Epidemiol. Infect. (2008), **136**, 1547–1551. © 2008 Cambridge University Press
doi:10.1017/S0950268807000222 Printed in the United Kingdom

SHORT REPORT
Multi-jurisdictional investigation of interactive fountain-associated cryptosporidiosis and salmonellosis outbreaks

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(*Accepted 4 December 2007; first published online 16 January 2008*)

SUMMARY

Interactive water fountains are established sources of gastrointestinal infections yet most health codes fail to regulate their design and operation. This report describes multi-agency, concurrent interactive fountain-associated cryptosporidiosis and salmonellosis outbreak investigations and highlights the need for the adoption of appropriate regulations for interactive fountains.

The San Francisco Bay Area Cryptosporidiosis Surveillance Project (CSP) is a voluntary, laboratory-based, active surveillance system operated by the San Francisco Department of Public Health. Primarily designed to detect drinking water-associated cryptosporidiosis cases, CSP receives laboratory reports for cases among residents in the five counties receiving treated filtered and unfiltered drinking water from the San Francisco Public Utilities Commission (SFPUC): Alameda, San Francisco, San Mateo, Santa Clara, and Tuolumne. Upon receiving case reports, CSP interviews cryptosporidiosis cases from the surveillance region. Although the project's principal purpose is to detect drinking water-associated outbreaks of cryptosporidiosis, it is also able to detect non-drinking water-associated outbreaks.

CSP worked with local and state agencies to develop a plan for how agencies would cooperate to investigate *Cryptosporidium* detection in drinking water sources or an increased number of cryptosporidiosis cases. The Cryptosporidium Detection Action Plan was the result of collaboration with the SFPUC, representatives for the 26 municipal and private water utilities that retail SFPUC water, five county health departments and the California Department of Public Health. The plan is activated when CSP receives ten or more cryptosporidiosis cases within a 7-day period, or when the SFPUC detects *Cryptosporidium* oocysts with internal structures in raw or treated drinking water over a threshold action level. Upon activation of the Cryptosporidium Detection Action Plan, the SFPUC and any affected retail water utilities initiate an investigation of treatment processes and operations. When the plan is activated by excess cases, the goal of this phase of the plan is to determine whether drinking water is a potential source of the exceedance. Concurrently, CSP cooperates with the affected local health agency to enhance case finding and initiate a complete outbreak investigation.

From 11 to 18 August 2006, CSP received laboratory-confirmed reports of ten cryptosporidiosis cases triggering the Cryptosporidium Detection Action Plan. A review of water treatment performance and monitoring data by regional and associated local water systems was undertaken immediately. The drinking water investigation did not reveal any treatment problems and confirmed that none of the 17 samples that had been collected in the previous 4 weeks contained oocysts with internal structures.

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Table. *Cryptosporidiosis case characteristics**

Cases	No. Total	No. Interviewed†	Male (%)	Age Median (min, max)
Santa Clara	45	43	58	7 (0, 57)
Alameda	11	10	55	11 (1, 88)
San Mateo	8	8	63	14 (1, 47)
San Francisco	5	4	80	49 (33, 66)
Total	69	65	59	11 (0, 88)

Exposure	No.	% ($n=65$)	Exposure	No.	% ($n=65$)
Recreational water			Drinking water		
Amusement Park A	7	11	Always bottled	23	35
Amusement Park B	3	5	Always Tap	18	28
Water Park X	4	6			
Public Park Y	16	25			
Total‡	45	69	Personal contacts		
			Confirmed case	5	8
Farm animals§	4	6	Suspected case‖	17	26

* Onset dates were between 4 July 2006 and 2 October 2006, except one case with onset in 2005.
† Demographic information for cases interviewed is nearly identical to those for all cases.
‡ Total includes other recreational water exposures, and does not sum because some cases had more than one category of recreational exposure.
§ Contact with farm animals includes two cases with contact with a family-owned goat and two cases who separately visited petting zoos.
‖ Contact with suspected cases based on confirmed case interviews. Suspected cases were not contacted or interviewed.

