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Severe giardiasis and cryptosporidiosis in Scotland, UK

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SUMMARY

Hospital discharge data from 1990–4 for 26 hospitals were used to estimate and compare the cost and describe the epidemiology of severe giardiasis and cryptosporidiosis in Scotland, UK. The incidence of severe cryptosporidiosis was almost double that of severe giardiasis and the median duration of hospitalization was longer for cryptosporidiosis than giardiasis. Impaired immunity was frequently listed as co-diagnosis with cryptosporidiosis and associated with extended hospitalization. Although both infections were associated with infants, the median age was lower for cryptosporidiosis (5 years compared with 30 years). Whereas hospitalization was not significantly longer for infants with cryptosporidiosis, hospitalization for this age group with giardiasis was longer (4 days compared with 3 days). Comparison with similar data for giardiasis from USA revealed various differences and similarities. These points are discussed in relation to the epidemiology of these infections and published data were used to estimate costs of hospitalization.

INTRODUCTION

Cryptosporidium and *Giardia* are both intestinal protozoan pathogens which may cause disease in man, with diarrhoea as the most frequent symptom. However, both infections may also be asymptomatic or characterized by only mild signs and symptoms. Both infections have a relatively low infective dose [1–3]. Although direct faecal–oral transmission is probably the more common transmission route, large outbreaks of waterborne giardiasis and cryptosporidiosis have been documented [e.g. 4–7].

Despite the similarities in transmission and clinical symptoms of these diseases, two major differences have affected our perspective of these infections and may also have an impact on their epidemiology. First, generally consistent shedding of oocysts in faeces and simple and conclusive staining techniques have allowed cryptosporidiosis to be diagnosed relatively easily, except where excretion falls below the limit of detection. However, diagnosis of giardiasis, even in symptomatic infections, is less easy due to variability of excretion of cysts in faeces [8]. Second, whereas treatment of giardiasis is relatively uncomplicated, prophylaxis and chemotherapy for cryptosporidiosis are presently unavailable.

Although cryptosporidiosis may be severe, particularly in the immunocompromised, the young and the elderly, the self-limiting nature of the disease in the immunocompetent means that in industrialized nations the infection is seldom considered to be of great concern. *Giardia*, likewise, may cause debilitating disease, both chronic and severe, but might also be regarded as a benign, or even symbiotic, organism. These perspectives on both infections may not only

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mask the burden imposed by severe giardiasis and cryptosporidiosis in UK, but may also limit our understanding of the epidemiology of these infections.

By examining data from hospital discharge records an attempt was made both to describe the epidemiology and estimate the burden of severe giardiasis in the United States [9]. In the present paper, hospital discharge data from Scotland, UK, from January 1990 to December 1994, were similarly examined to investigate the epidemiology and quantify the burden of both severe giardiasis and cryptosporidiosis.

METHODS

Hospital records for Scottish hospitals from January 1990 to December 1994 obtained from Information and Statistics Division (ISD) of the National Health Service in Scotland (Trinity Park House, Edinburgh) were explored for giardiasis and cryptosporidiosis. Scottish Morbidity Records (SMR) 1 (medical), 2 (maternity and obstetric), 4 (pyschiatric or mental handicap) and 11 (neonatal) were all searched to ensure that no cases were overlooked. All diagnostic codes used were those designated in the International Classification of Diseases – 9th revision [ICD-9] [10]. For giardiasis, cases which had a listing of giardiasis (ICD-9 rubric 007.1) in any of the diagnostic fields were initially selected. As a diagnostic code may not indicate the actual reason for hospitalization, giardiasis was only considered to be the cause of hospitalization if it met the criteria used by Lengerich and colleagues [9]; i.e., if it was the first diagnosis listed or if the previously listed diagnoses could be considered to be signs or symptoms of giardiasis (e.g. dehydration, diarrhoea, vomiting, failure to thrive, etc.) or non-specific causes of gastro-enteritis (e.g. unspecified colitis, unspecified sprue, etc.). If another intestinal pathogen was specified, regardless of order of listing, giardiasis was not considered the cause of hospitalization. By using these criteria, Lengerich and colleagues [9] felt able to use the phrase *hospitalization for giardiasis* to refer to discharges for which giardiasis was considered to be the cause of hospitalization and this terminology has also been followed in this paper.

