The water feature comprised two separate water bodies with separate holding tanks and water treatment systems using bromide and sand filtration. A large pool with water to a depth of 20cm was used as a paddling pool, although it was not intended for this purpose. Cryptosporidium oocysts were isolated from all four cases and detected in water samples taken from the fountain.

The second outbreak, which occurred in central England, was linked to a newly opened purpose-built interactive water feature, and involved 122 cases. More than 80% (102) of those infected were under 15 years old. Thirty five (85%) of 41 cases tested for cryptosporidium were positive. Indicator organisms of faecal contamination were identified from the water but no cryptosporidium oocysts were recovered.

These outbreaks raised issues about the lack of national guidance on operation and maintenance of water-based recreational attractions, which have now been addressed by the United Kingdom Pool Water Treatment Advisory Group [8]. The principal public health measure for preventing infections and outbreaks associated with these devices is risk assessment and management. The principal microbiological risks are cryptosporidiosis from inadequate filtration, and bacterial and viral infections, including legionella, from inadequate disinfection. This guidance proposes design and operational standards for filtration, chlorination and reducing contamination hazards.

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ORIGINAL ARTICLES

Outbreak report

OUTBREAK OF *E. COLI* O157 INFECTION IN THE SOUTH WEST OF THE UK: RISKS FROM STREAMS CROSSING SEASIDE BEACHES

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In August 2004 seven cases of Escherichia coli O157 infection were identified in children on holiday in Cornwall, southwest England, all of whom had stayed at different sites in the area. Isolates from all seven cases were confirmed as *E. coli* serogroup O157 phage type 21/28. We carried out a case-control study among holidaymakers who visited the beach. A standardised questionnaire was administered by telephone to parents. They were asked where on the beach the children had played, whether they had had contact with the stream that flowed across the beach, and about their use of food outlets and sources of food eaten. Cases were more likely to have played in the stream than controls (OR [1.72- undefined]). The time spent in the stream by cases was twice spent there by controls. Cases and controls were equally exposed to other suspected risk factors. PFGE profiles for all the cases were indistinguishable. Increased numbers of coliforms were found in the stream prior to the outbreak. Cattle were found grazing upstream. We suggest that the vehicle of infection for an outbreak of acute gastrointestinal illness caused by *E. coli* O157 was a contaminated freshwater stream flowing across a seaside beach. The onset dates were consistent with a point source. Heavy rainfall in the days preceding the outbreak might have lead to faeces from the cattle potentially contaminated by *E. coli* O157 contaminating the stream, thereby leading to the outbreak. Control measures included fencing off the part of the stream in which children played, and putting up warning signs around the beach.

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Introduction

Human infection with verocytotoxic *Escherichia coli* O157:H7 (*E. coli* O157) is associated with clinical illness ranging from non-bloody diarrhoea to haemolytic uraemic syndrome (HUS) and death. It is the most common cause of renal failure in children [1,2]. It is transmitted to humans through contaminated food, water, and direct contact with infected people or animals [2-4]. The infectious dose is very low, under 100 organisms [2,5]. *E. coli* O157 is one of the most commonly identified causes (25% in 2002) of recreational fresh water-associated outbreaks involving gastroenteritis in the United States [6].

In August 2004 seven cases of *E. coli* O157 infection were identified in children who had been on holiday in Cornwall (resident population 500 000), a popular holiday destination in southwest England. Initial investigations found that the patients had been camping at different sites but had all played in a stream flowing across the same beach within a period of a few days. Isolates from all seven cases were

confirmed as *E. coli* serogroup O157 phage type 21/28. The pulsed field gel electrophoresis (PFGE) profiles for all the isolates were indistinguishable. Prior to this there had been no clustering of this phage type in the area. The other six cases of *E. coli* O157 reported via the surveillance system with links to Cornwall during August were phage types 2 or 8. None of the patients in these six cases had visited this beach. We carried out a case-control study to search for supportive evidence that the stream or other exposure was the vehicle of infection in this outbreak of *E. coli* serogroup O157 phage type 21/28.

