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Waterborne Outbreak of SALMONELLOSIS

Investigation & Risk Factor Survey of Splash Pads

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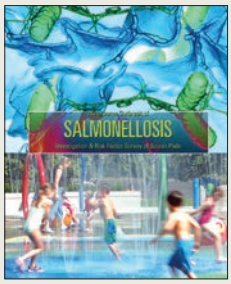

This month's cover article explores the investigation that resulted from an uncommon outbreak of salmonellosis linked to a splash pad. The authors also conducted a survey to gauge water quality and patron behaviors at splash pads. Most splash pads surveyed used a recirculating water system, but 21% tested below recommended free residual chlorine levels and 33% contained an indicator of environmental or fecal contamination. Among the patrons observed, common high-risk behaviors included sitting on the fountain or spray head and putting mouth to water. The article argues that water venue regulations and improved patron education are important to prevent future outbreaks.

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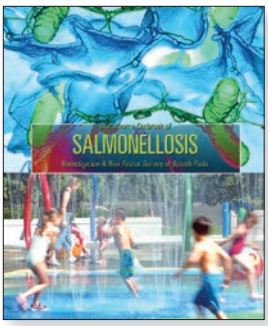

Water Quality Survey of Splash Pads After a Waterborne Salmonellosis Outbreak —Tennessee, 2014

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Abstract **Waterborne outbreaks of salmonellosis are uncommon. The Tennessee Department of Health investigated a salmonellosis outbreak of 10 cases with the only common risk factor being exposure to a single splash pad. Risks included water splashed in the face at the splash pad and no free residual chlorine in the water system. We surveyed water quality and patron behaviors at splash pads statewide. Of the 29 splash pads participating in the water quality survey, 24 (83%) used a recirculating water system. Of the 24, 5 (21%) water samples were tested by polymerase chain reaction and found to be positive for *E. coli, Giardia*, norovirus, or *Salmonella*. Among 95 patrons observed, we identified common high-risk behaviors of sitting on the fountain or spray head and putting mouth to water. Water venue regulations and improved education of patrons are important to aid prevention efforts.**

Introduction

During 2009, more than 50 million people swam during an estimated 300 million visits to recreational waters in the U.S. (U.S. Census Bureau, 2011). Included among recreational waters are hot tubs, swimming pools, lakes, oceans, and rivers. Among potential risks for recreational swimming is waterborne illness resulting from ingestion of contaminated water. Diarrhea, the most common manifestation of waterborne illness, results when a person ingests water contaminated with enteric pathogens, including *Cryptosporidium*, *Giardia*, *Shigella*, norovirus, and *E. coli* O157:H7 (Hlavsa et al., 2011).

Despite being among the most common enteric pathogens, nontyphoidal *Salmonella* is rarely identified as the source of waterborne illness (World Health Organization, 2008). During June 2014, the Tennessee Department of Health (TDH) investigated a salmonellosis outbreak associated with a single splash pad. Splash pads, which are not regulated in Tennessee, are any fountain or water spray device intended for or accessible to recreational use (see photo on page 9). A limited number of outbreaks associated with splash pads have been reported, and a study of water quality was rarely included (Bancroft, Keifer, & Keene, 2012; Eisenstein, Bodager, & Ginzl, 2008; Kirian, Meregillano, Gennette, & Weintraub, 2008; Nett et al., 2010). We investigated the outbreak of salmonellosis and then conducted a statewide survey of splash pads to learn more about their water quality and observe patron behaviors that might increase the risk for infection.

Methods

Outbreak Investigation

During June 2014, routine disease surveillance and patient interviews conducted by TDH identified an outbreak of five *Salmonella* Newport infections among patrons of a single splash pad. Standard outbreak investigation methods were used, including case finding from local healthcare providers, patient interviewing, and laboratory isolation and subtyping by pulsed-field gel electrophoresis (PFGE). A case-control study was performed to identify exposures associated with *Salmonella* infection among patrons of the implicated splash pad.