As there is no rubric for cryptosporidiosis in ICD-9, this infection may be classified as either coccidial infection (ICD-9 rubric 007.2) or other specified protozoal intestinal disease (ICD-9 rubric 007.8), depending upon the policy of the coding department or coder preference. To ascertain that diagnoses with ICD-9 rubrics 007.2 and 007.8 did refer to cryptosporidiosis, and not to other infections which could also be classified under either of these codings, e.g. *Isospora* infection, for each discharge with these diagnostic codes the case notes or consultant's discharge letter were referred to. If it was decided that the rubric used did refer to *Cryptosporidium* infection, similar criteria to those described above for giardiasis were used to decide whether hospitalization for cryptosporidiosis had occurred.

Statistical analyses of the results were carried out using a Microsoft Excel spread-sheet and an SPSS computer package to perform calculations for Kruskal–Wallis, Mann–Whitney-U, Chi-squared and Fisher's exact probability tests. Estimates of cost due to hospitalization for cryptosporidiosis and giardiasis were calculated from published data [11].

RESULTS

Of the 240 cases classified as giardiasis (007.1) between 1990–4, 189 (79%) were considered to fulfil the criteria for hospitalization due to giardiasis. One further case of giardiasis which had been incorrectly classified as coccidial infection (007.2) was also included in the analyses. A further two cases which had not been included on the data-base but were identified following communication with hospital records departments, were also included. Therefore, a total of 192 cases were considered to be hospitalized due to giardiasis during this period. Of these, 184 were individuals with a single hospitalization, 2 individuals had had 2 separate hospitalizations and 1 individual had been hospitalized on 4 separate occasions.

Of the 352 cases with either specified protozoal intestinal disease (007.8) or coccidial infection (007.2) between 1990–4, 304 (86%) were considered to fulfil the criteria for hospitalization due to these codings (potentially cryptosporidiosis). Of these 304 cases (18 with ICD-9 rubric 007.8 and 286 with ICD-9 rubric 007.2) reference to case notes and/or discharge letters indicated that *Cryptosporidium* was the aetiological agent in 279 (92%); 2 with ICD-9 rubric 007.8 and 277 with ICD-9 rubric 007.2. One case with ICD-9 rubric 007.8 had toxoplasmosis and another amoebic dysentery. Other cases with ICD-9 rubric 007.8 and 007.2 were campylobacter and *Giardia* infections or diarrhoea of unknown aetiology which had been incorrectly classified. Case notes had been mislaid for 8 individuals from 3 hospitals, and these cases were

Table 1. *Hospitalization for giardiasis in Scotland by year from January 1990 to December 1994*

	1990	1991	1992	1993	1994	1990–1994
Number of cases	35	41	39	30	47	total = 192 mean = 38
Annual rate per 100000 persons	0·6	0·8	0·8	0·6	0·9	mean = 0·7
Number with at least one overnight stay (%)	28 (80)	34 (83)	30 (77)	24 (80)	38 (81)	154 (80)
Median length of stay (days) (range)	3 (0–14)	4 (0–49)	3 (0–20)	2 (0–11)	3 (0–49)	3 (0–49)
Total number of patient-days in hospital	160	217	140	75	210	total = 802 mean = 160
Median age (years) (all cases)	32	31	21	30	30	30
Median age (years) (cases with at least one overnight stay)	31	27	18	24	27	25
Number of cases hospitalized overnight staying > 5 days (%)	13 (46)	12 (35)	9 (30)	3 (13)	8 (22)	45 (29)
Median age (years) of those staying > 5 days (range)	22 (< 1–80)	28 (< 1–83)	22 (< 1–88)	31 (< 1–32)	41 (< 1–86)	31 (< 1–88)
Modal age (years)	< 1	1	1	2	3	1
Male:female ratio	1·5:1·0	1·3:1·0	1·9:1·0	1·0:1·5	1·0:1·2	1·2:1·0
Number < 5 years (%)	10 (29)	12 (29)	11 (28)	10 (33)	10 (22)	53 (28)
Number < 5 years with at least one overnight stay (% of < 5 year olds)	9 (90)	11 (92)	10 (91)	9 (90)	9 (90)	48 (91)
Median length of stay (days) for children < 5 years (range)	5 (0–14)	4 (0–8)	4 (0–20)	2 (0–6)	3 (0–11)	4 (0–20)
Number women 18–38 years (%)	6 (17)	5 (12)	5 (13)	8 (27)	9 (20)	33 (17)
Number women 18–38 years with at least one overnight stay (% of 18–38 year old women)	6 (100)	4 (80)	4 (80)	8 (100)	8 (89)	30 (91)
Median length of stay (days) for women 18–38 years (range)	4 (1–8)	4 (0–6)	3 (0–3)	3 (1–11)	3 (0–8)	3 (0–11)
Number men 18–38 years (%)	10 (29)	10 (24)	7 (18)	3 (10)	8 (17)	38 (20)
Number men 18–38 years with at least one overnight stay (% of 18–38 year old men)	7 (70)	8 (80)	5 (71)	2 (66)	7 (88)	29 (76)
Median length of stay (days) for men 18–38 years (range)	2 (0–6)	4 (0–11)	1 (0–3)	2 (0–7)	2 (0–5)	2 (0–11)
Number > 70 years (%)	4 (11)	2 (5)	2 (5)	2 (7)	4 (9)	14 (7)
Number > 70 years with at least one overnight stay (% of > 70 year olds)	4 (100)	2 (100)	2 (100)	1 (50)	3 (75)	12 (86)
Median length of stay (days) for > 70 year olds (range)	11 (11–14)	27 (4–49)	9 (8–9)	1 (0–1)	19 (0–49)	11 (0–49)

