A descriptive epidemiology of giardiasis in New Zealand and gaps in surveillance data

Ekramul Hoque, Virginia Hope, Robert Scragg, Michael Baker, Rupendra Shrestha

Abstract

Introduction *Giardia* is the most commonly notified waterborne disease in New Zealand, which has high incidence rates compared with other developed countries. Four years of giardiasis notification data were analysed to describe the epidemiological patterns of infection in New Zealand and compared with local and international data.

Methods Anonymised information was collected nationally for 7818 notified cases of giardiasis between July 1996 and June 2000. International data were collected from the data sources of respective countries. Infection rates adjusted for confounding factors were calculated and presented by age, gender, ethnicity, and area using statistical and spatial methods.

Results Most cases occurred in the 1–4 year age group followed by the 25–44 year age group, and were of Pakeha/European ethnicity. Ethnicity was unknown for 18% of cases, thus affecting demographic calculations. Rates were elevated for several Health Districts in New Zealand (West Coast, Wellington, Waikato, Auckland, Hawke’s Bay, Hutt, Rotorua, and Tauranga).

Conclusions The higher rates of giardiasis observed in New Zealand, in comparison with other developed countries, may be related to environmental or social factors. Time-trend analysis suggests a seasonal pattern. This study identified vulnerable groups and major data-gaps. Recommendations for improvements in disease surveillance and data quality are discussed. Geographical information system (GIS) applications are useful for disease monitoring.

Public health interest in *Giardia* is increasing because of the growing recognition of its role as a cause of disease outbreaks in a range of settings. *Giardia duodenalis* is now the most widespread human intestinal parasite in the world. Approximately 200 million people are infected with the parasite globally, with 500,000 new cases reported annually. *Giardia* occurs throughout tropical and temperate regions. In developed countries, *Giardia* has the distinction of being the most commonly reported human parasite. The prevalence of the disease varies from 2%–5% to 20%–30% in developed and developing countries respectively.

A prevalence of 2%–7% has been reported for most developed countries, including North America, Australia, and New Zealand. Most infected persons will remain asymptomatic, thus acting as a source of infection for other persons in the community.

Giardiasis has been a notifiable disease in New Zealand since 1 July 1996. Before then, surveillance data were collected on an ad hoc basis. Giardiasis is the third-most commonly notified communicable disease in New Zealand, after
campylobacteriosis and salmonellosis. Between 1500 and 2200 cases of *Giardia* infection are notified each year. The incidence rate in New Zealand in 2002 was 41.4 per 100,000 population\(^1\) and is thought to be one of the highest among developed countries.\(^10\)

This paper aims to describe the epidemiology of giardiasis in New Zealand based on the first 4 years of notification data. It also applies a number of analytical approaches to evaluate the quality of surveillance data and to detect spatial and temporal trends.

**Methods**

Giardiasis notifications for New Zealand for the 4-year period July 1996 to June 2000 were collected from the national notifiable disease database, EpiSurv, operated by Environmental Science and Research (ESR) Ltd. Population data were accessed from Supermap, which was based on the 1996 New Zealand census.

The New Zealand surveillance data were checked for consistency and validity, and logical values were introduced as necessary. The surveillance data were grouped by age, gender, ethnicity, Local Authority (as area of residence) and reporting month and year. Ethnicity was categorised into four groups: Pakeha/European, Maori, Pacific people, and Asian/others. Crude annual infection rates for these groups were calculated and adjusted for age, gender, ethnicity, and area of residences (as appropriate) using a direct standardised method.

*Giardia* infection rates, both crude and adjusted, were calculated and plotted geographically using ArcView 3.0 GIS,\(^12\) to compare the distribution of cases by Local Authority (LA) and Health District (HD). A spatial map of New Zealand was initially divided by LA boundaries. Blocks of LAs were merged together to define Health District boundaries. Notification rates were converted separately into ArcView shape files for LAs and HDs, which were then overlaid on the respective maps. To highlight the rate differences between geographic areas, infection rates were expressed in groups and in descending order.

Overseas data were collected from the surveillance networks of Australia (NSW Health, Victoria Health), Canada (Canada Com Dis Report), the United Kingdom (PHLS), and the United States (CDC). Their data were available for periods of 2 to 9 years, depending on jurisdiction. The denominator populations used were those from the census data published by the respective government census authorities.