CSP and the Santa Clara County Public Health Department (SCCPHD), under whose jurisdiction 65% of the reported cases resided, cooperated to investigate the outbreak. From 11 August to 9 October 2006, CSP received reports of 69 laboratory-confirmed cryptosporidiosis cases. Interviews were completed for 94% of cryptosporidiosis cases. Cases were interviewed using a standard questionnaire, including questions on municipal and bottled water consumption and recreational water use. Of the 65 interviewed cases, 35% consumed only bottled water and 28% reported tap water consumption only. Those who consumed bottled water were questioned on bottled water brands. Those who purchased water from a water filtration vending machine were asked the location and name of the machine. No data supporting any specific bottled water brands or vending sites were identified.

In late July 2006, Northern California experienced a prolonged heat wave and many residents sought relief in pools, lakes and fountains. Of interviewed cryptosporidiosis cases, 69% reported recreational water exposure. Case interviews suggested four common recreational water sites. Reported water contact was as follows: Amusement Park A, 11%; Amusement Park B, 5%; Water Park X, 6%; Public Park Y, 25%. Amusement Parks A and B and Water Park X each contain multiple pools, water slides and/or interactive water fountains; Public Park Y hosts one interactive water fountain (Table). Interactive water fountains include fountains, sprays or sprinklers designed for play. They do not include non-interactive decorative fountains or drinking fountains. Interactive water fountains may either utilize a fresh water supply which is disposed to the sanitary sewer or recirculate water. Typically, those that recirculate water feature an underground collection reservoir to which water flows from the play platform. Through case interviews CSP obtained reports of confirmed and suspected illness among multiple case contacts attending Public Park Y's interactive water fountain. To obtain additional information on the recreational water sites mentioned during interviews, an internet query was performed using a search engine (Google Inc., Mountain View, CA, USA). The query identified two negative reviews of the Public Park Y's interactive fountain on Yahoo Travel [1]. These reports had been published prior to any public awareness of the investigation and cited illness among

https://doi.org/10.1017/S0950268807000222 Published online by Cambridge University Press

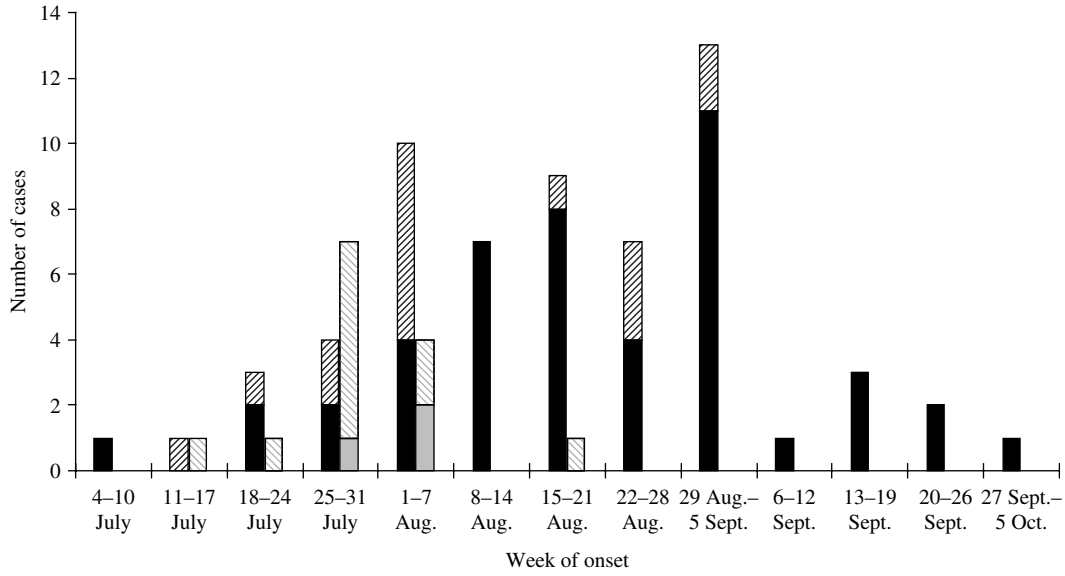

Fig. Reported case-patients with cryptosporidiosis (■) or salmonellosis (▤) by week of onset, July 2007 to October 2007. Cases with known contact with the interactive fountain at Public Park Y are highlighted for cryptosporidiosis (▨) and salmonellosis (▧) separately. Weeks in which temperatures in San Francisco Bay Area counties rose above 37 °C are denoted by an asterisk (*). Because salmonellosis has a shorter incubation period (6–72 h) than cryptosporidiosis (1–12 days) salmonellosis case reports peaked before cryptosporidiosis case reports.

multiple attendees following water exposure at the fountain.