Methods

Cases were defined as children aged between one and ten years, with laboratory confirmed *E. coli* O157 phage type 21/28 infection, present at the beach at any time between 11 and 18 August 2004, and with onset of illness between two and eight days after a visit to the beach. This definition included all cases of confirmed *E. coli* O157 phage type 21/28 infection. Two of the seven cases were siblings, and so to avoid introducing potential bias arising from common behaviour patterns found in sibling groups, random numbers were used to choose one of these two children. This resulted in six cases for the study.

Controls were defined as children aged between one and ten years who visited the same beach between 11 and 18 of August (the range of likely exposure dates of the cases). We considered that the source population of cases consisted of all tourists who had stayed in various campsites in the area and we set out to recruit four controls per case from residents of holiday campsites in this area.

The primary hypothesis was that cases were more likely than controls to have been exposed to water from the stream. Also, the time spent playing in the stream by cases and controls was compared. The use of local food outlets and restaurants, and types of food consumed, were also investigated.

A detailed standardised questionnaire was administered by telephone to parents of cases and controls. Cases and controls were asked where on the beach they sat or played (each was sent a map of the local area to mark areas where the children had played and eaten), whether they went in the stream, used food outlets, used toilet facilities and washed hands before eating. The questionnaires were entered into an EpiData (v 3.02) database. STATA (v 8.2) was used to analyse the data.

Environmental investigation included sampling water from the stream and cattle grazing on the surrounding fields above the stream. Stream sediment samples were tested using immunomagnetic enrichment.

Results

Epidemiological Investigation

All seven cases had laboratory confirmed *E. coli* O157 phage type 21/28. They were all very ill, with clinical symptoms including diarrhoea, abdominal pain, vomiting and blood in stool, and four required admission to hospital. All played in the same stream for some time between 7 and 23 August 2004 (six on 15 August 2004). Six of the seven cases definitely had contact with the stream on the three days between 15 and 17 August 2004 [TABLE 1].

Table 1

Cases of *E. coli* O157 phage type 21/28 with exposure to the stream, Cornwall, United Kingdom, August 2004

Age	Sex	Contact with stream (dates)	Onset date
7	M	15/08	18/08/04
4*	M	12/08 and 15/08	19/08/04
7*	F	12/08 and 15/08	19/08/04
3	M	17/08	20/08/04
3	M	Daily between 14/08 and 23/08	20/08/04
7	M	Most days between 07/08 and 21/08	21/08/04
4	F	11/08 and 15/08	21/08/04

* Siblings

Six of the seven cases were included in the case-control study. Four hundred and twenty families were contacted by phone from lists of residents from four local campsites. We identified 27 children who were eligible as controls. The ages of the six cases ranged from 3 – 7 years with a median of 5.5 years. The ages of the controls ranged from 1 – 10 years with a median of 7. The mean age was 5.2 years for cases and 6.7 for controls. (p = 0.191). Males and females were equally distributed between cases and controls (p=0.665).

Cases were more likely to have played in the stream than controls (OR [1.72- undefined]).

p= 0.02) [TABLE 2]. Of the children who played in the stream, cases were more likely to have had water splashed onto their faces than controls (OR [1.22- undefined], p= 0.05) [TABLE 2]. The time spent in the stream by cases was twice that spent by controls. This difference was not statistically significant, but there was a dose response using the mid-point of time played in stream as the exposure score (p= 0.002) [TABLE 3]. Cases and controls were equally exposed to each of the other suspected risk factors.

Table 2

Cases (n=6) of *E. coli* O157 phage type 21/28 and controls (n=27) according to possible exposure factors, Cornwall, United Kingdom, August 2004

