Outbreak of Giardiasis and Cryptosporidiosis Associated with a Neighborhood Interactive Water Fountain–Florida, 2006

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Abstract

An outbreak of giardiasis and cryptosporidiosis was identified in central Florida in September 2006. Environmental and epidemiological investigations indicated the likely source was a neighborhood interactive water fountain in a large upscale urban neighborhood. Forty-nine cases meeting the case definition were identified, of which 38 were giardiasis, nine were cryptosporidiosis, and two were co-infections. The median age of those affected was four years old, and 32 (65.3%) cases were male. This outbreak and other similar occurrences highlight the need to design and implement more stringent disinfection practices and filtration requirements for treated interactive water venues. *Giardia* cysts and *Cryptosporidium* oocysts are small and chlorine-resistant, and they may require supplemental disinfection methods, such as ultraviolet light irradiation, ozonation, or chlorine dioxide. Individuals who use these types of venues also need to change their behavior to prevent disease transmission. This is the first documentation of a giardiasis outbreak associated with exposure to an interactive water fountain in the United States.

Introduction

Exposure to recreational water resulted in more than 18,500 illnesses and 24 deaths in the United States from 1995 to 2004. Recreational water venues include swimming pools, wading pools, spas, waterslides, and interactive water fountains, and include both fresh and marine waters. Morbidity and mortality from exposure to recreational water were associated with 255 outbreaks from 1995 through 2004, of which 136 (53.3%) were gastroenteritis. Seventy-six (55.9%) of these outbreaks were attributed to treated water venues. *Cryptosporidium* was responsible for the majority (61.8%) of the gastroenteritis outbreaks from treated venues, while *Giardia* accounted for only a small portion (2.6%) of these outbreaks. One outbreak (1.3%) reported both *Cryptosporidium* and *Giardia* as the causative agents (Centers for Disease Control and Prevention [CDC], 1998, 2000, 2002, 2004, 2006).

Florida reported 29 recreational waterborne disease outbreaks with 478 cases from 1994 through 2006. Twenty-four (82.8%) of these were outbreaks of gastroenteritis, of which 15 (62.5%) were associated with a treated water venue. *Cryptosporidium* accounted for the majority (53.3%) of these outbreaks. No recreational waterborne disease outbreaks in Florida have been attributed to *Giardia*.

Interactive water fountains have gained popularity in recent years. Interactive water fountains typically consist of multiple jets of water, with little or no standing water, and human interaction is encouraged. These features are increasingly seen in areas surrounding pools and in nontraditional areas, such as outdoor malls, amusement parks, and other community locations. These features are ideal for young children, especially those who are diaper-aged, as there is negligible drowning risk and minimal supervision is required. Heavy use by diaper-aged children increases the risk of fecal contamination (Castor & Beach, 2004). The misperception that these venues use potable fresh water instead of recycled chlorinated nonpotable water may encourage children to intentionally swallow water. The spray from interactive water fountains also increases the opportunities to swallow water (Castor & Beach, 2004).

Six waterborne disease outbreaks resulting in 542 illnesses were associated with interactive water fountains between 1995 and 2004, according to the Centers for Disease Control and Prevention (CDC). Three (50.0%) of these outbreaks were caused by *Shigella*, two (33.3%) by *Cryptosporidium*, and one (16.7%) by both *Shigella* and *Cryptosporidium* (CDC, 1998, 2000, 2002, 2004, 2006). The outbreak involving *Shigella* and *Cryptosporidium* was reported in Florida in 1999.

Between September 1 and September 6, 2006, a county health department in central Florida received reports of three children infected with *Giardia* and one child co-infected with *Giardia* and *Cryptosporidium*, with dates of onset ranging from July 21 to August 21, 2006. While all four cases lived in the same geographical area

and were close in age, the only common risk factor identified was exposure to a neighborhood interactive water fountain (Splash Park A). This paper provides the first epidemiological and environmental documentation of a giardiasis outbreak associated with exposure to an interactive water fountain in the United States.

Methods

Environmental Evaluation

Splash Park A was investigated by a county health department environmental health specialist and an epidemiologist using Florida Department of Health standard environmental inspection forms. Facility appearance, filtration method, disinfection, water chemistry testing and management, record keeping, and waste disposal were evaluated. All prior inspection records and the original facility permit were reviewed.

