



## Legionnaires' Disease Outbreak at a Long-Term Care Facility Caused by a Cooling Tower Using an Automated Disinfection System—Ohio, 2013

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**Abstract** On July 9, 2013, an outbreak of Legionnaires' disease (LD) was identified at Long-Term Care Facility A in central Ohio. This article describes the investigation of the outbreak and identification of the outbreak source, a cooling tower using an automated biocide delivery system. In total, 39 outbreak LD cases were identified; among these, six patients died. Water samples from a cooling tower were positive for *Legionella pneumophila* serogroup 1, reactive to monoclonal antibody 2, with matching sequence type to a patient isolate. An electronic control system turned off cooling tower pumps during low-demand periods, preventing delivery of disinfectant by a timed-release system, and leading to amplification of *Legionella* in the cooling tower. Guidelines for tower maintenance should address optimal disinfection when using automated systems.

### Introduction

Legionnaires' disease (LD) is a severe and potentially fatal pneumonia caused by colonization of human-made water systems and subsequent aerosolization and inhalation of *Legionella* bacteria (Fraser et al., 1977; McDade et al., 1977). *Legionella* amplifies in warm, stagnant water systems (25°C–42°C), particularly in the presence of scale, sediments, biofilms, and amoebae, and in the absence of adequate biocides (e.g., chlorine) (Cooling Technology Institute, 2008). Outbreaks have been associated with multiple sources, including evaporative cooling systems (e.g., cooling towers), potable water, whirlpool spas, industrial equipment, and decorative water features (Blatt et al., 1993; Centers for Disease Control and Prevention [CDC], 1997; Dondero et al., 1980; Fiore et al., 1998; Hanrahan et al., 1987; Hlady et al., 1993;

Kool et al., 1998; Lau, Maqsood, Harte, Caughley, & Deacon, 2013; Mahoney et al., 1992; Nguyen, et al., 2006; Rangel, Delclos, Emery, & Symanski, 2011). Hospitals and long-term care facilities are particularly prone to LD outbreaks because they serve susceptible populations (Hanrahan et al., 1987; Kool et al., 1998).

During July 9–July 12, 2013, Franklin County Public Health (FCPH) and the Ohio Department of Health (ODH) were notified of nine cases of LD among residents of Long-Term Care Facility A (LTCFA), a retirement community located in a suburb of Columbus, Ohio. With the assistance of the Centers for Disease Control and Prevention (CDC), an epidemiologic and environmental investigation was conducted to describe the scope of the outbreak, identify the source, and recommend control measures to prevent additional cases.

### Methods

#### Setting

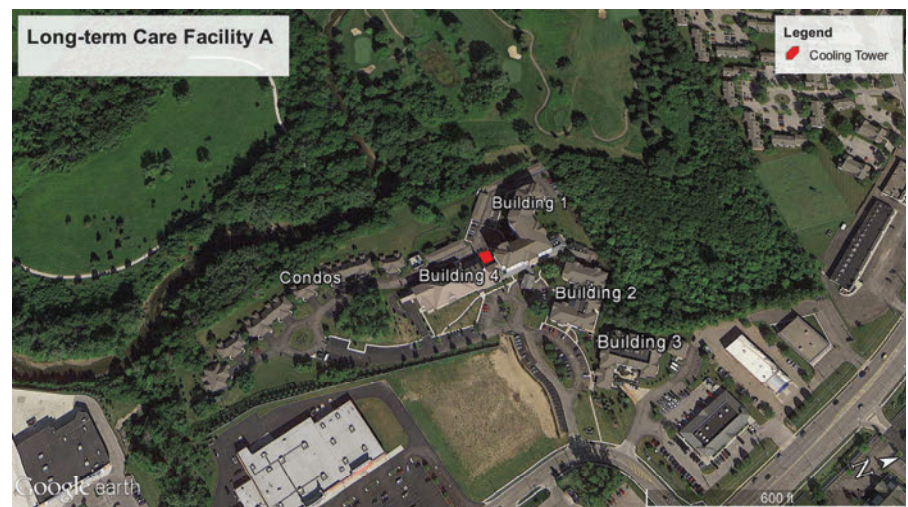
LTCFA is a retirement community offering independent living in single-story duplex condominiums and a high-rise building (Building 1), assisted living (Building 2), and memory care and hospice care (both housed in one building, Building 3) (Figure 1). An acute rehabilitation facility (Building 4) was completed during March 2013. The typical census for LTCFA is >200 older adults; approximately 70% are women.

