International Perspectives

An Outbreak of Cryptosporidium at a Recreational Water Park in Niagara Region, Canada

Abstract Cryptosporidium is a parasitic protozoan found in water sources and spread through the fecal-oral route. Cryptosporidiosis is characterized by gastrointestinal illness and is increasingly associated with recreational water sources. On December 3, 2010, Niagara Region Public Health was informed of a lab-confirmed case of Cryptosporidium. Over the subsequent two weeks, a total of three additional laboratory-confirmed cases were reported. All cases had visited the same water park in Niagara Region, Canada, over November 14-16, 2010. A total of 12 cases associated with the outbreak ranged in age from 1 to 66 years. This article describes the outbreak, environmental investigation, and control measures. The environmental investigation revealed that the ultraviolet disinfection system was offline on November 14, 2010, which may have allowed for the transmission of Cryptosporidium to bathers. Further research into the detection of Cryptosporidium outbreaks and regulations and guidelines for water park operators may help to decrease future outbreaks.

Introduction Cryptosporidium is a parasitic protozoan found in water sources and spread through fecal-oral transmission (Centers for Disease Control and Prevention [CDC], 2011a; Heymann, 2008; Putignani & Menichella, 2010). Two species, C. hominis and C. parvum, are primarily responsible for human illness (CDC, 2011a; Heymann, 2008; Putignani & Menichella, 2010). Infection presents as gastrointestinal diarrhea, although some may also have cramping, abdominal pain, malaise, fever, anorexia, nausea, and vomiting (CDC, 2011a; Ministry of Health and Long-Term Care, 2009; Putignani & Menichella, 2010). Asymptomatic infections are common and may be a source of transmission (CDC, 2011a; Heymann, 2008). Cryptosporidium has the ability to produce oocysts that are resistant to chlorine levels normally used to disinfect drinking water or swimming pools (Heymann, 2008; Putignani & Menichella, 2010). Cryptosporidiosis outbreaks have been increasingly associated with exposure to recreational water sources, such as splash pools and swimming pools (Causer et al., 2006; CDC, 2011b; Coetzee, Edghere, Orendi, Chalmers, & Morgan, 2008; Insulander, Lebbad, Stenstrom, & Svennungsson, 2005).

On December 3, 2010, a symptomatic laboratory-confirmed case of Cryptosporidium was reported to Niagara Region Public Health (NRPH). During the next two weeks, a total of three additional laboratory-confirmed cases were reported to NRPH. All cases had visited the same water park in Niagara Region over November 14-16, 2010. This article describes the outbreak investigation and interventions to prevent subsequent spread in the community. It also highlights the need for proactive interjurisdictional communication, as cases resided in other parts of Ontario and the U.S.

Methods

Outbreak Investigation NRPH was informed of a lab-confirmed case of Cryptosporidium on December 3, 2010 (case 1), by Halton Public Health. The initial investigation by this health department demonstrated the major risk factor for the case was a visit to a water park in Niagara Region; NRPH was contacted to initiate an environmental investigation. For all cases, NRPH used a cryptosporidiosis questionnaire to determine potential risk factors, including exposure to swimming pools, splash pads, water parks, restaurants (including those at the water park), drinking water, other recreational water sources, and travel.

As further cases were reported, NRPH declared an outbreak and engaged in active surveillance and risk communication with local physicians and public health depart-
ments in Ontario and the U.S., provincial public health officials, and Canadian public health practitioners to encourage enhanced surveillance for cryptosporidiosis, appropriate testing, and reporting to local public health.

Environmental Investigation
Early in the outbreak investigation, a water park in Niagara Region was identified as a common source among cases. Public health inspectors conducted an environmental investigation of the water park to determine potential sources and risk for past and ongoing spread of Cryptosporidium.

Results

Case Definitions
A confirmed primary case was defined as laboratory confirmation of infection with symptoms of diarrhea with or without one or more of cramping, abdominal pain, fever, anorexia, vomiting, or malaise with exposure to a water park in Niagara Region in November 2010. A probable case had signs and symptoms consistent with a laboratory-confirmed case and with exposure to a water park in Niagara Region in November 2010. A secondary case may or may not have had lab confirmation, but had signs and symptoms consistent with a case and was epidemiologically linked to a confirmed or probable case.

Outbreak Investigation
On December 7, 2010, a referral was received from Wellington Dufferin Guelph Public Health for laboratory-confirmed (case 2) and probable (case 3) cases of cryptosporidiosis in a family whose main risk factor for disease was having visited a water park in Niagara Region. Table 1 provides a summary of the cases associated with the outbreak.

On December 9, 2010, a laboratory-confirmed case of cryptosporidiosis was reported to NRPH (case 4). This case and three family members (cases 5–7) had visited the same water park as cases 1–3 during the same time period of November 14–16, 2010. Clinical signs and symptoms included diarrhea, abdominal pain, nausea, and vomiting.

