Public Health Laboratory Service

Final report to Drinking Water Inspectorate

Review of outbreaks of cryptosporidiosis in swimming pools.

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Part 1a.
Review of outbreaks of cryptosporidiosis in swimming pools

Scope of this document

The scope of this report is the description, analysis and interpretation of the epidemiology, microbiology and pool water treatment of swimming pools associated with outbreaks of cryptosporidiosis in the UK. The study was retrospective, and provides background information for prospective studies.

Executive summary

Eighteen outbreaks of the diarrhoeal disease cryptosporidiosis associated with swimming pools are known to have occurred in the UK between 1989 and 1999. Seven were during 1999. The DWI commissioned work to investigate these outbreaks since this could provide information pertinent to drinking water outbreaks and to the treatment of drinking water supplies. A retrospective review of reported outbreaks, including consideration of relevant pool treatment and pool operation data, was undertaken to provide the Inspectorate with information pool treatment and operation procedures, identification of any consistent failures in treatment products or processes and a sound basis for prospective studies.

All the reported outbreaks were in England, and the majority occurred during the summer and autumn. 14 of the outbreaks were associated with pool facilities on the basis of descriptive epidemiology, supported by the detection of *Cryptosporidium* in environmental samples in five outbreaks. The other four outbreaks were associated with swimming pool facilities by analytical epidemiology, with detection of the parasite in environmental samples from one pool location. While for many outbreaks there is strong evidence for the association with a swimming pool, in some the evidence is weak and it is recognised that there could be other causes. Similarly, while there is evidence that contaminated swimming pool water was the vehicle of infection in some outbreaks, other possibilities such as changing room/toilet hygiene should also be considered during outbreak investigations.

Outbreaks occurred associated with pools disinfected with chlorine and with ozone, and with pools reported to be poorly-managed and well-managed. Details of pool water treatment and bacteriological monitoring were often sparse. Recognised faecal accidents at the pool occurred in just four outbreaks although faecal contamination was known or suspected locally in five further outbreaks. Reporting systems for incidents were often lacking at the pools. The potential for swimming pool-associated giardiasis has been noted in the report. General recommendations and outline proposals for further research by the PHLS are made in the report.

The work described in this report was funded by the Department of the Environment, Transport and the Regions. The Drinking Water Inspectorate was responsible for contract management.

Introduction

The first reported outbreak of cryptosporidiosis associated with a swimming pool in the UK was in 1988 in Doncaster (Joce *et al*., 1991), when 67 confirmed cases occurred following ingress of sewage from faulty plumbing into a swimming pool. An increase in the number of such outbreaks reported to the Public Health Laboratory Service (PHLS) Communicable Disease Surveillance Centre (CDSC) during 1999 above previous years raised concerns not only about the source of the contamination but also the possible failure of pool water treatment to provide adequate removal or disinfection (Anon, 1999). *Cryptosporidium* is resistant to commonly used swimming pool disinfectants such as chlorine at normal operating levels, and although it has been suggested that ozone can be an effective disinfectant (Finch *et al*, 1993) precise application of this and other disinfectant systems (such as UV) to swimming pool water has not been fully evaluated. Filtration systems currently used in most pools were designed prior to knowledge of *Cryptosporidium* as a risk factor and cannot generally be relied upon for effective oocyst removal (Kebabjian, 1995). Details of disinfection generally and filtration studies on *Cryptosporidium* are out-with the scope this report and reviews have been undertaken elsewhere (Casemore and Watkins, 1997; Anon, 2000).

A number of factors can contribute to inadequate treatment: poor operating procedures (including product application), inadequate or inappropriate equipment; excessive numbers of bathers, a high contamination load or a combination of these factors. Swimming pool and other recreational pool-associated outbreaks have been subject to epidemiological investigations and review in England and Wales (Furtado *et al*., 1998; Rooney *et al*, in preparation), but investigations of the treatment process have previously only been undertaken on an *ad hoc* basis (Anon, 1999). In order to investigate this further, more systematic information is required about the disinfection provision and operation of treatment processes at pools associated with outbreaks of cryptosporidiosis. To explore the possible links, the Drinking Water Inspectorate commissioned the PHLS to investigate the outbreaks with particular respect to the pool water treatment prior to and during the outbreaks, to identify any common features in the nature of the problems identified. This information could also be pertinent to drinking water outbreaks and to the treatment of drinking water supplies.

A retrospective review of reported swimming pool outbreaks, including consideration of relevant pool treatment and pool operation data, was undertaken to provide the Inspectorate with:

1. information and evaluation of the correlation between illness and treatment and operation procedures,

2. identification of any consistent failures in treatment products or processes and

3. a sound basis for prospective studies.

Methods

Prior to this study, outbreaks of illness associated with all pool types had been identified by analysis of the national database of infectious intestinal disease (Wall *et al*., 1996) and information available from CDSC surveillance of water-related outbreaks of infection. Further identification of outbreaks of swimming pool-associated cryptosporidiosis had also been undertaken by circulating a letter from CDSC to all Consultants in Communicable Disease Control (CsCDC) in England, Wales and Northern Ireland and counterparts in the Republic of Ireland and Scotland *via* the Scottish Centre for Infection and Environmental Health (Appendix 1). An outbreak was defined as an incident in which two or more people with a common exposure experience a similar illness, or proven infection where at least one is ill.

The study reported here was undertaken to satisfy three objectives:

Objective (i) Identification and review of outbreaks for epidemiological and microbiological data.

Objective (ii) Retrospective follow-up of outbreaks for pool water treatment information.

Objective (iii) Pool water treatment as a factor in outbreaks of cryptosporidiosis.

Each outbreak was followed up initially by administration of a questionnaire to the CCDC and Environmental Health Officers (EHOs) who had originally investigated the outbreak (Appendix 2). Further conversations were entered in to where details were unclear and to obtain information on variables identified as the study proceeded (detailed in Tables 1 to 3). Genotyping data was obtained from the Food Safety and Hygiene Laboratory, Central Public Health Laboratory. Outbreaks were numbered sequentially and with the CDSC database outbreak number. A short text summary of each outbreak was also written (Appendix 3). Data were entered on an EpiInfo database (Dean *et al*., 1994) for analysis by person, time and place and for emerging themes in pool water treatment and features of the outbreaks. Cases included in descriptive epidemiology were anyone who had cryptosporidiosis, whether a primary or secondary case. The results of analytical epidemiological studies undertaken at the time of the outbreak are quoted in this report.

Results

Objective (i). Identification and review of outbreaks for epidemiological and microbiological data (Tables 1 and 2).

18 outbreaks of swimming pool-associated cryptosporidiosis were identified occurring between January 1990 and December 1999 (Appendix 3). In addition, one outbreak associated with a municipal paddling pool in Trent Regional Health Authority occurred in 1995 (outbreak 95/745) but not included in this dataset since it did not occur at a swimming pool and has different implications for public health. No outbreaks were identified in 1990 and 1991. One outbreak was reported in 1992, two

in 1993, three in 1994, none in 1995, one in 1996, one in 1997, three in 1998 and seven in 1999. All were in England: Wales, Northern Ireland, Republic of Ireland and Scotland reported no outbreaks. The distribution of the outbreaks in England was: six in the South East Health Authority Region, three in each of the South West, the West Midlands and the Eastern Regions, two in London and one in Trent.

Three outbreaks were in the spring (March, April, May), eight in the summer (June, July, August), six in the autumn (September, October, November) and one in the winter (December, January, February) (by date of onset of illness of the first case). The outbreaks in 1999 were all in the summer and autumn. The mean duration of 16 outbreaks was 42 days and the median was 40 days (range 1 day to 90 days). The duration of two outbreaks was unknown. In the outbreak lasting one day, all four cases had swum in the pool and were from three different families.

A total of 293 cases (272 confirmed microbiologically) were involved in the outbreaks and 151 of the cases in 16 outbreaks were known to have swum in the pool in question within the incubation period. In two outbreaks the number of people who swam was not confirmed. The mean number of cases who swam was 9 and the median was 8.5 (range 3 cases to 21 cases). One small outbreak involving 4 cases lasted 20 days but all cases had swum in a pool where deliberate defecation in the pool water had occurred previously.

Of the cases who swam, 16 were known to be adults aged 15 or over and 100 were children. Of these 38 were under five years old. The majority of cases in all outbreaks were children, and the overall adult:child ratio of cases who swam was 1:6.

Descriptive epidemiology formed the basis of the association with a swimming pool in fourteen outbreaks, and was supported by the detection of cryptosporidial oocysts (microbiological evidence) in environmental samples in five of these. Analytical epidemiological evidence in the form of a case control study had been sought and found in a further four outbreaks, one of which also had microbiological evidence.

Where an analytical epidemiological study had been undertaken, this involved a case control design. Cases included in such studies were primary cases with the exception of 99/582 where all cases following the hypothesis generation were included. In one outbreak (93/227) use of the swimming pool was significantly associated with illness but two other risk factors were also identified in univariate analysis. These were a dose response relationship with drinking un-boiled tap water and an association with having an ill family member. In outbreak 99/582 univariate analysis identified any swimming pool use, use of the pool in question and drinking bottled water as risk factors. It was speculated that swimmers also drank bottled water during swimming sessions. Other risk factors were also identified in outbreak 99/741. These were drinking iced drinks, consuming cream, going swimming and swimming at the leisure centre. In adjusted analysis only swimming at the leisure centre remained significant. In outbreak 96/569 the only significant risk factor identified in univariate analysis was increased frequency of total immersion in the water, which almost reached significance in multivariate analysis ($p=0.06$). However, the number of cases considered in the study was just four.