#### Case Definitions

A case of LD associated with LTCFA required clinical criteria and laboratory criteria consistent with LD with illness onset during May 1–August 31, 2013, among persons who lived in, worked at, or visited LTCFA 2–10 days before symptom onset. Clinical criteria for

FIGURE 1

**Long-Term Care Facility A, Ohio, July 2013**



LD were signs or symptoms of pneumonia, defined as cough or shortness of breath plus one or more of the following: fever, nausea, diarrhea, confusion, malaise, or headache; or physician diagnosis of pneumonia; or chest radiograph consistent with pneumonia. Cases were classified as suspect or confirmed according to laboratory criteria defined in the 2005 national legionellosis surveillance case definition (CDC, 2005). Cases that met clinical criteria for LD associated with LTCFA but did not meet laboratory criteria for either a suspect or confirmed case, including those with unavailable or negative laboratory testing, were classified as possible cases.

**Case Finding**

LD is a reportable disease in Ohio. To identify all cases of LD associated with LTCFA, we used enhanced surveillance and conducted retrospective case finding. To enhance surveillance, we requested that LTCFA residents with pneumonia symptoms be evaluated for LD with *Legionella* urine antigen testing (UAT) and respiratory culture. LTCFA notified the local health department of all residents transferred to hospitals during the outbreak. Information about the outbreak was communicated to residents, their families, and their physicians directly by LTCFA; to physicians, hospitals, and emergency departments by FCPH; and to the community

through media reports, further enhancing surveillance for outbreak-associated cases.

For retrospective case finding, we queried the Ohio Disease Reporting System, an electronic reportable diseases database, for LD cases among residents of the three counties surrounding LTCFA during May 1–July 15, 2013. Each patient was contacted by their local health department to determine whether the patient had any connection to LTCFA during their 2–10-day incubation period. We reviewed death certificates for LTCFA residents who had died during the three months before the outbreak onset and searched death certificates for all residents of six central Ohio counties during January 1–July 15, 2013, for any decedents with legionellosis (or any variation) listed as the immediate or contributing cause of death.

**Case Investigation**

Each possible, suspect, and confirmed case of LD associated with LTCFA was investigated by using an outbreak-specific patient questionnaire and a medical record and long-term care facility chart abstraction tool developed by the investigation team. The patient questionnaire collected patient demographics, illness characteristics, LD risk factors, and water exposures and was administered through an in-person or telephone interview by members of the investigation team, either

with the patient or a proxy. Proxies were used when the patient was unable to be interviewed because of illness, advanced dementia, or death. When available, medical records and long-term care facility charts were reviewed to document onset and duration of symptoms, medications, medical history, and documented LTCFA water exposures (e.g., showering) for each case under investigation.

**Environmental Assessment**

A multidisciplinary team from FCPH, ODH, and CDC visited the facility during July 12–14 to perform an environmental assessment. The team included epidemiologists, physicians, nurses, environmental health specialists, a plumber familiar with Ohio plumbing code, and a microbiologist. The design and construction of the facility, design of the potable water system, and maintenance practices were discussed with facility administrators and building facilities staff. The design, use, and maintenance of a newly installed cooling system for Building 4 was discussed with the system manufacturer, facility administrators and staff, and contractors involved in its installation and maintenance.

**Laboratory Testing**

*Environmental Specimens*

The investigation team collected environmental bulk water and biofilm swab samples to evaluate possible *Legionella* colonization of the potable and other water systems at LTCFA during July 13–14. Samples were taken from hot water tanks, sinks and showers in selected patient rooms and rooms located at the distal end of the water distribution system, and sinks and showers from common areas, including the salon and kitchens in Buildings 1–3 and the condominiums. Bulk water and biofilm swab samples were taken from the below-ground reservoir and above-ground drip pan of a newly installed cooling tower and from an outdoor decorative fountain.

