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Stool submission data to help inform population-level incidence rates of enteric disease in a Canadian community

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SUMMARY

Laboratory-based surveillance data is essential for monitoring trends in the incidence of enteric disease. Current Canadian human enteric surveillance systems report only confirmed cases of human enteric disease and are often unable to capture the number of negative test results. Data from 9116 hospital stool specimens from the Waterloo Region in Canada, with a mixed urban and rural population of about 500 000 were analysed to investigate the use of stool submission data and its role in reporting bias when determining the incidence of enteric disease. The proportion of stool specimens positive for *Campylobacter* spp. was highest in the 15–29 years age group, and in the 5–14 years age group for *Salmonella* spp. and *E. coli* O157:H7. By contrast, the age-specific incidence rates were highest for all three pathogens in the 0–4 years age group which also had the highest stool submission rate. This suggests that variations in age-specific stool submission rates are influencing current interpretation of surveillance data.

Key words: *Campylobacter*, enteric bacteria, *Escherichia coli* O157:H7, *Salmonella*, surveillance.

INTRODUCTION

Foodborne illness due to *Campylobacter* spp., *Salmonella* spp., and *Escherichia coli* O157:H7 persists despite control efforts guided by research and surveillance from government agencies [1]. These three bacterial pathogens account for a considerable amount of the burden of gastrointestinal disease in Canada, representing an estimated annual *per capita* cost of $115 CAD [2, 3]. Determination of the true burden of disease requires laboratory confirmation of community cases, which relies on patients seeking medical attention, physicians requesting stool specimens and specimens being submitted to the laboratory. Under-ascertainment at each step contributes to an underestimate of the true incidence [4]. In Ontario, it is estimated that for every reported case of gastrointestinal illness 313 cases exist in the community [5]. Nationally, for every case of *E. coli* O157:H7, it is estimated that there are 20·1 cases in the community. Similarly, estimates for *Salmonella* spp. and *Campylobacter* spp. infections suggest that there are 26·1 cases and 27·2 cases, respectively, for every

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reported community case [6]. Although surveillance systems are subject to reporting bias, which may cause an underestimation of the true burden of enteric disease, these systems can also be subject to sampling bias. Considerable variation in age group sampling rates may influence how surveillance data and incidence rates are interpreted, while providing insight into stool testing behaviours [7].

C-EnterNet is an integrated enteric pathogen surveillance system that is coordinated by the Public Health Agency of Canada [8]. It was launched in 2005 to aid in capturing the true burden of enteric disease, and to inform food and water policy development and evaluation. C-EnterNet builds on existing passive reporting systems using a sentinel site surveillance model that collects information on both cases of infectious gastrointestinal illness and sources of exposure within defined communities. These data provide valuable information including estimates of disease incidence, age groups at risk of disease and seasonal disease trends [8]. However, data routinely collected by C-EnterNet and other Canadian surveillance systems for enteric disease do not capture the number of laboratory tests performed (stool submission data), which can be used to calculate the proportion of positive test results. The analysis of only laboratory-confirmed cases may identify real changes in disease trends; however, these trends may also be influenced by changes in stool submission rates [7]. Capturing stool submission data, rather than relying on absolute counts, is one way to evaluate trends in stool submissions [9].

The purpose of this study was to evaluate the influence of stool submissions (and potential age and season effects) on the reported incidence of human cases of *Campylobacter* spp., *Salmonella spp. and E. coli* O157:H7 in the Region of Waterloo (ROW), over the 6-year study period. We evaluated the effect of season, age, patient status and hospital site on the incidence rates, using absolute counts, and the proportion of positive tests for the three enteric pathogens, using stool submission data collected from one laboratory within a C-EnterNet sentinel site.