Although analytical epidemiological evidence was obtained in all four outbreaks where such studies were undertaken, environmental sampling for *Cryptosporidium* was undertaken in 16 outbreaks and oocysts detected in just six. Sampling varied from single 10 litre grab samples of swimming pool water (*eg*. outbreak 99/350) to extensive sampling of large volumes of pool water and filter backwash water (*eg*. outbreak 93/067) and strainer basket material (*eg*. outbreak 99/582). In five instances although sampling was undertaken details of the nature of the sampling were not available.

Table 1. Epidemiology of swimming pool-associated outbreaks of cryptosporidiosis in the UK, 1990-1999.

Ref.	NHS Region	Dates of outbreak: first case last case	Duration (days)	Total number of cases (confirmed)	Number of cases who swam in the pool	Ages of affected swimmers	Active case finding	Basis for association with a swimming pool	Statistical associations with illness
1. 92/079	South West	06/03/92 23/03/92	17	13 (13)	10	1 adult, 3 children 5-14 yrs 6 children 0-4 yrs	No	Descriptive epidemiology, microbiological evidence	Not done
2. 93/067	West Midlands	10/01/93 19/02/93	40	23 (21)	18	4 adults 10 children 5-14 yrs 4 children 0-4 yrs	Not known	Descriptive epidemiology	Not done
3. 93/227	South East	23/07/93 05/10/93	74	27 (27)	7	All were children <12 years old	Yes Details not available	Analytical epidemiology. Case control study on 23 cases	1. Use of the swimming pool (OR=7.87; CI=1.12-55.02); 2. dose response with drinking unboiled tap water; λ^2 for trend = 4.92, p=0.03 3. having ill family members (OR=9.25, CI=1.02-83.8)
4. 94/347	South West	07/10/94 06/11/94	30	14 (8)	Not known	Not known	Yes – reports of diarrhoea in pool user groups and pool attendants	Descriptive epidemiology, microbiological evidence	Not done
5. 94/453	Eastern	July 1994	Not known	3 (3)	3	3 children 5-14 yrs	Yes	Descriptive epidemiology, microbiological evidence	Not done

Table 1 (continued)

Ref.	NHS Region	Dates of outbreak: first case last case	Duration (days)	Total number of cases (confirmed)	Number of cases who swam in the pool	Ages of affected swimmers	Active case finding	Basis for association with a swimming pool	Statistical associations with illness
6. 94/454	Eastern	03/10/94 04/10/94	1	4 (4)	4	4 children 0-4 yrs	No	Descriptive epidemiology, microbiological evidence	Not done
7. 96/569	South East	10/07/96 mid-09/96	49	8 (8)	8	3 adults 4 children 5-14 yrs 1 child 0-4 yrs	No	Analytical epidemiology. Case control study on 4 cases	Increased frequency of total immersion in the pool. p=0.04
8. 97/309	South East	18/05/97 23/05/97	5	9 (9)	6	1 adult 5 children 0-14 yrs	No	Descriptive epidemiology	Not done
9. 98/181	London	March 1998	Not known	6 (6)	Not known	Not known	Not known	Descriptive epidemiology	Not done
10. 98/626	South East	06/09/98 11/11/98	66	35 (31)	14	Children <10 years	No	Descriptive epidemiology	Not done
11. 98/631	Eastern	14/09/98 17/11/98	64	9 (9)	9	2 adults 3 children 5-14 yrs 4 children <5 yrs	No	Descriptive epidemiology	Not done
12 99/350	South West	07/07/99 17/07/99	10	11 (11)	11	2 adults 5 aged 5-14 yrs 1 aged <5 yrs 3 unknown	No	Descriptive epidemiology	Not done
13. 99/582	South East	23/08/99 21/11/99	90	54 (54)	21	Only 4 of the total cases were adults	Enhanced surveillance (screening to include adults)	Analytical epidemiology. Case control study of 23 cases, and microbiological evidence	1. any swimming pool use (OR=3.59, CI=1.04-12.74) 2. this pool use (OR=37.09, CI=4.08-854.5) 3. drinking bottled water (OR=5.82, CI=1.01-47.3)

Table 1 (continued)

Ref.	NHS Region	Dates of outbreak: first case last case	Duration (days)	Total number of cases (confirmed)	Number of cases who swam in the pool	Ages of affected swimmers	Active case finding	Basis for association with a swimming pool	Statistical associations with illness
14. 99/679	West Midlands	24/08/99 27/09/99	34	8 (4)	4	1 adult >14 yrs 2 children 5-14 yrs 1child 0-4 yrs	Yes – contacted GP's	Descriptive epidemiology	Not done
15. 99/741	London	15/09/99 06/11/99	51	30 (30)	14	7 children 5-14 yrs 4 children 0-4 yrs 3 unknown	Yes. GPs sent stools for testing	Analytical epidemiology. Case control study on 15 cases	Adjusted analysis showed only swimming at the leisure centre was significant ($\lambda^2 = 19.65$, $p<0.0001$)
16. 99/583	West Midlands	29/08/99 08/10/99	40	16 (14)	7	22 months-39 years	Yes. GPs increased stool sampling of diarrhoeic children <5	Descriptive epidemiology, microbiological evidence	Not done
17. 99/669	South East	05/11/99 25/11/99	20	4 (4)	4	4 children 0-4 yrs	No	Descriptive epidemiology	Not done
18. 99/600	Trent	06/08/99 30/10/99	85	19 (16)	11	2 adults 8 children 0-4 yrs 1 unknown	No	Descriptive epidemiology	Not done

Objective (ii) Follow up of outbreaks for pool water treatment information and Objective (iii) Pool water treatment as a factor in outbreaks of cryptosporidiosis (Tables 2 and 3).

13 outbreaks were associated with local authority leisure centre swimming pools, one with a school pool, two with private leisure club pools and two were of unknown ownership. One pool, at a private leisure club, was outdoors but all the others were indoor pools. 15 outbreaks were at pools with a main pool and a learner pool and in six of these the cases were known to be associated primarily with the learner pool. Three outbreaks were at single pool facilities and one outbreak was at a leisure complex with a variety of pools and water features.

In 11 outbreaks some sort of contamination of the pool was known or suspected. In four outbreaks this was an acute faecal contamination event known to have occurred. Two of these (outbreaks 92/079 and 94/347) were toddlers defecating at the pool, but not reported to the pool attendants at the time. In 92/079 a toddler left the pool abruptly and in the changing rooms was found to have passed a loose stool. He was washed in the shower. Details were not available about the sampling in 94/347 but extensive environmental samples were tested for *Cryptosporidium* 26 days after the event in 92/079. Oocysts were isolated in both outbreaks. The pool in outbreak 92/079 was a well-run pool with no treatment faults reported. In a third outbreak (97/309) faeces were detected in the pool towards the end of the day with subsequent closure of the pool, which was not sampled for *Cryptosporidium*. The pool management was reported to be good but the ozone generator had not been working. The fourth event was deliberate defaecation in the pool in the recent past (outbreak 99/669). The faeces were scooped out and the children's pool drained and cleaned. Backwash water from the filters was sampled but *Cryptosporidium* was not detected. These four outbreaks of cryptosporidiosis lasted for a significantly shorter period (median = 18.5 days, range 5 to 30 days) than in the pools where such acute events were not known to have occurred (median = 50 days, range 1 to 90 days) (Mann Whitney test $p<0.05$). There was no significant difference in the number of cases who swam in pools with a known acute event (median = 6 cases, range 4 to 10 days) compared with other outbreaks (median = 9 cases, range 3 to 21 days) (Mann Whitney test, $p>0.05$).

Five other faecal events were suspected or unconfirmed. In outbreak 96/569, *Enterobius vermicularis* ova were detected in samples from the pool, indicating faecal contamination. No faults were reported with the pool water treatment. In outbreak 98/631 people with diarrhoea were known to have been swimming in the pool. This pool was not sampled for *Cryptosporidium*. Problems with both the ozone plant and filtration system were reported. In outbreak 99/741 a parent, who was herself a case of cryptosporidiosis, allowed her child who had diarrhoea to swim. Sampling of the pool did not detect cryptosporidial oocysts. The pool was due to be refurbished but general management of the pool was reported to be good. In two other outbreaks (93/227 and 99/350) unrecognised faecal accidents were thought to have occurred in the pool, but sampling did not detect the presence of *Cryptosporidium* occysts. In outbreak 93/227 the ozone plant was not working and chlorination was increased. In 99/350, no faults were reported.

In two further outbreaks concern was raised over the integrity of the pool water. In one, outbreak 98/181, water from the children's pool mixed with the main pool. There were extensive problems with all disinfection systems, filtration and the plumbing.

Sampling did not reveal the presence of *Cryptosporidium* but *Giardia* cysts were detected. In another outbreak, reference 98/626, a history of flooding with sewage contamination was reported earlier in the year. The pool was not sampled and no other problems were reported.

In seven outbreaks no contamination events were reported. Environmental sampling had been undertaken in all these pools, and *Cryptosporidium* was detected at four pools, once also with *Giardia*. *Giardia* cysts alone were detected in environmental samples from a further pool, where cases of giardiasis were also known to have swum.

Table 2. Swimming pool type, contamination and sampling of swimming pools associated with outbreaks of cryptosporidiosis in the UK, 1990-1999.

