

SHORT REPORT

Multi-pathogen waterborne disease outbreak associated with a dinner cruise on Lake Michigan

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SUMMARY

We report an outbreak associated with a dinner cruise on Lake Michigan. This took place on the same day as heavy rainfall, which resulted in 42·4 billion liters of rainwater and storm runoff containing highly diluted sewage being released into the lake. Of 72 cruise participants, 41 (57%) reported gastroenteritis. Stool specimens were positive for *Shigella sonnei* ($n=3$), *Giardia* ($n=3$), and *Cryptosporidium* ($n=2$). Ice consumption was associated with illness (risk ratio 2·2, $P=0\cdot011$). *S. sonnei* was isolated from a swab obtained from the one of the boat's ice bins. Environmental inspection revealed conditions and equipment that could have contributed to lake water contaminating the hose used to load potable water onto the boat. Knowledge of water holding and distribution systems on boats, and of potential risks associated with flooding and the release of diluted sewage into large bodies of water, is crucial for public health guidance regarding recreational cruises.

Key words: Outbreaks, water-borne infections.

Cruise ships have served as settings for bacterial, parasitic, and viral disease transmission, and contamination at water distribution points (e.g. loading, circulation, storage, waste removal) has been implicated as a contributing factor in outbreaks [1–3]. Of waterborne disease outbreaks reported recently in the USA multi-pathogen outbreaks are much less common than those implicating a single aetiological agent [4].

On 13 September 2008, 16·87 cm of rain fell in Chicago, Illinois – at the time, the highest 1-day rainfall ever recorded in the city [5]. That same day, 42·4 billion liters of rainwater and storm runoff containing highly diluted sewage were released into Lake Michigan, located on Chicago's eastern border [6, 7]. We report a multi-pathogen waterborne outbreak associated with a 3-h, chartered dinner cruise that took place on Lake Michigan on the evening of this unprecedented weather event.

The Chicago Department of Public Health (CDPH) received a report of illnesses in cruise participants on 22 September 2008 and initiated a retrospective

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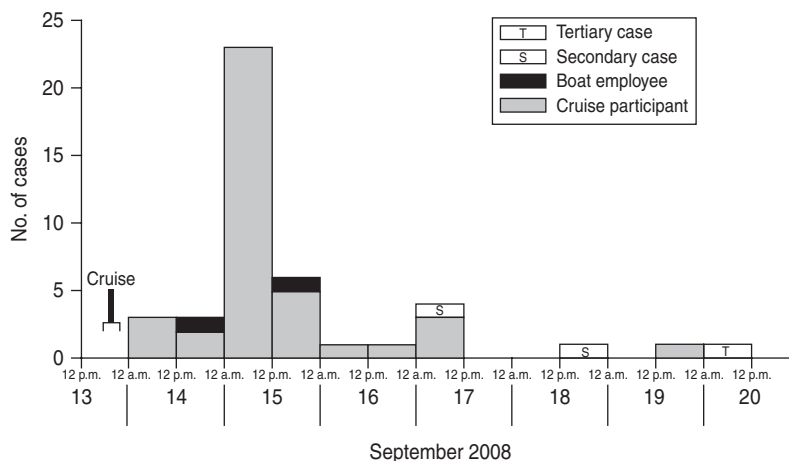


Fig. 1. Date and time of illness onset in cases associated with a Lake Michigan dinner cruise occurring on the evening of 13 September 2008.

cohort study. Attendees' illness and activity histories were obtained through telephone interviews using a standardized questionnaire. Data were entered into an Access 2000 database (Microsoft Corp., USA) and imported into SAS (version 9.1, SAS Institute Inc., USA) for the calculation of unadjusted risk ratios (RRs) and *P* values using the FREQ procedure. A case was defined as self-reported acute onset of diarrhoea within 2 weeks of taking the cruise with one or more of the following symptoms: abdominal cramps, nausea, vomiting, fever.

