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# Risk factors for giardiasis: a case-control study in Avon and Somerset

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## SUMMARY

*Giardia lamblia* is a common and increasing cause of gastrointestinal illness in the UK. We report a case-control study that examined risk factors for giardiasis. Patients with giardiasis were identified from reports to the Consultants in Communicable Disease in Avon and Somerset, and age–sex matched controls were obtained from their general practitioners' lists. Details of travel history, water consumption and recreational water use were collected by postal questionnaire. Over the period July 1992 to May 1993, 74 cases and 108 matched controls were obtained. The data were analysed using conditional logistic regression. Swimming appeared to be an independent risk factor for giardiasis (odds ratio 2·4, 95% CI 1·0 to 6·1, $P = 0{\cdot}050$). Travel ($P = 0{\cdot}001$), particularly to developing countries, and type of travel ($P = 0{\cdot}004$) – that is, camping, caravanning or staying in holiday chalets – were also observed to be significant risk factors. Other recreational water use and drinking potentially contaminated water were found to be not statistically significant after adjustment for other factors.

## INTRODUCTION

*Giardia lamblia* is a flagellated protozoan parasite which causes acute gastrointestinal upset in man. Of those infected, 25–50% become symptomatic and the illness often lasts over 3 weeks [1]. Recognized routes of infection include faecal-oral spread, especially in infant day-care facilities [2–4], consumption of contaminated or inadequately filtered water [3–6], consumption of food where food was directly contaminated [7–10], male homosexual contact [11] and swimming in contaminated pool water [12, 13]. The first documented outbreak of waterborne giardiasis associated with mains water in the UK occurred in Bristol in 1985 [14]. In the United States, where giardia is the most frequently identified pathogen in waterborne outbreaks of infectious disease [6], increased risk of infection is associated with contact with a case, drinking untreated water, attendance at day-care, contact with a day-care attendee, camping, or following foreign travel [3, 4]. In a previously reported descriptive study based in Bristol most cases were found to fall into one of three main risk groups; 23% of cases had

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travelled abroad in the month before onset of symptoms, 67% of those aged over 10 years had engaged in recreational water activity and 24% were pre-school children [15]. Flanagan in his recent review commented on the lack of studies in this country examining risk factors in sporadic giardiasis [16]. Described below is a case control study undertaken to explore further the epidemiology of endemic giardiasis in Avon and Somerset, in particular the risk associated with recreational water use, and associations with foreign travel and potentially contaminated water consumption.

## METHODS

Cases were defined as all those patients in whom *Giardia lamblia* was demonstrated to be present in the stool and who were subsequently reported to either the Somerset or Bristol Consultant in Communicable Disease Control (CCDC) during the study period. Secondary cases, defined as those occurring within a month of a case and living in the same household, were excluded. Nearly all stool samples are examined routinely for giardia in the microbiology laboratories in Avon and approximately 40% in the Somerset Public Health Laboratory. In all laboratories specimens are examined by direct microscopy of an unstained emulsion of faeces at a magnification of $\times 40$. In addition, in Somerset Public Health Laboratory, concentration techniques (emulsification of stool samples in saline, followed by addition of ethyl acetate and centrifugation for 2–3 min at 800 rev./min) prior to direct microscopy are performed on samples from those with a history suggestive of giardiasis, an estimated 5–10% of all samples. Positive results are routinely reported to the relevant CCDC. A postal questionnaire was mailed to all identified cases. Details were requested on travel, recreational water activity, attendance at nursery or day-care and water consumption in the 4 weeks prior to submission of the positive sample. Two age and sex matched controls, chosen at random from the index cases' general practitioners' lists, were sent a similar questionnaire requesting details of activities in the same 4-week period. Reminders were sent to non-responders after 3 weeks. Sample size calculations based on the prevalence of recreational water activity reported in the previous study [15] suggested a total of 80 cases and matched controls would be needed in order to demonstrate a 25% difference in recreational activities between the two groups with an 80% power and a 5% significance level. Demographic characteristics of those included in the analysis were compared with those of all cases reported during the study period, some of whom did not respond to the questionnaire, and others who were excluded because no matched controls responded. The age and seasonal distribution of cases in Avon and Somerset were compared with national figures (CDSC, personal communication).

### *Data analysis*

The matched data were analysed using the conditional logistic regression analysis element of the 'EGRET' package for PCs. For these analyses, the information collected was represented by the following five variables grouped as shown below.

