Ubiquity of the water-borne pathogens, Cryptosporidium and Giardia, in KwaZulu-Natal populations

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Abstract

The prevalence of the diarrhoea disease caused by the water-borne pathogens Cryptosporidium and Giardia in KwaZulu-Natal, was determined from pathology laboratory data. Cryptosporidium and Giardia were found to be endemic in KwaZulu-Natal with laboratory-confirmed incidences ranging from 2.9 to 3.7% and 2.9 to 3.0% respectively of diarrhoea samples submitted for protozoan parasite analysis. Increases in the number of samples submitted for Cryptosporidium or Giardia analysis were independent of the actual incidence of either protozoan pathogen. Female and male patients tested for cryptosporidiosis had similar positive percentages while giardiasis was more prevalent in female patients. Cryptosporidium and Giardia prevalence in children under 5 years indicated that Cryptosporidium was most prevalent (39.3%) in the <1 year age group while Giardia was most prevalent in the 3 to 4 year age group (38.5%). A low percentage of Cryptosporidium and Giardia positive cases were recorded in symptomatic (4.5% and 5.3% respectively) and asymptomatic (2.4% and 0.8% respectively) HIV patients. The incidence of Cryptosporidium and Giardia did not appear to correlate (Pearson’s correlation test) with climatic factors such as rainfall, season or year, possibly indicating that water-borne transmission is not the predominant route and other factors such as personal hygiene, potable water supply, sanitation and education probably have a more significant impact.

Introduction

Inadequate water supply and sanitation are largely responsible for more than 800 m. estimated cases of diarrhoeal disease and 4.5 m. associated deaths in developing countries every year (Esrey et al., 1990). In South Africa more than 7 m. people (approximately 17% of the population) do not have access to an adequate potable water supply (Dept, Water Affairs and Forestry, 1999) and nearly 21 m. (54%) lack basic sanitation (Dept. Water Affairs and Forestry, 1996) that further highlights the potential of infection by waterborne disease. At present updated figures for households with basic sanitation are not available, but tools are being developed to monitor and evaluate the implementation of sanitation (Crowder, 1999). Although there are many causes of diarrhoea, the enteric protozoa Cryptosporidium parvum and Giardia lamblia have been recognised as important causes of both outbreak-related and sporadic diarrhoea in humans (Casemore, 1990). Their major means of transmission is the faecal-oral route (person-to-person) while water and zoonotic transmission are also of importance and Giardia has been reported to be sexually transmitted (Phillips et al., 1981). Person-to-person transmission, particularly involving children and cross infection from patient-to-patient and between patients and staff in hospitals is common (Casemore et al., 1997). Zoonotic exposure occurs during farming of livestock particularly during the lambing and calving seasons, educational trips to farms and livestock markets and during backpacking excursions (Kreier and Baker, 1987; Casemore, 1990). Companion animals, particularly cats and dogs, have occasionally been implicated in human cryptosporidiosis (Casemore et al., 1997). Cryptosporidiosis and giardiasis have emerged as important causes of travelers’ diarrhoea suggesting a common epidemiology involving contaminated water or food and poor hygiene practices (Fayer and Ungar, 1986; Casemore, 1990).

The survival of Cryptosporidium oocysts in animal and human faeces is highlighted by the fact that 60% of oocysts were non-viable after 176 d. Once in a receiving body of water (e.g. river) the die-off rate increases dramatically as the length of time Cryptosporidium oocysts or Giardia cysts survive in water is dependent on the temperature. After 176 d, 96% of oocysts stored in water in a laboratory flow-through system at room temperature were non-viable (Robertson et al., 1992). Giardia cysts have survived at least 77 d in water at less than 10°C whilst above 20°C, cyst viability decreased after 3 d storage (DeRegnier et al., 1989). However, high temperatures (above 45°C) render (oo)cysts in water non-infectious (DeRegnier et al., 1989; Fayer, 1994). High-risk categories for infection by both protozoa include young children (< 5 years) and immuno-compromised patients (Current and Haynes, 1983). In South Africa 11 out of 110 children who were infected with cryptosporidiosis died, according to a study by Moodley et al. (1991a) and relatively high mortalities in patients with diarrhoea due to Cryptosporidium have also been reported by Smith and Van den Ende (1986) (22.6%) and Wittenberg et al. (1987) (23%). In economic terms, diarrhoeal disease in South Africa is estimated to cost R 3 375 m./a and in KwaZulu-Natal R 785 m./a (Pegram et al., 1998).