Ref.	Swimming pool ownership and type	Case clustering at the pools	Acute contamination event of the pool	Response to contamination	Sampling for *Cryptosporidium*	Detection of *Cryptosporidium*
1 92/079	Local authority leisure centre with indoor learner and main pools	Not known	Yes. On 02/03/92 a toddler who left the learner pool was found to have passed a loose stool	None. The faecal accident was unreported to pool operators at the time.	3 x 10 litre grab samples on 28/03/92 and on 30/03/92. 1 x 5 litres each from main pool and learner pool and 1 sample backwash water on 30/03/92. 2 x 5 litres backwash water and 332 litres pool water sampled by filtration on 10/04/92	1 sample taken on 28/03/92 was positive (1 confirmed oocyst)
2 93/067	High school indoor swimming Pool		None reported		Yes. Details not available.	*Cryptosporidium* not detected
3 93/227	Local authority leisure centre with indoor learner and main pools	All cases had used only the learner pool	None reported (but there was retrospective suspicion of an unrecognised faecal accident in learner pool)		Sampling by filtration of 489 litres and 1332 litres from main pool, 409 litres and 1062 litres from learner pool on 01 and 02/10/93 and of 8 litres backwash from sand filters and 2 litres backwash from carbon filter for each pool.	*Cryptosporidium* not detected
4 94/347	Local authority leisure centre with indoor learner pool	Learner pool was associated with the outbreak by the investigators	Yes. A toddler released a stool in the pool. People continued to swim following onset of symptoms	Immediate action not known	Yes – details not available	Yes – details not available
5 94/453	Private country club outdoor pool	All cases used the pool in a 48 hour period	None reported		Yes – details not available	Yes – details not available

Table 2 (continued)

Ref.	Swimming pool ownership and type	Case clustering at the pools	Acute contamination event of the pool	Response to contamination	Sampling for *Cryptosporidium*	Detection of *Cryptosporidium*
6 94/454	Local authority leisure centre with indoor main and learner pool	Cases all had lessons in the learner pool	None reported		Yes – details not available	Yes – details not available
7 96/569	Local authority leisure centre with indoor main and learner pool	All cases used the learner pool. Two had also used the main pool	None reported, but *Enterobius vermicularis* ova in the backwash samples indicates faecal contamination		Backwash samples tested	*Cryptosporidium* not detected but *Enterobius vermicularis* ova were
8 97/309	Local authority leisure centre with indoor learner and a main pool	All cases had used the learner pool before 14:00 on 13/05/97	Yes. At 19:45 on 13/05/97 faeces were discovered "having been in the pool for some time"	Pool closed immediately on discovery of faeces. Cleaning and disinfection carried out.	Not done	
9 98/181	Fitness and leisure club with indoor children's and a main pool	Not known	None reported But water from childrens' pool contaminated main pool. Pool had been closed 2 years previously due to an incident		Two backwash samples taken on 12/03/98	*Cryptosporidium* not detected, but *Giardia* cysts were
10 98/626	Local authority leisure centre leisure complex with indoor pools	Not known	None reported but local flooding and sewage contamination reported in April 1998. Pool cleaned prior to re-opening in June 1998		Swimming pool water and filter samples	*Cryptosporidium* not detected
11 98/631	Local authority leisure centre with two indoor pools	No	None reported , but people with diarrhoea were known to swim		Not done	

Table 2 (continued)

Ref.	Swimming pool ownership and type	Case clustering at the pools	Pool-associated contamination event	Response to contamination	Sampling for *Cryptosporidium*	Detection of *Cryptosporidium*
12 99/350	Local authority leisure centre with indoor main and learner pools	Learner pool	None reported But there was speculation concerning a suspected faecal accident		10 litre pool water	*Cryptosporidium* not detected
13 99/582	Local authority leisure centre indoor pool	Not known	None reported		28/10/99 Pool water, strainer basket material and filter flocculant sampled 02/11/99 Pool water, filter A and filter B sampled	2 *Cryptosporidium* oocysts in the strainer basket material, 1 in filter floccutant with several *Giardia* cysts. 3 *Cryptosporidium* oocysts in filter A and 1 oocyst in filter B. *Giardia*-like cysts in both.
14 99/679	Local authority leisure centre with indoor baby and main pools	Not known	None reported		Yes – details not available	*Cryptosporidium* not detected
15 99/741	Local authority leisure centre with indoor baby and adult pools	Not known	None reported But a parent (a case) allowed her diarrhoeic young child to swim.		10 litres water from both pools and backwash water	*Cryptosporidium* not detected
16 99/583	Private leisure centre with indoor children's and adult pool	Not known	None reported		Adult and children's pool 10 L After flocculation and backwashing the filters: Adult and children's pool 10 L After further backwashing children's pool sampled	9 and 188 *Cryptosporidium* oocysts detected respectively Not detected in adult, 2 oocysts detected in children's. *Cryptosporidium* not detected
17 99/669	2 pools at one location	Not known	Yes. Boys has deliberately defaecated in the baby pool previously	Faeces removed with a net. Stringent cleaning	Backwash from filters tested	*Cryptosporidium* not detected
18 99/600	Local authority leisure centre, two indoor pools	Not known	None reported.		Both pools sampled (50 L membrane filtration), sand from tops of both filters, hair and detritus from sieves	No cryptosporidia but *Giardia* detected in all sample points. Cases of giardiasis had also used the pool.

11 of the 18 outbreaks of cryptosporidiosis were associated with pools chemically disinfected by chlorination only ("chlorinated pools") and 7 with pools treated by a combination of ozonation and chlorination ("ozonated pools"). There was no significant difference in the duration of outbreaks where the pool was chlorinated (median = 37 days, range 1 to 66 days) compared with ozonated (median = 69 days, range 5 to 90 days) (Mann Whitney test, $p>0.05$). Similarly there was no difference in the size of the outbreak (measured by the number of cases who swam) at chlorinated pools (median = 7.5 days, range 3 to 18 days) and ozonated pools (median = 9.5 days, range 6 to 21) (Mann Whitney test, $p>0.05$).

Specific faults concerning either the filtration and/or disinfection systems were noted prior to the outbreak in eight pools, none reported for a further eight pools, and not known in two outbreaks. Six pools that had faults prior to the outbreak were ozonated, significantly more than the two chlorinated pools where faults were noted ($p<0.05$). The faults identified were faulty ozone generators (2 pools), ozone plant and filter problems (3 pools), filter leaking (1 pool), the chlorination, filtration and ozonation plants all faulty and plumbing defective (1 pool), pool water not changed for seven years (1 pool). In addition, one pool was due for refurbishment prior to the outbreak. However, there was no significant difference in the duration of the outbreaks in pools reporting faults (median = 69 days, range 1 to 90 days) compared with those reporting no faults (median = 37 days, range 10 to 66 days) (Mann Whitney test $p>0.05$). There was also no significant difference in the number of cases who swam in pools reporting faults (median = 7 cases, range 3 to 21 cases) and those reporting no faults (median = 10 cases, range 4 to18 cases) (Mann Whitney test, $p>0.05$).

Data concerning disinfectant and bacteriological monitoring prior to the outbreak were available for some pools. Eight of the 11 chlorinated pools reported that the disinfectant was monitored, but it was not known whether the rest monitored or not. Three reported satisfactory results, but the quality of treatment was not known in the other five pools. Three of the chlorinated pools reported bacteriological monitoring, two with satisfactory results and the other unknown. Four chlorinated pools did not monitor the bacteriological quality of the water.

Of the seven ozonated pools, three reported that they monitored the results and two were satisfactory. It is not known whether the other pools were monitored prior to the outbreak. Of the three pools doing microbiological monitoring, two had satisfactory results and in one pool the results were unsatisfactory. This pool had problems with the ozone plant and subsequently the filtration system. One ozonated pool did not monitor for bacteriological quality.

Subjective assessment of the pool treatment and general pool management from the reports obtained showed that the treatment was regarded as satisfactory in seven pools, unsatisfactory in two pools and unknown in nine pools. Management was satisfactory in nine pools, unsatisfactory in two pools and unknown in seven pools. Five pools had no policy for reporting faecal accidents and while only one pool stated it had such a policy, it was not known whether the remaining 12 pools had such a policy or not.

Isolates of *Cryptosporidium* from some swimming pool-associated cases had been genotyped in five outbreaks (one in 1998 and four in 1999). All were outbreaks where no specific acute faecal accident was reported. Genotype 1 (almost exclusively found in humans) was detected in three samples tested from people in outbreak 98/626, and genotype 2 (found in humans and animals) in 10 samples from cases in outbreak 99/350. The other three outbreaks were of mixed genotype. Genotype 1 was detected in six samples and genotype 2 in three samples from cases in outbreak 99/583, and genotype 1 in 20 samples and genotype 2 in two samples from outbreak 99/741. In outbreak 99/582, genotype 1 was detected in 10 samples, genotype 2 in one sample and 3 people shed both genotypes 1 and 2 in their faeces. This outbreak was the largest and of the longest duration of all the outbreaks reported.

Table 3. Pool water treatment at swimming pools associated with outbreaks of cryptosporidiosis in the UK, 1990-1999.

