belmont, California: Wadsworth Publishing Company, 1996.
30. Baqui AH, Black RE, Yunus MD, Hoque ARA, Chowdhury HR, Sack RB. Methodological issues in diarrhoeal diseases epidemiology: definition of diarrhoeal episodes. Int J Epidemiol 1991; **20**: 1057–1063.
31. Herwaldt BL, Arroyave KR, Roberts JK, Juranek DD. A multiyear prospective study of the risk factors for and incidence of diarrheal illness in a cohort of peace corps volunteers in Guatemala. Ann Intern Med 2000; **132**: 982–988.
32. Bytzer P, Talley NJ, Leemon M, Young LJ, Jones MP, Horowitz M. Prevalence of gastrointestinal symptoms associated with diabetes mellitus: a population based survey of 15 000 adults. Arch Intern Med 2001; **161**: 1989–1996.
33. Kagan LJ, Aiello AE, Larson E. The role of the home environment in the transmission of infectious diseases. J Community Health 2002; **27**: 247–267.
34. Humphries KH, van Doorslaer E. Income-related health inequality in Canada. Soc Sci Med 2000; **50**: 663–671.
35. Jerrett M, Eyles J, Cole D. Socioeconomic and environmental covariates of premature mortality in Ontario. Soc Sci Med 1998; **47**: 33–49.
36. Mustard CA, Frohlich N. Socioeconomic status and the health of the population. Med Care 1995; **33** (Suppl): DS43–DS54.
37. Bytzer P, Howell S, Leemon M, Young LJ, Jones MP, Talley NJ. Low socioeconomic class is a risk factor for upper and lower gastrointestinal symptoms: a population based study in 15 000 Australian adults. Gut 2001; **49**: 66–72.
38. Social and Public Health Services Division, Community Planning and Development Division. The urbanization of poverty in Hamilton-Wentworth: preliminary findings. Hamilton, Ontario: Regional Municipality of Hamilton-Wentworth, 1999.
39. Michel P, Wilson JB, Martin SW, Clarke RC, McEwen SA, Gyles CL. Temporal and geographical distributions of reported cases of *Escherichia coli* O157:H7 infection in Ontario. Epidemiol Infect 1999; **122**: 193–200.
40. Mounts AW, Ando T, Koopmans M, Bresee JS, Noel J, Glass RI. Cold weather seasonality of gastroenteritis associated with Norwalk-like viruses. J Infect Dis 2000; **181**: S284–S287.
41. Cook SM, Glass RI, LeBaron CW, Ho MS. Global seasonality of rotavirus infections. Bull World Health Organ 1990; **68**: 171–177.
42. Chin J, ed. Control of communicable diseases manual, 17th edn. Washington, DC: American Public Health Association, 2000.
43. Rodo X, Pascual M, Fuchs G, Faruque AS. ENSO and cholera: a nonstationary link related to climate change. Proc Natl Acad Sci USA 2002; **99**: 12901–12906.
44. Patz JA, Engelberg D, Last J. The effects of changing weather on public health. Annu Rev Public Health 2000; **21**: 271–307.
45. Barza M, Travers K. Excess infections due to antimicrobial resistance: the 'attributable fraction'. Clin Infect Dis 2002; **34**: S126–S130.
46. de Wit MAS, Koopmans MPG, Kortbeek LM, van Leeuwen WJ, Bartelds AIM, van Duynhoven YTHP. Gastroenteritis in sentinel general practices, the Netherlands. Emerg Infect Dis 2001; **1**: 82–91.
47. Tijssen JGP. Representativeness and response rates from the Domestic/International Gastroenterology Surveillance Study (DIGEST). Scand J Gastroenterol 1999; **34**: 15–19.