excluded from the analyses. On contacting the hospitals, a further 48 cases with hospitalization due to cryptosporidiosis were discovered which had not been included on the ISD data-base, giving a total of 327 cases considered to be hospitalized due to cryptosporidiosis during this period. Of these 327 hospitalizations, 306 were individuals with a single hospitalization, 6 individuals with 2 hospitalizations and 3 individuals had been hospitalized on 3 separate occasions.

Of all the discharges over the 5-year period, only two had diagnoses of both cryptosporidiosis and giardiasis, and, by following the criteria used by Lengerich and colleagues [9] as described above, they were not included in either group (hospitalization for giardiasis and hospitalization for cryptosporidiosis) for further analysis.

Results by year, age, sex, and duration of stay in hospital for both infections are shown in Tables 1–3. Tables 1 and 2 show the results for each infection by

Table 2. *Hospitalization for cryptosporidiosis in Scotland by year from January 1990 to December 1994*

	1990	1991	1992	1993	1994	1990–1994
Number of cases	62	62	65	83	55	total = 327 mean = 65
Annual rate per 100000 persons	1·2	1·2	1·3	1·6	1·1	mean = 1·3
Number with at least one overnight stay (%)	61 (98)	62 (100)	65 (100)	82 (99)	55 (100)	325 (95)
Median length of stay (days) (range)	4 (0–29)	4 (1–17)	5 (1–103)	4 (0–46)	3 (1–36)	4 (0–103)
Total number of patient-days in hospital	323	280	480	497	254	total = 1834 mean = 367
Median age (years) (all cases)	4	3	4	7	8	5
Median age (years) (cases with at least one overnight stay)	4	3	4	7	8	5
Number of cases hospitalized overnight staying > 5 days (%)	22 (36)	18 (29)	25 (39)	22 (27)	11 (20)	98 (30)
Median age (years) of those staying > 5 days (range)	3 (< 1–85)	4 (< 1–32)	12 (< 1–45)	22 (< 1–62)	31 (< 1–91)	7 (< 1–91)
Modal age (years)	1	1	1	1	1	1
Male:female ratio	1·1:1·0	1·0:1·5	1·0:1·5	1·1:1·0	1·0:1·5	1·0:1·2
Number < 5 years (%)	33 (53)	37 (60)	34 (52)	32 (39)	24 (44)	160 (49)
Number < 5 years with at least one overnight stay (% of under 5 year olds)	33 (100)	37 (100)	34 (100)	32 (100)	24 (100)	160 (100)
Median length of stay (days) for children < 5 years (range)	5 (1–17)	4 (1–17)	4 (1–17)	3 (1–8)	3 (1–6)	4 (1–17)
Number women 18–38 years (%)	5 (8)	3 (5)	8 (12)	9 (11)	12 (22)	37 (11)
Number women 18–38 years with at least one overnight stay (% of 18–38 year old women)	5 (100)	3 (100)	8 (100)	8 (89)	12 (100)	36 (97)
Median length of stay (days) for women 18–38 years (range)	3 (2–5)	3 (3–7)	13 (4–103)	4 (0–14)	3 (1–11)	4 (0–103)
Number men 18–38 years (%)	6 (10)	0 (0)	3 (5)	13 (16)	6 (11)	28 (9)
Number men 18–38 years with at least one overnight stay (% of 18–38 year old men)	5 (83)	— —	3 (100)	13 (100)	6 (100)	27 (96)
Median length of stay (days) for men 18–38 years (range)	5 (0–12)	— —	12 (5–13)	5 (1–44)	3 (1–36)	5 (0–44)
Number > 70 years (%)	2 (3)	0 (0)	0 (0)	1 (1)	3 (6)	6 (2)
Number > 70 years with at least one overnight stay (% of > 70 year olds)	2 (100)	—	—	1 (100)	3 (100)	6 (100)
Median length of stay (days) for > 70 year olds (range)	18 (7–29)	—	—	3	10 (9–19)	10 (3–29)

year, and Table 3 compares the cumulative results over the 5-year period for cryptosporidiosis and giardiasis. Pertinent points from these three tables are highlighted below.