Environmental swabs and 1-L water samples were collected and maintained in an insulated cooler at room temperature according to CDC's *Legionella* recovery procedures (CDC, 2005). Bulk water samples and environmental samples were processed by using previously published standard procedures (CDC, 2005) at CDC's *Legionella* laboratory. Isolates with suspect morphology that required L-cysteine

for growth were typed by a dot blot with specific antisera to determine whether the organisms were *Legionella pneumophila* serogroup 1 and if they were monoclonal antibody 2 (MAb-2) positive (Joly et al., 1986; Sanden, Cassidy, & Barbaree, 1993). Five isolates were selected for further sequence-based typing (SBT) (Farhat, Mentasti, Jacobs, Fry, & Lück, 2011; Gaia et al., 2005; Ratzow, Gaia, Helbig, Fry, & Lück, 2007). MAb and SBT typing are complementary methods of strain discrimination and are epidemiologic tools used during outbreak investigations but not for treatment decisions or patient care.

*Clinical Specimens*

Patients were tested for LD at LTCFA by submission of clinical specimens to a commercial laboratory or at hospital laboratories. In Ohio, adult patients with pneumonia are frequently tested for LD by using UAT only. FCPH requested that LTCFA, local hospitals, and physicians order collection of sputum for *Legionella*-specific culture for all patients with pneumonia symptoms and exposure to LTCFA or any other patient with suspected LD. Sputum specimens were cultured for *Legionella* either at hospital laboratories or at CDC's *Legionella* laboratory. Polymerase chain reaction was performed on respiratory specimens at CDC according to published methods (Benitez & Winchell, 2013). SBT was performed on the one available clinical isolate to compare with SBT of *Legionella* isolated from environmental samples.

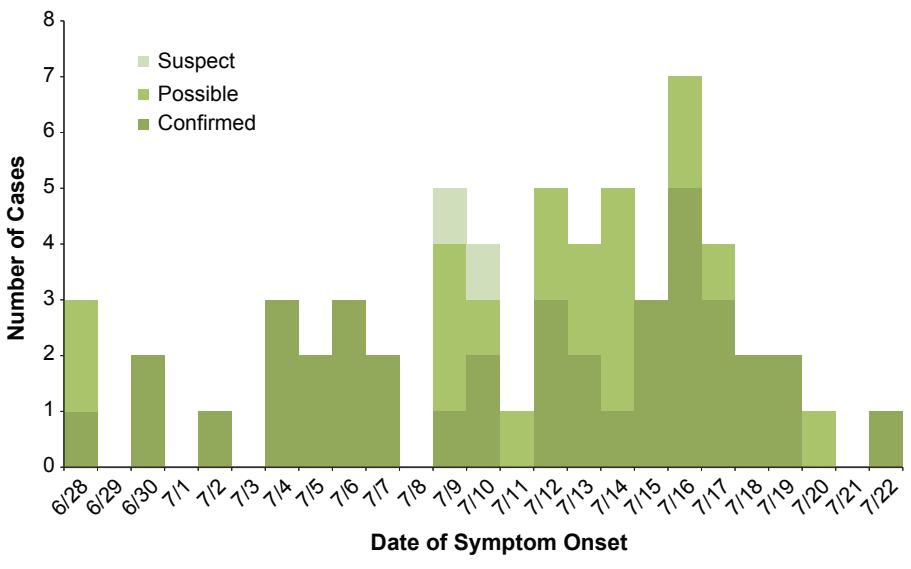
**Results**

**Case Finding and Investigation**

A total of 39 confirmed, 2 suspect, and 19 possible LD cases associated with LTCFA were identified, with illness onset dates during June 28–July 22, 2013 (Figure 2). Among confirmed cases, 69% of patients were women; ages ranged from 53 to 99 years (median: 88 years; interquartile range: 83–92.5). Six patients with confirmed LD died (Table 1). Interviews with patients revealed that a majority of residents were exposed to potable water sources within their building of residence. Seven patients, however, were visitors to LTCFA who did not report showering or assisting residents with showering or bathing during their visit, and therefore had only minimal exposure to the facility's potable water. Attack rates for LTCFA