MATERIAL AND METHODS

Sentinel site surveillance system

The ROW is located in southwestern Ontario, Canada. It is composed of three urban municipalities (Kitchener, Cambridge, Waterloo) and four rural townships (North Dumfries, Wellesley, Wilmot, Woolwich), with a total population of about 500000 [10]. The region is served by three hospitals, all of which send stool submissions to the Waterloo Wellington Regional Microbiology Laboratory (WWRML) for culture and sensitivity testing. The WWRML follows a common standard operating procedure when testing stool specimens [11]. Each sample is tested for *Campylobacter* spp., *Salmonella* spp., *E. coli* O157:H7, *Yersinia* and *Shigella.*

The data, for years 2006–2011, included the following information: sample date (including year, month, day and time); hospital site of sample collection (three different sites); test result details (including species); and the age and gender of the patient (Table 1). Patient status (inpatient *vs.* outpatient) was only available for data obtained from one hospital site. Unique specimen numbers and patient identification information were removed from the dataset by the WWRML and were unknown to the researchers. All rejected and duplicate specimens, defined as specimens with identical patient age and gender and date and time of sample collection, were removed from the dataset.

A culture was considered positive if the presence of *Salmonella* spp., *Campylobacter* spp., or *E. coli* O157:H7 was confirmed.

Data analysis

Season-specific and age-specific population incidence, for each of the three pathogens, was calculated based on the number of positive specimens detected per 100 000 people during the 6-year study period. The proportion positive (sample yield) for each of the three pathogens was also calculated and was defined as the number of positive stool specimens per 100 stool specimens tested during the 6-year study period. The OpenEpi proportion calculator (http://www.openepi.com/oe2.3/menu/openepimenu.htm) was used to calculate Fisher's exact 95% confidence limits for the binomial proportions.

The χ^2 goodness-of-fit test was used (http://graphpad.com/quickcalcs/chisquared1.cfm) to compare seasonal prevalence, and the similarities in age-group distributions in the study population *vs.* the Waterloo region, based on ROW population data [14].

RESULTS

Descriptive results

Campylobacter spp. positive stool sample submissions to WWRML represent 45% (259/573) of all positive stool

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Table 1. *Age, gender, season, year, hospital site and patient status distribution of stool sample submissions and of positive* Campylobacter *spp.,* Salmonella *spp. and* E. coli *O157:H7 stool sample submissions between 2006 and 2011 to the Waterloo Regional Microbiology Laboratory*

		No. (%) positive stool specimens†		
Predictor	No (%) of observations*	*Campylobacter* ($n = 259$)	*Salmonella* ($n = 233$)	*E. coli* O157:H7 ($n = 81$)
Age (years)				
0–4	1098 (12·1)	26 (10·0)	39 (16·7)	12 (14·8)
5–14	556 (6·1)	24 (9·3)	39 (16·7)	20 (24·7)
15–29	1261 (13·8)	69 (26·6)	59 (25·3)	19 (23·5)
30–44	1241 (13·6)	50 (19·3)	42 (18·1)	8 (9·9)
45–59	1379 (15·1)	37 (14·3)	31 (13·3)	10 (12·3)
⩾60	3581 (39·3)	53 (20·5)	23 (9·9)	12 (14·8)
Gender				
Male	4126 (54·7)	153 (59·1)	109 (46·8)	32 (39·5)
Female	4990 (45·3)	106 (40·9)	124 (53·2)	49 (60·5)
Season				
Spring	2361 (25·9)	39 (15·1)	55 (23·6)	13 (16·0)
Summer	2315 (25·4)	111 (42·9)	76 (32·6)	46 (56·8)
Autumn	2128 (23·3)	85 (32·7)	63 (27·1)	18 (22·2)
Winter	2312 (25·4)	24 (9·3)	39 (16·7)	4 (5·0)
Year				
2006	1589 (17·4)	35 (13·5)	43 (18·5)	29 (35·8)
2007	1777 (19·5)	48 (18·5)	44 (18·8)	12 (14·8)
2008	1525 (16·7)	56 (21·6)	23 (9·9)	6 (7·4)
2009	1495 (16·4)	40 (15·4)	41 (17·6)	11 (13·6)
2010	1360 (14·9)	36 (14·0)	42 (18·0)	12 (14·8)
2011	1370 (15·0)	44 (17·0)	40 (17·2)	11 (13·6)
Site				
Site 1	1753 (19·2)	43 (16·6)	52 (22·3)	11 (13·6)
Site 2	5174 (56·8)	118 (45·6)	126 (54·1)	56 (69·1)
Site 3	2189 (24·0)	98 (37·8)	55 (23·6)	14 (17·3)
Patient status				
Inpatient	2181 (42·2)	12 (10·2)	41 (32·5)	9 (13·8)
Outpatient	2993 (57·8)	106 (89·8)	85 (67·5)	56 (86·2)

* Total number of observations, $n = 9116$.
† Total number of observations, $n = 573$.

samples within the region and study period. *Salmonella* spp., and *E. coli* O157:H7 positive stool sample submissions to WWRML represent 41% (233/573) and 14% (81/573), of all positive samples, respectively.