Ref	Pool water treatment regime	Disinfection monitoring	Bacteriological monitoring	Quality of treatment	Overall pool management	Pool treatment plant faults reported?	Response to outbreak
1 92/079	Filtration with side stream ozonisation, marginal chlorination. Water circulated between learner and main pools.	Details sparse but report that disinfection adequate for bacteriological control	Not done	Water clarity "good"	"Well managed and maintained", in accordance with general guidelines and manufacturers instructions.	None	Not known
2 93/067	Filtration Chlorination	Not known	Not known	Not known.	Not known	Not known	Pool closed cleaned and disinfected (no details)
3 93/227	Sand and charcoal filtration (turn over time 3.5 hours), Sodium hypochlorate to maintain free chlorine at 0.7-0.8ppm, side stream ozonisation for the two pools separately	Details not given but log books were kept	Tests every 6 weeks.	Bacteriological results "good" and no indication of faecal contamination.	Treatment plant working well on inspection. No reporting system for faecal accidents in place. Superchlorination not employed.	During the first 3 weeks of September the ozone generator was faulty. Additional chlorine was added.	Pool closed, surround disinfected, filters backwashed and water tested.
4 94/347	Filtration Chlorination	Monitored every 4 hours	Tested by local authority. Frequency not known	Not known	There was no policy for handling faecal accidents.	None	The pool was closed, water circulated with superchlorination and filters backwashed. Policy for handling faecal accidents was introduced.
5. 94/453	Filtration Chlorination	Monitored daily	Not done	Not known. Records were not kept	Inadequate reporting procedure for disinfection, pH, maintenance, faecal accidents.	Pool water not been changed for 7 years. Pool closed in the winter and simply "restarted" in summer.	Pool closed for complete water change. Sand filter medium replaced, pipes and filtration system disinfected. Better reporting for pool disinfection and management put in place.

Table 3 (continued)

Ref	Pool water treatment regime	Disinfection monitoring	Bacteriological monitoring	Quality of treatment	Overall pool management	Pool treatment plant faults reported?	Response to outbreak
6 94/454	Filtration Chlorination	Not known	Not known	Not known	Chlorine and turbidity reported to be satisfactory. Risk assessment adequate.	Yes. Filtration plant was leaking	The pool was closed for 24 hours, the water heated to 37°C, superchlorinated and circulated for 5-6 passes.
7 96/569	Sand filtration separate for the two pools. Backwashing twice weekly. Alum dosing 2x weekly. Chlorination.	Check 3x daily	Details not known	Bacteriological results "acceptable"	Generally good. Regular cleaning of pool area. Sand filter in good condition. Main pool water used to replenish learner pool	No indication of any system failure	Pool remained open. Additional flocculation and backwashing of filters carried out
8 97/309	Filtration (turnover time for learner pool 1 hour). Ozone with chlorine resiual.	Not known	Not known	Not known	Management reported to be good	Ozone generator faulty on 13/05/97 and out of action, pool disinfected by chlorination only.	Learner pool closed overnight for disinfection. Action actually taken not clear.
9 98/181	Filtration Chlorination Ozonisation	Not known	Not known	Poor due to trouble with ozonisation unit.	Not known	Chlorination, filtration and ozonisation reported to be defective and warning systems from ozone generator not working. Plumbing defective and allowed water from children's pool to enter main pool. Childrens' pool operating at an elevated temperature	Filtration repaired
10 98/626	Filtration Chlorination	Pool side tests 3x daily and automatic monitoring	Not known	Not known	Not known	None reported A pool consultant reported no design or functioning faults	Pool closed for routine maintenance in December, filter media changed.

Table 3 (continued)

Ref	Pool water treatment regime	Disinfection monitoring	Bacteriological monitoring	Quality of treatment	Overall pool management	Pool treatment plant faults reported?	Response to outbreak
11 98/631	Filtration Chlorination Ozonisation	Not known	Not known	Not known	Not known Backwashing carried out to standard practice	Ozonisation plant failures and filter problems. Turnover rate reduced from 1.5 to 4 hours	Pool closed until ozonisation and filter plant fixed, pool cleaned. Notices in place to advise people with diarrhoea not to swim
12 99/350	Filtration Chlorination	2x daily	Not done	Chlorination and filtration systems "satisfactory"	Appeared satisfactory	None reported.	Pool closed for approx one week awaiting *Cryptosporidium* test result. Then re-opened
13 99/582	Filtration Chlorination Ozonisation	Not known	Bacteriological results in September "satisfactory" but elevated coliform counts. On 27/10/99 TVC >300, coliforms 43, E. coli 43, indicating faecal contamination	Without ozone the chlorination was inadequate and pH too high for flocculation. Filter backwashing was inadequate. The current system was overloaded	No system for reporting and recording faecal accidents	Ozone plant "off line" for two months previously. A plank of wood was found in one filter. Without ozone the filters were not acting as biological filters and carbon was removing chlorine from the pool	Pool closed 16:00 on 27/10/99 for investigation and remediation work applied to filters. Recommendations made to improve whole disinfection system
14 99/679	Filtration Chlorination	Checked every 2 hours	Not done	Not known	Pool plant and water treatment logs were maintained, maintenance and repair programme in place Advice on dealing with faecal accidents had been given to all sites/appropriate staff	None identified	Pool closed. Coagulant / flocculant introduced. 6 turnovers of cleansing / vacuuming each with two backwashes recommended prior to re-opening

Table 3 (continued)

Ref	Pool water treatment regime	Disinfection monitoring	Bacteriological monitoring	Quality of treatment	Overall pool management	Pool treatment plant faults reported?	Response to outbreak
15 99/741	Vertical pressure sand filters Alum sulphate flocculant (not continually used). Separate water circulation in each pool. Sodium hypochlorite chlorination.	Chlorine and pH checked every 2 hours Not recent failures reported	Routine bacteriological samples monthly. No recent failures reported	Satisfactory	General procedures satisfactory but no procedure for reporting or managing a faecal accident. Small notice in place asking public to shower before using pool.	None, but pool due to be refurbished	Pool drained and refilled following outbreak Sand filters cleaned and media replaced
16 99/583	Filtration Chlorination Separate treatment for each pool	Cholorine and pH tested 3x daily	Not done .	Water clarity satisfactory, so flocculation was not employed	Filters backwashed "regularly", general pool management good	No faults reported in maintenance schedule.	Pool closed on 24/09/99 Filters backwashed extensively Pool re-opened following final negative result.
17 99/669	Filtration Chlorination	Not known	Not known	Not known	Not known	Not known	Junior pool drained and cleaned
18 99/600	Separate treatment for each pool Filtration Chlorination Ozonation	Regular monitoring	Not known	Satisfactory on most occasions		Ozone treatment had been tripping out, so chlorination increased.. Filter design faulty	Pool closed, sand in filters replaced

Discussion

Cryptosporidium was the aetiological agent in the majority of outbreaks of illness associated with pools in the UK over the past ten years (Rooney *et al*., in preparation). The increase in outbreaks of cryptosporidiosis associated with swimming pools, with seven reported in 1999 against a mean annual background of 1.2 over the previous nine years, may be a real increase or may be a result of improved ascertainment. While laboratory testing for *Cryptosporidium* did not increase during 1999, an increasing awareness of swimming pools as a risk factor for cryptosporidiosis and hence increased investigation, or indeed detection and/or increased investigation of outbreaks of cryptosporidiosis in general may have occurred. No outbreaks were reported north of Trent Regional Health Authority in England, in Wales, Scotland, Northern Ireland and the Republic of Ireland and may reflect regional differences in the detection of outbreaks or their investigation. It is likely that swimming pool associated outbreaks of cryptosporidiosis (and indeed giardiasis) are under-reported.

More outbreaks occurred during the summer and autumn, possibly reflecting the popularity of swimming as a pastime during this season. There is a rise in the number of cases of cryptosporidiosis reported to CDSC during the spring and again in the late summer/ autumn each year. It could also be speculated that many people return from holidaying abroad at this time of year, perhaps bringing new strains of *Cryptosporidium*. Genotyping isolates from the outbreak cases showed that genotype 1 and genotype 2 isolates have been detected in cases from swimming pool outbreaks of cryptosporidiosis. However, it will be necessary to type more isolates from more outbreaks and collect further information about possible contamination events at the pools involved to reveal any themes in water treatment. Single genotype outbreaks may result from single acute contamination of the pool whereas outbreaks of mixed genotypes are likely if continued contamination occurs over a period of time with the introduction of different strain. It is interesting that three out of 51 people tested from swimming pool outbreaks had both genotype 1 and 2 in their faeces. This is a ten-fold increase in the rate of mixed infections compared with drinking water-associated outbreak and six-fold over sporadic cases. Given the apparent rarity of mixed infections in the community, those in the swimming pool outbreaks probably arose due to contamination of the pool by more than one infected bather providing a mixed inoculum Continued typing of all isolates and the application of more discriminatory methods may in the future shed further light on the sources of contamination and infection, as will application of typing methods to environmental samples.

Swimming pools have been associated with outbreaks of cryptosporidiosis, but it may also be argued that in many outbreaks the evidence for the association is based purely on descriptive epidemiology. While in some cases this may produce compelling evidence, other risk factors may be present and were indeed identified in some analytical studies. During some outbreaks the number of people who actually swam in the pool was small compared with the total number of cases occurring at the time. It may be the case that for some outbreaks where there is weak evidence for association with a swimming pool there are other causes, either for the outbreak or for a certain proportion of cases. Because relatively few people may be involved in some outbreaks a strong association may be difficult to prove by analytical epidemiology. It is also difficult in many outbreaks to distinguish between routes of transmission at the

pool which could include contaminated pool water, toilet or shower facilities. However, the application of cohort studies to outbreaks may be useful in identifying specific risk factors for illness at swimming pools.

Statistical and microbiological evidence were obtained singly in three and five outbreaks respectively, and both were obtained in one outbreak. While environmental sampling for *Cryptosporidium* was undertaken in 16 outbreaks, the parasite was detected in just six. However, a negative result does not mean that the organism is absent. Detection of *Cryptosporidium* in such samples is difficult since low numbers may be present and not evenly distributed. Sampling varied in nature and intensity, and may be undertaken at a date well after the initial contamination and from inappropriate points. Given the difficulties in detecting *Cryptosporidium* in water in general, pool filter media may be more appropriate (if the decision is made to undertake sampling) but methodology needs to be investigated further since difficulties in sampling some filter material can be considerable. The detection of *Giardia* cysts in pool samples from three outbreaks, one with a rise in cases of giardiasis, highlight the potential for this organism to cause swimming pool-associated illness.