Concurrently, NRPH was receiving alerts through the emergency department syndromic surveillance system for gastrointestinal illness. From November 28 to December 6, 2010, the incidence of people with gastrointestinal complaints presenting to local emergency departments was higher than expected for the time period. When the alerts first began appearing, no mandatory reportable diseases exceeded baseline levels, and we initially suspected a viral gastroenteritis in the community. With three laboratory-confirmed cases of cryptosporidiosis linked to a water park in Niagara Region, however, we questioned whether the gastrointestinal illnesses may have been related to the previous cryptosporidiosis cases. An outbreak was declared on December 8, 2010, and further investigations were undertaken. Cases were questioned about whether or not they visited the food service establishments at the water park; cases did not all eat at the restaurants.

Epidemiologic Investigation
From November 14 to December 9, 2010, four confirmed cases, six probable cases, and two secondary cases presented (Figure 1). As all cases attended the water park on November 14 or November 15, 2011, it was challenging to determine whether or not cases 9–12 were due to exposure at the water park or through person-to-person contact with case 8. Fifty percent (n = 6) attended only on November 14, 25% (n = 3) attended only on November 15, 17% (n = 2) attended on both days, and 8% (n = 1) on November 15 and 16. The average age of all cases was 21 years with a median of 12 and a range of 1 to 66 years. Figure 2 illustrates the percentage of cases that played in each of the water park areas.

Active Surveillance and Risk Communication
On December 10, 2010, a medical advisory was sent to all physicians, emergency departments, and walk-in clinics in Niagara Region encouraging heightened surveil-
lance and testing for Cryptosporidium in people with exposure to local water parks during November 2010. A summary of the investigation was posted to national and provincial infectious diseases message boards. Given the proximity of Niagara Region to the U.S. and resultant cross-border tourist traffic, we contacted the relevant county health authorities in the U.S. This resulted in case 8 and his family (cases 9–12) coming to our attention.

**Laboratory Investigation**
Three specimens were identified as Cryptosporidium species using initial testing with auramine-rhodamine fluorescent stain and confirmatory testing with safranin stain or on formalin, either concentrate or on a direct wet prep, from a sodium acetate formalin container. Further speciation was not possible as the specimens had been discarded by the laboratory. Further speciation for research purposes was conducted on two secondary cases by Public Health Ontario; these demonstrated C. hominis. No water samples were obtained from the pools or backwash as the full volume of water for the water park had been changed prior to the investigation.

**Environmental Investigation**
The water park is a large complex of water features that is a popular tourist destination. It is comprised of seven distinct bodies of water, including a splash pad, a larger spray/splash pad with water slides, a wave pool, two groups of water slides (“body” slides and “tube” slides), two spas, and an outdoor wading pool. The wading pool is open year-round and is a non-regulated recreational water facility due to its water depth (Ministry of Health and Long-Term Care, 2010).

The wave pool and the “body” slides share the same water and recirculation system (Figure 3). All others operate with their own separate water and recirculation system. The spas were emptied and refilled daily. Half the volume of water in the larger spray/splash pad with water slides was replaced daily. All other water features had water added daily in accordance with provincial regulations requiring a minimum of 20 L per bather per day.

All bodies of water were designed to utilize the oxidation-reduction potential (ORP) system. The sanitizer was a mixture of liquid chlorine and chlorine pucks. Alarms for the...
Recirculation Systems for the Water Features

ORP, pH, filter, and pump were present and functioning. The recirculation systems in all bodies of water used diatomaceous earth (DE)-like filters, automatic chlorination, and automatic acid feed. With the exceptions of the two spas and outdoor wading pool, all were equipped with a surge or balancing tank.

A medium-pressure ultraviolet (UV) light system was incorporated into the recirculation system for the wave pool/body slides and was positioned prior to chlorination. The system consisted of a single bulb unit with a flow rate of 1,319 gallons per minute. The UV unit had a digital readout of the “percentage” of UV strength plus an alarm if it fell below a specified level. The bulb was replaced according to the sensor reading and the system had a built-in screen to capture glass from broken bulbs. This was the only body of water equipped with a UV light system and it had been in service for less than one year. Documentation and discussion with the operator demonstrated appropriate changing of the bulbs.

The water park had separate washrooms/change rooms and showers. Signage was present at the entrances to the washrooms/change rooms regarding showering and other related issues, such as diaper protocols. Swim diapers were available to patrons for a nominal fee. All other appropriate safety signage as per legislation was present. Attendants or lifeguards were present throughout the facility and placed appropriately at the various water features. Other areas of the water park included a children’s play area and a fast food sit-down restaurant. Investigation of the food service establishments did not reveal any concerns.

A site inspection of the water park was conducted on December 3, 2010. Daily records showed no lapses in free available chlorine levels (documented minimums above 0.5 parts per million) or other parameters, such as pH (documented in the range of 7.2 to 7.8), on November 14, 2010. Approximately 200 persons used the water park that day, and no pool fouling was noted that day. A pool fouling episode was documented on November 12, 2010, however, at the wave pool; it was documented as a formed stool. The procedure for a pool fouling incident was documented in accordance with the pool fouling protocol for formed stool (CDC, 2010). The records indicated that the UV light system for the wave pool/body slides was shut down for maintenance from 8 a.m. to 4 p.m. on November 14, 2010.