**Results**

Between July 1996 and June 2000, there were 7818 notifications throughout New Zealand. There were three missing cases for age. Gender was recorded for 99% of cases. Of these, half (50.10%) were females. There was no significant difference in age between genders (Chi\(^2\)=1.04).

The mean age for giardiasis cases was 26.0 (SE 0.23) years. Rates showed a bimodal pattern, peaking in children under 5 years of age and in the 25–44 years age group. The infection pattern did not change after adjusting for ethnicity, gender, or area of residence in combination or separately. Notification rates were higher among male children in the 1–4 years age group, whereas females had higher rates in the 25–34 years age group (Figure 1).

The completeness of information varied by Public Health Unit (PHU) and time. Ethnicity was recorded for 82% of cases. Of these, most were of Pakeha/European origin. Maori and Asian/others shared equal proportions of notifications, whereas Pacific people accounted for only 1%. The incidence of giardiasis varied significantly between ethnic groups (Chi\(^2\) 2133, df 5, p<0.0001). The Asian/other category had a two-fold increased risk of infection compared with Europeans, whereas Pacific people and Maori rates were lower than for Europeans (Figure 2).
Table 1. Frequency of giardiasis notifications in New Zealand by age-group and ethnicity

<table>
<thead>
<tr>
<th>Age group</th>
<th>European</th>
<th>Maori</th>
<th>Pacific people</th>
<th>Asian/others</th>
<th>Unspecified</th>
<th>Total*</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>100.3 (126)</td>
<td>43.8 (26)</td>
<td>32.0 (6)</td>
<td>101.0 (12)</td>
<td>1570.0 (52)</td>
<td>101.4 (222)</td>
</tr>
<tr>
<td>1-4</td>
<td>215.2 (1151)</td>
<td>70.0 (159)</td>
<td>19.2 (14)</td>
<td>208.8 (95)</td>
<td>1774.3 (333)</td>
<td>194.8 (1752)</td>
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<tr>
<td>5-9</td>
<td>71.3 (494)</td>
<td>15.6 (42)</td>
<td>4.8 (4)</td>
<td>113.2 (65)</td>
<td>230.4 (114)</td>
<td>62.3 (719)</td>
</tr>
<tr>
<td>10-14</td>
<td>23.0 (149)</td>
<td>2.2 (5)</td>
<td>5.8 (4)</td>
<td>62.5 (40)</td>
<td>80.0 (37)</td>
<td>22.2 (235)</td>
</tr>
<tr>
<td>15-19</td>
<td>15.4 (100)</td>
<td>1.9 (4)</td>
<td>0.0 (0)</td>
<td>30.1 (24)</td>
<td>75.2 (36)</td>
<td>15.6 (164)</td>
</tr>
<tr>
<td>20-24</td>
<td>29.7 (213)</td>
<td>11.6 (22)</td>
<td>9.6 (6)</td>
<td>47.0 (30)</td>
<td>132.6 (72)</td>
<td>31.6 (343)</td>
</tr>
<tr>
<td>25-34</td>
<td>73.3 (1149)</td>
<td>16.7 (57)</td>
<td>14.6 (18)</td>
<td>66.7 (88)</td>
<td>283.7 (295)</td>
<td>70.9 (1607)</td>
</tr>
<tr>
<td>35-44</td>
<td>64.2 (1026)</td>
<td>21.3 (55)</td>
<td>12.5 (11)</td>
<td>51.8 (66)</td>
<td>274.7 (249)</td>
<td>65.1 (1407)</td>
</tr>
<tr>
<td>45-54</td>
<td>32.1 (439)</td>
<td>22.1 (34)</td>
<td>9.2 (5)</td>
<td>32.4 (22)</td>
<td>163.3 (110)</td>
<td>35.6 (610)</td>
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<tr>
<td>55-64</td>
<td>32.5 (316)</td>
<td>21.8 (21)</td>
<td>0.0 (0)</td>
<td>43.9 (13)</td>
<td>155.6 (74)</td>
<td>36.1 (424)</td>
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<tr>
<td>65-74</td>
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<td>30.2 (14)</td>
<td>12.5 (2)</td>
<td>39.0 (6)</td>
<td>103.2 (45)</td>
<td>24.7 (244)</td>
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<tr>
<td>75+</td>
<td>10.0 (64)</td>
<td>11.8 (2)</td>
<td>15.8 (1)</td>
<td>44.6 (3)</td>
<td>53.8 (18)</td>
<td>12.5 (88)</td>
</tr>
</tbody>
</table>

| All       | 52.1 (5404) | 21.1 (441) | 10.3 (71) | 66.2 (464) | 236.5 (1435) | 54.0 (7815) |