Two thirds of the cases who swam were children, and one quarter of the cases were under five years old. Diarrhoea is more likely to be investigated in this age group over adults, and outbreaks of illness may be more readily noticed amongst groups of children. However, young children are thought to be more susceptible to infection. The distribution of cases of cryptosporidiosis associated with swimming pools may also be a function of habits of the age groups affecting the profile of the people at risk. Outbreaks were most frequently clustered in learner pools as opposed to main pools, and while at the same time being a vulnerable group who need to be protected, users of such pools could also be the source of infection. It may be better that learner pools have separate circulation systems from the main pool if faecal accidents are more likely to occur here. Separate learner pools are more easily drained for cleaning and disinfection.

Although it is possible that a swimming pool could be replenished by contaminated potable mains water it is highly unlikely that, following dilution, filtration and turnover of the pool water, sufficient oocysts would be present to cause an outbreak. Unless sewage enters the pool through defective plumbing, the most likely source of oocysts in swimming pools is human faeces from a faecal accident in the pool. Acute faecal contamination events were known to have occurred in four outbreaks, but procedures for dealing with them were often lacking. It is also likely that faecal material can enter the pool water unnoticed, either from watery diarrhoea or contaminated skin, and it is clear from the outbreaks that faecal accidents go unreported to pool operators. Few pools had guidelines in place before the outbreak occurred for dealing with faecal accidents. The Pool Water Treatment Advisory Group (1999) produces guidelines for reporting and dealing with faecal accidents, and for “keeping diarrhoea out of the pool”.

Effective pool water treatment for *Cryptosporidium* is clearly a problem (Kebabjiam, 1995). Outbreaks have occurred in apparently well-run pools, in chlorinated and in ozonated pools. However, the majority of pools associated with outbreaks did report faults, mainly with ozone treatment failures. Monitoring of

disinfection and for bacteriological quality was often unclear. However, outbreaks included pools with both satisfactory and unsatisfactory results. Chlorination is not effective against *Cryptosporidium* as a routine pool water treatment. It is unclear at present whether the contact time for ozone in most pools is sufficient to significantly reduce *Cryptosporidium* infectivity. Ozone systems were often reported to have failed, and filtration remained the only barrier. However, this is a progressive treatment and a high number of passes through the filters are required for substantial removal of oocysts, and the swimmers in the vicinity of a faecal accident are at risk of infection until the water has been treated. Effective filtration for the removal of oocysts may be more likely in the type of filter systems employing flocculation but little information was available about its use, or the filter types, from the study.

It remains a fact that the source of the oocysts in swimming pool water is, in most cases, human faecal contamination of the pool water and any removal relies on a turnover time for the pool water to be filtered. The significantly shorter duration of outbreaks associated with known faecal accidents, even if they were not dealt with immediately, could indicate that other outbreaks could be as a result of on going contamination from bathers with no action taken. However, recall bias may have occurred in outbreaks of longer duration resulting in the under reporting of faecal accidents to this study. Recognition, reporting to pool operators and a rapid response could help reduce the number of cases and duration of outbreaks of swimming pool-associated cryptosporidiosis.

Conclusions

- Outbreaks occurred at both chlorinated and ozonated pool facilities.
- Outbreaks occurred associated with both poorly- and well-managed pool facilities.
- Disinfectant and bacteriological monitoring and management varied widely but in many cases little information was available.
- There is some evidence for the potential for swimming pool-associated giardiasis.

General Recommendations

- Pool managers need to ensure that pool water treatment guidelines (produced by the Pool Water Treatment Advisory Group) are available to, read by and followed by all pool operators.
- Guidelines for the control of cryptosporidiosis associated with swimming pools and risk reduction need to be written to highlight actions which can be taken, but precise risks at swimming pools may need to be better defined.
- Increased education of the public about the importance of proper showering, not swimming with or after diarrhoea, the need to report faecal accidents and prevention of faecal material entering the pool.
- Separate water systems for learner and adult pools may help avoid cross contamination.

- Disinfection methods (both current and new methods such as UV), filtration effectiveness and best practice for backwashing filters need to be investigated with specific reference to pool water treatment.
- The use of flocculation and filtration needs to be better investigated by appropriate research studies.
- Better systems need to be developed to monitor filter function efficiency.
- Development and use of better methods for sampling and detection of *Cryptosporidium* from pools and associated plant (*eg*.filters) to assist in outbreak investigations and application of typing methods to environmental isolates.
- The burden of sporadic illness (including cryptosporidiosis and giardiasis) associated with swimming pool use is currently unknown.

Proposals for further research by PHLS (see Part 1b.)

- The burden of illness associated with pools needs to be investigated
- Prospective studies for systematic investigation of swimming pool associated outbreaks to obtain reliable and full data on pool water treatment and specific risk factors for infection in swimming pools.

References

Anon. Cryptosporidiosis associated with swimming pools. CDR Weekly 1999; 9:423.

Anon. Removal of *Cryptosporidium* oocysts in the treatment of swimming pool water: literature review and recommendations for research. Report to the Pool Water Treatment Advisory Group, March 2000.

Casemore DP, Watkins J. Review of disinfection and associated studies on *Cryptosporidium*. Report to DETR/Yorkshire Environmental Alcontrol UK, 1997.

Dean AD, Dean JA, Coulombier D, *et al.*, 1994. Centres for Disease Control, Atlanta, Georgia, USA.

Finch GR, Black EK, Gyurek L, Belosevic M. Ozone inactivation of *Cryptosporidium parvum* in demand-free phosphate buffer determined by *in vitro* excystation and animal infectivity. Applied and Environmental Microbiology 1993; 59: 4203-4209.

Furtado C, Adak GK, Stuart JM, Wall PG, Evans HS, Casemore DP. Outbreaks of waterborne infections of intestinal disease in England and Wales, 1992-5. Epidemiology and Infection 1998; 121:109-119.

Joce RE, Bruce J, Kiely *et al*., An outbreak of cryptosporidiosis associated with a swimming pool. Epidemiology and Infection 1991; 107: 497-508.

Kebebjian R. Disinfection of public pools and management of faecal accidents. Journal of Environmental Health 1995; 58: 8-12.

Pool water Treatment Advisory Group. Swimming Pool Water Treatment and Quality Standards 1999 Pool water Treatment Advisory Group, Diss.

Rooney R, Chalmers RM, Stanwell-Smith R, Nichols G, Hunter PR. Review of outbreaks of infection associated with swimming pools, whirl pool and spa pools in the UK from 1990 to 1999. In preparation.

Wall PG, de Louvois J, Gilbert RJ, Rowe B. Food poisoning: notification, laboratory reports and outbreaks – where do the statistics come from and what do they mean? CDR Review 1996; 6: R93-R100.

Appendix 1.

Letters to CsCDC or equivalent personnel

Appendix 1.

January 1999.

Dr Darina O'Flanagan
National Disease Surveillance Unit (NDSU)
Sir Patrick's Dun's
Lower Grand Canal St.
Dublin 2

Dear Dr O' Flanagan

Re:*Review of outbreaks of infection associated with swimming pools.*

There has been an increase in reported swimming pool outbreaks. particularly involving Crvptosporidium: it has been suggested that new guidance may be needed. I am conducting a review for CDSC and the PHLS Water Comrnittee of all outbreaks of infection associated with swimming pools in the UK from 1990 to 2000. including outbreaks caused by *Legionella* spp and *Pseudomonas* spp. I am collaborating with Dr Gordon Nichols and Dr. Ros Stanwell-Smith for the review. which involves analysing all outbreak data on swimming pools in the CDSC archives.

We would like to include all outbreaks of infection associated with swimming pools in all of the UK and Republic of Ireland. and would like a representative from the NDSU to participate in this review. All contributions will be acknowledged in the report and a report and subsequent guidance will be circulated to all participants.

If you wish to discuss this or any other details concerning this project. please contact me or Dr Ros Stanwell-Smith on the above number.

Yours sincerelv

Roisin Roonev
Senior Scientist (Environmental Health and Epidemiology)
Environmental Surveillance Unit

Cc: Dr Gordon Nichols. Environmental Surveillance Unit. CDSC.
Dr Ros Stanwell-Smith. Epidemiology Division. CDSC.
Dr Paul Hunter. Regional Epidemiologist. CDSC
Dr Mark Reacher. Epidemiology Division. CDSC.

January 1999

Dr Brian Smyth
Regional Epidemiologist
Belfast City Hospital
Lisburn Road
Belfast BT9 7AB

Dear Dr Smyth

Re:*Review of outbreaks of infection associated with swimming pools*

There has been an increase in reported swimming pool outbreaks. particularly involving Crvptosporidium: it has been suggested that new guidance may be needed. I am conducting a review for CDSC and the PHLS Water Committee of all outbreaks of infection associated with swimming pools in the UK from l990 to 2000. including outbreaks caused by *Legionella* spp and *Pseudomonas* spp. I am collaborating with Dr Gordon Nichols and Dr. Ros Stanwell-Smith for the review. which involves analysing all outbreak data on swimming pools in the CDSC archives. We would like to include any reports of incidents not reported to CDSC at the time or where the CDSC outbreak report is untraceable. So far. I have traced 15 outbreaks since 1990.