Over the 6-year study period 573/9116 (6·3%, 95% CI 5·8–6·8) stool specimens tested positive for one of the pathogens of interest. More male patients (54·7%, 95% CI 53·7–55·8) submitted stool specimens than females over the study period. The proportion of positive stool sample submissions for *Campylobacter* spp., *Salmonella* spp. and *E. coli* O157:H7 was 2·8% (95% CI 2·5–3·2), 2·6% (95% CI 2·2–2·9) and 0·9% (95% CI 0·7–1·1), respectively. There was no significant difference observed in yearly stool sample submissions. However, the highest proportion positive results for *Campylobacter* spp. were found in 2008 ($P = 0·0299$) and *E. coli* O157:H7 in 2006 ($P < 0·0001$) (Fig 1.)

Seasonal trends

The incidence rates for *Campylobacter* spp., *Salmonella* spp. and *E. coli* O157:H7 (2·4, 1·7, and 1·0/100 000 person-years, respectively) peaked in the summer months and remained high for the autumn months. This same trend was observed when analysing the proportion positive per 100 specimens for each pathogen.

Age-specific trends

When considering season, stool sample submissions followed an even seasonal distribution in age groups,

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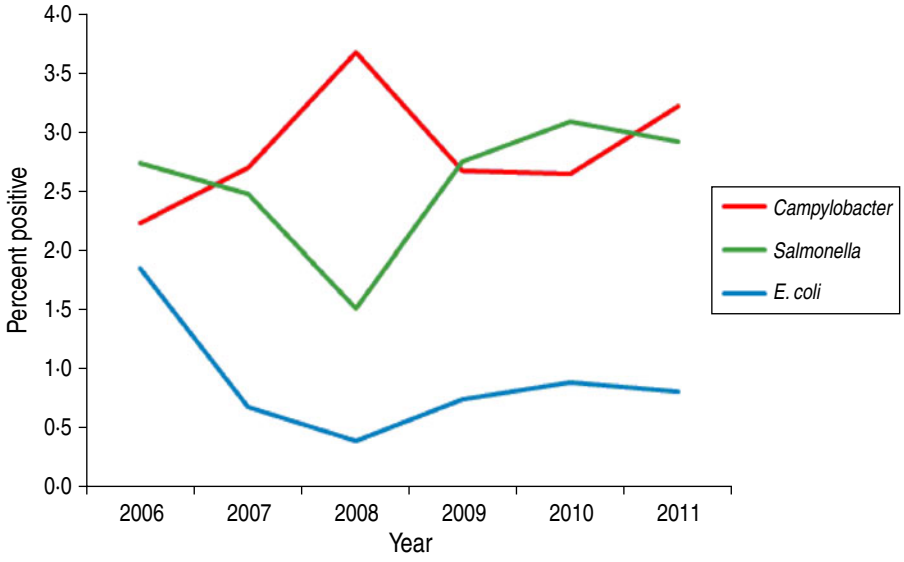

Fig. 1. Distribution of *Campylobacter* spp., *Salmonella* spp. and *E. coli* O157:H7 positive stool specimens from the Grand River Hospital Regional Microbiology Laboratory between 2005 and 2011 by year.