Epidemiological Evaluation

Epidemiology staff interviewed all giardiasis and cryptosporidiosis cases, or his/her guardian, who were reported to the county health department after May 1, 2006. This time period represented three full giardiasis incubation periods before the earliest known onset of the four initial Splash Park A cases. All new giardiasis and cryptosporidiosis cases reported to the county health department through December 9, 2006, were also interviewed. The number of reported cases had returned to expected levels by this time. An expanded standardized questionnaire was developed and administered via telephone to determine persons who met the case definition and to identify any commonalities including exposure to Splash Park A or other possible risk factors.

A confirmed Splash Park A case was defined as a person with laboratory-confirmed *Giardia* or *Cryptosporidium* infection, clinically compatible symptoms, and exposure to Splash Park A within the appropriate incubation period for giardiasis or cryptosporidiosis (three to 25 days and one to 12 days, respectively). A probable Splash Park A case was defined as a person meeting the confirmed case definition, but who had an epidemiological link to a confirmed case in lieu of laboratory confirmation. Primary Splash Park A cases were defined as all confirmed or probable Splash Park A cases, which included all persons who acquired *Giardia* or *Cryptosporidium* from direct contact with the splash park. Secondary Splash Park A cases were defined as any person with clinically compatible symptoms, no exposure to the splash park within the appropriate incubation period for giardiasis or cryptosporidiosis, and close-contact exposure to a confirmed Splash Park A case within the appropriate period for giardiasis or cryptosporidiosis.

A local news station aired reports on September 13 and 19, 2006, detailing the health and safety deficiencies at Splash Park A and the potential for the spread of disease. A local newspaper ran similar stories on September 22 and 26, 2006, which alerted parents of children who had visited Splash Park A to the possible health threat. These events likely contributed to case-finding activities. In addition, a notice was posted on Florida's statewide epidemiology communication forum asking neighboring counties to notify the lead county health department of any giardiasis or cryptosporidiosis cases who reported exposure to Splash Park A.

Results

Environmental Results

Splash Park A is located in a large, recently constructed neighborhood in Orange County, Florida. The neighborhood features a central, unsupervised, public park area, including sports courts, a playground, and Splash Park A. Splash Park A consists of a flat, circular area 24 feet in diameter, multiple jets that spray water into the air, and a central drain to remove standing water. As with a swimming pool, recirculated water passes through a cartridge filter and a chlorine feeder before being pumped back to the jets.

Examination of prior inspection reports revealed that the splash park was permitted in July 2005 and had since been inspected twice. Both inspections resulted in the closure of Splash Park A due to unsafe water chemistry. Splash Park A was inspected again on September 8, 2006, as a result of the four giardiasis cases reported to the county health department with histories of exposure to Splash Park A. The county health department determined that the chlorine level was below 0.5 parts per million, which is significantly lower than required for treated recreational water. Other violations included a non-functioning pH/oxidation reduction potential sensor unit and improperly maintained maintenance logs. Splash Park A was ordered closed immediately upon these findings. The certified pool operator responsible for Splash Park A, as well as other community pools in the neighborhood, was subsequently replaced by the neighborhood's homeowners' association, violations were corrected, and Splash Park A was cleared for provisional reopening on October 11, 2006.

Epidemiology Results

There were 93 giardiasis cases, 50 cryptosporidiosis cases, and three co-infection cases reported to the county health department with onset dates between May 1, 2006, and December 9, 2006. The date reported to the county health department was used if the onset date was unavailable. One hundred eleven (76.0%) of these 146 cases were interviewed. Forty (36.0%) of the 111 local county cases interviewed met the case definition for a confirmed Splash Park A case, five (4.5%) met the definition for a probable Splash Park A case, and six (5.4%) met the definition for a secondary Splash Park A case. In addition to the local county's Splash Park A cases, a neighboring county reported four confirmed Splash Park A cases and two secondary Splash Park A cases for a total of 49 primary Splash Park A cases and eight secondary Splash Park A cases, as depicted in Table 1. In the course of answering public inquiries, six persons were identified who had clinically compatible symptoms and exposure to Splash Park A within the appropriate incubation period for giardiasis and cryptosporidiosis, but did not have laboratory confirmation or an epidemiologic link to a confirmed Splash Park A case and thus did not meet the case definition used for this investigation.

Ages for primary splash park cases ranged from two to 38 years, with a median age of four years (mean = eight years). Ages for secondary splash park cases ranged from 29 to 40 years with a median age of 37 years (mean = 36 years). Thirty-two (65.3%) primary Splash Park A cases were male and five (62.5%) secondary splash park cases were male. Ages for the 60 Orange County giardiasis and cryptosporidiosis cases that were interviewed but not connected to the splash park ranged from one to 66 years, with a median age of 17 years (mean = 22 years). Thirty-two (53.3%) cases not connected to Splash Park A were male. Signs and symptoms reported by the 49 primary splash park cases and eight secondary Splash Park A cases are presented in Table 2.