1 Recreational water use

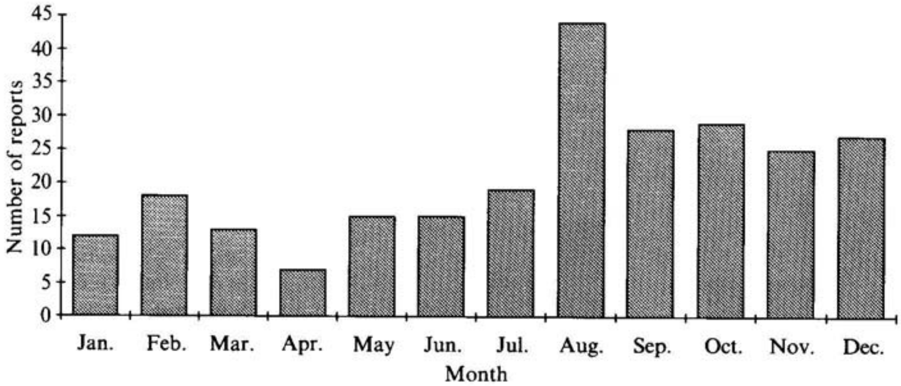


Fig. 1. Giardia reports in Avon and Somerset 1992.

(a) Swimming: in swimming pools, fresh or seawater.
(b) Other recreational water use: canoeing, sailing, windsurfing, scuba diving, fishing, caving, or playing in ponds or streams.

2 Drinking potentially contaminated water: from wells, streams or rivers, or tap water or ice cubes when abroad.

3 Travel
(a) Travel was divided into four categories – no travel, travel in the UK, travel in developed countries (Western Europe, Australia, Canada and the USA), and travel in developing countries (predominantly the Indian sub-continent).
(b) Type of travel: camping or staying in caravans or holiday chalets.

Omitted from the list is the information collected on playgroup attendance; given the age distribution, most cases could not have been exposed to this risk factor.

For the first stage of the analysis, each of the above five factors were considered separately (the 'unadjusted' analyses). In the second stage, relationships between them were accounted for in 'adjusted analyses', first within the above groups, then by modelling across the groups in order to arrive at the final model. Case-control sets with missing data on any of the variables in a given model were excluded from that particular analysis. The maximum number of sets excluded in this way was five.

## RESULTS

### *Demographic characteristics of giardia reports: Avon and Somerset 1992*

Fig. 1 shows the age distribution of all giardia reports in Avon and Somerset for 1992. The pattern is similar to that seen nationally with approximately a quarter of cases aged less than 5 and a quarter aged 25–34 years. Forty-nine percent of reported cases were in males. Fig. 2 shows the seasonal variation in reporting rates, which is similar to that seen nationally with the greatest number of reports submitted in late summer and autumn. In detail, the local peak was in August with 18% of all reports for 1992; nationally the greatest number (13%) was in September. Altogether over 40% of cases both nationally and in Avon and Somerset are reported in the 4 months August to November.

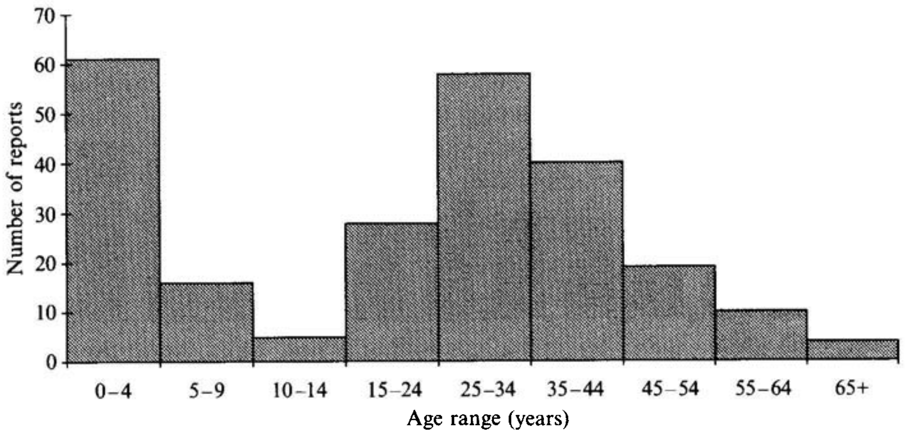


Fig. 2. Age distribution of giardia reports in Avon and Somerset 1992.