Would it be possible for you to ask a member of your staff or colleagues in the local authorities to check records for any swimming pool outbreaks? I know you receive many requests. but it would be invaluable to be able to include as much district experience as possible. All contributions will be acknowledged in the report and a report and subsequent guidance will be circulated to all CCDCs and EHOs.

I enclose a pay reply slip. In the first instance it would be helpful simply to have a year and a few words summarising each outbreak. If I cannot find any information about particular outbreaks. I shall contact you for more details. All contributions will be acknowledged in the report and a report and subsequent guidance will be circulated to all participants.

If you wish to discuss this or any other details concerning this project. please contact me or Dr Ros Stanwell-Smith on the above number.

Yours sincerely

Roisin Rooney
Senior Scientist (Environmental Health and Epidemiology)
Enviromnental Surveillance Unit

January 1999

Dr Peter Christi
SCIEH
Clifton House
Clifton Place
Glasgow G37 LN.

Dear Dr Christi

Re:*Review* of *outbreaks of infection associated with swimming pools.*

There has been an increase in reported swimming pool outbreaks. particularly involving Cryptosporidium: it has been suggested that new guidance may be needed. I am conducting a review for CDSC and the PHLS Water Committee of all outbreaks of infection associated with swimming pools in the UK from 1990 to 2000. including outbreaks caused by *Legionella* spp and *Pseudomonas* spp. I am collaborating with Dr Gordon Nichols and Dr. Ros Stanwell-Smith for the review which involves analysing all outbreak data on swimming pools in the CDSC archives.

We would like to include all outbreaks of infection associated with swimming pools in all of the UK and Republic of Ireland. and would like a representative from SCIEH to participate in this review. All contributions will be acknowledged in the report and a report and subsequent guidance will be circulated to all participants.

If you wish to discuss this or any other details concerning this project. please contact me or Dr Ros Stanwell-Smith on the above number.

Yours sincerely
Roisin Rooney
Senior Scientist (Environmental Health and Epidemiology)
Environmental Surveillance Unit

Cc: Dr Gordon Nichols, Environmental Surveillance Unit, CDSC.
Dr Ros Stanwell-Smith Epidemiology Division. CDSC.
Dr Paul Hunter. Regional Epidemiologist. CDSC
Dr Mark Reacher, EpidemiologyDivision. CDSC.

January 1999

All CCDCs

Dear CCDC
Re:Review of outbreaks of infection associated with swimming pools.

There has been an increase in reported swimming pool outbreaks. particularly involving Cryptosporidium: it has been suggested that new guidance may be needed. I am conducting a review for CDSC and the PHLS Water Committee of all outbreaks of infection associated with swimming pools in the UK from 1990 to 2000. including outbreaks caused by *Legionella spp* and *Pseudomonas* spp. I am collaborating with Dr Gordon Nichols and Dr. Ros Stanwell- Smith for the review. which involves analysing all outbreak data on swimming pools in the CDSC archives. We would like lo include any reports of incidents not reported to CDSC at the time or where the CDSC outbreak report is untraceable. So far. I have traced 15 outbreaks since 1990.

Would it be possible for you to ask a member of your staff or a colleague in the local authority to check records for any swimming pool outbreaks? I know you receive many requests. but it would be invaluable to be able to include as much district experience as possible. All contributions will be acknowledged in the report and a report and subsequent guidance will be circulated to all CCDCs and EHOs.

I enclose a pay reply slip. In the first instance it would be helpful simply to have a year and a few words summarising each outbreak. If I cannot find any information about particular outbreaks. I shall contact you for more details.

If you wish to discuss this or any other details concerning this project. please contact me or Dr Ros Stanwell-Smith on the above number

Yours sincerely

Roisin Roonev
Senior Scientist (Environmental Health and Epidemiology)
Environmental Surveillance Unit

Cc: Dr Gordon Nichols. Environmental SurveillanceUnit. CDSC.
Dr Ros Stanwell-Smith. Epidemiology Division. CDSC
Dr Paul Hunter. Regional Epidemiologist. CDSC

Appendix 2.

Swimming pool outbreak questionnaire

Swimming pool outbreak questionnaire

Ref……..

Contact name, address and telephone number

Name and address of swimming pool complex

NHS Region:

Year and month of outbreak……..……

1. **Date of first case……..……...…….**
2. **Date of last case……..……..……**
3. **Total number of cases in outbreak……...…**
4. **Total number of cases confirmed……**
5. **Number of cases that swam in the pool in question……..…**
6. **Age range of affected swimmers…….**
7. **Did the local authority or health authority carry out active cases finding during the outbreak? ….…….**
8. **What was the basis for the association of the outbreak with the swimming pool?(e.g. descriptive epidemiology, statistical evidence or microbiological evidence)……**
9. **What was the swimming pool type? (e.g. outdoor pool, learner pool, children's pool, indoor pool)**
   ……...
10. **What disinfectant was used in the pool before the outbreak? (e.g. Chlorine, Ozone)**
    ….……..……
11. **How frequently was the water tested to check levels of disinfectant?…….**
12. **Were records kept of disinfection procedures?……**
13. **Was there a breakdown in disinfection before the outbreak?**
    ……
14. **Were any problems with the filtration system detected before or during the outbreak?……**
15. **If faults were detected were these reported to the management before the outbreak?……..……**
16. **Were routine bacteriological tests of the water carried out before the outbreak?……..……**

17. Was there a pool associated event before the outbreak? (e.g. faecal accident, ingress of sewage)……

18. If there was a faecal accident was this suspected or confirmed?

……

19. During the outbreak was the pool water sampled for *Cryptosporidium*?

……

20. If yes, was *Cryptosporidium* detected in the water?

……

21. Was the local water authority informed of the outbreak?

……

22. What measures were taken to reduce spread of infection from the pool following the outbreak? (e.g. Cleaning and disinfection of pool, backwashing, change of filters).

……

……

23. Please comment on overall pool management (e.g. log book, procedures for recording and acting on faults, procedures for dealing with faecal accidents, availability of handbooks for staff) before the outbreak.

……..

……..

Appendix 3.

Summary reports of each outbreak

Outbreak 1 (92/079)

An outbreak involving 13 cases of cryptosporidiosis, all confirmed microscopically, occurred in the South West Health Authority Region in March 1992. 10 cases had swum at the Cotswold Leisure Centre, Cirencester, Gloucestershire, a local authority facility with two pools. Cases who swam were one adult, three children aged 5-14 years and 6 children aged 0-4 years. Nine of the cases had swum within 24 hours of a faecal accident at the learner pool on 2nd March. A distressed toddler was taken from the learner pool and found to have passed a loose stool, but this was not reported to the pool attendants at the time and so no action was taken. The child was cleaned in the showers. The onset of the first case was 6th March and the outbreak lasted for 17 days. The pool was sampled for *Cryptosporidium* on 28th March, and one oocyst detected in a 10 litre sample of the pool water. Oocysts were not detected in further environmental samples. Although details are sparse, disinfection was reported to be sufficient for bacteriological control prior to the outbreak although bacteriological monitoring was not undertaken. The pool was disinfected by side stream ozonisation and marginal chlorination, with water circulated between the two pools. No faults in the pool water treatment system were reported prior to the outbreak and the overall pool management was reported to be good.

Data sources: Hunt *et al*., Cryptosporidiosis associated with a swimming pool complex. CDR Review 1994; 4: R20- R22; CDSC database report form 92/079.

Outbreak 2 (93/067)

Of 23 cases (21 confirmed) between 10th January and 19th February 1993, 18 swam at a school swimming pool in Walton, Mid Staffordshire, West Midlands. These were four adults, 10 children aged 5-14 years and four children 0 to 4 years. The pool was chlorinated but details about the pool management, disinfectant and bacteriological monitoring prior to the outbreak were not available. Details about sampling for *Cryptosporidium* were not available, and the organism was not detected. As a result of the outbreak the pool was closed for cleaning and disinfection.

Data sources: CDSC outbreak report form 93/067; swimming pool outbreak questionnaire completed by the CCDC.

Outbreak 3 (93/227)

Between 23rd July and 5th October 1993, seven out of 27 community cases (all confirmed) swam in the learner pool in Bittern Leisure Centre, Bittern, Southampton, a local authority leisure centre in the South East Region. All the cases were children under 12 years. Active case finding was undertaken and a case control study conducted on 23 cases revealed the following risk factors for infection: use of the swimming pool (OR=7.87, CI=1.12-55.02), a dose response with drinking un-boiled tap water (λ^2 for trend=4.92, p=0.03) and having ill family members. The outbreak duration was 74 days. Extensive sampling at the beginning of October failed to isolate *Cryptosporidium*. Pool water disinfection was side stream ozonation and chlorination. Bacteriological data showed no evidence of faecal contamination prior to the outbreak

and although the treatment plant was working well on inspection during the outbreak, the ozone generator had been faulty during the first three weeks of September. There was no system for reporting faecal accidents. The outbreak report concluded a that unrecognised faecal contamination, person-to-person transmission and undetected contamination of the drinking water supply contributed to the outbreak. As a result of the outbreak the pool was closed, the surround disinfected, and the filters backwashed.

Data sources: CDSC outbreak report 93/227; swimming pool outbreak questionnaire completed by Environmental Health Officer, Southampton; District Health Authority outbreak report "An outbreak of cryptosporidiosis".