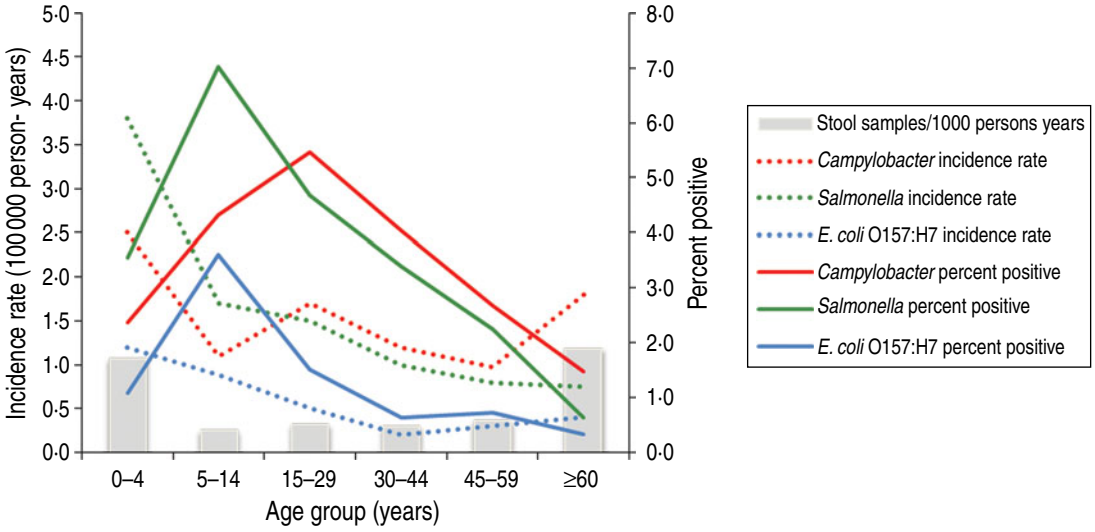

Fig. 2. Age-specific trends in *Campylobacter* spp., *Salmonella* spp. and *E. coli* O157:H7 positive stool specimens submitted to the Waterloo Regional Microbiology Laboratory between 2006 and 2011.

except in the 0–4 and 5–14 years age groups. Children aged 0–4 years had a significant increase in stool sample submissions in spring ($P < 0{\cdot}0001$), whereas those aged 5–14 years submitted more specimens in summer ($P = 0{\cdot}0061$).

Throughout the study period, age-specific adjusted stool sample submissions ranged from 0.25/1000 person-years in those aged 5–14 years to 1.2/1000 person-years in adults aged $\geqslant 60$ years (Fig. 2). The age-specific stool sample submissions followed a dissimilar age distribution to the census population data for ROW ($P < 0{\cdot}0001$) (Table 2). A comparison between the age group distribution of ROW population data and the age group distribution of stool sample submissions illustrates that children aged 0–4 years and adults aged $\geqslant 60$ years submit stool specimens 2·2 and 2·4 times their population proportion, respectively (Table 2).

By examining the data as incidence rates, and only considering the number of positive stool specimens per 100 000 for all three pathogens, the rates were highest in the 0–4 years age group (Fig. 2). The

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Table 2. *Age-specific population distribution in the Region of Waterloo (ROW), compared with the age-specific distribution of stool sample submissions to the Waterloo Regional Microbiology Laboratory between 2006 and 2011*

Age (years)	ROW population distribution (%)	Stool specimen submission distribution (%)	Proportion of specimens compared to the population distribution
0–4	5·6	12·0	2·2
5–14	12·3	6·1	0·5
15–29	21·7	13·8	0·6
30–44	22·9	13·6	0·6
45–59	20·9	15·1	0·7
⩾60	16·5	39·3	2·4

highest proportion of *Campylobacter* spp.-positive stool specimens was in the 15–29 years age group (5·5%, 95% CI 4·3–6·8), whereas the highest proportion of *Salmonella* spp. and *E. coli* O157:H7 positive stool specimens was seen in the 5–14 years age group [7·0% (95% CI 5·1–9·4) and 3·6% (95% CI 2·2–5·4), respectively] (Fig. 2).

Hospital site

Stool submissions in hospital site one followed an even seasonal distribution over the 6-year study period. However, in hospital site 2, a significant increase in stool sample submissions occurred in winter (P = 0·0237). Conversely, in hospital site 3, the majority of stool submissions occurred in the summer months (P = 0·0020). The seasonal trends for positive stool specimens for each of the three study pathogens remained consistent for the three hospital sites.