Concurrent with the ongoing cryptosporidiosis investigation, the SCCPHD received reports of 15 *Salmonella* Stanley infections indistinguishable by pulse-field gel electrophoresis. In an investigation independent of that for the cryptosporidiosis cases, 11 of the 12 interviewed salmonellosis cases reported visiting the interactive fountain at Public Park Y during their incubation period. Onset dates, ranging from 17 July to 18 August, coincided with those of the cryptosporidiosis cases (Fig.). None of the cases reported concurrent *Salmonella* and *Cryptosporidium* infections.

An environmental assessment of the interactive fountain at Public Park Y by the Santa Clara County Department of Environmental Health revealed water recirculation following drainage from a stone platform into an underground reservoir. The fountain's high-rate sand filtration system was inadequate for the removal of *Cryptosporidium* oocysts; effective elimination of *Cryptosporidium* oocysts requires a filter with a pore size of $\leqslant 1\ \mu$m. The fountain lacked an automated disinfection system and based upon interviews with the fountain maintenance crew, it was determined that chlorine was added sporadically. Chlorine at doses used for recreational and drinking water disinfection does not inactivate *Cryptosporidium*. The fountain's disinfection system did not include techniques, such as UV disinfection, designed for the removal/inactivation of *Cryptosporidium* oocysts. Following physical inspection of the fountain and its appurtenances (i.e. pumps, filters) the fountain was closed. Swab samples taken from the water pump hair and lint strainer processed by the Santa Clara County Public Health Laboratory subsequently tested negative for *Salmonella*.

The EPA-approved laboratory at the Santa Clara Valley Water District used EPA Method 1623, to identify *Cryptosporidium* oocysts. The method consists of three microscopy techniques: immunofluorescence, DAPI nucleic acid stains and differential interference contrast microscopy [2]. Ten-litre samples were taken from the recirculation line feeding the fountain and from the public water connection line servicing the park. Results indicated no *Cryptosporidium* oocysts in the meter connection; however, more than 100 oocysts per litre were identified in the interactive fountain recirculation system sample. A total chlorine residual of 0·9 ppm was detected.

As only 25% of cryptosporidiosis cases reported attendance at the interactive fountain, the existence of other sources could not be ruled out. Interview data suggested localized spread at Amusement Park A; however, the park's season ended and its ten pools were drained before collection of water samples could take place. To reduce the likelihood of

https://doi.org/10.1017/S0950268807000222 Published online by Cambridge University Press

person-to-person transmission – 34% of cases had contact with confirmed or suspected cases during their incubation periods – SCCPHD sent a medical alert to physicians and restricted school and day-care attendance by children aged <5 years pending resolution of diarrhoea and three negative stool specimens taken at least 72 h apart.

Although salmonellosis case interviews strongly implicated the interactive fountain, no conclusive evidence linking the interactive fountain at Public Park Y to the *Salmonella* cases was obtained. After consideration of several factors, the SCCPHD decided that a formal case-control investigation was not necessary to ensure public health protection. These factors included lack of evidence indicating an ongoing source, limited resources, and the high likelihood that the source was eliminated because the interactive fountain at Public Park Y had already been closed as a result of the cryptosporidiosis investigation. Case interviews did not implicate any food or beverage vendors in or near Public Park Y in the transmission of *Salmonella*. Although investigators were unable to isolate *Salmonella* from the filtration system, lapses in chlorination may have increased the risk of contamination and the subsequent spread of *Salmonella* in the implicated fountain. *Salmonella*, unlike *Cryptosporidium*, is susceptible to chlorine disinfection.

Cryptosporidiosis surveillance in the San Francisco Bay Area has been conducted since 1996 and data on specific exposures dating back to 2003 are available. From 2000 to 2005 no more than 70 cases were reported in a year. One interviewer conducts all interviews, which include information on exposures such as the names, dates of contact and locations of restaurants frequented, recreational water sites, social gatherings, preschools and travel locations. Common exposures are so rare that when otherwise unrelated cases report a common exposure, CSP is able to initiate an investigation of a suspect source. In this outbreak, limited resources precluded conducting a formal case-control study, however, the link to the particular contaminated water source was judged qualitatively significant. However, only 25% of cases reported attendance at the interactive fountain, and the case-series study design cannot rule out the influence of other exposures.