Dates of onset for primary Splash Park A cases ranged from July 4 to September 24, 2006, with a median onset date of August 21. Dates of onset for secondary Splash Park A cases ranged from August 23 to September 23, 2006, with a median onset date of September 2. The frequency distributions of illness onsets by week are shown in Figure 1. Due to poor recall and multiple visits to the splash park over several months, it was not possible to calculate incubation periods in most cases. However, 14 primary giardiasis

Splash Park A cases had only a single exposure. The median incubation period was 7.5 days for these cases, which is consistent with the known incubation period for giardiasis.

The expanded standardized questionnaire used in all case interviews collected exposure history for the known risk factors for acquiring *Giardia* and *Cryptosporidium* infections, including exposure to recreational water, drinking water, animals, schools or daycares, travel, and restaurants. No other single exposure was nearly as prevalent as exposure to Splash Park A. Eleven of the 49 primary Splash Park A cases did not live in the neighborhood surrounding the splash park, nor did these cases attend daycare in the neighborhood, which also implicates the splash park as the source of infection for this cluster.

During the study period, 53 giardiasis cases and 42 cryptosporidiosis cases were reported to the county health department for which no direct connection to Splash Park A was found. This represented a substantial increase from the same period in this county during 2005 (44 cases and 11 cases, respectively) and 2004 (40 cases and three cases, respectively), particularly for cryptosporidiosis cases.

TABLE 1

Frequency of Primary and Secondary Splash Park A Cases (*N* = 57), by Disease

Splash Park A Cases	Giardiasis Cases	Cryptosporidiosis Cases	Co-Infection Cases	Total Cases
Primary	38	9	2	49
Confirmed	35	7	2	44
Probable	3	2	0	5
Secondary	5	2	1	8

TABLE 2

Frequency of Symptoms among Primary and Secondary Splash Park Cases (*N* = 57)

Symptom	Primary Splash Park A Cases		Secondary Splash Park A Cases	
	Number	% (*n* = 49)	Number	% (*n* = 8)
Diarrhea	49	100.0	8	100.0
Loss of appetite	34	69.4	3	37.5
Cramps	27	55.1	5	62.5
Vomiting	25	51.0	1	12.5
Weight loss	20	40.8	3	37.5
Weakness	17	34.7	2	25.0
Fatigue	16	32.7	2	25.0
Bloating	14	28.6	4	50.0
Fever	14	28.6	0	0.0
Nausea	13	26.5	2	25.0
Chills	3	6.1	2	25.0
Constipation	1	2.0	0	0.0

Discussion

This outbreak was characterized by 49 cases (38 giardiasis, nine cryptosporidiosis, and two co-infection) whose only common exposure was a neighborhood interactive water fountain, Splash Park A. An additional eight cases (five giardiasis, two cryptosporidiosis, and one co-infection) were from secondary transmission. The outbreak began in early July, continued through late September, and then abated after the closing of Splash Park A. In addition to the cases associated with Splash Park A, an increase in the number of cases reported to the county health department occurred during the same time period with no known connection to the splash park.