*Missing value = 3

Table 2. Proportion of giardiasis cases by ethnicity and crude rates in Health Districts (July 1996-June 2000)

<table>
<thead>
<tr>
<th>Health Districts (HD)</th>
<th>HD Code</th>
<th>Total Cases</th>
<th>Cases/100,000/year</th>
<th>European</th>
<th>Maori</th>
<th>Pacific people</th>
<th>Asian/Other</th>
<th>Unspecified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Bay of Plenty</td>
<td>BE</td>
<td>45</td>
<td>30.9</td>
<td>7.6</td>
<td>0.0</td>
<td>164.5</td>
<td>56.6</td>
<td>22.3</td>
</tr>
<tr>
<td>Central Auckland*</td>
<td>CA</td>
<td>939</td>
<td>70.9</td>
<td>17.4</td>
<td>14.4</td>
<td>35.0</td>
<td>278.2</td>
<td>67.9</td>
</tr>
<tr>
<td>Canterbury</td>
<td>CB</td>
<td>784</td>
<td>39.0</td>
<td>15.2</td>
<td>23.1</td>
<td>168.7</td>
<td>226.4</td>
<td>47.6</td>
</tr>
<tr>
<td>Gisborne</td>
<td>GS</td>
<td>114</td>
<td>75.6</td>
<td>37.4</td>
<td>98.0</td>
<td>110.4</td>
<td>115.7</td>
<td>62.3</td>
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<tr>
<td>Hawkes Bay</td>
<td>HB</td>
<td>382</td>
<td>41.2</td>
<td>25.3</td>
<td>29.3</td>
<td>78.9</td>
<td>703.8</td>
<td>66.9</td>
</tr>
<tr>
<td>Hutt</td>
<td>HU</td>
<td>354</td>
<td>71.6</td>
<td>37.6</td>
<td>3.2</td>
<td>84.5</td>
<td>168.2</td>
<td>66.7</td>
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<tr>
<td>Manawatu</td>
<td>MW</td>
<td>159</td>
<td>27.9</td>
<td>10.4</td>
<td>0.0</td>
<td>14.4</td>
<td>98.1</td>
<td>26.4</td>
</tr>
<tr>
<td>Northland</td>
<td>NL</td>
<td>229</td>
<td>52.3</td>
<td>14.5</td>
<td>0.0</td>
<td>51.0</td>
<td>77.0</td>
<td>41.8</td>
</tr>
<tr>
<td>Nelson-Marlborough</td>
<td>NM</td>
<td>113</td>
<td>22.3</td>
<td>15.7</td>
<td>0.0</td>
<td>69.2</td>
<td>79.4</td>
<td>24.2</td>
</tr>
<tr>
<td>Northwest Auckland</td>
<td>NW</td>
<td>961</td>
<td>58.0</td>
<td>11.8</td>
<td>5.8</td>
<td>36.8</td>
<td>337.2</td>
<td>60.9</td>
</tr>
<tr>
<td>Otago</td>
<td>OT</td>
<td>259</td>
<td>34.6</td>
<td>12.2</td>
<td>0.0</td>
<td>114.9</td>
<td>109.0</td>
<td>37.5</td>
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<tr>
<td>Rotorua</td>
<td>RO</td>
<td>165</td>
<td>46.5</td>
<td>65.1</td>
<td>17.0</td>
<td>34.9</td>
<td>342.9</td>
<td>64.0</td>
</tr>
<tr>
<td>Ruapehu</td>
<td>RU</td>
<td>23</td>
<td>35.3</td>
<td>8.1</td>
<td>0.0</td>
<td>0.0</td>
<td>201.4</td>
<td>34.4</td>
</tr>
<tr>
<td>South Auckland</td>
<td>SA</td>
<td>614</td>
<td>53.7</td>
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<td>10.5</td>
<td>31.3</td>
<td>194.3</td>
<td>44.9</td>
</tr>
<tr>
<td>South Canterbury</td>
<td>SC</td>
<td>85</td>
<td>42.3</td>
<td>8.3</td>
<td>0.0</td>
<td>37.7</td>
<td>0.0</td>
<td>39.1</td>
</tr>
<tr>
<td>Southland</td>
<td>SO</td>
<td>150</td>
<td>36.4</td>
<td>10.9</td>
<td>0.0</td>
<td>99.7</td>
<td>22.4</td>
<td>33.7</td>
</tr>
<tr>
<td>Tauranga</td>
<td>TG</td>
<td>291</td>
<td>45.8</td>
<td>13.6</td>
<td>0.0</td>
<td>246.9</td>
<td>783.9</td>
<td>64.5</td>
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<tr>
<td>Taranaki</td>
<td>TK</td>
<td>81</td>
<td>18.1</td>
<td>11.7</td>
<td>0.0</td>
<td>56.6</td>
<td>56.3</td>
<td>19.0</td>
</tr>
<tr>
<td>Taupo</td>
<td>TP</td>
<td>71</td>
<td>35.5</td>
<td>29.5</td>
<td>0.0</td>
<td>0.0</td>
<td>583.9</td>
<td>57.9</td>
</tr>
<tr>
<td>West Coast</td>
<td>WC</td>
<td>121</td>
<td>65.4</td>
<td>53.0</td>
<td>170.1</td>
<td>3586.5</td>
<td>130.2</td>
<td>93.2</td>
</tr>
<tr>
<td>Wanganui</td>
<td>WG</td>
<td>93</td>
<td>41.2</td>
<td>22.7</td>
<td>0.0</td>
<td>0.0</td>
<td>70.8</td>
<td>37.9</td>
</tr>
<tr>
<td>Waikato</td>
<td>WK</td>
<td>944</td>
<td>80.2</td>
<td>27.5</td>
<td>12.7</td>
<td>124.9</td>
<td>307.8</td>
<td>78.0</td>
</tr>
<tr>
<td>Wellington</td>
<td>WN</td>
<td>811</td>
<td>95.7</td>
<td>38.6</td>
<td>1.5</td>
<td>66.1</td>
<td>149.2</td>
<td>83.5</td>
</tr>
<tr>
<td>Wairarapa</td>
<td>WR</td>
<td>30</td>
<td>18.9</td>
<td>4.3</td>
<td>38.4</td>
<td>171.2</td>
<td>42.6</td>
<td>19.5</td>
</tr>
</tbody>
</table>

