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## ORIGINAL ARTICLE

# An Outbreak of Legionnaires Disease Associated with a Decorative Water Wall Fountain in a Hospital

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**OBJECTIVE.** To detect an outbreak-related source of *Legionella*, control the outbreak, and prevent additional *Legionella* infections from occurring.

**DESIGN AND SETTING.** Epidemiologic investigation of an acute outbreak of hospital-associated Legionnaires disease among outpatients and visitors to a Wisconsin hospital.

**PATIENTS.** Patients with laboratory-confirmed Legionnaires disease who resided in southeastern Wisconsin and had illness onsets during February and March 2010.

**METHODS.** Patients with Legionnaires disease were interviewed using a hypothesis-generating questionnaire. On-site investigation included sampling of water and other potential environmental sources for *Legionella* testing. Case-finding measures included extensive notification of individuals potentially exposed at the hospital and alerts to area healthcare and laboratory personnel.

**RESULTS.** Laboratory-confirmed Legionnaires disease was diagnosed in 8 patients, all of whom were present at the same hospital during the 10 days prior to their illness onsets. Six patients had known exposure to a water wall-type decorative fountain near the main hospital entrance. Although the decorative fountain underwent routine cleaning and maintenance, high counts of *Legionella pneumophila* serogroup 1 were isolated from cultures of a foam material found above the fountain trough.

**CONCLUSION.** This outbreak of Legionnaires disease was associated with exposure to a decorative fountain located in a hospital public area. Routine cleaning and maintenance of fountains does not eliminate the risk of bacterial contamination. Our findings highlight the need to evaluate the safety of water fountains installed in any area of a healthcare facility.

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Outbreaks of Legionnaires disease have been linked to contaminated water supplies in a variety of healthcare settings, including hospitals, nursing homes, and dental clinics.<sup>1-8</sup> *Legionella* are present at low levels in most water systems, and under proper conditions they can multiply to dangerous levels. *Legionella*-related illness can occur when water contaminated with *Legionella* becomes aerosolized and is inhaled or aspirated. Aqueous environments are of considerable concern in healthcare settings because of the increased risk of Legionnaires disease among patients, particularly those with compromised immune systems.<sup>9</sup>

During February and March 2010, 8 cases of Legionnaires disease occurred among residents of 5 contiguous public health jurisdictions in southeastern Wisconsin. Only 6 reported cases of Legionnaires disease had occurred among residents of these same jurisdictions during March 2007 through January 2010. This report describes the investigation to detect the outbreak-related source of *Legionella* and the

efforts to control the outbreak and prevent additional *Legionella* infections from occurring.

## METHODS

### Initial Report and Case Follow-up

On March 4, an infection preventionist (IP) for a group of hospitals in southeastern Wisconsin notified the Wisconsin Division of Public Health (WDPH) of 4 patients hospitalized since February 8 with Legionnaires disease, 1 at Hospital A and 3 at Hospital B. The patients resided in 4 contiguous local health department (LHD) jurisdictions in southern Milwaukee County. Patient interviews were conducted by LHD staff or an IP using a routine case report form that included information regarding patient demographic features, underlying illnesses, *Legionella* laboratory test results, travel history, and high-risk exposures. Review of completed forms did not identify a common exposure among the patients. On March

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9, WDPH staff were notified of 3 additional southern Milwaukee County residents hospitalized with Legionnaires disease at Hospital A. A more detailed hypothesis-generating questionnaire was developed and distributed to LHD officials; patients with Legionnaires disease were promptly interviewed or reinterviewed.

On March 10, review of the first 3 completed hypothesis-generating questionnaires revealed that all 3 patients had visited Hospital A during the 10 days prior to illness onset. Two patients had visited the outpatient cancer clinic. The third patient had waited in the hospital main lobby during a relative's outpatient appointment and recalled sitting near a water wall-type decorative fountain. After consulting with hospital staff, investigators hypothesized that the outbreak-related source of *Legionella* was either the decorative fountain in the lobby or a water source in the cancer clinic located near the lobby. On the basis of this preliminary evidence, hospital officials immediately decided to shut down the fountain on March 10.