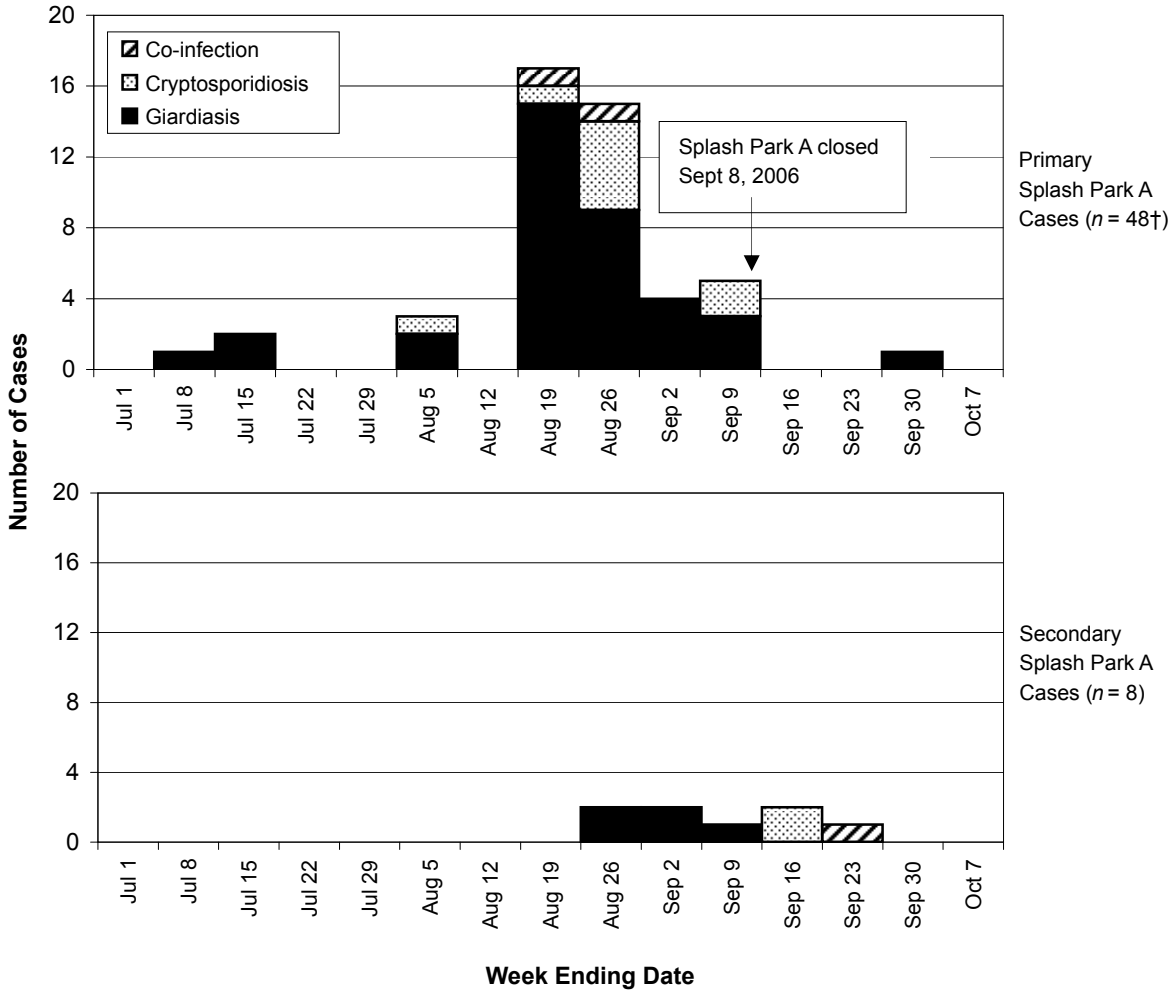
The median age of four for primary Splash Park A cases is consistent with young children being exposed and infected at the splash park, while the median age of 37 for secondary Splash Park A cases is consistent with the caregivers of these children having secondary infections. In contrast, the median age for cases not connected to the splash park was 17. The age difference of these populations could indicate different modes of transmission.

The ongoing nature of the outbreak implies that not just a single breach of proper pool sanitation practices occurred resulting in a point-source exposure, but recurring breaches and most likely multiple contamination incidents. As more persons were infected and continued to play in the fountain, more opportunities for contamination events arose. The asymptomatic carrier rates for *Giardia* and *Cryptosporidium* are known to be high so it is also possible that an asymptomatic carrier was the source of the outbreak or that carriers contributed to the propagation of the outbreak (Heymann, 2004; Katz, Heisey-Grove, Beach, Dicker, & Matyas, 2006). While many cases were linked directly or indirectly to Splash Park A, other routes of transmission were occurring in the area, as demonstrated by large numbers of cases observed during the study period compared to previous years. This outbreak investigation effort and the increased prevalence of both parasites involved is an example of how difficult it can be to track and control person-to-person transmission of an agent, once it becomes established in a population from a point source.

Biological, environmental, and behavioral factors all contribute to the transmission of parasites via recreational water (Castor & Beach, 2004). *Giardia* cysts and *Cryptosporidium* oocysts are environmentally stable, relatively small (8–14 microns and 4–6 microns, respectively), and resistant to chlorine (Shepherd & Wyn-Jones, 1996). Most pool filters used in treated recreational water facilities range from 25 microns to four microns in particle removal size. Cartridge filters, the type of filter used by Splash Park A, only remove particles 15 microns or larger, making them ineffective against small parasites. Routine chlorination for a treated recreational water venue will not immediately destroy chlorine-resistant organisms. At a chlorine level of 1.0 parts per million, a *Giardia* cyst can survive for 45 minutes and a *Cryptosporidium* oocyst can survive for 10.6 days (CDC, 2007). Splash Park A's chlorine level was observed to be below 1.0 parts

FIGURE 1

Frequency of Giardiasis and Cryptosporidiosis Onsets by Week



† There were 49 primary Splash Park A cases, but one date of onset was unknown and was excluded from this graph.

per million on more than one occasion, which would have permitted these parasites to survive for a relatively long period of time .