Of the 192 cases with hospital admission due to giardiasis, 154 (80%) required at least one over-night stay. The median duration of stay due to giardiasis was 3 days (range 0–49 days) and the average total number of days per year spent in hospital due to giardiasis was 160. Of those spending at least one night in hospital due to giardiasis, approximately 30% spent > 5 days; the median age of these patients was 31 years (range < 1–88 years).

Adults > 70 years hospitalized due to giardiasis spent significantly longer in hospital than all the other age groups combined ($P < 0.0005$). Over 25% of the cases were children < 5 years and 90% of these cases spent at least one night in hospital. The length of stay for children < 5 years was significantly higher than that of other age groups, excluding the > 70 age

Table 3. *Comparison of hospitalization for giardiasis and cryptosporidiosis in Scotland between 1990–1994*

	Giardiasis	Cryptosporidiosis
Total number of cases	192	327
Mean annual rate	38	65
Total number of patient-days in hospital	802	1834
Mean annual number of patient-days in hospital	160	367
Number of cases with at least one overnight stay (%)	154 (80)	325 (95)
Median age of cases with at least one overnight stay (years)	25	5
Median age (years) of those staying > 5 days (range)	31 (< 1–88)	7 (< 1–91)
Number < 5 years (%)	53 (28)	160 (49)
Number < 5 years with at least one overnight stay (%)	48 (91)	160 (100)
Median length of stay (days) for children < 5 years (range)	4 (0–20)	4 (1–17)
Number of women 18–38 years (%)	33 (17)	37 (11)
Number of women 18–38 years with at least one overnight stay (%)	30 (91)	36 (97)
Median length of stay (days) for women 18–38 years (range)	3 (0–11)	4 (0–103)
Number of men 18–38 years (%)	38 (20)	28 (9)
Number of men 18–38 years with at least one overnight stay (%)	29 (76)	27 (96)
Median length of stay (days) for men 18–38 years (range)	2 (0–11)	5 (0–44)
Number > 70 years (%)	14 (7)	6 (2)
Number > 70 years with at least one overnight stay (%)	12 (86)	6 (100)
Median length of stay (days) for > 70 year olds (range)	11 (0–49)	10 (3–29)

group ($P < 0{\cdot}01$). In the 18–38 years group, more men were hospitalized with giardiasis than women, but the difference was not significant. Although women in this age group tended to be hospitalized for longer than men, no significant difference in duration of stay between men and women of this age group was detected.

The number of hospitalizations for giardiasis each year and the patterns seen for age group, sex and duration of hospitalization varied only slightly between years, although there were over 1·5 times as many cases in the year with the most cases (47 in 1994) as in the year with the least cases (30 in 1993).

Of the 327 cases with hospital admission due to cryptosporidiosis, 325 (95%) required at least one overnight stay; not a significantly higher proportion than those with giardiasis ($P > 0{\cdot}1$). The median duration of stay due to cryptosporidiosis was 4 days (range 0–103 days), significantly longer than the median length due to giardiasis ($P < 0{\cdot}001$). The average total number of days per year spent in hospital due to cryptosporidiosis was 367, more than double the average total number of days per year due to giardiasis. Of those spending at least one night in hospital due to cryptosporidiosis, approximately 30% spent > 5 days, and the median age of these individuals was 7 years (range < 1–91 years). Although the proportion of individuals spending > 5 days in hospital did not differ significantly between cryptosporidiosis and giardiasis, the median age of those hospitalized with giardiasis for > 5 days was significantly older than those hospitalized with cryptosporidiosis.

Almost 50% of the cases hospitalized with cryptosporidiosis were children < 5 years and all of these cases spent at least one night in hospital. Unlike children < 5 years hospitalized with giardiasis, the length of stay for children < 5 years with cryptosporidiosis was not significantly higher than that of other age groups. In the 18–38 years age-group, more women were hospitalized with cryptosporidiosis than men, but the difference was not significant. In the 18–38 years age group, although men tended to be hospitalized for longer than women, no significant difference in duration of stay between men and women was detected.