The proportion of positive stool specimens for *Campylobacter* spp. was 2·5% (95% CI 1·8–3·3) and 2·3% (95% CI 1·9-2-7) in hospital sites 1 and 2, respectively. By contrast 4·5% (95% CI 3·7–5·4) of stool specimens tested positive for *Campylobacter* spp. at hospital site 3. Of the 4·5% of specimens testing positive for *Campylobacter* spp., 33·7% (95% CI 11·6–62·3) were aged between 15 and 29 years. The proportion of stool specimens testing positive for *E. coli* O157:H7 and *Salmonella* spp. was consistent across hospital sites.

Patient status

Data were only available from hospital site 2 for inpatient and outpatient status of stool submissions. An outpatient is defined as a person submitting a stool sample upon consultation with an emergency room physician. An inpatient is defined as a person admitted to hospital. There were 5174 stool specimens collected at site 2 during the study period, of which 2993 were collected from outpatients (57·8%, 95% CI 56·9–59·2) (Table 1). Of the outpatient specimens collected 247/2993 (8·3%, 95% CI 7·3–9·3) stool specimens tested positive for one of the pathogens of interest, compared to only 62/2181 (2·8%, 95% CI 2·2–3·6) inpatient stool specimens (Table 1) The proportion of positive outpatient stool specimens for *Campylobacter* spp., *Salmonella* spp. and *E. coli* O157:H7 was 3·5% (95% CI 2·9–4·3), 2·8% (95% CI 2·3–3·5), and 1·9% (95% CI 1·3–2·4), respectively. The proportion of positive inpatient stool specimens for each of the three pathogens was 0·6% (95% CI 0·3–0·6), 1·9% (95% CI 1·4–2·5), and 0·4% (95% CI 0·2–0·8), respectively.

Children aged 0–4 years submitted the largest proportion of stool specimens for both inpatients and outpatients (0·35 and 0·42/1000 person-years, respectively) (Fig 3). The lowest incidence rate of inpatient stool sample submissions was from patients aged 15–29 years, whereas patients aged 5–14 years submitted the lowest rate of outpatient specimens (0·04 and 0·09/1000 person years, respectively). In both inpatients and outpatients the age-specific adjusted incidence rates of *Campylobacter* spp., *Salmonella* spp. and *E. coli* O157:H7 were highest in children aged 0–4 years. Conversely, the highest proportion of *Campylobacter* spp., *Salmonella* spp. and *E. coli* O157:H7 positive stool specimens, for both inpatients and outpatients were from patients aged 5–14 years (Fig. 3). The percent positive inpatient stool specimens for *E. coli* O157:H7 and *Campylobacter* spp. were identical except for patients aged ⩾60 years. Overall both inpatients and outpatients followed similar age-specific trends, the incidence rates and the percent of specimens positive for one of the study pathogens were much lower for inpatients. The only exception to this trend was observed for *Salmonella* spp.; inpatient specimens in the 0–4 years age group reported similar incidence rates and percent positive results to those reported in outpatients in the same age group.

DISCUSSION

Collecting stool submission data illustrates that patients aged 0–4 and ⩾60 years submit stool specimens more frequently for enteric pathogen testing, while those in age groups 5–14 and 15–29 years are