#### Case Definition

A case of Legionnaires disease was defined as clinical signs and symptoms or radiographic findings suggestive of pneumonia in a patient residing in southeastern Wisconsin who had illness onset during February 1–March 20, 2010, and laboratory confirmation of Legionnaires disease. Laboratory confirmation included a positive urine antigen test, a tissue or sputum culture positive for *Legionella*, or a fourfold increase in *Legionella* antibody titers in paired sera.

#### Case Finding

On March 9, the WDPH notified LHD officials, IPs, and clinicians in the WDPH Southeastern Region of the Legionnaires disease cluster and requested that all patients with illnesses consistent with Legionnaires disease (fever, chills, myalgia, headache, and coughing) undergo a *Legionella* urine antigen test and a bacterial culture of respiratory specimens using buffered charcoal yeast extract (BCYE) media. Laboratories that did not perform *Legionella* cultures were requested to immediately forward respiratory specimens to the Wisconsin State Laboratory of Hygiene for *Legionella* testing. During March 13–16, Hospital A officials sent an e-mail notification to all staff, contacted all hospital volunteers, and established a call center with clinical and nonclinical Hospital A staff to notify potentially exposed individuals known to have visited the facility during March 1–10 to encourage them to seek medical care if they had an illness consistent with Legionnaires disease.

#### Environmental Investigation

WDPH staff and a registered sanitarian from the LHD conducted an initial environmental assessment at Hospital A on March 10 and an environmental assessment of the entire hospital on March 15–16. The procedures incorporated

guidelines from the Centers for Disease Control and Prevention (CDC).<sup>10</sup> During the assessments, water samples were collected in 100-mL sterile plastic bottles and sponge samples were obtained and placed in separate sterile plastic bottles. Sterile single-tipped cotton swab samples were placed in culturettes or submitted in fountain water. All specimens were placed in a cooler with cool packs and delivered overnight to the Wisconsin Occupational Health Laboratory for *Legionella* testing.

#### Laboratory Testing

All samples were processed and cultured according to a modified CDC method.<sup>11</sup> Sponge samples and culturette swabs were rehydrated with 20 and 10 mL of sterile tap water, respectively. All samples were filtered through a 0.2- $\mu$ m polycarbonate filter, sonicated, and acid treated. Samples were cultured on BCYE agar with and without antibiotics (polymixin B, vancomycin, and cycloheximide). Cultures were incubated at 35°C for 10 days and examined every 48 hours. Cultures overgrown with contaminant bacteria were acid treated, diluted 1:1,000, and replated to BCYE agar and BCYE agar with antibiotics.

Presumptive *Legionella* colonies were screened by culturing on BCYE agar with and without L-cysteine and brain-heart infusion with sheep blood plates at 35°C for 48 hours. Presumptive colonies were further identified as *Legionella pneumophila* using indirect immunofluorescent antibody tests (Bio-Rad MONOFLUO *Legionella pneumophila* immunofluorescent assay).

Water samples were also submitted for heterotrophic plate count (HPC) analyses according to the published standard method.<sup>12</sup> HPC enumerations estimate the number of viable aerobic bacteria in the sample. Isolates of *Legionella* cultured from environmental samples were submitted to the Wisconsin State Laboratory of Hygiene's Bacteriology Laboratory, where pulsed-field gel electrophoresis (PFGE) was conducted to determine their genetic relatedness.

## RESULTS

#### Epidemiologic Investigation

Eight cases of laboratory-confirmed Legionnaires disease were detected during this investigation; illness onsets occurred from February 10 to March 6, 2010. Of the 8 patients, 4 were hospitalized at Hospital A and 4 at Hospital B, and 4 (50%) were male; ages ranged from 50 to 86 (median, 64) years. All 8 patients either had an underlying medical condition (diabetes, alcoholism, rheumatoid arthritis, or chronic obstructive pulmonary disease), used an immune-suppressive medication, or reported other factors (smoking) that may have increased their risks of acquiring Legionnaires disease.