At least 18 of the cryptosporidiosis cases were immunocompromised. Several of these were HIV-positive patients and cryptosporidiosis was considered to be a major factor contributing to mortality in some of these cases. Between them, the immunocompromised patients spent a total of 307 days in hospital, or over 16% of the total number of patient-days. Of those cases known to be immunocompromised, the median age was significantly higher than that of the non-immunosuppressed cases ($P < 0.05$; median age, 31 years; range, 1–60 years) and the median length of stay was significantly longer than that of the non-immunocompromised ($P < 0.05$; median length of stay, 11 days; range, 1–103 days).

The number of hospitalizations for cryptosporidiosis each year and the patterns in age group, sex and length of hospitalization tended to vary between years, and there were over 1·5 times as many cases in the year with the most cases (83 in 1993) as the year with the least cases (55 in 1994). One variation of note over the 5-year period is that the median age of those hospitalized with cryptosporidiosis increased significantly from 4 years in 1990 to 8 years in 1994 ($P < 0.02$). A similar trend was not observed with giardiasis (median age in 1990, 32 years; in 1994, 30 years).

Of the cases hospitalized due to giardiasis, 62 (32%) had other diagnoses also listed. The mean number of co-diagnoses, in addition to giardiasis, was 0·6 (range 0–5). Of these, the most frequently listed were lack of expected normal physiological development (ICD-9 rubric 783.4) recorded for 6 (3·1%) of the 192 discharges, unspecified intestinal obstruction (ICD-9 rubric 560.9) recorded for 5 (2·6%) of the 192 discharges, and irritable colon (ICD-9 rubric 564.1) also recorded for 5 (2·6%) of the 192 discharges. Of the 53 hospitalizations of children < 5 years of age, lack of expected normal physiological development (failure to thrive) was recorded for 6 (11·3%). Of the > 70 age group hospitalized due to giardiasis, 10 (71·4%) had other diagnoses listed and the mean number of co-diagnoses in addition to giardiasis was 2·1 (range 0–5). In this age group the most frequently listed symptoms or co-diagnoses were incontinence of urine and faeces (ICD-9 rubrics 788.3 and 787.6 respectively), oesophagitis (ICD-9 rubric 530.1) and diverticula of colon (ICD-9 rubric 562.1); all 4 of these co-diagnoses were recorded for 3 (21·4%) of these cases. Only 3 of the cases (1·6%) had co-diagnoses directly indicative of impaired immunological function; these co-diagnoses were unspecified immunity deficiency (ICD-9 rubric 279.3) for 1 case and deficiency of humoral immunity (ICD-9 rubric 279.0) for a further 2 cases. The duration of hospitalization for these cases ranged between 1–5 days and the patients' ages ranged between 3–61 years.

Of the cases hospitalized due to cryptosporidiosis, 75 (23%) had other diagnoses also listed. No significant difference was detected between this proportion and the proportion of cases with co-diagnoses seen with giardiasis ($P > 0.05$), however the mean number of co-diagnoses, in addition to cryptosporidiosis (0·4; range 0–5) was significantly lower than the mean number of co-diagnoses seen with giardiasis ($P < 0.05$). The most frequently listed co-diagnoses were colitis, enteritis and gastroenteritis of presumed infectious origin (ICD-9 rubric 009.1) recorded for 8 (2·5%) of the 327 discharges and deficiency of cell-mediated immunity recorded for 7 (2·1%) of the 327 discharges. Infectious colitis, enteritis and gastroenteritis (ICD-9 rubric 009.0), diarrhoea of presumed infectious origin (ICD-9 rubric 009.3), nausea and vomiting (ICD-9 rubric 787.0), and abdominal pain (ICD-9 rubric 789.0) were all recorded for 6 (1·8%) of the 327 discharges. Of the 160 hospitalizations with cryptosporidiosis of children < 5 years of age, lack of expected normal physiological development (failure to thrive) was never recorded as a co-diagnosis. In this age group the most frequently listed co-diagnoses were colitis, enteritis and gastroenteritis of presumed infectious origin (ICD-9 rubric 009.1) and infectious colitis, enteritis and gastroenteritis (ICD-9 rubric 009.0), both recorded for 5 (3·1%) of this age group. In this age group, the co-diagnosis of deficiency of cell-mediated immunity (ICD-9 rubric 279.1) did not occur; the median age of individuals recorded as having this co-diagnosis was 31 years (range 29–60 years) and the median length of stay for individuals with this co-diagnosis was 11 days (range 1–34 days). Of the > 70 age group hospitalized due to cryptosporidiosis, 3 (50%) had other diagnoses listed and the mean number of co-diagnoses in addition to cryptospori-

Table 4. *Annual laboratory reports of cryptosporidiosis and giardiasis diagnosed in Scotland*

	Giardiasis		Cryptosporidiosis	
Year	No. of reports	Percentage hospitalized	No. of reports	Percentage hospitalized
1990	331	10·6	791	7·8
1991	332	12·4	980	6·3
1992	427	9·1	954	6·8
1993	354	8·5	898	9·2
1994	395	11·8	893	6·2
Total	1839	10·4	4516	7·2

diosis was 0·8 (range 0–2). In this age group no single co-diagnosis predominated.