| New Zealand | NZ      | 7818       | 52.1                | 21.1     | 10.3  | 66.2           | 237.0       | 54.0        |

*Central Auckland includes data from Central, North and West Auckland health regions
The proportion of age specific notifications across the ethnic groups was similar other than for the Maori population who were distributed more towards the younger (<10 years) age group (Table 1). A significant difference in mean age among ethnic groups was also observed (F=18.2, p<0.0001). The mean age was higher for females than for males in each ethnic group other than for Asian/others, for whom the opposite was true.

The Local Authority (LA) was used as the unit for residence. Notification data from 73 LAs were analysed; no notifications were from the Chatham Islands. Infection rates varied widely across the boundaries of LAs from 7.86/100,000 (Stratford, Taranaki) to 117.03/100,000 (Hurunui, Canterbury). Notification rates for the North and South Islands were 57 and 42 cases per 100,000 population, respectively. This variation was statistically significant (Chi²=534.08, p<0.0001).

Analysis of unadjusted giardiasis rates by LA showed high notification rates (>100/100,000) in parts of the East and West Coasts of the South Island and in one area of the central North Island. Moderately high notification rates (>60/100,000) were also found in the West Coast, central Canterbury, the south of the South Island, the central North Island, Gisborne, Hastings, Rotorua, Waikato, Auckland, and Wellington. When these rates were adjusted for age, gender and ethnicity, the notification rates in ‘moderately high’ areas actually increased.