Due to further cases of cryptosporidiosis, another inspection was conducted on December 8, 2010. Further information was gathered on engineering and maintenance. It was reported that the total volume of water in the wave pool/body slides was wasted in order to repair a section of flooring at the beach front of the wave pool on December 5, 2010. Fresh water was being added at the time of the inspection (the water park was not open to the public on this day). The DE filters for the wave pool were backwashed and new filter media added. The water in all bodies of water had been replaced since November 14, 2010. Wasting and adding fresh make-up water was carried out daily and exceeded the minimum 20 L/bather/day required by Ontario regulations (Health Protection and Promotion Act, 2007). The total volume of water for the splash pad and the two spas was wasted daily. The larger splash pad wasted and replaced approximately three-fourths of the volume daily during times of high bather load. Water slides were regularly cleaned depending on usage.

The DE filter fabric or elements (a polyester synthetic fiber that held the filter media) were routinely checked every three months. Checks and replacement occurred more frequently if anything suggested tears in the fabric. The filters in the larger bodies of water (e.g., wave pool), were arranged in parallel so that if one filter malfunctioned, it was bypassed and a new filter was installed quickly.

Discussion
This outbreak of cryptosporidiosis resulted in four confirmed, six probable, and two secondary cases. Although it was not possible to confirm the water park as the source of Cryptosporidium, all cases had exposure to the water park on November 14 or 15, 2010. November 14, 2010, was also the day when the UV light system, which would have inactivated Cryptosporidium oocysts, was shut down for most of the day. Cryptosporidium is known to survive for days under normal chlorine levels found in recreational waters (Heymann, 2008). In Ontario, pools having a water depth of 0.75 m or less are exempt from the public pools regulation. In spite of the water park operators being highly compliant with recreational water guidelines and protocols, given the incubation period mean of seven days (range 1–12 days), we hypothesize that a pool fouling incident, such as the one that occurred on November 12, 2010, led to this outbreak of cryptosporidiosis.
Outbreak Detection and Interjurisdictional Challenges
The detection of cryptosporidiosis outbreaks associated with water parks is challenging. Water parks are often tourist destinations, so people may travel distances or from out of the country to visit. In Ontario, provincial monitoring of mandatory reportable disease rates may allow detection of such events. Health units that border other provinces or the U.S., however, may not be aware of cases outside of their jurisdiction. Strong interjurisdictional communications are essential to remaining abreast of potential outbreaks.

Laboratory Methods
Laboratories play an important role in identifying organisms responsible for infectious disease outbreaks. In this outbreak, challenges arose around specimen management, including discarded specimens and specimens sitting too long in media for further analysis. Speciation is currently considered experimental. As further recreational water outbreaks of cryptosporidiosis occur, however, it will be helpful to develop policies and procedures so that health care practitioners; public health departments; and local, provincial, and national laboratories can collaborate to determine responsible species and advance research in this area.

Environmental Measures
Cryptosporidium is a hardy protozoan that withstands levels of chlorine commonly used in swimming pools. Previous studies have demonstrated that medium-pressure UV light is effective in inactivating Cryptosporidium oocysts (Bukhari, Hargy, Bolton, Dussert, & Clancy, 1999; Clancy et al., 2000; Craik, Weldon, Finch, Bolton, & Belosevic, 2001). Although this water park had a UV light system in one of its recirculation systems, it was off during the suspected exposure time. We believe it is of interest to public health to better understand the effectiveness of current legislation and regulations for public pools in preventing waterborne illness. This outbreak highlights the fact that even highly compliant facilities following current guidelines may serve as sources of recreational water illness. Further research should explore the effectiveness and cost effectiveness of UV light systems in preventing recreational water illness and processes that could minimize risk to swimmers when UV light systems are offline. Water parks should also be encouraged to ensure children in diapers wear only swim diapers while in water features. Parents may benefit from education around proper attire for young children and diaper change facilities to minimize pool-soiling events. Although swim diapers are of minimal benefit in a diarrheal accident, they may prevent the release of formed stool, with the hope of decreasing the bacterial load released into the pool environment.

Limitations of the outbreak investigation included the lack of definitive laboratory evidence linking the water park to the cases and possible underestimation of the number of cases involved in the outbreak due to self-resolution of cases without seeing a physician, lack of testing of symptomatic cases, and failure to attribute cases to the outbreak in jurisdictions beyond Ontario and New York State.

Conclusion
This article described NRPH's experience of an outbreak of cryptosporidiosis associated with a water park. This outbreak investigation highlights the challenges encountered and the need for ongoing research into surveillance, laboratory testing, environmental control, and communications for the prevention of recreational water illness.

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References
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NEHA has a new credential—the Certified in Comprehensive Food Safety (CCFS) credential. This new credential tests an individual’s knowledge base through the food safety continuum from farm to fork. The first credential course and exam for the CCFS will be offered at the NEHA 2013 AEC. Additional information and registration for the course and/or exam are available at neha2013aec.org.

References