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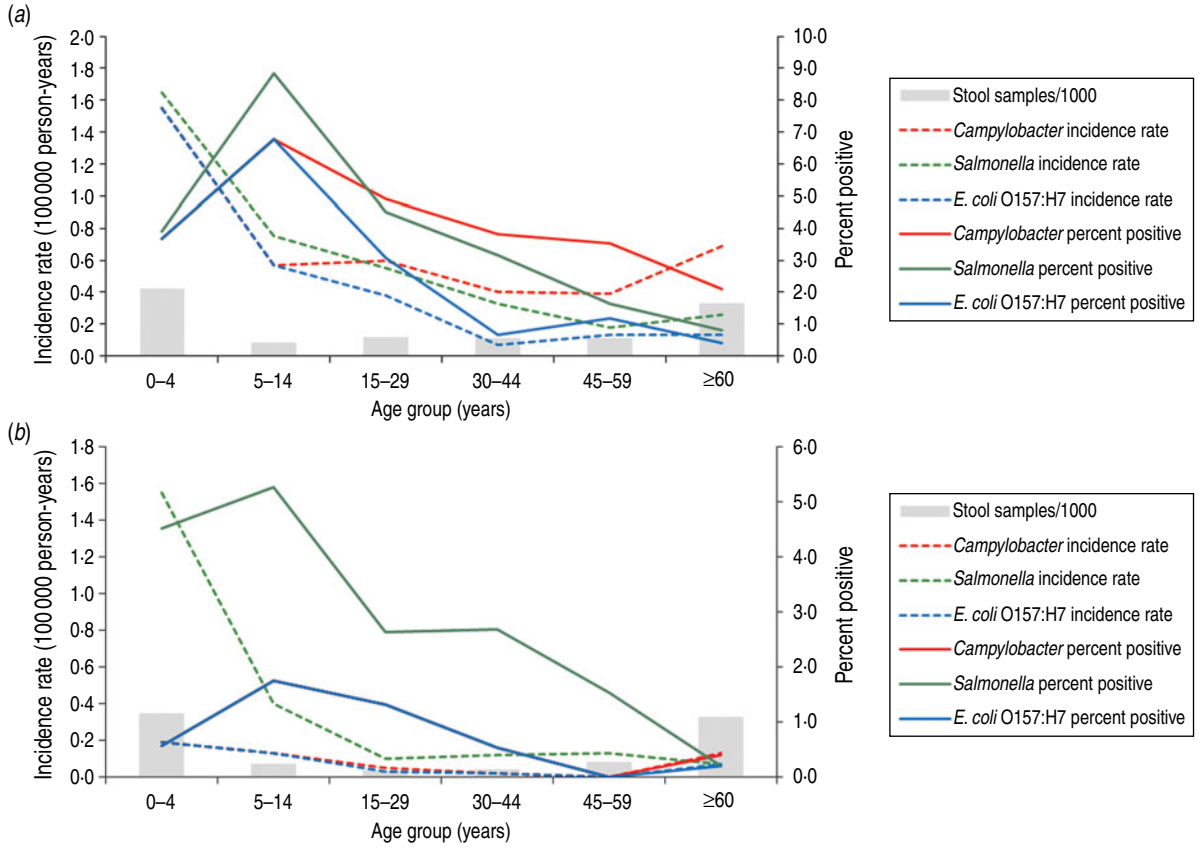

Fig. 3. Outpatient (*a*) and inpatient (*b*) age-specific trends in *Campylobacter* spp., *Salmonella* spp. and *E. coli* O157:H7 positive stool specimens submitted to the Waterloo Regional Microbiology Laboratory between 2006 and 2011.

sampled less frequently. While only representing three hospitals and one study region, this study illustrates how stool submission behaviour can influence overall incidence or prevalence rate estimates that are developed at the provincial or national level, based solely on positive stool sample data available at the provincial and national levels. Differences in stool sampling rates may be due to differences in health status (e.g. immunity, vulnerability), health-seeking behaviours by age group, testing practices by physicians or the patient's status at the time of sampling. We suggest that a physician-based survey would help inform how these data are interpreted for incidence and burden estimates. Repeating this type of analysis every few years to evaluate stool submission trends would help in the interpretation of incidence rate trends by age group by surveillance systems. Reporting negative tests may not be feasible as an on-going practice given the impact it would have on current laboratory reporting procedures. However, a periodic evaluation of the stool submission behaviours within sentinel communities can help us evaluate how we interpret population-level incidence rates, to better understand age and season effects. In addition, this evaluation can be used to inform physician practices, laboratory testing regimens, and under-ascertainment and under-reporting estimates for broader burden of enteric illness estimations.

In Canada, the Canadian Notifiable Disease Surveillance System (CNDSS) currently reports only laboratory-confirmed results and does not provide the total number of stool sample submissions. This is similar to other countries, and due to the lack of human enteric disease studies that report the proportion of positive results, comparisons among pathogen yields are often difficult. Understanding the dynamics of stool submission behaviour, both by age, season, and patient demographics (or proxies like hospital site) can help to inform our understanding of stool submission behaviour, the burden of enteric disease, and under-ascertainment by age group.