Questionnaire responses were obtained for all 72 cruise participants, and 41 (57%) reported gastrointestinal illnesses consistent with the clinical case definition. The only exposure in common that could account for the illnesses was participation in the boat cruise. Case-patients ranged from 64–78 years of age and 24 (59%) were female. Reported symptoms included diarrhoea (100%), cramps (83%), nausea (63%), vomiting (54%), fever (27%), and bloody stools (5%). Information on duration of diarrhoea was known for 31 (76%) case-patients. Diarrhoea lasted 1–10 days (median 5 days). Seventeen (41%) case-patients sought healthcare in an outpatient setting, and four (10%) additional cases resulted in hospitalization. Thirty-four (82%) illness onsets occurred within 12–72 h of the cruise (Fig. 1). Of 11 case-patient stool specimens tested, five yielded positive results. One case-patient's specimen was positive for *Shigella sonnei*, *Cryptosporidium*, and *Giardia*. Another case-patient's specimen was positive for *S. sonnei* and *Cryptosporidium*. *Giardia* alone was detected in two additional case-patients' specimens, and one case-patient's specimen yielded *S. sonnei*, but was

not tested for parasites. The remaining six specimens were tested for enteric bacteria or parasites and were negative for all pathogens tested. One of the four hospitalized patients was positive for *Clostridium difficile* toxin after having been treated with levofloxacin for her diarrhoeal illness following the cruise. Two instances of secondary and one of tertiary transmission to family members of primary cases were identified.

Boat employees were interviewed about tasks they performed on the boat, and about illness around the time of the cruise. Of five employees who served food and drink aboard the boat cruise, two reported acute onset of diarrhoea within 48 h following the cruise, but both denied illness before or during the cruise. Two other employees did not report illness before, during, or after the cruise, and the remaining employee was not located for an interview. The two ill boat employees each submitted a stool specimen that was negative for bacterial and parasitic pathogens.

Foods were brought aboard from a catering establishment and served buffet style. Beverages were served by boat employees at two bars, one on the main level and one on the upper deck. Water from the boat's holding tank was used to make ice for drinks; consumption of this one item, ice, was associated with illness in cruise participants (RR 2.2, *P*=0.011) (Table 1). The two ill employees reported consumption of drinks with ice during the cruise.

Water samples were collected on 24 and 26 September 2008 from the potable water source from which the boat filled its water-holding tank. Water and ice were sampled from the boat's holding tank and ice machine and from the neighbouring boat's ice

Table 1. Reported consumption of items served on the dinner cruise, 13 September 2008 (n=72)

Item†	Consumed				Did not consume				Risk ratio	P value
	Ill	Not ill	Total	% Ill	Ill	Not ill	Total	% Ill		
Beef	38	29	67	57%	3	2	5	60%	0.95	1.00*
Caesar salad	31	19	50	62%	10	11	21	48%	1.30	0.266
Cheese	29	21	50	58%	10	10	20	50%	1.16	0.546
Chicken satay	22	17	39	56%	16	14	30	53%	1.06	0.800
Crabcakes	23	15	38	61%	16	15	31	52%	1.17	0.461
Crackers	25	18	43	58%	16	12	28	57%	1.02	0.934
Fish	36	23	59	61%	5	8	13	38%	1.59	0.140
Ice	35	19	54	65%	5	12	17	29%	2.20	0.011
Potatoes	37	28	65	57%	4	2	6	67%	0.85	1.00*
Quiche	21	15	36	58%	19	13	32	59%	0.98	0.931
Shrimp	28	22	50	56%	13	8	21	62%	0.90	0.648
Stuffed mushroom caps	23	17	40	58%	17	12	29	59%	0.98	0.926
Watermelon	21	14	35	60%	18	16	34	53%	1.13	0.557

† Sixteen items reportedly consumed by fewer than 21 (51%) of case-patients are not shown in the table. Counts exclude item-specific responses that were 'do not remember' or not given.

* P values calculated using two-tailed Fisher's exact test are denoted by an asterisk; all other values were calculated using the Mantel-Haenszel χ^2 test.

machine. Swabs of the boat's ice machine and the neighbouring boat's ice machine were obtained. *S. sonnei* was isolated from an environmental swab obtained from the interior of the boat's upper deck ice-storage bin. No pathogens were identified in three samples of ice taken from the boat, nor from six water samples taken from the boat, the outside water line, and the water main. *Shigella* was not found in two swabs of the lower deck ice bin. Environmental samples obtained from the neighbouring boat, including ice from that boat's ice machine, were negative for bacterial and parasitic pathogens.

