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An outbreak of cryptosporidiosis associated with a resort swimming pool

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SUMMARY

An outbreak of cyptosporidiosis occurred in late April 1993 among resort hotel guests which was temporally associated with, but geographically distant from, a massive waterborne outbreak of cryptosporidiosis in Milwaukee, Wisconsin, that occurred in late March and early April of 1993. A case-control study was performed among groups with members who reported illness and among a systematic sample of groups who stayed at the resort hotel during the risk period. Of 120 persons interviewed, 51 (43%) met the case definition. Swimming in the resort hotel's pool was significantly associated with case status (OR = 9·8; 95% Cl 3·4, 29·7), as was consumption of ice from the hotel's ice machines (OR = 2·3; 95% Cl 1·01, 5·2). When analysis was restricted only to laboratory-confirmed cases and controls, swimming pool use was the only risk factor significantly associated with illness (OR = 13·0; 95% Cl 2·6, 88·7). Following waterborne outbreaks of cryptosporidiosis associated with water supplies, swimming pools should be considered as possible ongoing sources for transmission regionally.

INTRODUCTION

Cryptosporidium parvum is an emerging pathogen that has been increasingly recognized as an important source of human gastrointestinal illness. A variety of water sources have been associated with outbreaks of cryptosporidiosis, including recreational surface waters [1], an artesian well [2] and public water supplies [3–5]. Recently, there have been several reports of outbreaks of *Cryptosporidium* infection associated with swimming in public pools [7–11]. We report a swimming pool-associated outbreak of cryptosporidiosis that possibly occurred secondary to a massive waterborne outbreak in a distant city.

During late March and early April 1993, the Milwaukee, Wisconsin, vicinity experienced a waterborne outbreak of cryptosporidiosis that resulted in an estimated 403000 persons with watery diarrhoea [6]. On 28 April 1993, the Wisconsin Division of Health (DOH) was contacted by the Oshkosh Health Department about illness in a guest who stayed at a resort hotel in Oshkosh, Wisconsin, 12–14 April. The city of Oshkosh is situated approximately 70 miles

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northwest of Milwaukee. The guest had experienced watery diarrhoea beginning on 20 April 1993, with subsequent laboratory confirmation of cryptosporidiosis. Seven other members of his party had experienced similar illnesses. Additionally, 11 of 13 persons in a second party of guests who had visited the resort hotel on 17 April experienced gastrointestinal illness characterized by watery diarrhoea and abdominal cramping. These ill individuals had no history of travel to the Milwaukee vicinity during April.

The waterborne outbreak due to *Cryptosporidium parvum* in Milwaukee had been preceded by marked increases in the turbidity of treated water from a water treatment plant that receives water from Lake Michigan [6]. The city of Oshkosh draws its water from Lake Winnebago. No significant increase in the turbidity of treated water had been noted by Oshkosh Water Works. Surveillance of medical clinics in Oshkosh found no evidence of increased gastrointestinal illness among city residents.

Cryptosporidium infection in the Oshkosh area was limited to individuals who had been guests or visitors at the resort hotel.

The resort hotel had 196 guest rooms, 2 restaurants, 5 public bin-type ice machines, an indoor swimming pool and a whirlpool. Several guests of and visitors to the resort hotel noted that during their stay the pool water had been murky and they believe that the swimming pool was the likely source of *Cryptosporidium* oocysts. The DOH recommended closing the pool and testing the water for *Cryptosporidium* oocysts; however, the pool operator had drained the swimming pool and whirlpool on his own initiative and removed the sand filter media on 29 April. That action allowed for the collection of only 10 gallons of water that had been backflushed through the pool's sand filter and 10 pounds of sand from the whirlpool filter. The drained swimming pool, whirlpool and filter housings had been washed and scrubbed with undiluted bleach before refilling.