Although patient status was collected for only one of the three hospital sites, this site represented the largest proportion of stool submissions in the database (57%). We consider that inpatient results capture

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hospital trends in stool testing behaviour and outpatient results may be a better representation of community-level testing behaviours, since outpatients are more likely to present in a similar way at a physician's office. Many individuals in this community do not have a family doctor and instead present at the hospital emergency room [12].

The positivity rate for *Campylobacter* spp. (2·8%) for all three sites combined was quite low in this study, but somewhat higher when restricting the analysis to outpatients (more similar to general practice trends in the community) in site 2 (3·5%). By comparison, a similar study of laboratory-based surveillance and stool submission data in the UK [7] reported *Campylobacter* spp. yields in 7·9% and in 1·6% of general practice and hospital specimens, respectively. The variation in *Campylobacter* spp. rates between the two studies is probably influenced by the actual rates of campylobacteriosis that occur at the community level in the study community *vs.* in Wales, where reported rates are higher than those in Ontario. However, other factors such as health-seeking behaviour, the number of stool sample requests and submissions, as well as laboratory methods and reporting procedures may have also contributed to the variation. Although a variation in the rate of *Campylobacter* spp. was observed, the ratio of *Campylobacter* spp. *vs. Salmonella* spp. remained consistent in the two studies. In 2004 the Health Protection Agency Centre for Infections reported a rate of 91·3/100 000 *Campylobacter* spp. infections in Wales, compared to rates in Ontario that were reported by CNDSS, in the same year, to be 31·77/100 000 [13].

The proportion of stool specimens testing positive for *Salmonella* spp. (2·6%) is higher than the only other study of this kind [7] (1·6% and in 0·4% of general practice and hospital specimens, respectively). This result is probably due to a higher rate of salmonellosis in the study community compared to published studies; however, differences in healthcare-seeking behaviours, test ordering and the number of test submissions may have also contributed to the difference observed between the two studies.

There was an increase in *Campylobacter* spp. positive stools in 2008 at all three hospital sites (Fig. 1). Our hypothesis is that this increase coincides with a local outbreak that occurred at a summer camp [14], but this cannot be confirmed retrospectively.

Seasonal peaks occurred for all three pathogens during the summer months, with declining disease frequency during autumn and more abruptly throughout the winter months. Neither patient status nor hospital site influenced the seasonality of reported enteric diseases. Considering season alone, children aged 0–4 years were more likely to submit a stool sample in spring, whereas those aged 5–14 years were more likely to submit a stool sample in summer. Children are at an increased risk for bacterial, viral and parasitic infections due to a less developed immune system and a smaller infective dose required for infection [15]. In addition, the spring/summer spike in stool submissions in these age groups may be attributed to viral infections, such as rotavirus, which often peaks in late winter or early spring [16].

The stool submission rates exhibit an overrepresentation of children aged 0–4 years and adults aged $\geqslant$60 years (Table 2). Both of these age groups are reported to be at greatest risk of illness based on current incidence rate data [17]. However, our data suggest that these rates may also be the result of increased sampling and testing for the pathogens. The higher proportion of stools submitted by the 0–4 years age group may in turn be masking a prominent peak in both *Salmonella* spp. and *E. coli* O157:H7 incidence rates in the 5–14 years age group. With stool submission data, we see a more prominent peak in this age group (Fig. 2), suggesting that laboratory-based stool submission data may provide insight and guide future investigations into the burden of enteric disease among specific subpopulations. Previous studies suggest that high stool sampling rates in both young children and older adults, impact reported incidence rates [7, 18] and similar effects are observed in our study.