The annual number of laboratory reports of diagnosis of *Cryptosporidium* and *Giardia* infection in Scotland are presented in Table 4 [12; D. Campbell, personal communication]. By extrapolation from laboratory report data and the hospital discharge data obtained in this study, the percentage of cases reported and also hospitalized were calculated and are also shown in Table 4. Of the giardiasis cases diagnosed over the 5-year period, a significantly larger proportion were hospitalized (10·4%) than of the cryptosporidiosis cases diagnosed over this period (7·2%) ($P < 0·005$), although this varied annually.

The hospital facilities used for all but one case of cryptosporidiosis on the ISD data-base were described as inpatient admission. One case of cryptosporidiosis was classified as a day case inpatient. For giardiasis, of the 190 cases listed on the ISD data-base, 161 cases (85%) were coded as inpatient admissions, 18 cases (9%) were coded as using a day bed unit, 6 cases (3%) were coded as day case inpatients, 3 cases (2%) were coded as other day cases and 2 cases (1%) were coded as using the 5-day ward.

The estimated costs of hospital facilities within the various health boards within Scotland are available [11], and by extrapolation from these data the mean annual cost of hospital facilities used for severe giardiasis and severe cryptosporidiosis within Scotland can be estimated to be in excess of £31000 and in excess of £73000 respectively.

DISCUSSION

Although cryptosporidiosis and giardiasis have several similarities, differences exist in ease of diagnosis and availability of treatment. Whilst the potential severity of giardiasis and cryptosporidiosis, particularly in the immunocompromised, is widely accepted, both infections are frequently considered to be of minor importance in industrialized nations. Lengerich and colleagues [9] analysed hospital discharge data in the USA over a 10-year period in order to describe epidemiological patterns for severe giardiasis, estimate the burden of this disease on the US population, and to compare this data with similar data for shigellosis. In this paper, a similar approach was used to analyse and compare hospitalization for severe giardiasis and cryptosporidiosis over a 5-year period in Scotland, UK.

Because *Giardia* and *Cryptosporidium* infections may be diagnosed incidentally during clinical investigations of a hospital patient, the same approach was used as that utilized for giardiasis in the USA [9] to determine if the reason for hospital admission had been for giardiasis or cryptosporidiosis. However, as has been acknowledged [9], this approach may lack sensitivity as it may exclude some hospitalizations for giardiasis or cryptosporidiosis. This lack of sensitivity was noticeable here when some hospitals provided data of cases hospitalized with either giardiasis or cryptosporidiosis which had not been included on the data-base; this occurred for 2 cases of giardiasis and 48 cases of cryptosporidiosis. The hospitals concerned in these instances were either unable to offer an explanation or suggested that discharge codes were added to the patients' notes before the diagnoses were confirmed.

One of the most striking differences between the Scottish and the USA [9] giardiasis data is that the US rates of hospital admissions are much higher. In the editorial response to the US data [13], the high hospital admission rate of 2·0/100000 persons in the US and 1·4/100000 persons in the state of Michigan were highlighted. These figures are between 2–3 times greater than those described for Scotland.

In the USA there are no national surveillance data for giardiasis and cryptosporidiosis, but estimates from passive surveillance data from Vermont, Wisconsin and a number of large cities across the USA indicate that the annual incidence of giardiasis is *c.* 40 cases/100000 cases with *c.* 5% hospitalized [D. Addiss, personal communication]. The data from Scotland indicate an annual incidence of *c.* 7 cases/100000 population, but with *c.* 10% hospitalized.

That the incidence of giardiasis cases diagnosed in the USA is significantly higher than in Scotland may indicate various factors. These include: differences in the occurrence and infectivity of *Giardia*; increased exposure to infective *Giardia* cysts in the USA; increased severity of symptoms of *Giardia* infection in the USA compared to Scotland (due to more virulent strains in the USA or more attenuated strains in the UK) which results in more individuals presenting for diagnosis; differences in the susceptibility of the two populations to infection with *Giardia*; and greater awareness of this infection amongst both patients and doctors in the USA, which may result in more samples being submitted to diagnostic laboratories for examination for *Giardia* cysts and may also result in repeated samples being submitted if giardiasis is not diagnosed on an initial sample.