METHODS

Parties of guests and visitors at the resort hotel with at least one member reporting gastrointestinal illness were surveyed. Additionally, a systematic sample of parties staying at the resort hotel during all or part of the suspected risk period, 11–18 April, was obtained and surveyed. Using a roster of all parties (listed in chronological order of time of check in) that stayed at the hotel during the risk period we contacted every third party on the roster by telephone. Parties with members who lived in, worked in, or visited the Milwaukee vicinity in the previous month were excluded. A standard questionnaire was used to obtain basic demographic data; dates of stay; room number; date, time, and duration of use of the swimming pool; date of use of the whirlpool; use of the resort hotel ice machine; quantity of ice-machine ice consumed; restaurants where food or drink were consumed; date of video game use (examined as a possible fomite); and clinical characteristics of illness. Information for all party members (typically a family) was obtained from the party member most knowledgeable about the activities and health of all party members. These interviews were conducted from 10–17 May by DOH staff. Incubation period for illness was defined as the interval between the date of illness onset and the last day of stay at the hotel.

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All individuals who had not been previously tested were encouraged to submit a stool specimen for *Cryptosporidium* testing. Stool specimens were examined for *Cryptosporidium* oocysts by the Wisconsin State Laboratory of Hygiene using a modified acid fast stain [12].

Case-control study

Individuals with *Cryptosporidium* oocysts identified in their stool were considered to be a confirmed case of cryptosporidiosis. Individuals who had negative stool results for *Cryptosporidium* or for whom no stool specimen was submitted were considered to be probable cases of cryptosporidiosis if they had experienced either watery diarrhoea or diarrhoea with abdominal cramping within a 14-day incubation period. Individuals who had onset of illness more than 14 days after their last day of visiting the resort hotel or who had onset of illness 10 or more days after the onset of the first case in their household were considered to have cryptosporidiosis due to secondary household transmission. Individuals with confirmed or probable cryptosporidiosis not due to secondary household transmission are identified as cases in our analysis; those who did not meet this case definition (including individuals infected as a result of secondary household transmission) are identified as controls.

The association of possible risk factors with either confirmed or probable case status was evaluated using Kruskal–Wallis Chi-square test, Yates corrected Chi-square tests, or Fisher's exact test (one-tailed) when appropriate [13]. Standard formulae were used to calculate the 95% confidence intervals (CIs) and odds ratios (ORs).

The 10 gallons of water that had been backflushed through the swimming pool filter was filtered through a 1-micron filter that was then examined for *Cryptosporidium* oocysts using a standard immunofluorescent technique [14]. Additionally, 20 pounds of sand from the whirlpool filter were washed with water and the wash water was similarly filtered and examined [14].

RESULTS

The survey was administered to 48 parties comprising 120 individuals who were guests or visitors at the resort hotel during the risk period. The mean age was 29 years (range 2–71), and 65 (54%) were male. Of these 120 persons, 91 (76%) were at the hotel for 24 h or less. The peak days of stay among persons surveyed were 14 April when 46 (38%) stayed and 17 April when 52 (43%) stayed. The whirlpool, swimming, pool and video games were used by 74 (62%), 73 (61%), and 51 (43%) of those surveyed, respectively.

Gastrointestinal illness was experienced by 61 (51%) of 120 individuals; of these, 51 (43%) met our case definition for *Cryptosporidium* infection (22 had confirmed cases and 29 additional individuals had probable *Cryptosporidium* infection). The median age was 10 years (range 2–39) for confirmed cases, 27 years (range 3–71) for probable cases, and 37 years (range 2–71) for controls. Cases were significantly younger than controls (Kruskal–Wallis Chi-square = 22·9, $P <$ 0·001). The clinical characteristics of confirmed and probable cases of crypto-

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Table 1. *Clinical characteristics of confirmed and probable cases of cryptosporidiosis among resort hotel guests during a swimming pool related outbreak in Wisconsin, 1993*

	Confirmed cases (No. 22)		Probable cases (No. 29)	
	No.	%	No.	%
Diarrhoea	20	91	29	100
Watery diarrhoea	19	86	25	86
Mean duration of diarrhoea (days)	5·8	—	4·9	—
Mean maximum number of stools per day	13	—	7	—
Abdominal cramping	19	86	29	100
Fatigue	18	82	14	48
Nausea	18	82	11	38
Headache	15	68	8	28
Fever	10	46	9	31
Mean maximum temperature (°C)	38·3	—	38·4	—
Chills	8	36	9	31
Vomiting	5	23	2	7