The higher proportion of stool samples submitted by those aged <4 years and >60 years of age in this study could be a consequence of healthcare-seeking behaviour, physician sampling bias, or patients' status at the time of stool sample collection [6]. A study conducted in the USA identified that children aged <5 years and persons aged $\geqslant$65 years with acute diarrhoeal illness seek medical care at higher rates than the rest of the population [19]. The increased rates of healthcare-seeking behaviour for young children may reflect parental concern, while risk of severe illness and dehydration in both children and the elderly with acute diarrhoeal illness may also account for an increase in healthcare-seeking behaviour [18]. Other factors that impact an individual's decision to consult a physician are the severity of the illness [20], recent travel [20] and general health status [21]. Stool sample submissions are also be dependent on whether or not a

physician requests a stool sample to be submitted, and the factors that influence this decision. Since the risk of severe complication from diarrhoea is higher in the very young and the elderly, it is possible that physicians are more cautious and request stool specimens more often from these age groups, contributing to sampling bias. Finally, the higher number of stool sample submission among the very young and the very old may be a result of their increased susceptibility to viral pathogens. The stool specimens collected in this study were not tested for viruses and therefore we are not able to conclude how many of the negative results were due to viruses. However, a recent study in the UK [22] reports that norovirus was the most commonly detected agent in community cases.

Capturing hospital site-specific data illustrates how hospital site can influence stool submission rates and positivity rates for each disease. While age-specific stool sample submission trends were consistent between hospital sites 1 and 2, hospital site 3 had the lowest number of stool sample submissions for the 0–4 years age group. Hospital site 3 does not have a paediatric unit, so there may be fewer young children submitting stool specimens at that location. Hospital site 2, which accounts for over half of the stool specimens analysed in this study, contains a complex continuing care facility consisting of several programmes that provide interdisciplinary assessment, treatment and monitoring for those living with or recovering from chronic illnesses and may explain the increase in stool sample submissions from patients aged $\geqslant 60$ years.

Campylobacter spp.-positive proportions also differed by hospital site. Hospital site 3 stool sample submissions were evenly distributed throughout the study period while this site had the highest proportion of *Campylobacter* spp.-positive stool specimens. There was a significant increase in submissions in the 5–14 years age group in sites 1 and 2, especially in the summer months, when *Campylobacter* spp. infections are known to increase. Hospital-specific trends illustrate how data that reflect stool testing results from only one hospital site may be skewed due to both patient demographics and the services provided by the hospital.

Patient status was available for 57% (5174/9116 specimens), all from hospital site 2. There was no seasonal effect on the distribution of stool sample submissions when considering patient status; however, an age effect was observed. The greatest proportion of both inpatient and outpatient specimens were submitted from children aged 0–4 years. In addition, outpatients in the 15–29 and 33–44 years age groups submitted many more specimens than inpatients in the same age groups. *Campylobacter* spp. was the pathogen most often isolated overall from outpatient specimens, whereas *Salmonella* spp. was the most commonly isolated pathogen from inpatient stool specimens.

Wood *et al*. [23] suggest that the yield of bacterial enteric pathogens (excluding *Clostridium difficile*) collected after 3 days in the hospital is generally negligible ($\leqslant$0·6% *vs.* 2·6–6·4% from stool specimens sent within 3 days of hospitalization) [23]. In our study 1·9% of the inpatient stool specimens tested positive for *Salmonella* spp., compared to 2·8% of outpatient specimens. Of the 1·9%, 39% were isolated from patients aged 0–4 years, whereas only 20% of the *Salmonella* spp.-positive outpatient specimens were isolated in the same age group. It has been reported that the majority of enteric pathogens isolated from inpatients in a hospital represent patients who had been hospitalized for <2 days, suggesting the infection was a result of exposure to the pathogen prior to being admitted to the hospital [24]. The number of days hospitalized prior to submitting a stool sample was not collected in this study but would help inform our interpretation of exposure source, especially for inpatients aged 0–4 years, in future studies.

We suggest that outpatient results are more reflective of the community, while inpatient results reflect a subpopulation of the community and both stool-submission and proportion-positive rates are specific to the hospital and not generalizable to the broader population.

This study was limited to a small region in Ontario and the sample size was relatively small. More specifically, the patient status data were subject to potential biases given that the number of days hospitalized prior to submitting a stool sample was not collected in this study, thus we cannot conclude whether or not the pathogens isolated from inpatients in this study were from an exposure in the hospital or prior to their hospitalization. Furthermore, because there was no way to track outpatients that were transitioned to inpatients in the database, there may have been duplication of some results.

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DECLARATION OF INTEREST

None.

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