Cases were defined as either confirmed (a person who developed diarrhea, defined as ≥3 loose stools during 24 hours, within 16 days of visiting the splash pad, and with laboratory confirmation of *Salmonella* Newport) or probable (a person who developed diarrhea within 16 days of visiting the splash pad without laboratory confirmation). The 16-day incubation period for *Salmonella* was used because the ingestion dose was likely low because of the dilution effect of the splash pad water (Heymann, 2004). We attempted to match three control subjects per case-patient, stratified by age group. Control subjects were age matched to case-patients and had visited the splash pad in the previous 30 days. Internet directories were used to identify households in the community near the splash pad and telephone calls were made to enroll control subjects. TDH staff visited the splash pad to enroll additional patrons as control subjects via in-person contact. After the outbreak was identified, a chlorine reading was taken and TDH staff reviewed

TABLE **1**

Splash Pad Characteristics Related to Hygiene and Water Quality (*N* = 29)

Characteristic	# (%)
Recirculated water	24 (83)
Hygienic practices and policies	
Signs posted	15 (52)
No food allowed	9 (31)
No drinks allowed	8 (28)
No animals allowed	7 (24)
Child supervision required	7 (24)
Exclusion of ill persons	6 (21)
Avoid swallowing water	5 (17)
Shower before entry	3 (10)
Recommend swim diaper	5 (17)
No changing diapers	1 (3)
Written policies	12 (41)
Body fluid contamination policy	9 (31)
Hygienic facilities available	
Restrooms	17 (59)
Hand wash sinks	15 (52)
Drinking water fountains	11 (38)
Fence around facility	10 (35)
Food available on or near premises	10 (34)
Showers	5 (17)
Diaper changing stations	7 (24)
Changing rooms	5 (17)
Foot wash stations	4 (14)
Water quality	
pH, mean (*SD*)[a]	3.7 (3.1)
Free chlorine, mean ppm (*SD*)[a]	7.5 (0.4)
Total coliforms present[a]	3 (13)
E. coli present[a]	1 (4)
Specific pathogen identified[a,b]	5 (21)

SD = standard deviation; ppm = parts per million.
[a]*N* = 24 splash pads with recirculating water.
[b]1 for *Giardia*; 2 for enteropathogenic *E. coli*; 1 for norovirus, and 1 for Shiga toxin-producing *E. coli*, enterotoxigenic *E. coli*, *Salmonella*, and *Plesiomonas shigelloides*.

the maintenance logs during the initial visit. During a subsequent visit, an environmental assessment and water samples were taken.

Example of water features at a splash pad. Photo courtesy of Judy Manners.

Splash Pad Survey

In response to the waterborne *Salmonella* outbreak, we conducted a survey during August 2014 of all identified splash pads in Tennessee to learn about their operating characteristics. A comprehensive list of splash pads was unavailable, so we identified sites by searching the Internet for terms commonly used to name or describe them (e.g., splash pads, interactive fountains, or aquatic playgrounds); reviewing splash pad manufacturer web pages for past, current, and future projects; and reviewing award announcements from the Tennessee Department of Environment and Conservation's parks and recreation grants. Splash pad operators were requested to participate in the survey during an unannounced site visit. Participating site operators were asked questions addressing water recirculation, signage, written policies for hygienic behaviors, and hygienic facilities available to patrons.

During splash pad visits, water samples were collected from spray or fountain heads. Free chlorine levels were tested on site by using a commercial pool test kit. For microbial testing at TDH's Division of Laboratory Services, water samples of 100 mL for coliform culture and 1 gallon for polymerase chain reaction (PCR) analysis were collected. Total coliform and *E. coli* cultures were performed using methods approved by the U.S. Environmental Protection Agency (Standard Methods: 9223 B) for drinking water testing. Multiplex PCR (BioFire FilmArray Gastrointestinal Panel) analysis was used to test for 22 enteric pathogens. The gastrointestinal panel is not validated for water samples; therefore, the state laboratory developed a modified protocol. Water was passed through a 0.45 µm filter, and the filter was placed into 50 mL of lactose broth and incubated overnight (18–24 hours) at 35 °C. Broth was then tested by drawing a 200 µL sample for the multiplex PCR test and, if a *Salmonella* species was present, cultured using standard techniques.

Patron Observations

Splash pad patrons who appeared to be 18 years or younger were observed to examine behaviors that would increase the likelihood of venue contamination or fecal–oral disease transmission. This patron age group was chosen for their increased likelihood to participate in nonhygienic behaviors. A convenience sample of children was selected and risk behaviors were documented for 15 minutes or until they left the splash pad area. Risk behaviors of sitting on a fountain or spray head, putting their mouth to water, putting their fingers in their mouth, putting a hand down their swim shorts, and exposing their buttocks to water were recorded as present or absent during each 1 minute increment of the 15-minute observation period (Nett et al., 2010).