Local Authorities (LAs) were further aggregated to form the 24 Health Districts (HDs). Information on ethnicity was incomplete for a number of HDs, mostly in the North Island, including (in descending order) Taupo, Hawke’s Bay, Tauranga, Ruapehu, Auckland, and Rotorua (Figure 3). The proportion of missing information on ethnicity was statistically significant for these HDs separately compared to total cases. For example, Auckland Health District (chi²=1685.08, p<0.0001), Rotorua and Taupo (chi²=345.37, p<0.0001), and Tauranga (chi²=956.33, p<0.0001) all had significantly high proportions of undocumented ethnicity in case notifications.

Notification rates were low in a number of HDs but remained high for many others compared to the national rate of 46/100,000,13 including the West Coast, Wellington, Waikato and Tauranga (Table 2). When infection rates were adjusted for age, gender, and ethnicity, no additional changes were observed except for the West Coast (of the South Island). This variation disappeared when ethnicity was removed from controlling factors, suggesting a confounding effect.

The proportion of change in notification rate was calculated for each HD for the most recent year compared to previous years by using the formula: \[\{(CR-PR)\times100\} \text{ CR denotes current rate and PR denotes the average rate for previous years. A substantial reduction (50%) in infection rates was found in Wanganui and Gisborne (Figure 4). Rates were higher in the Wairarapa, central Auckland, Hawke’s Bay, and in the Ruapehu region; rates remained unchanged in north-west Auckland, and in Taupo.}\]

Analysing giardiasis notification rates by Health District ‘evened-out’ the range of rates to some extent. The notification rates for Auckland, central Canterbury, and southeastern Otago dropped from the >60/100,000 to <60/100,000 category (Figure 5). However, some areas of the North Island increased their rates at the expense of adjacent zones; for example, Tauranga rates increased compared to the comparable LA distribution.
Figure 1: Crude and adjusted (ethnicity) rates of *Giardia* infection by age & gender

![Crude and adjusted (ethnicity) rates of *Giardia* infection by age & gender](image)

Figure 2: *Giardia* infection rates by ethnicity

![*Giardia* infection rates by ethnicity](image)
Figure 3: Proportion of giardiasis cases notified by ethnicity and Health Districts in New Zealand

![Graph showing the proportion of giardiasis cases notified by ethnicity and Health Districts in New Zealand. The graph uses different colors to represent different ethnic groups and indicates the percentage of cases for each Health District.]

Figure 4. Proportion change in infection rates for the 1999–2000 year compared with previous years

![Graph showing the proportion change in infection rates for the 1999–2000 year compared with previous years. The graph indicates the percentage change for each Health District and compares it to the rates from previous years.]

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URL: http://www.nzma.org.nz/journal/117-1205/1149/ © NZMA
Figure 5: Spatial distribution of giardiasis notifications in New Zealand by Health Districts (HD)
A significant seasonal variation of Giardia notification was observed (Edward’s test: 
\( \chi^2 = 15.0, \text{df} = 2, p < 0.001 \)), peaking in late summer and early autumn. This varied by 
age group with, for example, the 10-19 year group rate peaking in autumn (Edward’s 
\( \chi^2 = 5.30, \text{df} = 2, p = 0.07 \)), and a sustained high in late summer, autumn and in winter 
in the 1-4 (Edward’s \( \chi^2 = 36.99, \text{df} = 2, p < 0.0001 \)) and 25-44 (Edward’s \( \chi^2 = 17.62, \text{df} = 2, p < 0.0001 \)) year group rates.

**Discussion**

This study provides the first comprehensive review of national giardiasis notification 
data since the disease became notifiable in June 1996. It describes the main 
edemiological characteristics of the disease in New Zealand, and also highlights 
potential improvements to the quality of surveillance data.

Giardiasis notifications were evenly distributed between genders in this study. This is 
inconsistency with one earlier GP-based active surveillance study which reported a 
higher proportion of cases for females than males at a regional level. However, the 
gender difference was not statistically significant in either study. An overseas 
prevalence study, however, reported a significant increase in infection rates for 
females.