The occurrence of cryptosporidiosis and giardiasis is probably higher than recorded as only one in fourteen people with diarrhoea in South Africa seek formal treatment from a health practitioner, clinic or hospital every year, while approximately 43 000 South Africans have been estimated to die every year from diarrhoea (Pegram et al., 1998). Many symptomatic people do not seek medical treatment as they cannot get to a hospital or they visit traditional healers. Medical treatment is also not sought if the infection is mild or due to ignorance of the symptoms.
A need to determine the prevalence of Cryptosporidium and Giardia in KwaZulu-Natal required a survey of hospital and private pathology laboratory recordings of their occurrence. Laboratory-based surveys are, however, subject to a variety of biases; ascertainment will inevitably vary according to specimen selection criteria (clinical and laboratory), diagnostic test method, availability of facilities and reporting systems (Casemore, 1991). This paper presents the number of cryptosporidiosis and giardiasis cases recorded from January 1996 to March 1998. Results were evaluated with regard to rainfall, race, gender and distribution of occurrence in children younger than five years of age. Results of the presence or absence of the protozoa in a group of HIV positive patients with and without diarrhoea, were evaluated and the percentage occurrence was calculated.

Methods

Source of data

The information used in this study was obtained from two government hospital pathology laboratories and a private pathology laboratory from January 1996 to March 1998. This represents 9.7% (3/31) of laboratories in KwaZulu-Natal that test for Cryptosporidium and 6.0% (3/50) of laboratories testing for Giardia (Haynes, 1998).

The study population varied with respect to race and income as the private pathology laboratory tests non-formed stools from patients of a higher income bracket and predominantly from the White and Indian population in the Durban and Pietermaritzburg metropolitan areas, while government hospitals test non-formed stools from patients of various race and socio-economic backgrounds within KwaZulu-Natal.

The test criteria required for the analysis of stools for Cryptosporidium and Giardia at Government hospital laboratories differed. The one laboratory tests all stools for Cryptosporidium while Giardia analyses are only performed on request from the doctor. The other government hospital laboratory tests all stools received from patients younger than two years of age or on request from the doctor for the presence of Cryptosporidium while Giardia testing is performed on all stools received. The private pathology laboratory analyses are performed for Cryptosporidium in

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**Figure 1**

The percentage of Cryptosporidium and Giardia positive cases recorded each month during 1996

**Figure 2**

The percentage of Cryptosporidium and Giardia positive cases recorded each month from January 1997 to March 1998

**Figure 3**

The percentage prevalence of cryptosporidiosis and giardiasis, in patients tested, with respect to rainfall during 1996
Pearson’s correlation coefficient was used to examine possible relationships of the incidence of Cryptosporidium or Giardia with respect to rainfall, month and year, from results recorded by laboratories in the Pietermaritzburg (inland) and Durban (coastal) areas. The relationship between the prevalence of Cryptosporidium and Giardia was also examined.

Results

Occurrence

During 1996, 2.9% (96/3 274) of patients who were tested for cryptosporidiosis were tested positive while 3.0% (102/3 426) were tested positive for giardiasis (Fig. 1). From January 1997 to March 1998, 3.7% (193/5 161) of stools analysed were tested positive for Cryptosporidium and 2.9% (135/4 683) were tested positive for Giardia (Fig. 2).

Rainfall

Cryptosporidium and Giardia occurred throughout 1996 and monthly prevalence varied between 0.7 to 5.1% and 0.9 to 5.3% respectively (Fig. 3). Prevalence of cryptosporidiosis infections was higher in February, April, July and December while giardiasis infection prevalence was high in February, May and November. The number of diarrhoeal samples analysed increased during January, August, September, October, November and December while high rainfall occurred in January, February, November and December.

Cryptosporidium prevalence was high during January, September, October and November of 1997 while giardiasis prevalence was higher during February, April, October and November. The prevalence of diarrhoeal samples submitted for analysis increased during February, March, April and May while rainfall increased in January, March, April and November. During 1998 Cryptosporidium and Giardia cases were more prevalent in February and March while diarrhoeal prevalence and rainfall also increased during these months.

Age

Of the cryptosporidiosis cases recorded for children < 5 years, the highest percentage (39.3%) (1100/2 800) occurred in the < 1 year age group (Fig. 5) with the fewest cases occurring in the 1 to 2 year and 2 to 3 year age group (200/2 800).

The race distribution of cryptosporidiosis cases varied with respect to age and gender (Table 1). Black male children had the highest incidence of Cryptosporidium in all age groups < 5 years, except the 1 to 2 year and 4 to 5 year age group. Black female children had the highest occurrence of cryptosporidiosis in all age groups except the 4 to 5 year age group. White male cases were predominant in the 1 to 2 year age group while Asian male children had the highest occurrence in the 4 to 5 year age group. An equal

Rainfall data

Rainfall data were compared with seasonal variation in the occurrence of Cryptosporidium and Giardia. The assumption was made that high runoff from faecally contaminated land or farm slurry can contaminate water sources resulting in the infection of those using the water further downstream.