Outbreak 4 (94/347)

Eight out of 14 cases were confirmed microbiologically and an unreported number had swum in a local authority South Dartmoor leisure centre at Ivybridge, Plymouth, South West Region during a four week period from 7th October 1994. The outbreak investigators attributed the outbreak to the learner pool since a toddler was known to have defecated in that pool, but the date was not specified. In addition, people with diarrhoea continued to swim. The age distribution of cases was not known. The outbreak duration was 30 days. Cases were also sought among pool user groups and pool attendants with diarrhoea. Details of environmental sampling during the outbreak were not known but *Cryptosporidium* was detected. Disinfection of the pool water was by chlorination but monitoring results and those of bacteriological testing prior to the outbreak were not available, although no faults were reported in the pool water treatment. As a result of the outbreak the pool was closed, the water superchlorinated and the filters backwashed. A policy for handling faecal accidents was introduced after the outbreak.

Data sources: Anon. Surveillance of waterborne diseases. CDR Weekly 1995; 5:129, CDSC outbreak report 94/347; swimming pool outbreak questionnaire completed by EHO and CCDC.

Outbreak 5 (94/453)

A small outbreak involving three cases, all microbiologically confirmed, who swam in Courtlands private country club outdoor pool in Southend on Sea, Eastern Region occurred during July1994. The cases were aged between 5 and 10 years and all used the pool within a 48 hour period, although the dates of onset of illness were not available. The pool was chlorinated and chlorine levels monitored daily prior to the outbreak, but bacteriological testing was not undertaken. Inadequate reporting of disinfection monitoring was noted and the pool water had not been changed for seven years. The pool was closed each winter and simply reopened in the summer. Environmental sampling was undertaken for *Cryptosporidium*, and oocysts were detected, although details were not available. As a result of the outbreak the pool was closed and drained, sand filter media replaced, pipes and filtration system disinfected. Better reporting mechanisms for pool disinfection and management were put in place.

Data sources: CDSC outbreak report 94/453; swimming pool outbreak

questionnaire completed by EHO.

Outbreak 6 (94/454)

In an outbreak associated with Clements Hall Leisure Centre, Hawkeswell, Essex, in which four cases (all microbiologically confirmed) were all children aged 0-4 years with an onset of illness within a 24 hour period in October 1994. All had swimming lessons in the learner pool at the local authority leisure centre. The pool disinfection was chlorination but information about disinfection and bacteriological monitoring prior to the outbreak was not available, although chlorine and turbidity were considered to be adequate and a risk assessment satisfactory. However, the filtration plant was leaking prior to the outbreak and replacement was advised. Sampling for *Cryptosporidium* resulted in the detection of oocysts but details were not available. As a result of the outbreak the pool was closed for 24 hours, the water heated to 37°C, superchlorinated and circulated for 6 passes through the filters before reopening.

Data sources: CDSC outbreak report 94/454; swimming pool outbreak questionnaire completed by EHO; memo concerning replacement advice and costs of the filtration plant, EH department.

Outbreak 7 (96/569)

Between 10th July and mid-September 1996, eight cases (all microbiologically confirmed) all reported swimming in the learner pool at Andover local authority leisure centre in Hampshire, South East Region. Two cases had also used the adult pool. The cases were three adults, four children aged 5-14 years, one child under 5. A case control study of four cases showed illness to be associated with increased frequency of total immersion in the pool (p=0.04). The pool was disinfected by chlorine and checked three times daily prior to the outbreak. The bacteriological testing programme was not reported but results said to be satisfactory prior to the outbreak. The management of the pool was generally good with regular cleaning of the pool area, the filters in good condition and clear procedure for reporting faecal accidents. No water treatment faults were reported prior to the outbreak. The filters were backwashed and alum dosing carried out twice weekly. Backwash samples were tested from the filters and while *Cryptosporidium* was not detected, *Enterobius vermicularis* ova were, indicating faecal contamination of the pool, although no instances of faecal accidents were reported to pool operators. As a result of the outbreak additional flocculation was introduced and the filters backwashed.

Data sources: Anon. Surveillance of waterborne disease and water quality: July to December 1996. CDR Weekly 1997; 7: 73-74; Sundkist *et al.*, Outbreak of cryptosporidiosis associated with a swimming pool in Andover. CDR Review 1997; 7: R190-192; CDSC outbreak report 96/569; swimming pool outbreak questionnaire completed by EHO; Sandkvist, T “Outbreak of cryptosporidiosis in Andover summer 1996” Final report to PHLS CDSC.

Outbreak 8 (97/309)

Of nine cases (all microbiologically confirmed) during May 1997, six had swum in at the local authority leisure centre, Flemming Park, Southampton, South East Region. The cases who swam were one adult and five children between 0 and 14 years, and all cases had used the learner pool the morning of the day when faeces, thought to have been in the pool for some hours, were detected in the evening. This occurred five days before the onset of the first case. The pool was closed on their discovery, cleaned and disinfected. No cases were reported amongst those who used to pool in the afternoon. The pool was normally disinfected by ozone with chlorine as a residual but the ozone generator was faulty and not used on the day in question May 1997. Environmental sampling for *Cryptosporidium* was not undertaken.

Data sources: Anon. Surveillance of waterborne disease and water quality: January to June 1997. CDR Weekly 1997; 7: 317-319; CDSC outbreak report 97/309; Taylor, J. "*Cryptosporidium* outbreak connected with the learner pool, Fleming Park Leisure Centre" report by Eastleigh Borough Council

Outbreak 9 (98/181)

Six cases of cryptosporidiosis were confirmed during March 1998, and the outbreak associated with Harbour fitness and leisure club, Hammersmith and Fulham in London Region. Precise details of the number of cases who swam were not available. Water from the children's pool was known to breach the main pool, and the pool had been closed two years previously because of unspecified incidents. The pool was routinely disinfected by ozone and chlorine, but details of disinfection and bacteriological monitoring prior to the outbreak were not available. However, the chlorination, ozonation and filtration units were all reported to be faulty and the plumbing done by "cowboys". The warning system on the ozone plant did not signal a low dose. The children's pool was taken off the chlorine circuit, water from this pool entered the main pool and the children's pool was operating at an elevated temperature. Two backwash samples were taken on 12th March 1998: *Cryptosporidium* was not detected but *Giardia* cysts were. The filtration system was repaired before the pool was reopened.

Data sources: CDSC outbreak report 98/181; swimming pool outbreak questionnaire completed by CCDC; Anon. Surveillance of waterborne disease quality: January to June 1998. CDR Weekly 1998; 8: 305-306; CDR 1999; 9: 305-307.

Outbreak 10 (98/626)

Of 35 cases between 6th September and 11th November 1998, 31 were microbiologically confirmed and 14 had swum at Spice Ball Centre, a local authority leisure pool complex in Banbury, South East Region, in the two weeks prior to onset of symptoms. Three faecal isolates were genotyped from the outbreak and all were genotype 1. The cases who swam were all children under 10 years of age. Local flooding had resulted in ingress of sewage to the pool in April that year and the pool

subsequently closed. The pool had been cleaned prior to reopening in June. The pool water and filters were sampled following the outbreak but *Cryptosporidium* was not detected. Prior to the outbreak, the pool was chlorinated with pool-side tests three times daily and automatic monitoring of dosing. Information about bacteriological sampling was not available. A pool consultant reported no faults in the pool water treatment. The pool was closed for routine maintenance in December that year, and the filter media was changed.

Data sources: CDSC outbreak report 98/626; swimming pool outbreak questionnaire completed by EHO; CDR 1999; 9: 305-307; CDR 1999; 9: 73-75; Mayon-White and Meisner S. "Outbreak of cryptosporidiosis in North Oxfordshire, Autumn 1998" Oxfordshire Health Authority final report; Food Safety and Microbiology Laboratory, CPHL.

Outbreak 11 (98/631)

In September 1998, an outbreak associated with swimming at the local authority Blackwall leisure centre pools in Maldon, Essex, Eastern Region occurred. All nine cases were microbiologically confirmed and had swum in the two pools at the leisure centre. The cases were two adults, three children aged 5 to 14 years, and four children under 5 years. The outbreak lasted for 64 days. Although no faecal contamination event was reported prior to the outbreak, people with diarrhoea were known to swim. No environmental sampling for *Cryptosporidium* was undertaken. The pool was disinfected by ozonation, but details of disinfection and bacteriological monitoring were not available. However, prior to the outbreak ozonation plant failures and filtration problems were reported with the turnover rate reduced from 1.5 hours to 4 hours. As a result of the outbreak the pool was closed and the filter plant fixed. Notices were installed advising people with diarrhoea not to swim.

Data sources: CDSC outbreak report 98/631; swimming pool outbreak questionnaire completed by EHO; Further information from EHOs; CDR 1999; 9: 305-307; CDR 1999; 9: 73-75

Outbreak 12 (99/350)

11 cases of cryptosporidiosis (all confirmed) during July 1999 had all swum at the Carn Brae local authority leisure centre pool in Redruth, Cornwall. The outbreak lasted for 10 days. The cases were two adults, five children aged 5 to 14 years, one aged under 5 and the ages of three cases were unknown. The learner pool was associated with the outbreak by the EHOs, although evidence for this was not available. Although a faecal accident was not reported, there was speculation that one might have occurred. Ten faecal isolates from cases were genotype 2. *Cryptosporidium* was not detected in a 10 litre sample of pool water. The pool water disinfection was by ozone and chlorine and monitored twice daily prior to the outbreak, although bacteriological monitoring was not done. The chlorination and filtration systems were satisfactory and no faults reported before the outbreak. As a result of the outbreak the pool was closed until the *Cryptosporidium* test result was obtained.

Data sources: CDSC outbreak report 99/350; swimming pool outbreak questionnaire completed by EHO; CDR 2000; 10:65-67; Food Safety and Microbiology Laboratory, CPHL.