If the sensitivity of hospital discharge data for ascertaining hospitalization does not differ significantly between the USA and UK, the elevated incidence of hospitalization for giardiasis in the USA may be due to factors similar to those proposed above for the differences in incidence of giardiasis (not necessarily requiring hospital admission). It may also indicate differences in hospitalization policy between the USA and UK.

Whereas Lengerich and colleagues [9] found that the highest rates of hospitalization for giardiasis were observed among children < 5 years of age and women of child-bearing age (which they put as between 20–39 years), our data indicate a different pattern for Scotland. Although children < 5 years in Scotland had a high rate of hospitalization (each year the modal age for admission was 3 years or under and, over-all, over 25% of admissions for giardiasis were children < 5 years), women of child-bearing age (for this paper selected as being between 18–38 years) were no more likely to be hospitalized with giardiasis than men of this age group. Children < 5 years in Scotland also spent significantly longer in hospital than other age groups (excluding the > 70 years age group). This pattern of age distribution is also observed in cases of giardiasis diagnosed in Scotland but not requiring hospitalization (D. Campbell, personal communication).

Children of < 5 years may be more likely to suffer from severe giardiasis as a consequence of a range of factors including increased exposure due to lower standards of personal hygiene and a tendency to suck communally-handled objects, and also due to lack of immunity [14]. Lengerich and colleagues [9] postulated that women of child-bearing age may be more likely to suffer from giardiasis because of increased exposure to infected children. The data presented here suggest that women of child-bearing age in Scotland are no more at risk to infection with *Giardia* than any other group, or that an increased risk of infection need not result in increased risk of hospitalization due to giardiasis.

Only one of the women of this age group hospitalized with giardiasis was recorded as pregnant (3%) and there were no instances where giardiasis was listed as a complication of pregnancy. This contrasts with the US data [9] in which > 15% of women of child-bearing age hospitalized with giardiasis were also coded as pregnant.

Lengerich and colleagues [9] found that the mean number of diagnoses in addition to giardiasis was 1·7 per hospitalization and that the most frequently listed co-diagnosis was volume depletion. This is almost three times the mean number of co-diagnoses found in this study, in which volume depletion was never listed. These differences are most likely to reflect differences in terminology or coding practices between the two countries. However, they may also indicate that dehydration (volume depletion) does not occur as frequently with giardiasis in Scotland, either because of strain differences in the infecting organisms resulting in a different spectrum of symptoms or because rehydration treatments are more widely self-administered in Scotland. Failure to thrive was diagnosed in > 18% of the children < 5 years of age hospitalized with giardiasis in the US study [9] and this proportion is not significantly different from the 11·3% of children < 5 years who also had a diagnosis of lack of expected normal physiological development identified in this study. On the basis of the result obtained in the US study [9], the authors felt able to suggest that physicians should consider the diagnosis of giardiasis for children with failure to thrive and that, if confirmed, treatment should be considered even if the children do not present with diarrhoea. The results described in this paper are very similar, which reinforces the view that this practice, presently in place in the UK, should be continued.

The US study [9] identified women of between 20–39 years of age and children < 5 years of age as being of particular importance when assessing the burden of severe giardiasis in the USA. The data in this paper confirmed children < 5 years of age as being important and also identified a further group, the > 70 age group, which might also be of significance. Although in this study only 14 (7%) of cases were in this age group, the median length of stay in hospital was significantly longer (11 days as compared to 3 days) than for all other age groups. Also the proportion of cases with co-diagnoses in addition to giardiasis was considerably higher than that seen in the whole group and the mean number of co-diagnoses was over three times that of the whole group. Thus, although this age group may not be particularly at risk from giardiasis, the symptoms may be of greater severity, perhaps due to immunosenescence or perhaps because of other problems which may be exacerbated by the infection. However, it is probably more likely to be the co-diagnoses, rather than the *Giardia* infection, which are responsible *per se* for the protracted hospital stay.