Giardia and *Cryptosporidium* have infectious doses thought to be as low as one to 10 cysts or oocysts, respectively. With excretion concentrations as high as 10^6 cysts or oocysts per gram of stool, these cysts or oocysts can be shed in low concentrations for weeks after symptoms resolve (Caster & Beach, 2004; Dillingham, Lima, & Guerrant, 2002; Food and Drug Administration, 1992). The communal nature of treated recreational water venues is conducive to the fecal-oral transmission of pathogens. Frequent exposures, high bather densities, and heavy use by diaper-aged children increase the likelihood of fecal contamination (Caster & Beach, 2004). A diarrheal fecal accident in a recreational water venue poses a significant risk of transmission for *Giardia*, *Cryptosporidium*, and many other enteric pathogens (CDC, 2001). CDC provides fecal accident response recommendations for proper disinfection and protection of the health of swimmers (CDC, 2007). These recommendations assume, however, that some form of supervision exists to identify fecal accidents. The interactive water fountain involved in this outbreak did not have any regular supervision—just the caregivers for the children who played there. These caregivers may or may not notice and report a fecal accident. A watery diarrheal accident would be difficult to detect even with supervision, and therefore an interactive water fountain may rely solely on routine chlorination and filtration for inactivation or removal of pathogenic microorganisms. Even in the absence of a fecal accident, the average bather sheds 0.14 grams of fecal material and children may shed up to 10 grams (Caster & Beach, 2004). Thus, the average bather infected with *Giardia* or *Cryptosporidium* could introduce 140,000 cysts or oocysts into water, with up to 10^7 cysts or oocysts shed by infected children, which is substantial considering the low dose of infection.

Recommendations from the county health department issued as a result of this disease outbreak for the implicated splash park included monthly inspections, installation of an ultraviolet radiation system, monthly cartridge filter changes, and signage at the pool entrance prohibiting children with diarrhea

from entering the splash park area. The homeowners' association was also advised to outfit the interactive water fountain with an automatic shut-off device or audible alarm to alert the public and an emergency contact if the feature is not operating correctly. Administrative legal action was initiated to enforce these provisions and a cooperation agreement was signed by the neighborhood's homeowners' association and the county health department.

Other potential ways to avoid this kind of disease outbreak include: 1) reducing contamination of water by not allowing sick children into recreational water, 2) showering before entering recreational water, 3) proper diaper changing behaviors, and 4) practicing good hand washing. Preventing contaminated water from being ingested by teaching children not to swallow recreational water is also essential.

Delays in recognition and reporting were important limitations of this investigation. Giardiasis and cryptosporidiosis both have long incubation periods (one to 12 days and three to 25 days, respectively). Parents often ignore symptoms of diarrhea, which results in delays in seeking medical attention, and many physicians do not routinely recommend parasite testing (Heymann, 2004; Wheeler et al., 2007). The delayed recognition of the outbreak allowed biological, environmental, and behavioral conditions to sustain transmission of these parasites. Delayed reporting significantly reduced the recall of those interviewed. No formal study was conducted to estimate the magnitude of the association between Splash Park A exposure and illness, therefore, the statistical significance of personal characteristics and behaviors could not be assessed.

Conclusion

Interactive water fountains that are popular among diaper-aged children and lack supervision to identify fecal accidents appear to be increasing in number. The outbreak described here and other similar occurrences highlight the need to design and implement more stringent disinfection practices and filtration requirements for interactive water fountains. Filtration media with the smallest particle removal size should be utilized and encouraged during the design process. Further, supplemental disinfection methods, such as ultraviolet light irradiation, ozonation, or chlorine dioxide that quickly kill *Giardia* and *Cryptosporidium*, should be considered (CDC, 2006). These technologies and designs will target the specific pathogenic microorganisms that are of concern with these types of venues. Good evidence-based feature design and maintenance will deactivate or minimize the presence of pathogenic contaminants in recreational water.

County health departments must be vigilant in routinely monitoring all types of swimming pools to ensure compliance with health and safety standards, including appropriate follow-up visits as necessary. Resources need to be allocated to ensure sufficient training and education for both environmental health professionals and swimming pool technicians on appropriate swimming pool design and maintenance. Investigations of possible clusters of giardiasis and cryptosporidiosis should include questions assessing exposure to interactive water fountains.

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