Rainfall for each month from January 1996 to March 1998 was averaged from data collected at two points namely Durban Heights Waterworks, Durban (coastal) and Darvill Wastewater Works (a meteorological station), Pietermaritzburg (inland).
number of positive cases were present in Black female and White female children between 4 and 5 years of age (Table 1).

The proportion of males and females in each age group is shown in Table 2. Overall, 41.8% (560/1,340) of children under the age of 5 years who had cryptosporidiosis were male and 58.2% (780/1,340) were female.

The highest occurrence (38.5%) (500/1,300) of giardiasis cases was in the 3 to 4 year age group (Fig. 6) while the lowest number of cases occurred in the 1 to 2 year age group (100/1,300). Within each age group, the distribution of giardiasis cases differed with respect to race and gender (Table 3). The highest number of giardiasis cases occurred in Black male children between 4 and 5 years (100%) and Black female children < 1 year (100%), 3 to 4 year (83.3%) and 4 to 5 year age groups (100%). In the 1 to 2 year age group, White male children (75%) and Asian female children (55.6%) had the highest incidence of giardiasis (Table 4).

Of the giardiasis positive children < 5 years of age, 32.5% were male (130/400) and 67.5% were female (270/400). The proportion of males and females with giardiasis is shown in Table 4. Overall, 32.5% (130/400) of children under the age of 5 years who had giardiasis were male and 67.5% (270/400) were female (Table 4).

### Table 1

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Percentage Cryptosporidiosis cases for each gender and race</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Black</td>
<td>White Asian</td>
</tr>
<tr>
<td>&lt; 1</td>
<td>45.8 (110/240) 20.8 (50/240) 33.3 (80/240)</td>
</tr>
<tr>
<td>1 to 2</td>
<td>26.1 (60/230) 52.2 (120/230) 21.7 (50/230)</td>
</tr>
<tr>
<td>2 to 3</td>
<td>100 (20/20) N/d N/d</td>
</tr>
<tr>
<td>3 to 4</td>
<td>50 (20/40) 25 (10/40) 25 (10/40)</td>
</tr>
<tr>
<td>4 to 5</td>
<td>N/d 33.3 (10/30) 66.6 (20/30) 50 (20/40)</td>
</tr>
</tbody>
</table>

N/d = no data recorded

### Table 2

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Percentage Cryptosporidium cases for each gender and age group</th>
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<tbody>
<tr>
<td></td>
<td>Percentage male (%) (sample size)</td>
</tr>
<tr>
<td>&lt;1</td>
<td>66.7 (240/360)</td>
</tr>
<tr>
<td>1 to 2</td>
<td>30.3 (230/760)</td>
</tr>
<tr>
<td>2 to 3</td>
<td>25.0 (20/80)</td>
</tr>
<tr>
<td>3 to 4</td>
<td>57.1 (40/70)</td>
</tr>
<tr>
<td>4 to 5</td>
<td>42.9 (30/70)</td>
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</table>
Race group

The race group of only 64% of patients, tested by the pathology laboratories, for cryptosporidiosis was recorded (2 690/4 201), of which 93% were Black (2,502/2,690), 2.5% were Asian (67/2,690) and 5% were White (134/2,690). Of the 151 cryptosporidiosis positive cases, 75.5% were Black (114/151), 13.2% were Asian (20/151) and 11.3% were White (17/151). Within race groups, however, 4.6% of Black patients (114/2,502), 12.7% of White patients (17/134) and 29.9% of Asian patients (20/67) tested for cryptosporidiosis were positive.

Gender

From data that recorded the gender of the patient, 47.7% (210/440) of females had cryptosporidiosis compared to 52.3% (230/440) of males while 63.6% (140/220) of female cases and 36.4% (80/220) of males tested positive for giardiasis. Each gender was further divided into age groups as shown in Tables 5 and 6.

Cryptosporidiosis cases were predominant in males in the 5 to 10 and 30 to 50 year age groups while female cases were highest in the 10 to 20 and 20 to 30 year age groups (Table 5). The highest number of giardiasis cases for males was recorded in the 30 to 50 year age group while female cases were predominant in the 5 to 10 and 10 to 20 year age groups (Table 6).