The mean age for all cases nationally (and by gender) was consistent with other 
published reports where the means for females were slightly higher than for males but 
not significantly so. This finding was also consistent with our study of Auckland 
notification data. A higher mean age in females of childbearing age may reflect 
closer association with children, resulting in person-to-person transmission. However, 
an increased rate of *Giardia* infection in females is not universal either in developed 
or developing countries. The gender difference, therefore, could be biased by 
presenting behaviour, ethnicity and socioeconomic conditions. A pattern of 
transmission typical of developing countries is not uncommon among minorities or 
economically disadvantaged groups. The bimodal pattern of infection peaking in 
children under 5 years old and in adults 20–40 years is common, especially in 
developed countries. Cross-sectional studies in Australian Aborigines, and in 
Africa and Asia found the highest incidence in those among under 15 years, especially 
in the 6–14 years age group.

Infection rates in children may be confounded by ethnicity. Ethnicity differences in 
the under 5 age group were highly significant (\( \chi^2 = 474.05, \text{df} = 4, p < 0.0001 \)). 
Australian data indicated a higher proportion of *Giardia* infection among Aborigine 
children. However, a US survey of pre-school children attending early childhood 
education facilities reported an eight-fold lower infection rate in children of African 
(Black) descendants compared with their White counterparts. Very high rates of 
notifications observed for some ethnic groups in a number of HDs could be due to 
misclassification error or unreported outbreaks; for example, the high rates among 
Asians in the West Coast and elsewhere or the unknown ethnic group in Tauranga 
(Table 2).

The pattern of *Giardia* infection has remained relatively similar over the years, but 
variations in rates persist between the areas. Although infection rates decreased in 
most areas, they have increased in five areas (representing 30% of the national 
population). No specific reasons for these changes have been promoted. Random
variation in yearly rate could be a possibility. However, anecdotal reports suggest that enhanced surveillance, better provision of drinking water, and health promotion are likely to have contributed to these changes in some areas,\textsuperscript{10}—eg, in the West Coast (Humphrey A, Canterbury Health, NZ – personal communication). Nevertheless, reductions in giardiasis notifications of up to 50\% in a number of HDs, compared to the previous rates, warrants further investigation.

Infection rates in the South Island were lower than in the North Island compared to the national average rate.\textsuperscript{11} Among the 12 PHUs reporting average annual infection rates above the national average for 2000, two were in the South Island, and the remainder from the North Island. Of the 12 PHUs, the West Coast (of the South Island) had the highest infection rate (93.2/100,000), followed by Wellington (83.5/100,000). Three out of four regions of Auckland had notification rates of more than 60 cases per 100,000 population. A similar higher infection pattern has been reported from the metropolitan regions of Victoria, Australia, with an average rate of 20 cases per 100,000 population for the region\textsuperscript{23}—although their rate was one-third that of Auckland rates.

Giardiasis surveillance in England and Wales has also highlighted a regional trend, where one-quarter of cases are reported from the South-East regions.\textsuperscript{24} Regional high \textit{Giardia} infection rates have also been reported from the US but at much lower rates than in New Zealand. Giardia infection rates in the US varied from 0.9 to 42.3 cases per 100,000 with a national average of 9.5 cases per 100,000 population.\textsuperscript{25} Out of 43 states reporting giardiasis regularly, 10 states reported more than 20 cases per 100,000, including New York State (20.3/100,000), with Vermont (42.3/100,000) being the highest. Unlike New Zealand, these American states have active surveillance systems in place for giardiasis.

The seasonal distribution of giardiasis cases over the years showed a consistent pattern of peaking in late summer and early autumn, and low incidence in winter and early spring. This finding was consistent with other giardiasis studies.\textsuperscript{8,10,18,19} The summer peak possibly reflects enhanced outdoor activities and more contact with contaminated water, or could be a result of more personal contact between friends and family during summer vacations. However, it is difficult to explain why the 10–19 years age group, which would be expected to be most exposed to recreational water during the summer, had the lowest reported infection rate. This group also showed a weak seasonal distribution peaking slightly in early autumn, as also reported elsewhere.\textsuperscript{18}

In contrast, the age-group with the highest reported infection rate, 1–4 year old children, showed a significant seasonal variation with sustained peak periods in both late summer and autumn, and in the winter, suggestive of recreational exposure to contaminated water during summer vacation.\textsuperscript{19} Increased family activities and contact during the vacation season has been reported to favour person to person transmission of giardiasis.\textsuperscript{18}