In addition to the environmental *S. sonnei* isolate, two isolates from case-patients were available for pulsed-field gel electrophoresis (PFGE) typing; three distinct PFGE patterns were identified, as might be expected if sewage, rather than a single ill individual, were the source of the outbreak. In addition, our investigation implicated *Cryptosporidium* and *Giardia* as causative agents. Epidemiological findings provided evidence that ice was the most likely vehicle of transmission, and the multiplicity of pathogens identified suggests that a boat employee was unlikely to have contaminated the ice.

On 10 October 2008 officials from CDPH and the Food and Drug Administration (FDA) conducted an environmental inspection of the boat, a neighbouring boat, and the surrounding dock area. The inspections included a review of water loading, storage, and circulation on the boat. The ship had a properly

constructed 1893-liter closed tank for holding potable water. A pump with a pressure tank was used to distribute the water in a closed piped system from the holding tank to the fixtures throughout the ship including hand sinks and the ice machine. The holding tank was filled from a municipal watering point on the dock and was reported to have been chlorinated at least once during the previous year.

The watering point pedestal serving as the boat's water source was equipped with a reduced pressure zone (RPZ) assembly at the base of the pedestal just below the deck. The piping from the RPZ was connected to a faucet equipped with a Y-shaped connection with hoses attached to each end of the Y-connection in order to service two boat slips. This Y-connection did not include any backflow prevention device that would have regulated the direction and flow of water. At the time of inspection, the two hoses were not on reels. One hose was attached to the Y-connection at the faucet with the other end attached to the implicated boat. The other hose that serviced the adjoining boat slip, which was empty at the time of the inspection, had one end attached to the Y-connection with the other end hanging off the dock and floating in Lake Michigan.

The lack of a backflow prevention device in the Y-connection where potable water is loaded onto the boat might have contributed to lake water being mixed with potable water. If either of the boats sharing the cross-connection drew water from the potable

water supply while the end of the hose for the other boat was submerged in the lake, negative pressure could have been created, possibly resulting in contamination of the supply line. Additionally, if the hose of the implicated boat had been submerged in the lake water during the time of the combined sewer overflow situation, the hose itself could have become contaminated and pollute any potable water drawn into the hose.

CDPH, with FDA assistance, provided public health recommendations that included mechanical and structural remediation as well as infection control guidance. Recommendations included sanitizing and replacing filters in the water distribution system; sanitizing ice machines, dishes, and utensils; flushing, chlorinating, and sanitizing all hoses, waterlines, and tanks; and keeping hoses out of the lake and storing them in a sanitary manner. Use of food-grade water hoses was recommended. Finally, installation of a backflow prevention device where the boat connects to the city's potable water system and removal of the Y-connector on the dock faucet were also recommended.

The number of individuals affected and pathogens identified through this investigation could be an underestimate. Four case-patients were found to have parasitic infections, but it is possible that additional illnesses were missed because of the long incubation period of parasitic infections. Almost all of the interviews were conducted and stool specimens collected within 13 days of the cruise, but the incubation period for *Cryptosporidium* is up to 14 days and for *Giardia* it is up to 4 weeks. Not all submitted stool specimens were tested for parasitic pathogens nor were any tested for norovirus, and in part because none of the cruise participants resided in Chicago, specimens could not be collected directly from case-patients by CDPH. Nonetheless, on 30 September 2008, a letter describing preliminary investigative findings and fact sheets regarding shigellosis, giardiasis, and cryptosporidiosis were mailed to all participants.

On 26 September 2008 a Health Alert Network (HAN) notice was distributed electronically to the Chicago medical community requesting that all cases of *S. sonnei*, *Cryptosporidium*, and *Giardia* occurring since 13 September 2008 be reported expeditiously to CDPH, and encouraging healthcare providers to submit stool specimens for bacterial culture and ova and parasite testing in patients presenting with a gastrointestinal illness and a recent history of boating or participation in a boat cruise. However, no cases with

this exposure profile were reported, and no increases in reported case counts were noted in the weeks following the alert.

An understanding of potable water holding and distribution systems on commercial boats, as well as knowledge of potential risks associated with flooding and release of diluted sewage into large bodies of water, is crucial for public health guidance regarding recreational cruises.

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DECLARATION OF INTEREST

None.

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