HIV

Of the HIV patients who exhibited diarrhoea, 4.5% (6/133) were tested positive for cryptosporidiosis (symptomatic) while 2.4% (3/124) without diarrhoea had oocysts in their stools (asymptomatic). Seven of the 133 HIV patients with diarrhoea (5.3%) (symptomatic) had giardiasis while about 0.8% (1/124), without diarrhoea, were Giardia positive (asymptomatic).

<table>
<thead>
<tr>
<th>TABLE 3</th>
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<tbody>
<tr>
<td>Distribution of giardiasis cases within the &lt; 5 year age groups</td>
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<tr>
<td>Age (years)</td>
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<td>Black</td>
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<td>N/d = no data recorded</td>
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<th>TABLE 4</th>
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<tr>
<td>Percentage giardia cases for each gender and age group</td>
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<tr>
<td>Age group</td>
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<tr>
<td></td>
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<tr>
<td>&lt;1</td>
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<td>4 to 5</td>
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<td>N/d = no data recorded</td>
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</table>
The incidence of these diseases is not significantly related to climatic factors such as rainfall, month or year, despite the large sample size (8 435 from January 1996 to December 1996 and 8 109 from January 1997 to March 1998). Cryptosporidium and Giardia were also not significantly related (p < 0.05). This points, therefore, to some other factor(s), social or environmental, which are controlling the incidence of these diseases.

### Discussion

#### Laboratory-based survey

The recording of data associated with Cryptosporidium and Giardia testing by most laboratories was found to be insufficient. Often only samples that tested positive were recorded. Only 20% of the data recorded made reference to race or gender or to the age of the patient.

The rates of stool positivity vary according to diagnostic techniques employed (Bogaerts et al., 1984; Crawford and Vermund., 1988) making it difficult to gain an accurate picture of incidence rates or of prevalence. However, the data do indicate the ubiquity of the parasite (Current, 1994). Reports of laboratory-confirmed Cryptosporidium incidence in developed countries generally yield figures of approximately 1-2% overall (Fayer and Ungar, 1986). Cryptosporidium rates are generally higher in developing countries (2.5 to >30%; mean 8.5%), especially in children younger than 2 years, where it may be symptomatic or asymptomatic (cited by Casemore et al., 1997). Similarly Cryptosporidium and Giardia results in KwaZulu-Natal were 2.9 to 3.7% and 2.9 to 3.0% respectively indicating that infection due to these protozoa is endemic.

Pathology laboratories should be encouraged to include Cryptosporidium diagnostic techniques with the routine diagnosis of stool specimens as 62% (31/50) of laboratories are unable to test for Cryptosporidium. There is a need for conformity in testing and a standard diagnostic test needs to be devised so that the results are comparable countrywide, a view shared by Moodley et al. (1991b).

### Occurrence and rainfall

Cryptosporidium and Giardia occurred throughout each year and the monthly incidence varied between 0.7 to 6.8% and 0.7 to 11.8%, of diarrhoeal cases submitted for protozoan analysis, respectively (Figs. 3 and 4).

High numbers of Cryptosporidium and Giardia cases were generally recorded during the summer rainfall months of November, December, January, February and March each year, although the incidence of either disease did not correlate statistically with rainfall. Giardia was found to be more prevalent, although sporadic outbreaks of Cryptosporidium occurred every year. It is possible that contamination of rivers by stormwater runoff, containing faeces of infected humans and animals, resulted in the higher numbers of cryptosporidiosis and giardiasis cases during high rainfall months, if water transmission occurred. Moodley et al. (1991a) also found Cryptosporidium infections in children, admitted
to a hospital in Durban, KwaZulu-Natal, to be more prevalent during high rainfall seasons.

Results from the analysis of diarrhoea samples indicated that cholera, salmonella, amoebic dysentery, Shigella, or enteropathic _E. coli_ were often the cause of diarrhoea in samples testing negative for _Cryptosporidium_ or _Giardia_.

**Age**

The difference in prevalence of the two diseases was dependent on the accurate recording of data that was often limited and therefore may not represent the actual occurrence within the age groups. Cases of cryptosporidiosis were found to be most prevalent in the < 1 year age group whereas Walters et al. (1988) found 100% positivity for cryptosporidiosis (8/8) in the <1 year age group attending a day-care centre in Durban. Surveys in the United Kingdom and in some developing countries have also found _Cryptosporidium_ to be common in children <1 year (Casemore, 1990). High occurrence of cryptosporidiosis infection in children < 2 years of age is consistent with the findings of others such as Shahid et al. (1988) and Smith and Van den Ende (1986) who analysed samples from Bangladesh and Durban respectively.

This high occurrence of cryptosporidiosis may be attributed to malnourished babies with immunocompromised systems, unsterilised feeding bottles or faecal-oral transmission by care-givers who change the baby’s nappies. Faecal-oral transmission by care-givers has been reported by others (Walters et al., 1988).