*Demographic characteristics of study cases included in analysis*

Data collection commenced on 1 July 1992 and continued until 31 May 1993. Of the 125 reported cases identified in Avon and Somerset during that period, 99 (79%) responded. However, 25 of those responding were excluded since they were either identified as secondary cases ($n = 3$) or because no matched control was obtained ($n = 22$). Of the remaining 74, 40 had just one responding control, and 34 had two responding controls. Whilst all controls were age, sex and practice matched, no further information was available on the non-responding controls.

Of those cases included in the study, 34 (46%) were male, only slightly less than the proportion of males in the overall population of reported cases (49%). The age distribution of those included in the analysis differed slightly from the overall local distribution. There were fewer 25–34 year olds (only 18% of the group) and those aged less than 5 (only 15% of the group), whereas these two age groups make up 50% of reported cases overall. The main reason for this shortfall was non-response either by cases or their matched controls; analysis was not possible for 11 (61%) of 25–34 year old cases. The response rate was much better for those aged over 45 (83%).

Twelve cases reported that another member of the household had been ill with diarrhoea in the 4 weeks prior to the notification of giardiasis. It is possible therefore that some of these cases were secondary or co-primary cases. Given that the number of non-primary cases amongst these 12 is likely to be small it was decided to include them in the analysis.

*Results of logistic regression analyses*

*Unadjusted.* The results of the unadjusted conditional logistic regression for each variable are shown in Table 1. Swimming, travel abroad, type of travel and drinking potentially contaminated water emerged as statistically significant risk factors for giardiasis.

*Adjusted.* The five variables were then modelled in various groups in terms of their relationship with giardiasis. First, swimming and other recreational water use were considered together. After adjustment for swimming, the odds ratio for

Table 1. *Odds ratios for each risk factor for giardiasis: results of unadjusted conditional logistic regression analysis*

| Risk factor (reference category) | Category | Cases exposed ($n$ = 74) | Controls exposed ($n$ = 108) | Odds ratio | 95% Confidence interval | $P$ value |
|---|---|---|---|---|---|---|
| Swimming (no swimming) | Swimming | 35 | 34 | 3·0 | 1·4–6·2 | 0·003 |
| Recreational water sports (no recreational water sports) | Recreational water sports | 14 | 14 | 1·7 | 0·7–3·9 | 0·226 |
| Drinking potentially contaminated water (not doing so) | Drinking potentially contaminated water | 19 | 12 | 5·7 | 1·6–19·8 | 0·002 |
| Travel (no travel) | | | | | | < 0·001 |
| | UK | 10 | 27 | 0·7 | 0·3–1·8 | |
| | Developed countries* | 6 | 6 | 1·7 | 0·4–6·1 | |
| | Developing countries* | 18 | 3 | 22·2 | 2·9–173·1 | |
| Type of travel (no camping, caravanning, or use of holiday chalets) | Camping, caravanning or use of holiday chalets | 11 | 3 | 6·9 | 1·5–32·1 | 0·004 |

* See text for definition.

recreational water use dropped to 1·1 (95% CI 0·4 to 2·7, $P = 0{\cdot}91$), suggesting it is not an independent risk factor when swimming is taken into account. On the other hand, the odds ratio for swimming remained at 2·9 ($P = 0{\cdot}006$) when other recreational water use was taken into account, suggesting that swimming is an independent risk factor. Only the former was therefore retained for further modelling.

When travel and type of travel were examined together, type of travel remained significant ($P = 0{\cdot}014$) independent of place of travel. Similarly, travel remained significant ($P < 0{\cdot}001$) independent of type of travel; both risk factors were therefore retained for further analysis.

Following these analyses, four variables were modelled together: swimming, drinking water, travel and travel type. As shown in Table 2, travel and type of travel emerge as significant variables, with swimming on the borderline of statistical significance with an odds ratio of 2·4. Although drinking potentially contaminated water does not remain as statistically significant, the magnitude of the odds ratio (4·4) suggests that this may nevertheless still be an important risk factor. Removing the factor on drinking water did not fundamentally change the results for the remaining three factors.