All 8 patients had urine-antigen tests positive for *Legionella* antigen and were hospitalized with radiographically confirmed pneumonia; respiratory specimens were not obtained from any of the patients. Three of the 8 patients were admitted

to an intensive care unit; all three were intubated and mechanically ventilated. The median duration of hospitalization was 12 days (range, 4–21 days), and the median duration of intensive care stays was 10 days (range, 4–21 days). All 8 patients survived.

All 8 patients had visited Hospital A during the 10 days prior to their illness onset. Hospital A exposure was the only reported exposure common to all 8 patients. None of the 8 patients was an inpatient at Hospital A at their time of exposure: 3 visited Hospital A as outpatients, 3 picked up medication at the pharmacy, 1 made a delivery to the facility, and 1 waited in the lobby during a relative's outpatient visit. Six of the 8 patients reported that they had entered or exited the facility through the main lobby and had passed by the fountain; 2 patients were uncertain whether they had passed through the main lobby. Six patients reported shopping at grocery stores where vegetable misters were used; however, only 3 reported exposure to the same store.

During March 13–15, call center staff called approximately 4,000 potentially exposed individuals (3,300 hospital or clinic patients and 700 pharmacy customers) and contacted all Hospital A employees and physicians and 89 volunteers. No one had reported illness consistent with Legionnaires disease. Review of *Legionella* urine antigen test results from 4 area hospitals identified 1 additional confirmed case of Legionnaires disease in a patient with no Hospital A exposure who had been exposed to *Legionella* during foreign travel. No known additional cases of Legionnaires disease occurred after the fountain shutdown.

### Environmental Investigation

The initial environmental assessment conducted at Hospital A on March 10 focused on the cancer clinic and hospital lobby. Three water samples and 3 swab specimens were obtained from hot-water taps in the cancer clinic. The water wall-type decorative fountain in the lobby was inspected. The fountain had been shut off during the morning of March 10 but had not been drained, cleaned, or treated. Two water samples from the fountain filter reservoir and 2 swab specimens of the fountain trough were collected, including 1 swab of an apparent biofilm visible as a discoloration on the sides of the trough where water collected under decorative rocks. A foam material that supported decorative rocks was noted in the fountain trough. The sanitarian returned to the hospital on March 12 to collect specimens of the foam material that had been removed as part of the fountain cleanup and placed in a plastic bag for disposal; 4 specimens of still-moist foam were obtained for culture. On March 15–16, samples were collected from 30 hot water faucets located throughout the hospital (Table 1). In addition, to determine the effectiveness of chlorine in the facility water supply and whether the building plumbing was supporting biofilm growth that could harbor *Legionella* bacteria, water samples were collected from 4

randomly selected faucets distal to the facility water inlet and tested for the presence of bacteria with the HPC (Table 1).

Among 44 environmental specimens and samples collected for *Legionella* culture, 9 were positive for *Legionella*. *Legionella pneumophila*, group 1 (Lp1), was isolated in high concentrations from cultures of 4 specimens of the spongelike foam material (range, 53,000–1,200,000 colony-forming units [CFU]/sample; Table 1). Four additional specimens (from the fountain filter housing, fountain trough, and water recirculation system in a maintenance room) were positive for Lp1 at concentrations substantially lower than that in the foam material (Table 1). Non-*pneumophila* *Legionella*, in a low concentration, were isolated from a swab specimen of a water heater in the boiler room. The remaining 35 specimens and samples collected from various locations throughout the hospital were negative for *Legionella*. HPCs of the 4 water samples collected from randomly selected faucets in Hospital A were very low (range, <1–3 CFU/mL).

Because respiratory specimens for culture were not obtained from any case patients, it was not possible to compare environmental *Legionella* isolates to isolates from clinical specimens. The PFGE patterns of *Legionella* isolated from the 7 Lp1-positive fountain specimens were indistinguishable, and they differed from the PFGE pattern of the Lp1 isolate from the maintenance room specimen.