The high occurrence of _Giardia_ in the 3 to 4 year age group could be as a result of faecal-oral transmission particularly at crèches where children play together in sand-pits and handle toys. In rural situations this infection may arise as a result of contact with animals. Contaminated water could also be a major source (Nimri and Batchoun, 1994).

Parents, care-givers, crèches and hospital personnel need to be well-informed of the risks of transmission in order to prevent the spread of infection.

**Race**

Although a larger portion of the Asian and White race groups tested positive for cryptosporidiosis and _giardiasis_ compared to the Black patients, the sample size of the Black population was approximately ten times greater. It is possible that fewer Asian and White people suffer from diarrhoea or are not tested for the aetiology of diarrhoeal disease, but are merely prescribed anti-diarrhoeic medicines.

However, overall a higher percentage of Black patients were tested positive for _Cryptosporidium_ and _Giardia_. This is probably due to socio-economic conditions, as many people in KwaZulu-Natal do not have access to an adequate potable water supply or sanitation.

**Gender**

Male and female patients tested for cryptosporidiosis had similar positive percentages. _Giardiasis_, on the other hand, was found to be more prevalent in female patients tested. A study of hospitalized children in Delhi found _Cryptosporidium_ infection to be predominant in males (Mahajan et al., 1992) while an increased prevalence was found for females in Nigeria (Okafor and Okunji, 1994). In rural communities of developing countries, UNICEF found that girls may be more susceptible to diarrhoeal disease as they are often fed less, given less nutritious food, provided with less health care and given more work (Doyle, 1995).

**HIV**

A low percentage of _Cryptosporidium_ and _Giardia_ positive cases were recorded in the HIV patients sampled, but the percentages were similar in both symptomatic and asymptomatic patients. Asymptomatic _Cryptosporidium_ infections have been documented previously in AIDS cases (Zar et al., 1985). The prevalence of asymptomatic infections has not been determined and its potential may be underestimated. The 4.5% positive cases for _cryptosporidiosis_ in HIV patients were comparable with 4.2 to 6.2% reported by Sorvillo et al. (1994).

**Statistical analysis**

As rainfall, season or year did not appear to be correlated with the prevalence of _Cryptosporidium_ or _Giardia_, water-borne transmission does not appear to be the primary route and other factors such as personal hygiene, sanitation, education or potable water availability probably have a more significant impact on the incidence of these diseases.

**Conclusions**

- _Cryptosporidium_ and _Giardia_ were found to be endemic in KwaZulu-Natal with laboratory-confirmed prevalence ranging from 2.9 to 3.7% and 2.9 to 3.0%, of cases submitted for analysis, respectively.
- _Cryptosporidium_ and _Giardia_ prevalence did not appear to correlate statistically with rainfall, month or year indicating that water-borne transmission is not important and other factors such as personal hygiene, potable water supply, sanitation and education probably have a more significant impact on their incidence. However, the graphs appeared to indicate that prevalence of diarrhoea and infection increased when rainfall increased.
- Increases in the number of diarrhoeal samples submitted for _Cryptosporidium_ or _Giardia_ analysis were independent of the prevalence of either protozoan pathogen.
- Overall, female and male diarrhoeal patients had similar percentages of cryptosporidiosis while _giardiasis_ was more prevalent in female patients. However, the prevalence of both diseases for each gender differed with respect to age.
- _Cryptosporidium_ and _Giardia_ prevalence in children younger than 5 years indicated that _Cryptosporidium_ was most prevalent (39.3%) in the <1 year age group while _Giardia_ was most prevalent in the 3 to 4 year age group (38.5%).
- In _cryptosporidiosis_ positive children < 5 years of age, 41.8% were male and 58.2% were female while 32.5% of _giardiasis_ positive children were male and 67.5% were female.
- A low percentage of _Cryptosporidium_ and _Giardia_ positive cases were recorded in symptomatic (4.5% and 5.3% respectively) and asymptomatic (2.4% and 0.8% respectively) HIV patients.
- Clear recording and storage of data including gender, age, race, environment (location) and socio-economic factors of the patients are essential so that trends and outbreaks may be easily identified.
- Detection techniques need to be enhanced and standardised so that results can be comparable.
Acknowledgements

The Director of Scientific Services of Umgeni Water is acknowledged for supporting the production of this paper. The pathology laboratories of Grey’s Hospital, King Edward Hospital and Pillay MacIntosh & Partners are acknowledged for data used in this study. Ms L. Mthembu is thanked for assistance in data acquisition.

References