Environmental health departments in Santa Clara and San Francisco counties conducted surveys to identify additional interactive fountains. In Santa Clara County, eight interactive fountains with recirculated water and 15 fountains with non-recirculated water were identified. Test results for *Cryptosporidium* oocysts on two fountains with recirculated water and one with non-recirculated water were negative for *Cryptosporidium* spp. All fountains with recirculated water were subsequently closed as they lacked treatment methods to effectively remove or inactivate *Cryptosporidium*. Santa Clara County has since required the installation of a secondary disinfection system (UV system) in addition to the standard recirculation and filtration system. In San Francisco County, four interactive fountains without water recirculation were identified. These fountains drained into sandy playgrounds. Three of these were out of service for unrelated reasons, and one was under construction. The potential for the pooling of water on top of the sand is a concern which will be further investigated by health inspectors prior to operation.

The early detection and rapid identification of the probable source of the outbreak illustrated the efficacy of CSP and the importance of the existing communication structure between water and health agencies. Pre-event activities such as interdisciplinary meetings and workshops, emergency planning, and preparedness exercises enabled the development of professional contacts, created an awareness of locally available skills and resources among participating agencies, bridged the education gap between water and health professionals, and provided a framework for information sharing and decision making.

The outbreak investigation and response revealed that the ability to respond to and evaluate an outbreak could be enhanced by a number of improvements. First, increased capacity to collect and integrate case data from health-care providers would have ensured complete case finding, and enhanced the ability to epidemiologically link cases to potential exposures. Similarly, higher utilization of *Cryptosporidium* testing with ova and parasite examination would have improved confidence that case finding was complete. Second, regulation of these types of facilities and the availability of data describing location, monitoring and operational details of local recreational water sites might have accelerated the investigation. Third, the investigation of potential drinking-water contamination could have been enhanced by mapping cases to their residential drinking-water systems; CSP has since added GIS case mapping to regular surveillance activities. Finally, although the outbreak investigation and response benefited from the existing collaborative relationships between health

departments, it would be enhanced by the establishment of formal protocols and priorities for regional resource sharing. Although CSP is located in the San Francisco Department of Public Health, its principal responsibility is for surveillance and response to drinking water-related cryptosporidiosis. Once drinking water was ruled out, San Francisco was not jurisdictionally required to participate further in the investigation. However, the outbreak investigation would not have proceeded as efficiently without the additional resources from San Francisco. The provision of epidemiological support to interview cases and analyse data was sensible because secondary case transmission could have impacted on San Francisco even though the primary cases were outside San Francisco's jurisdiction. The outbreak thus pointed to the need for establishing protocols and priorities for coordinating regional resources to respond to local and regional contamination incidents.

Interactive fountains are an established route of infection for gastrointestinal illness such as cryptosporidiosis, shigellosis and norovirus infection [3–5]. Inappropriate equipment or maintenance is cited as the cause of multiple cryptosporidiosis outbreaks involving fountains and spray attractions [6, 7]. While design and operation guidelines for interactive fountains have been published by a number of sources including the Pool Water Treatment Advisory Group and the California Conference of Directors of Environmental Health [8, 9], the implementation of these guidelines is on a voluntary basis. In fact, most often, interactive water fountains are not regulated at the local level; in CSP's catchment area the existence and location of all interactive fountains was not even known by environmental health officials at the time of the outbreak. To prevent further recreational water-associated outbreaks, health codes must be amended to regulate interactive fountains that are designed to pool or recirculate water. New regulations must mandate water treatment with ultraviolet light or other techniques proven to effectively inactivate *Cryptosporidium* oocysts, regular inspection to ensure compliance with filtration, disinfection and maintenance requirements, and, to prevent short-term exposures, that facilities such as showers and bathrooms be accessible to interactive fountain patrons.

ACKNOWLEDGEMENTS

Investigations of drinking water systems and/or *Cryptosporidium* testing were performed by: N. Quesada and B. Wilson of the City of San Jose Municipal Water System, C. deGroot of the City of Santa Clara, M. Hoang of the San Jose Water Company, B. Cabral, A. Cheung, J. Scott and C. Carbone of the Santa Clara Valley Water District, and J. Tin of the San Francisco Public Utilities Commission. Environmental investigations and/or *Salmonella* testing were performed by E. Wong, R. Gaddi and S. Muzzio of the Santa Clara County Department of Environmental Health. Technical advice was provided by L. Anderson of the San Francisco Department of Public Health.

DECLARATION OF INTEREST

None.

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