Variable	Cases	Controls	OR (95% CI)	P-value
Played in the stream	6 (100.0)	12 (44.4)	– (1.72, –)*	0.02
Played in the sea	6 (100.0)	20 (74.1)	– (0.47, –)*	0.30
Played around pipes	1 (16.7)	0 (0.0)**	– (0, –)*	0.21
Consumed food/drink	4 (66.7)	8 (30.8)***	4.5 (0.50, 56.5)	0.17
Bought food/ drink for child	4 (66.7)	14 (51.9)	1.86 (0.22, 23.4)	0.67
Brought own food / picnic	4 (66.7)	15 (55.6)	1.6 (0.19, 20.3)	1.00
Further analysis of those who did play in the stream				
Average time in stream (hours)	3.17	1.58		0.10
Splashed water onto face	6 (100.0)	6 (50.0)	– (1.22, –)*	0.05
Lay flat in stream water	2 (33.3)	1 (8.3)	5.5 (0.20, 353.18)	0.25
Sat in stream water	6 (100.0)	7 (58.3)	– (0.88, –)*	0.11
Washed hands in stream	3 (50.0)	11 (91.7)	0.09 (0.002, 1.87)	0.08
Drank water from stream	2 (33.3)	0 (0.0)	– (1.20, –)*	0.10

* Exact confidence limits not possible with zero cell counts – these are Cornfield approximations
– = No OR due to '0' in one cell
** n = 23
*** n = 26

Table 3

Cases of *E. coli* O157 phage type 21/28 and controls according to time spent in the stream, Cornwall, United Kingdom, August 2004

Time spent playing	Exposure score	Cases	Controls	Total
No time	0	0	15	15
Less than 1 hour	0.5	1	7	8
1 - 2 hours	1.5	2	1	3
3 - 4 hours	3.5	1	4	5
> 4 hours	6	2	0	2
Total		**6**	**27**	**33**

Chi square for linear trend = 9.70 p = 0.00184

Environmental Investigation

After the incident, environmental samples positive for *E. coli* O157 were found at five sites, both in the stream and in cattle faeces in the catchment area of the stream. None of the environmental isolates were phage type 21/28.

Routine sampling in the stream had recorded an increase in contamination from total and faecal coliforms in the lower reaches of the stream in the two months before the outbreak, but there were no tests carried out specifically for *E. coli* serogroup O157. Three potential sources of sewage contamination from overflow drains around the stream were discovered upstream.

Discussion

This investigation supports the hypothesis that the vehicle of infection for an outbreak of acute gastrointestinal illness caused by *E. coli* O157 was a contaminated freshwater stream flowing across a seaside beach in Cornwall. The illness onset dates and the dates of contact with the stream are consistent with a point source. In 1999, a similar outbreak involving *E. coli* O157 phage type 21/28, associated with a bathing beach, occurred in a neighbouring county [7], but this is the first reported outbreak of *E. coli* O157 in the UK associated with recreational exposure to a stream.

The exact source contamination of the stream was not discovered. *E. coli* phage type 21/28 was not detected, despite extensive sampling of cattle faeces. However, this remains the most likely source of contamination of the stream. Cattle are a major reservoir for human infection with *E. coli* O157. Previous studies have suggested that shedding by animals is seasonal and that people with greater exposure to livestock are at a greater risk of infection [8, 9]. In the two days preceding the outbreak, heavy rainfall was recorded locally: 200.4 mm of rain fell in 24 hours on 16 August [10], leading to severe flooding [11]. This may have increased the likelihood of cattle faeces contaminated by *E. coli* O157 being washed into the stream. Another potential source for contamination of the stream was sewage overflow from overflow drains around the stream.

Initial control measures included fencing off the lower part of the stream in which children played, and putting up signs to warn people of the potential dangers of contact with the stream. The media also helped to inform residents and visitors of the area of the potential danger of playing in the stream. In the long term, a series of multi-agency meetings were initiated to assess the potential risks from such streams. This led to the initiation of environmental studies of the effects of summer storms on the bacteriological quality of local streams in 2005. Evidence from this study will inform future public health policy.

There is substantial potential for contamination of streams flowing across beaches and leading to outbreaks such as the one described above, especially in areas with a high cattle population. Rainfall and run-off have been implicated in outbreaks of *E. coli* O157 in the past [12,13] and the use of weather monitoring and forecast information has been used in the United States to predict day-to-day water quality for beach advisories [14]. This outbreak highlights the importance of *E. coli* O157 as a waterborne pathogen with a low infective dose, which allows water to act as an efficient vector [15]. We recommend that efforts are made to increase public awareness of this potential hazard and to explore with the agricultural industry other methods of reducing faecal contamination of streams and rivers, especially those used for recreation.

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