The winter peak in 1–4 year old children could be due to indoor confinement especially in institutional care or the presence of nappy wearing toddler/s in the family\textsuperscript{26}—an ideal situation for person to person transmission of \textit{Giardia} parasites. The same seasonal variation of infection was seen in the 22–44 years age group but to a lesser degree, suggestive of similar external environmental exposures and person-to-
person contacts. Although it is not clear why the usual incidence peak continues to be in autumn, one explanation could be the long incubation period of *Giardia* infection combined with the complacency of infected person for weeks or months at the end of their holidays, before acting on symptoms and then visiting a local GP for diagnosis and subsequent notification.

Cases of enteric diseases are suspected to be grossly under-reported in the national surveillance data. The main reason could be that most people with gastroenteritis do not consult a doctor. A large prospective study of infectious intestinal disease in England found that only half of community cases of giardiasis presented to a GP. However, even when diagnosed on the basis of laboratory tests, subsequent notification to health authorities is not guaranteed.

It is likely that the clinical diagnosis of *Giardia* infection will vary by attending GP and according to local environmental situations and presentations of disease. The rate of notification varies with the degree of severity of the disease. The frequency of notification of the disease also depends on GPs’ perceptions of the importance of the disease and the severity of illness in presenting patients as GPs do not request stool tests for most patients presenting with diarrhea.

An early laboratory-based study observed that GPs missed 66% of giardiasis cases due to not requesting stool examinations for patients with gastrointestinal complaints. In addition, data sampling and recording was performed by various people and was not uniform. Thus, adequate training on data management and the coding method is useful for maintaining a quality data collection process.

A major weakness in ethnicity information on *Giardia* infection in New Zealand was data incompleteness. Unknown ethnicity in this study was considered to be high at 18% of cases. This was reminiscent of the previous study on Auckland notification data. Unlike laboratory based reported cases, notified giardiasis cases are usually investigated by local public health units, where recording ethnicity is a routine step in epidemiological investigation in a multiethnic population.

Incomplete ethnicity information has been reported in other notifiable disease surveillance studies in multiethnic communities. The CDC has reported that 37-40% of case notifications do not identify the ethnicity of cases. Variation in the completeness of ethnicity reporting may reflect differences in sources of notification and the frequency of case investigation by the local health department. Reporting may also be influenced by disease priority.

Overseas experiences suggest that the completeness of diagnosis and reporting is reduced in vulnerable ethnic groups due to cultural complexities and economic difficulties. Under-representation in GP visits among socially deprived communities, which are often ethnic minority groups in New Zealand, has been observed elsewhere. Information gaps in ethnic data in the present study are age-group sensitive. Given the lowest rates of ethnicity recording are in areas with high proportions of mixed ethnic groups (such as Auckland, Rotorua), this information could be influenced by cultural factors.

Under-diagnosis and the data gaps limit our capacity to estimate the true burden of giardiasis in New Zealand as well as hampering an effective and meaningful analysis.
of risk factors for the disease. Nevertheless, we were able to compare the information with exposure information collected from external sources.

The spatial depiction of data in the present study has helped to identify areas with high rates of notification. Descriptive analysis using GIS could be useful for the monitoring of surveillance performance and/or the need for enhancement. Superimposing multi-layer information, and displaying it simultaneously by the administrative boundaries of an area, can facilitate the step from descriptive to analytical epidemiological work and raise hypotheses about associations.

Analysis of spatial information is critically dependent on the accuracy of the source data and technology-driven which implies additional cost and skilled manpower. ‘Point data’, which identify individuals by residential address, are desirable for investigating causal relationships or for longitudinal studies and to maximise the benefits of GIS in public health studies, although they may not be accessible due to perceptions of the ethical considerations of personal privacy.36 Information from LAs on area and population could not be correlated with exposure factors because of incomplete supporting data, such as lack of street addresses. Due to such data restrictions, aggregated point data was used in this study. This has restricted the capacity to manipulate information.

Lastly, further investigation of reasons for variation in reported rates could promote better understanding of the transmission of this disease in New Zealand and assist in the development of intervention strategies.

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