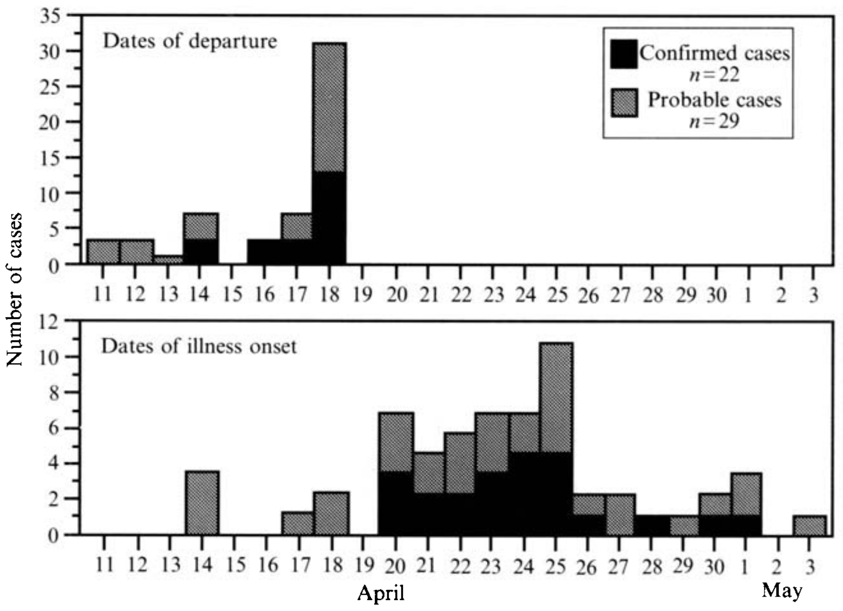

Fig. 1. Resort guests' dates of departure and dates of illness onset for confirmed and probable cases of cryptosporidiosis during an outbreak associated with swimming in a resort swimming pool. Wisconsin, 1993.

sporidiosis are shown in Table 1. Of the 30 persons who submitted a stool specimen, 22 (73 %) had *Cryptosporidium* oocysts identified. The earliest last day of stay was 14 April for a confirmed case and 11 April for a probable case (Fig. 1). The illness onset dates for confirmed and probable cases of cryptosporidiosis are shown in figure 1. The mean incubation period was 6·9 days (range 4–13 days) for confirmed cases and 6·1 days (range 2–13 days) for probable cases (Fig. 2).

When all 120 individuals were included in the analysis, swimming in the resort

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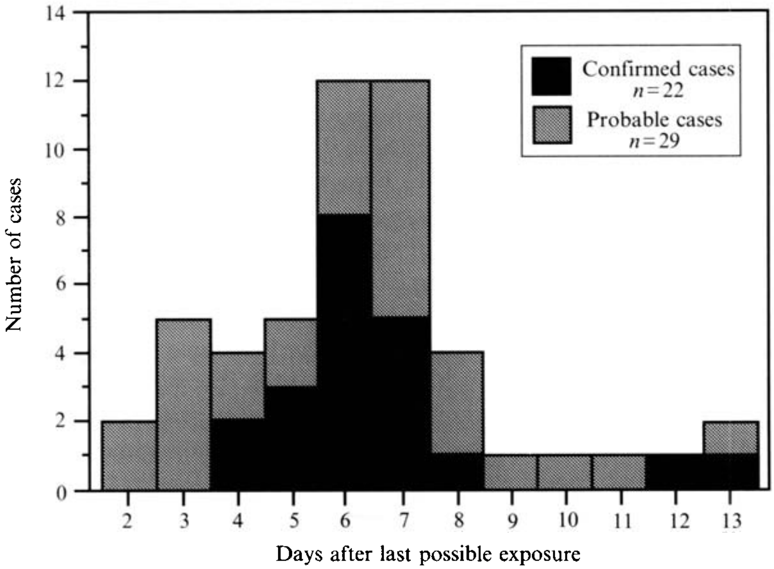

Fig. 2. Incubation periods for confirmed and probable cases of cryptosporidiosis during an outbreak associated with swimming in a resort swimming pool, Wisconsin, 1993.