### Fountain Description and Maintenance

The water wall-type decorative fountain was installed in 2008 on one side of a central corridor in the main Hospital A lobby (Figure 1). All visitors using the hospital main entrance passed by the fountain on their way to the information/registration desk. Fountain water flowed down a tiled wall approximately 8 ft wide and 5 ft high and then through a bed of decorative rocks that rested on a spongelike foam material (Figure 2). A glass shield extended from the trough approximately 6 in above the rocks to reduce splashing into the corridor. The water collected in a trough at the bottom of the fountain, beneath the rocks and foam, and an electric pump recirculated the water to the top of the water wall. Low-voltage floodlights were located on the ceiling above the fountain and in the water trough. The fountain was in use daily between 6:00 AM and 9:00 PM and was turned off at night. An electric fireplace was located on the opposite side of the same wall that housed the fountain and was used intermittently during the same hours as the fountain.

The fountain was equipped with an ionization-based disinfection system (Model 1100 Automatic Purification System, Carefree Clearwater). Weekly maintenance by hospital staff included testing fountain water for free chlorine, total alkalinity, and cyanuric acid using the Hth pool kit (test strips); testing for total dissolved solids (conductivity test); and adding 1 half-gallon of hydrogen peroxide and 1 oz of biocide to the water. Monthly maintenance included shutting down the water wall and removing the rocks, foam, metal grates,

TABLE 1. Results of Cultures of Environmental Foam and Swab Specimens and Water Samples for *Legionella* Bacteria, Hospital A, March 10–15, 2010

Location, sample or specimen	Plate counts (CFU)	Isolate	CFU/specimen <sup>a</sup>	CFU/mL <sup>b</sup>
Fountain				
Foam material	7	Lp1	53,000	
Foam material	14	Lp1	110,000	
Foam material	12	Lp1	90,000	
Foam material	156	Lp1	1,200,000	
Fountain filter housing				
Wipe	6	Lp1	0.45	
Water	41	Lp1		3.1
Fountain trough, water	540	Lp1		41
Maintenance room, swab	16	Lp1	120	
Boiler room				
Swab	4	<i>Legionella</i> np	30	
Swab <sup>c</sup>	NLI			
Water <sup>d</sup>	NLI			NLI
Cancer center				
Wipe <sup>e</sup>	NLI			
Water <sup>f</sup>	NLI			NLI
Random hospital				
Swab <sup>g</sup>	NLI			
Water <sup>h</sup>	NLI			
Random faucets, water <sup>i</sup>	≤3			

NOTE. CFU, colony-forming units; Lp1, *Legionella pneumophila* group 1; *Legionella* np, *Legionella* non-*pneumophila*; NLI, no *Legionella* identified.

<sup>a</sup> CFU/specimen for wipes and swabs only.

<sup>b</sup> CFU/mL for water samples only.

<sup>c</sup> 4 specimens.

<sup>d</sup> 5 samples.

<sup>e</sup> 3 specimens.

<sup>f</sup> 4 samples.

<sup>g</sup> 6 specimens collected from random areas of Hospital A.

<sup>h</sup> 13 samples collected from random areas of Hospital A.

<sup>i</sup> 4 samples collected for heterotrophic plate count testing. The low CFU suggests that biofilms were not a problem in the Hospital A water system.

and white drain pipe. The walls, trough, sump, and pump were cleaned with CLR cleaner and rinsed with tap water. A wet-dry vacuum was used to remove water that remained in the bottom of the sump. The rocks and foam were rinsed with tap water and placed back in the fountain. Facility staff followed manufacturer maintenance recommendations for the pump.

## DISCUSSION

This investigation detected 8 laboratory-confirmed cases of Legionnaires disease diagnosed during a 4-week period among persons whose only common exposure during the 10 days prior to illness onset was a visit to Hospital A. None of the 8 persons had been inpatients at the time of their exposure. Environmental testing detected Lp1 in samples collected from a water wall-type decorative fountain located in the Hospital A main lobby. Lp1 were present in high concentrations in 4 samples of a foam material used to support

a bed of decorative rocks above the fountain trough and at lower concentrations in a water sample and swab specimen collected from the fountain filter housing and a water sample collected from the fountain trough. These 7 isolates had indistinguishable PFGE patterns. The only other sample positive for Lp1 had an isolate with a different PFGE pattern.