Comparison of data for severe giardiasis and cryptosporidiosis in Scotland revealed some important differences which reflect distinctions in the epidemiology of the two infections. First, although between 2–3 times more cryptosporidiosis infections are diagnosed in Scotland each year and approximately 1·5 times more cases of cryptosporidiosis are hospitalized each year, giardiasis cases are significantly more likely to be hospitalized. This indicates that when clinical giardiasis occurs, the symptoms are likely to be of greater severity. However, although a greater percentage of giardiasis cases will result in hospitalization, the median duration of stay for cryptosporidiosis was significantly longer. This is almost certainly because of the availability of effective chemotherapy for giardiasis. Prolonged and severe cryptosporidiosis has been associated with impaired immunity [15]; in this study deficiency of cell-mediated immunity was found to be the second most common co-diagnosis with cryptosporidiosis, with *c.* 5% of the patients immunocompromised and reduced immunity associated with prolonged hospitalization. However, although giardiasis has been reported to be more severe in immunocompromised patients [16], in these Scottish data immunodeficiency was recorded in < 2% of giardiasis cases and not associated with prolonged hospitalization.

Infants and young children are considered to have increased susceptibility to both giardiasis and cryptosporidiosis, due both to behavioural factors (which are likely to increase exposure to cysts or oocysts) and to immunological factors [15–18]. Whilst these Scottish data support this, with the modal age over the study period for both infections being 1 year, and > 25% of the hospitalizations for both infections being in children < 5 years, marked differences in age distribution between the two infections are noticeable. Whereas the median age for hospitalization due to cryptosporidiosis was 5 years, the median age for hospitalization due to giardiasis was significantly older at 30 years. Also, whereas the proportion of cases < 5 years of age hospitalized for cryptosporidiosis was 49%, the proportion of cases < 5 years hospitalized for giardiasis was only 28%. Furthermore, the median age of individuals spending > 5 days in hospital due to cryptosporidiosis was 7 years, whereas the median age of individuals spending > 5 days in hospital due to giardiasis was significantly older at 31 years. These data indicate that the age group risk factor for cryptosporidiosis and giardiasis may be greater in the former infection; this difference may be due to a range of factors including host immunity, host behaviour or parasite factors. One possibility is that development of protective immunity to *Giardia* infection may be more prolonged than development of protective immunity to *Cryptosporidium* infection; development of protective immunity to *Giardia* infection has been considered to be a relatively lengthy process and not necessarily developed following a single infection [17]. Alternatively, exposure to infective *Giardia* cysts may increase with increased experiences (e.g. foreign travel), whereas exposure to infective *Cryptosporidium* oocysts may not increase significantly from that experienced in childhood. A further explanation is that there may be more immunological sub-types of *Giardia* than of *Cryptosporidium*, and immunity may be specific for the particular sub-types experienced; certainly the antigenic complexity of *Giardia* has been acknowledged and variation of antigenic profiles between *Giardia* isolates has been described [19].

Although these data suggest that infants may be at greater risk from severe cryptosporidiosis than giardiasis, the duration of hospitalization for cryptosporidiosis was no greater for the under < 5 years age group than for any other group hospitalized with that infection. In contrast, the period of hospitalization for giardiasis in the < 5 years age group was significantly higher than that of other age groups, excluding those > 70 years. Presumably greater severity of symptoms, to be expected in infants, accounts for the increased duration of hospitalization for those < 5 years, although this is not observed with cryptosporidiosis. One explanation for this difference is that cryptosporidiosis tends to be an acute infection and diagnosis is relatively simple. In contrast, giardiasis presents difficulties in diagnosis and there is the potential for chronic infection, which may be associated with lack of expected normal physiological development. These differences may result in giardiasis being a more insidious infection in this age group. Whereas laboratory confirmation of *Cryptosporidium* infection can usually be accomplished readily, laboratory confirmation of *Giardia* infection may take several days due to intermittent excretion of cysts.

Although Lengerich and colleagues [9] did not quantify the financial burden placed upon the US by severe giardiasis, they did suggest that it should be considered when studying cost-benefits of programmes intended to minimize transmission, such as potable water filtration or preventative schemes in child-care centres. However, it has been suggested [20] that the annual cost of hospital admissions due to giardiasis in US could be estimated to be > US$5 million (in excess of US$1900/100000 of population). Using data described in this paper and data from [11], the annual hospitalization cost of severe giardiasis in Scotland can be estimated to be in excess of £31000 (approximately US$48000 total or US$900/100000 of population). This difference in cost appears to be due to the increased hospitalization due to giardiasis in the US rather than to differences in hospital costs. It has been suggested [14] that when looking at the importance and financial impact of this infection that it is important to realize that the costs are much greater than those calculated from primary expenditure on chemotherapy and direct treatment, but also should include the secondary costs of lost earnings, lost productivity and lost education. Similarly, these costs should be considered when calculating the annual cost of severe cryptosporidiosis in Scotland which are almost 2·5 times as great as the costs of severe giardiasis (approximately £73000 or US$109500 total or US$2000/100000 of population).

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