Table 2. *Exposure characteristics, sex, and comparison of case- and control-individuals during an investigation of an outbreak of cryptosporidiosis associated with a resort swimming pool, Wisconsin, 1993*

	Confirmed cases		Probable cases		Controls		Odds ratio comparing all cases and controls
	No.	%	No.	%	No.	%	
All participants	(No, 22)		(No, 29)		(No, 69)		
Swimming pool use	20	91	25	88	30	44	9·8*
Whirlpool use	18	82	22	76	34	49	3·7*
Ice machine ice consumption	8	38	20	69	24	35	2·3*
Video game use	15	68	17	59	19	28	4·6*
Male sex	15	68	14	48	36	52	1·8
Swimming pool users	(No, 20)		(No, 25)		(No, 30)		
Whirlpool use	17	85	22	88	26	87	1·0
Ice machine ice consumption	6	30	17	68	15	50	1·1
Video game use	14	70	17	68	17	57	1·7
Male sex	14	70	11	44	16	53	1·1
Non-pool users	(No, 2)		(No, 4)		(No, 39)		
Whirlpool use	1	50	0	0	8	21	0·8
Ice machine ice consumption	2	100	3	75	9	23	16·7*
Video game use	1	50	0	0	2	5	4·5
Male sex	1	50	3	75	20	51	1·9

* = $P < 0·05$.

hotel's swimming pool was significantly associated with the risk of being a confirmed or probable case (OR = 9·8; 95% CI 3·4, 29·7; $P < 0·001$). Whirlpool use was associated with illness (OR = 3·7; 95% CI 1·5, 9·3; $P = 0·002$); however, whirlpool use was not associated with case status after stratification by swimming pool use (Table 2). Consuming ice from any of the resort hotel's public ice

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machines was significantly associated with case status (OR = 2·3; 95% Cl 1·01, 5·2; $P = 0·04$). Among non-swimmers this association was much stronger (OR = 16·7; 95% Cl 1·5, 439; $P = 0·008$), but it was not significant among swimmers (Table 2). Among the 43 hotel guests who stayed in rooms closest to ice machine A, 15 met the case definition and 13 of these drank beverages containing ice from ice machine A; while among 28 guests who were not ill and whose rooms were closest to ice machine A, 10 drank beverages using this ice. Consuming ice from ice machine A was significantly associated with case-status (OR = 11·7; 95% Cl 1·8, 95·5; $P = 0·004$); however, all of these case-individuals swam in the pool.

Among swimmers, cases were significantly younger than controls (Kruskal–Wallis Chi-square = 15·9, $P = 0·01$), but this age difference was not found among non-swimmers (Kruskal–Wallis Chi-square = 11·3, $P = 0·3$). The duration of swimming in the pools was not significantly associated with illness.

When analysis is restricted to the 22 confirmed case-individuals and 69 control-individuals, confirmed cases were significantly more likely to have used the swimming pool (OR = 13·0; 95% Cl 2·6, 88·7; $P < 0·001$). This association was stronger among males (OR = 17·5; 95% Cl 2·0, 402; $P = 0·003$) than females (OR = 8·1, 95% Cl 0·8, 205, $P = 0·046$). Though whirlpool use was significantly more common among confirmed cases (OR = 4·6; 95% Cl 1·3, 18·3, $P = 0·01$), whirlpool use was not associated with confirmed case status when stratified by swimming pool use. Consumption of ice from one of the resort hotel public ice machines was not significantly associated with confirmed case status (OR = 1·1; 95% Cl 0·4, 3·3; $P = 0·90$). Among the 35 individuals who stayed at the hotel on 17 April, 15 had laboratory confirmed *Cryptosporidium* infection. Among these 35, swimming pool use was highly associated with confirmed case status (OR = 42·0; 95% Cl 3·7, 1127; $P < 0·001$).

Three (4%) of 69 controls from two families met our definition for *Cryptosporidium* infection due to secondary household transmission. Each of these had a family member with laboratory confirmed *Cryptosporidium* infection. No *Cryptosporidium* oocysts were detected either in the water backflushed through the swimming pool filter or in the same from the whirlpool filter. The whirlpool and the swimming pool had separate filtration systems and there was no mixing of water between the two. Each received water from the Oshgosh Water Works via a single main line that also fed the remainder of the hotel.