*Legionella* are found in most water sources at low levels. With conditions conducive to their growth, *Legionella* can multiply to dangerous concentrations. Factors that promote the growth of *Legionella* include water temperatures of 77°–108°F (25°–42°C), stagnation of water within a system, and the presence of biofilms, which provide *Legionella* with nutrients and protection from disinfectants.<sup>13,14</sup>

Fountains have previously been associated with Legionnaires disease outbreaks and are recognized as a potential source of *Legionella* exposure.<sup>4–6</sup> Fountains provide a closed system in which recirculating water can stagnate, and they can create aerosols as a result of their spraying action or as



FIGURE 1. The water wall-type decorative fountain located in the main lobby of Hospital A. A color version of this figure is available in the online edition.

water cascades down walls or rocks. The wall water fountain associated with this outbreak had features that may have increased the risk of *Legionella* contamination. One was the semiporous foam bed that supported the decorative rocks at the bottom of the water wall. Despite routine cleaning, the foam was heavily contaminated with *Legionella*. A second was the use of floodlights and the electric fireplace on the back side of the same wall where the fountain was installed, which may have warmed fountain water to temperatures conducive to *Legionella* growth. Unfortunately, water temperatures were not measured while the fountain was in operation because it had been turned off soon after it was suspected as a source of exposure.

To our knowledge, this is the second documented outbreak of Legionnaires disease associated with a decorative fountain in a healthcare setting and the first to involve only outpatients and hospital visitors. This outbreak and the previously reported Legionnaires disease outbreak<sup>4</sup> were associated with exposure to a wall-type water fountain, a design that is increasingly popular in healthcare facilities, spas, hotels, and other public settings. In 2007, two oncology inpatients at a clinical center at the National Institutes of Health were diagnosed with Legionnaires disease after being exposed to a contaminated wall-type water fountain.<sup>4</sup> Those 2 patients had passed by the fountain 8 times during a 4-day period on their way to receiving radiation treatment, and they reported lin-

gering near the fountain on at least 2 occasions. In contrast, only 1 patient in our investigation reported lingering near the fountain while waiting in the lobby during a relative's outpatient visit. The other patients, who at the time of exposure were clinic outpatients, pharmacy patrons, and a deliveryman, are likely to have simply walked past the fountain on their way to and from their destinations within the facility.

None of the 8 patients had a sputum culture performed before initiation of antibiotic treatment. Because patient isolates of Lp1 were not available, the link between the water fountain and their diseases could not be confirmed with bacteriologic subtyping data. In addition, without a control group, other contributing factors, including other exposure sources, could not be excluded. Nonetheless, the epidemiologic data in this investigation are compelling. The similarity of exposures (visits to the first floor of the hospital by all 8 patients and known exposure to fountain by at least 6 patients) and the close temporal relationship between the patients' illness and the degree of contamination of the fountain with Lp1 both strongly support the conclusion that the decorative fountain was the source of the Lp1 that caused the outbreak. In addition, no cases of Legionnaires disease occurred after the shutdown of the fountain.

When this outbreak occurred, there was only 1 published study of a similar outbreak in the medical literature,<sup>4</sup> and there were no guidelines regarding risks of legionellosis as-



FIGURE 2. Internal view of the water wall-type fountain, showing a bed of decorative rocks that rested on a spongelike foam material. Arrow A points to the decorative rocks in the fountain, and arrow B points to the location of the foam material that was placed in the fountain to prevent splashing. A color version of this figure is available in the online edition.

sociated with decorative fountains in healthcare settings and the efficacy of disinfection/maintenance procedures to reduce such risks. Accordingly, WDPH staff developed interim guidelines advising healthcare facilities with similar wall-type water fountains or any other decorative fountains to establish strict maintenance procedures and conduct periodic bacteriologic monitoring to assess levels of *Legionella*. The guidelines stress that until further data are available to demonstrate that maintenance procedures eliminate the risk of *Legionella* transmission and associated Legionnaires disease in water fountains with specific designs, water fountains of any type should be considered at risk of contamination with *Legionella*. Healthcare facilities should follow current healthcare facility construction guidelines, which state “Fountains and other open decorative water features may represent a reservoir for

opportunistic human pathogens; thus they are not recommended for installation within any enclosed spaces in health environments.”<sup>15</sup> It should be noted these guidelines were developed in 2010, after the outbreak at Hospital A had occurred.

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