Results

Outbreak Investigation

All 10 case-patients (5 confirmed and 5 probable) and 27 control subjects were included in a case-control study. All 5 confirmed case-patients had stool cultures that yielded *Salmonella enterica* serotype Newport with matching PFGE patterns. The mean age of both case-patients and control subjects was 7 years; 5 (50%) case-patients and 12 (44%) control subjects were female. No other common exposure among case-patients was identified after examining shared events, food histories, and other exposures while at the park. All 10 (100%) case-patients had water splashed in their face while playing in the splash pad, compared with 19 (90%) of 21 control subjects. No free residual chlorine, which inactivates potential contaminants, was identified in the recirculated water during the TDH staff member's visit, and the splash pad was closed voluntarily. Review of maintenance logs revealed chlorine level testing was not routinely logged or performed. After cleaning and hyperchlorination, the splash pad was reopened. No samples were taken before closure and subsequent water samples collected upon reopening did not detect *Salmonella*, total coliforms, or *E. coli* by culture.

Splash Pad Survey

In Tennessee, 59 splash pad locations were identified, and operators were contacted to participate in our survey. Of these 59 splash pads, 29 operators (49%) voluntarily provided water samples for testing. Most of the splash pads, 24 of 29 (83%), used a recirculating water system. Of these, 5 (21%) tested below the 1.0 parts per million (ppm) free residual chlorine recommended by the Model Aquatic Health Code (Centers for Disease Control and Prevention [CDC], 2014) and 2 (8%) tested below the detectable limit. Water quality testing of the 24 recirculating water systems identified 3 (13%) that tested positive for total coliforms, 1 (4%) yielded *E. coli* by culture, and 5 (21%) tested positive for specific organisms via multiplex PCR (1 for *Giardia*; 2 for enteropathogenic *E. coli*; 1 for norovirus; and 1 for shiga toxin-producing *E. coli*, enterotoxigenic *E. coli*, *Salmonella* species, and *Plesiomonas shigelloides*). In total, 8 (33%) of 24 splash pads that recirculated water contained an indicator of environmental or fecal contamination.

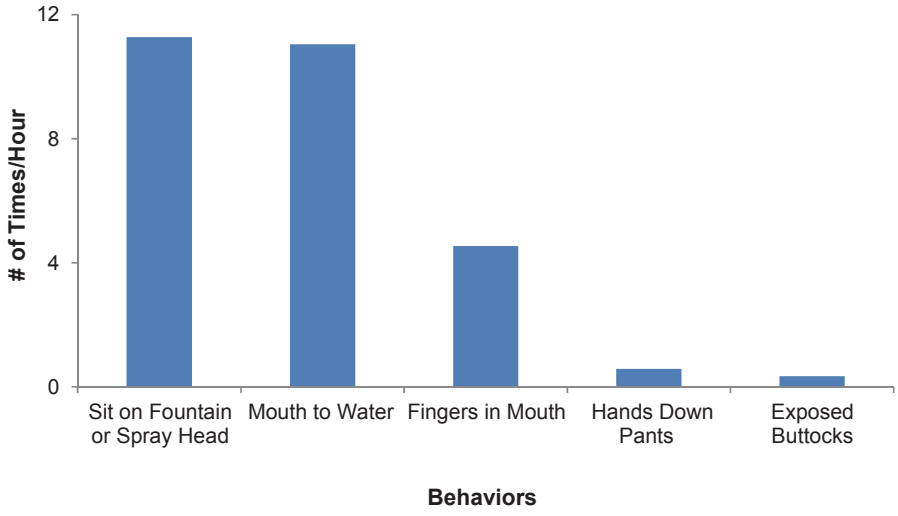
The 5 nonrecirculating splash pads tested negative for all organisms, and 2 had free residual chlorine levels <1.0 ppm. Examining hygienic practices and policies at the 29 splash pads, approximately half had posted hygiene signs (Table 1). Written hygiene policies were identified at less than half of splash pads, and less than one third reported having a written policy for body fluid contamination (e.g., blood, feces, or vomitus). Approximately half of splash pads had hygienic facilities, restrooms, or hand wash sinks, and approximately one third had a drinking water fountain available for patrons. Presence of environmental or fecal contamination indicators were not associated with inadequate water chlorination (p = .14) or the presence of posted hygiene signs (p = .99) or hygienic facilities (p = .71) at splash pads.

Patron Observations

From 95 patron observations at 17 splash pads, 20 (21%) were children wearing diapers or swim diapers, and 4 (20%) had a diaper changed in the splash pad area. Patrons spent an average of 11 minutes per hour sitting on a fountain spray head, 11 minutes per hour putting their mouth to water, and 4 minutes per hour putting their fingers in their mouth (Figure 1).