DISCUSSION

The resort hotel's swimming pool was clearly associated with crytosporidiosis among guests and visitors during the risk period 11–18 April. Among confirmed cases and controls only swimming pool use was significantly associated with infection: an effect that was enhanced in males. Whirlpool use and consumption of ice from the hotel ice machines did not prove to be important risk factors for illness after accounting for swimming pool use. The lack of diarrhoeal illness in the surrounding community which shares the same water supply as the hotel suggests that water coming into the pool was not contaminated with *Cryptosporidium*. There was no evidence of a cross connection between the whirlpool and the

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swimming pool or of backflow of sewage into the pool. This leads us to believe that a unrecognized faecal accident(s) in the swimming pool was the source of this outbreak.

Routine swimming pool maintenance is unlikely to prevent future pool-associated *Cryptosporidium* outbreaks. *Cryptosporidium* oocysts are relatively chlorine resistant, requiring a prolonged contact time (concentration [in ppm] × time [in min]) value of 9600 to eliminate infectivity [15]. Although ozone is a more effective disinfectant against this parasite [16], a pool outbreak has already been documented in association with a pool treated by filtration and side-stream ozonation [10]. High-grade rapid sand filtration was clearly ineffective at removing *Cryptosporidium* oocysts at a Milwaukee water treatment plant [6]; thus it is unlikely that lower-grade rapid sand filters used in swimming pools would be effective. Although all grades of diatomaceous earth filters have been shown to effectively remove *Giardia* [17] which is 6–10 microns in size, we are unaware of similar studies with *Cryptosporidium* oocysts which are 3–6 microns in size. Even if diatomaceous earth filters completely removed oocysts, the relatively slow turnover of pool water through filters would allow pool patrons to be exposed to oocysts for several hours following a faecal accident.

Human volunteer studies in adults have led to estimates that the ID_{50} for *Cryptosporidium* infection is 214 oocysts: however, many of these infections were asymptomatic [11]. In our study, the association of symptomatic infection with younger swimmers and not with duration of swimming may be because younger swimmers swallow more water during play activities or because older swimmers may have immunity to symptomatic infection because of previous infection. Interestingly, the age distribution cases in our study is similar to that of sporadic cases of *Cryptosporidium* infection. It is not surprising that *Cryptosporidium* oocysts were not detected in the water backflushed through the swimming pool and whirlpool sand filters given the time between exposure of ill individuals and sample collection (minimum of 12 days), the small volume of water tested, and the relative insensitivity of methods for testing water samples [18].

Though some cases with confirmed infection only swam in the resort pool before 15 April, the risk of acquiring *Cryptosporidium* infection by swimming in the pool was greatest on 17 April probably reflecting a higher concentration of oocysts in the pool water. This suggests that this outbreak was probably due to more than one unrecognized faecal accident in the pool, as occurred during a previous pool-related outbreak [7]. Following recognition of a pool-associated outbreak, hyperchlorination of the pool may decontaminate the pool; however, such a measure will be relatively ineffective unless the source of oocysts (infected pool patrons) is excluded from entering the pool.

A plausible, but unproven, scenario for the cause of this outbreak is that a person or persons infected with *Cryptosporidium* in association with the Milwaukee outbreak had a faecal accident(s) in the hotel swimming pool. Numerous Milwaukee County residents stayed at the hotel during the risk period. The watery nature of diarrhoea caused by *Cryptosporidium* infection [6] increased the likelihood that a faecal accident(s) occurred undetected by pool operators. By the time we became aware of this pool-associated outbreak, a survey of the Milwaukee-area residents had indicated that the prevalence of watery diarrhoea had decreased

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significantly [6], therefore, no public health recommendations regarding swimming pools were issued. Following outbreaks of cryptosporidiosis associated with water supplies, swimming pools should be considered as possible ongoing sources for secondary transmission. In such situations consideration should be given to recommending the exclusion from swimming pools of persons with high potential for faecal accidents. This would include children not yet toilet trained and persons with diarrhoea. Such recommendations should extend to swimming pools that are likely to be used by individuals from the outbreak vicinity (i.e. regional vacation sites) and should not necessarily be limited to the immediate geographic vicinity. The period during which these recommendations are maintained should be based upon an estimate of the prevalence of *Cryptosporidium* infection among persons living in the outbreak setting. Immunocompromised persons, who are at greatest risk for prolonged morbidity following infection, should be warned of the ongoing risk of *Cryptosporidium* infection that swimming pools may pose to their health.

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