FIGURE 2

**Epidemic Curve, Legionnaires' Disease Outbreak, Long-Term Care Facility A, Ohio, 2013**



residents with confirmed LD were calculated by building of residence by using the facility census on July 7, 2013, before recognition of the outbreak (Table 1). Higher attack rates were observed among settings with higher levels of care, reflecting the greater risk for contracting LD among older adults with higher care needs. Three patients (two residents of Building 3 and one resident of Building 2) reported that they did not leave their building of residence for any reason during their incubation period.

**Environmental Assessment**

*Potable Water Systems*

LTCFA's campus consists of four large buildings and six smaller buildings (condominiums), comprising 16 single-story homes for independent living. All construction was completed during 1998–2013. The four large buildings range from two to six stories. During March 2013, construction was completed for Building 4, a two-story acute rehabilitation facility; however, only a limited number of patients had used the building before the outbreak, and none were ill with pneumonia. All buildings were supplied by chlorine-disinfected municipal water from

a surface water reservoir, processed through one of three water treatment plants serving the greater Columbus area. Each building (Buildings 1–4) had independent potable water systems consisting of water heaters (set to 140°F), with thermostatic mixing valves located adjacent to the main holding tanks. The condominiums had individual residential water heaters regulated by the residents. No whirlpool spas, pools, or indoor fountains were located at the facility. Virtually all occupant rooms contained showers only. Communal showers were used in Building 3.

*Nonpotable Water Systems*

Two nonpotable water sources were identified. One, an outdoor decorative fountain, contained only a limited amount of circulating water. The second, a cooling tower, had been installed as part of Building 4 construction (Figure 1). The cooling tower was located behind Building 1 and approximately 15 feet from the fresh air intake for that building, and it provided cooling to Building 4 and the common spaces between Buildings 1 and 4. The three largest buildings on campus were located less than 500 feet from the cooling tower. Fresh air intakes for Building 1 were located on the side of the build-



TABLE 1

**Characteristics of Confirmed Legionnaires' Disease Cases, Long-Term Care Facility A (LTCFA) Outbreak, Ohio, 2013**

Characteristic	#	%
<b>Outcome</b>		
Survived	33	85
Died	6	15
<b>Demographics</b>		
Women	27	69
Median age (yrs; interquartile range)	88 (83–92.5)	
<b>Medical conditions</b>		
	36 <sup>a</sup>	
Heart condition	15	42
COPD <sup>a</sup> or chronic bronchitis	3	8
Immunocompromised	5	14
Dementia	5	14
Diabetes	5	14
<b>Type of Exposure to Facility</b>		
	#	Attack Rate <sup>b</sup>
Employee	1	Unknown
Visitor	7	Unknown
Adult day care (building 3)	1	Unknown
Resident	30	12
<b>Condominiums</b>		
	3	12
<b>Building 1</b>		
	12	10
<b>Building 2</b>		
	8	14
<b>Building 3</b>		
	7	19

<sup>a</sup>Medical conditions reported on patient questionnaire or with LTCFA chart; three cases had missing data from both sources. COPD = chronic obstructive pulmonary disease.  
<sup>b</sup>On the basis of LTCFA census (N = 243) reported on July 7, 2013.

ing more than 20 feet of the cooling tower, whereas fresh air intakes for Building 3 were located on the building roof.

#### Cooling Tower Operation

The cooling tower system was controlled electronically with set points for indoor and outdoor temperature and indoor humidity. When indoor or outdoor temperature or indoor humidity reached certain levels, the water pump and fans turned off automatically. The cooling demand for the system was likely lower than anticipated during the spring because of low occupancy in Building 4 and below-average temperatures for central Ohio during March–June 2013. Therefore, frequent periods when the cooling tower pump system was not operating were likely. Because of the tower's water treatment system setup, frequent on-and-off cycling prevented adequate delivery of biocide.