For interest some details of the interrelationships of the variables are outlined below. Of the 19 cases who had consumed potentially infected water, 8 had been

Table 2. *Odds ratios for risk factors for giardiasis: results of adjusted conditional logistic regression analysis*

| Risk factor (reference category) | Category | Adjusted odds ratio | 95% Confidence interval | *P* value |
|---|---|---|---|---|
| Swimming (no swimming) | Swimming | 2·4 | 1·0–6·1 | 0·050 |
| Drinking potentially contaminated water (not doing so) | Drinking potentially contaminated water | 4·4 | 0·3–60·3 | 0·233 |
| Travel (no travel) | | | | < 0·001 |
| | UK | 0·4 | 0·1–1·2 | |
| | Developed countries* | 0·2 | 0·2–3·3 | |
| | Developing countries* | 7·6 | 0·8–70·1 | |
| Type of travel (no camping, caravanning, or use of holiday chalets) | Camping, caravanning, or use of holiday chalets | 8·4 | 0·8–70·1 | 0·017 |

* See text for definition.

camping or caravanning; 11 had visited developing countries and 6 developed countries. Of the 35 cases who had been swimming, 13 had been swimming in the sea, 7 in fresh water and 27 in swimming pools. (Some swam in more than one site hence the numbers do not add up to 35). Of those who had been swimming, 16 had not travelled abroad: 15 of these had swum in swimming pools in the UK and 1 in the sea.

## DISCUSSION

As far as we are aware this is the first case-control study to examine risk factors for giardiasis in the UK and to suggest that swimming is a significant risk factor for the disease outside an outbreak situation. The results also confirm that travel abroad, particularly to developing countries, and type of travel (camping, caravanning and staying in holiday chalets), are significant independent risk factors for giardiasis. Other recreational water use and drinking potentially contaminated water were found to be not statistically significant in this study after adjustment for other factors.

There have been several outbreaks of giardiasis associated with swimming pools [12, 13, 17]. Two of these were associated with a clearly identified incident of faecal contamination of the swimming pool [12, 13] and another was associated with a pool with a water slide, which was adjacent to a wading pool for toddlers. In the latter, repeated use of the water slide, use of the water slide pool and swallowing pool water were associated with illness [17]. Although filtration and chlorinating systems are effective in removing giardia, the organism is known to be quite resistant to chlorine. If faecal contamination of pool water occurs, chlorinating systems may be overwhelmed and filtration processes can take several hours to

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circulate the total volume of water in a pool. The transmission of giardiasis through poorly maintained swimming pools, particularly if used heavily by toddlers or others prone to faecal accidents is thus clearly plausible. Swimming in the sea has been shown to be associated with an increased risk of gastrointestinal illness where there is sewage contamination [18]. Details of where swimming took place were collected this study, but because of the small numbers identified it was not possible to draw any reliable conclusions. The available data does not suggest any strong association with swimming in pools with specific features like shutes and jacuzzis. Swimming in fresh water appears to carry a higher risk of giardiasis than swimming in seawater or pools. These more detailed hypotheses would need to be tested in a larger study.

No significant association was shown between other recreational water sports and giardiasis. A large number of watersports with varying exposure to water were included, and it is possible that this may have masked any effect. For example, a higher proportion of cases than controls had been canoeing or windsurfing. Again, numbers here are too small to form an accurate assessment of significance.

Other studies examining risk factors for endemic giardiasis have been undertaken outside the UK [3, 4, 12, 20], and playgroup attendance, consumption of unfiltered water, travel to developing countries and camping have all been identified as carrying risk. One study in British Columbia [20] noted that camping and swimming increased the risk of giardiasis but did not differentiate between the two activities.

The number of cases of giardiasis appears to be rising in this country and in the USA, although it is not clear if this is due to better reporting or a real increase in cases. A consistent rise in reports has been shown in August and early autumn in both countries, with the autumn rise possibly reflecting disease contracted in the summer, given the frequent delay between onset of illness and diagnosis [16, 19]. In a descriptive analysis of giardiasis in Wisconsin, USA, Addis postulated that the later summer rise would be consistent with recreational water use during the summer months, and commented that further studies were needed [19].

Advice to travellers abroad currently emphasises the need to avoid consuming potentially contaminated food and water in order to avoid contracting gastrointestinal infections. This advice may be difficult to follow, particularly in developing countries, and however rigorously this advice is followed individuals may still contract infectious diseases [21]. In the case of giardiasis, swimming in contaminated water may be an additional important risk factor.

This study suggests that there is an association between swimming and giardiasis, and that therefore Consultants in Communicable Disease Control need to consider collecting details on use of swimming pools and other swimming venues in both outbreaks and in the routine surveillance of giardiasis.

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