FIGURE **1**

Observed Rate of Behaviors for Splash Pad Patrons ≤18 Years



Discussion

Our investigation documented an unusual waterborne *Salmonella* Newport outbreak after patron exposures to insufficiently chlorinated water at a splash pad that used recirculating water. In all, 10 cases of *Salmonella* were epidemiologically linked to activities at a single splash pad with no free residual chlorine detected in the water. In a survey of splash pads, evidence of enteric pathogens—including *E. coli*, *Giardia*, *Salmonella*, and norovirus—was found in splash pads with recirculating water systems. The majority of children observed at splash pads during this investigation engaged in unsanitary behaviors, including sitting on a fountain or spray head and putting water or their fingers in their mouths. Recirculation of water at splash pads likely allows fecal–oral transmission of enteric pathogens by prolonging patron exposure to contaminated water.

The majority of splash pads in our survey used recirculated water and water quality concerns included no free residual chlorine and contamination with enteric pathogens. Free residual chlorine levels were difficult to maintain and potentially inadequate to disinfect the water if organic material from patrons or the surrounding environment was introduced. Each patron entering the splash pad potentially introduces some amount of organic material and the most common waterborne illnesses are infectious at low doses (Gerba, 2000). Water quality testing for specific pathogens identified contamination consistent with environmental or fecal sources at multiple venues. Specific pathogens found in the water included *Salmonella*, *E. coli*, *Giardia*, and norovirus. Although certain enteric pathogens might have resulted from environmental contamination by birds or animals, humans are the only known reservoir of norovirus.

Observations of splash pad patrons 18 years or younger identified that behaviors of sitting on a spray or fountain head and putting water or their fingers in their mouth were common. The majority of patrons were young (<5 years old) and therefore less likely to be aware of proper hygiene etiquette than older splash pad patrons. These prevalent but modifiable risk factors can be targeted to reduce the risk for waterborne illness. The Centers for Disease Control and Prevention (CDC) recommends patrons minimize waterborne illness risk for themselves and others by taking frequent restroom breaks, not ingesting the water, and refraining from water play while ill with diarrhea (Hlavsa et al., 2011). Signs posted at splash pads can help educate patrons and serve as reminders about these prevention steps. Our study

reported only half of splash pads had any hygiene signs posted, and the facilities to support the prevention steps were often not available at the sites. Only half of splash pads had restrooms with a toilet and hand sink, and approximately one third had a drinking water fountain.

A number of splash pads were originally designed to be decorative rather than recreational sites, helping to explain the limited attention to water quality by operators and lack of hygiene signs at facilities in our study. As prevention of contaminants is not considered a concern for decorative fountains, they often have fewer barriers (e.g., fencing) to prevent domestic animals from contacting the water. Regardless, even gated recreational splash pads are open to contamination by wild animals and birds. Determining which splash pads are accessible for recreational use and inspecting them to meet water quality regulations is a challenge for regulators.

Waterborne outbreaks of salmonellosis are uncommon (Outbreak Collaborative, 1971; Taylor, Sloan, Cooper, Morton, & Hunter, 2000). During 2009–2010, none of the 33 drinking water outbreaks or 81 recreational waterborne outbreaks reported to state health departments was as a result of *Salmonella* species (CDC, 2013; Hlavsa et al., 2014). During 2006, a waterborne outbreak of 69 cryptosporidiosis cases and 15 salmonellosis cases was associated with an interactive fountain in California (Kirian et al., 2008). Similar to our Tennessee outbreak, factors contributing to the California outbreak included the recirculation of water and inadequate disinfection. A limited number of drinking water outbreaks were identified with *Salmonella* as the causative agent during the past decade (Ailes et al., 2013; Hlavsa et al., 2011).

This study had certain limitations, including that the multiplex PCR, although validated for stool specimens, was not validated for use with water samples and the test sensitivity and specificity is not known. The multiplex PCR also does not differentiate live from inactivated organisms, an important distinction for developing disease. Nevertheless, five different enteric pathogens were identified in splash pad water samples, and their presence indicates the potential to cause disease if effective chlorine disinfection was not being performed. Our findings likely underestimated the contamination occurring during peak usage in summer months because the study was performed during August when schools had resumed and fewer patrons were present.

Conclusion

Poor water quality and risky patron behaviors that facilitate fecal–oral transmission of waterborne illness were present at a substantial proportion of splash pads surveyed in Tennessee. Vigilance among splash pads operators is needed to maintain proper water quality. Splash pad patrons should take precautions to help prevent illness, such as hand washing after using the toilet or before eating, changing diapers in an area separate from the splash pad, and avoiding ingestion of recreational water. Hygiene signs posted around these popular water venues can serve as a reminder to patrons. Furthermore, toilet, hand washing, and drinking water fountain facilities located nearby are essential. Public health jurisdictions can consider extending existing regulatory oversight for swimming pools to splash pads.

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