Outbreak 13 (99/582)

An outbreak was associated with Temple Cowley local authority swimming pool in Oxfordshire, South East region between August and November 1999. Of 54 cases (all confirmed) 21 swam at the pool. Only four of the total number of cases were adults, although the age distribution of the cases who swam is not clear. Enhanced surveillance was undertaken by requesting that adults presenting to GPs with diarrhoea be screened for *Cryptosporidium*. 10 faecal isolates were genotype 1, one was genotype two and three were mixed genotypes. A case control study of 23 cases showed illness to be associated with any swimming pool use (OR=3.59, CI=1.04-12.74), Temple Crowley pool use (OR=37.09, CI=4.08-854.5) and drinking bottled water (OR=5.82, CI=1.01-47.3). Sampling on 28th October detected *Cryptosporidium* in strainer basket material, and *Giardia* in filter flocculant. *Cryptosporidium* and *Giardia* were also detected in pool water filters on 2nd November.

Normal pool water treatment was ozonation with chlorination but the ozone plant had been off line for two months prior to the outbreak. Details of disinfection monitoring were not available but bacteriological monitoring results were satisfactory in September, although coliform counts were elevated. On 27th October, the Total Viable Count was >300 ml^{-1}, coliforms 43 ml $^{-1}$and *E. coli* 43 ml^{-1}, indicating faecal contamination although no events were reported. Pool water treatment experts advised that without ozonation the chlorine was insufficient, and the pH too high for effective flocculation. The filters were not performing properly as a consequence of the disinfection problems and a plank of wood was found in one. Filter backwashing was inadequate and the disinfection system overloaded. The pool was closed on 27th October for investigation and work on the filters. Recommendations were made to improve the whole disinfection system.

Data sources: CDSC outbreak report 99/582; CDR 1999; 48: 423; CDR 2000; 10:65-67; Snape, S. “Outbreak of Cryptosporidiosis in Oxford City, Autumn 1999. Health Authority final report.

Outbreak 14 (99/679)

In an outbreak in the West Midlands in August and September 1999, four out of eight cases were microbiologically confirmed. Four cases, with an age distribution of 19 months to 42 years swam at the Wyndley Leisure Centre, Sutton Coldfield. The pool water treatment was chlorination, and prior to the outbreak checked every two hours. Bacteriological monitoring was not undertaken. Details are not available but environmental sampling for *Cryptosporidium* did not detect oocysts. No treatment plant faults were reported prior to the outbreak and overall pool management was satisfactory with log books and maintenance schedules in place. As a result of the outbreak the pool was closed, coagulant used, and filtration for 6 turnovers of pool

water undertaken before reopening.

Data sources: CDSC outbreak report 99/679; swimming pool outbreak questionnaire completed by EHO; CDR 2000; 10:65-67.

Outbreak 15 (99/741)

An outbreak was linked to a pool in Sutton, London involving 30 cases, all microbiologically confirmed. 14 cases swam in the pool prior to onset of illness. Seven cases were aged 5 to 14, four under 5 and the ages of three was not known. GPs were requested to submit stools for screening. The outbreak lasted for 51 days. 20 faecal isolates were genotype 2 and two were genotype 1. A case control study of 15 cases showed that by adjusted analysis only swimming at the leisure centre pool was associated with illness (λ^2 =19.65, $p<0.0001$). Although a faecal accident was not known to have occurred, a parent, who was herself a case, allowed her diarrhoeic child to swim. Details are sparse but 10 litre samples from the main and learner pools did not yield cryptosporidial oocysts. The pool water disinfection was by chlorination, and the chlorine and pH were checked every two hours, with no failures reported in either this or bacteriological monitoring prior to the outbreak. Although no faults in treatment or treatment plant were reported prior to the outbreak, the pool was due for refurbishment. As a result of the outbreak the pool was drained and cleaned, and the sand filters cleaned and replaced.

Data sources: CDSC outbreak report 99/741; Anon "Report on the investigation of an increase in reported cases of *Cryptosporidium* infection in the London borough of Sutton in Autumn 1999" Local Health Authority report; Food Safety and Microbiology Laboratory, CPHL.

Outbreak 16 (99/583)

16 cases (14 confirmed) were involved in an outbreak from 29th August to 8th October in the West Midlands. 7 cases, aged between 22 months and 39 years, had swum in the pool at a private leisure centre in Solihul. GPs increased stool sampling from children under five years. Six faecal isolates from cases was genotype 1 and three were genotype 2. 10 l samples from the adult and children's pool resulted in the detection of nine cryptosporidial oocysts from the adult pool and 188 oocysts from the children's pool. Cryptosporidia were detected in no further samples from the adult pool but two oocysts detected in one sample from the children's pool. A further sample was negative. Prior to the outbreak, the pool water was chlorinated, chlorine and pH being monitored three times daily. No information was available about bacteriological monitoring. Filters were backwashed regularly, no treatment faults were reported prior to the outbreak and pool management was generally considered to be good. The pool was closed on 24th September and the filters backwashed extensively. It was re-opened following the negative *Cryptosporidium* test results from both pools.

Data sources: CDSC outbreak report 99/583; swimming pool outbreak questionnaire completed by EHO; CDR 1999; 48: 423; CDR 2000; 10:65-67; Heath

Authority Final Report "An outbreak of *Cryptosporidium parvum* infection associated with a swimming pool"; Food Safety and Microbiology Laboratory, CPHL.

Outbreak 17 (99/669)

An outbreak involving four cases (all confirmed) occurred between 5th and 25th November 1999. All four cases had swum in. Farnham local authority swimming pool, Surrey, in the South East Region. The cases were children under five years. In the recent past, boys had been deliberately defecting in the pools at the centre but immediate action was taken and the stools removed with a net which was stringently cleaned. Backwash from the filters did not contain detectable *Cryptosporidium* oocysts. No details about disinfection or bacteriological monitoring prior to the outbreak were available for the chlorinated pool. As a result of the outbreak the junior pool was drained and cleaned.

Data sources: CDSC outbreak report 99/669; CDR 2000; 10:65-67

Outbreak 18 (99/600)

From August to October 1999, 19 cases (16 confirmed) were involved in an outbreak in the Trent region. 11 cases, two adults and eight children under five and one age unknown, had swum in Market Harborough local authority swimming pool, Leicestershire. No cryptosporidia were detected in 50 litres pool water from both pools, sand from the tops of both filters and hair and other detritus from the sieves. However, *Giardia* cysts were detected and cases of *Giardia* had also used the pool. Each pool had separate water treatment plants, comprising filtration, chlorination and ozonation. Regular disinfectant monitoring was undertaken and treatment deemed satisfactory on most occasions. Details about bacteriological monitoring were not available. The ozonation plant had been tripping out prior to the outbreak and so the chlorination had been increased. The filter design had a number of faults identified. As a result of the outbreak, the pool was closed and the sand filters replaced.

Data sources: CDSC outbreak report 99/600; swimming pool outbreak questionnaire completed by CCDC; CDR 1999; 48: 423; CDR 2000; 10:65-67; Lee, J. "Investigation of an outbreak of cryptosporidiosis linked to a swimming pool".

Part 1b.
Proposal for prospective studies of swimming pool-related cryptosporidiosis

Background

The review of outbreaks of cryptosporidiosis in swimming pools (Part 1a.) identified a number of areas for further investigation that can only be obtained by prospective studies. A case control study of sporadic cases of cryptosporidiosis in Wales and the North West of England (DETR/North West Water funded project number DWI 70/2/132) commencing in 2000, will investigate a variety of risk factors. Included in this is swimming, and the study will provide an estimate of the burden of reported sporadic cryptosporidiosis in people who have swum. The enhanced surveillance providing the backbone of that study will better identify any outbreaks in those two regions. However, to more clearly identify pool water treatment and circumstances surrounding outbreaks, there is a need for good quality data to be obtained at the swimming pool. This can only be done prospectively and epidemiological studies will identify specific risk factors at the pool, and lead to evidence-based guidance for the control of swimming pool-associated cryptosporidiosis.

Proposal aims

1. To obtain better quality data on the pool characteristics of swimming pools associated with outbreaks of *Cryptosporidium*
2. To identify specific risk factors for swimming pool-associated cryptosporidiosis
3. To produce guidelines for the control of swimming-pool associated cryptosporidiosis

Objective (i) Prospective follow up of outbreaks for comprehensive pool water treatment information

Construction of a new questionnaire and administration at the pool during outbreaks will prospectively gather detailed, accurate information about pool design and parameters (bather loads, circulation rate, turnover, hydraulics, treatment and dosing, filtration systems, pool operation and management, disinfection and bacteriological monitoring). The questionnaire will be administered at outbreaks over the course of a year.

Costs for Objective (i) would include the production of questionnaire, administration via EHOs, analysis and interpretation of data.

Objective (ii) Cohort study to identify risk factors for cryptosporidiosis amongst pool users

To further identify specific risk factors for infection at swimming pools, cohorts of pool users will be investigated.

- Cohort studies could be undertaken prospectively or retrospectively of groups using pools to establish rates of exposure or ill health and investigate association with swimming habits at the pool.
- Exposure data would be gathered by questionnaire and confounding factors taken in to account
- Evidence of exposure to *Cryptosporidium* could be investigated by development of a salivary antibody test. Since subjects are likely to include children, existing blood serum antibody tests would not be suitable on ethical grounds.

Costs involved for Objective (ii) would need to cover project administration, identification and recruitment of cohorts, interviews, travel and subsistence costs, salivary test development and implementation, analysis and interpretation of data.

Objectives (i) and (ii) would culminate in the production of guidelines for the control of swimming-pool associated cryptosporidiosis.

These proposals are provisional. Further details and costings will be provided on invitation to tender.