#### Cooling Tower Water Treatment

Water for the cooling tower was supplied by a connection with the potable water system. Three chemicals were used for water treatment, including two biocides (dimethyl-imino ethylene and sodium hypochlorite or sodium hydroxide) and one corrosion inhibitor (potassium hydroxide or hydroxyethylidene-1,1-diphosphonic acid). Each chemical was delivered by an automated pump programmed to inject a specific amount of chemical at a particular time; however, the facility had no record of the actual biocide delivery schedule before the outbreak. To prevent excess delivery of chemicals, the pumps had a lockout mechanism that prevented chemical delivery when the system was not operating. If the system was not operating (e.g., because of cool temperatures), even for a brief period, at the time of programmed biocide delivery no chemical was injected into the system.

The cooling tower was serviced monthly by a subcontracted water treatment company after becoming operational on February 19, 2013. Monthly service visits from the water treatment company included visual inspection and might have also included a check of residual corrosion inhibitor and a dip slide for total bacteria count. Biocide residuals were not routinely tested. Water treatment company records indicated that at two of four visits during February–July 2013, technicians noted the system was not operating (presumably because cooling was unnecessary or the programmed set points for temperature had been reached), and no residuals were checked. LTCFA was unable to provide information about when the system was operating during the months preceding the outbreak. The water treatment company was unable to provide further detail about the total amount of biocide used by the system during the months preceding the outbreak.

#### Laboratory Results

All confirmed cases were diagnosed by UAT for *L. pneumophila* serogroup 1. Two suspect cases were diagnosed by detection of *Legionella* species by using a validated nucleic acid assay. Of 15 clinical respiratory specimens available for *Legionella*-specific culture at CDC's *Legionella* laboratory (10 from patients with confirmed LD and 5 from patients with possible LD), only one was positive for *Legionella* spp.

*Legionella* was isolated from multiple potable water sampling sites in Buildings 1 and 2 and from the cooling tower reservoir and above-ground drip pan. Results of *Legionella*-specific culture of environmental and clinical specimens identified a matching strain of *Legionella* (sequence type 222) in the cooling tower, Building 2 potable water system, and one patient (Table 2). The patient, a resident of Building 1, denied exposure to potable water systems in Building 2.

#### Discussion

Our investigation revealed that a newly installed cooling tower with a disinfection system set to inject biocide only when it was in active use was the primary source of illness during this outbreak. The mechanism for patient exposure included aerosolized water from the cooling tower entering the fresh air intakes for the nearby buildings up to 500 feet away. This is supported by the fact

that LD was confirmed among six residents of Building 3 (furthest building from the cooling tower), where no *Legionella* was recovered from the potable water, and two of these patients reported never having left the building during their incubation period. Microbiologic evidence that supports this conclusion includes matching Lp1 strains between environmental isolates and a clinical isolate obtained from a patient who did not have exposure to the potable water in Building 2.

Although initial assessment of the cooling tower system at LTCFA indicated that it was an unlikely source because of its limited size, newer design, and reportedly adequate maintenance since installation fewer than five months earlier, the finding that both the drip pan and reservoir were heavily colonized with multiple strains of *Legionella* led to the immediate cessation of its use followed by cleaning and remediation. Our investigation revealed that the timed delivery of biocide to the system only when it was in use, combined with intermittent use of the system during February–June, likely resulted in inadequate provision of disinfectant to the system and led to the amplification of *Legionella*. Aerosolized water from the *Legionella*-contaminated system might be delivered into the buildings on the LTCFA campus through the fresh air intake systems.

Nineteen possible cases of LD among patients who experienced an illness compatible with pneumonia and had negative UAT were reported. Because multiple species and serogroups of *Legionella* were isolated from environmental samples at LTCFA, a negative UAT might represent an infection with a non-Lp1 *Legionella* species or might represent another etiology entirely. Heightened concern among residents and staff at LTCFA might have prompted persons with relatively mild illness or nonspecific symptoms to seek medical attention, and knowledge of the outbreak in the community might have led to overdiagnosis of pneumonia. Without

**TABLE 2**  
**Summary of Clinical and Environmental Laboratory Results, Long-Term Care Facility A (LTCFA) Outbreak, Ohio, 2013**

Sample	Culture Result	SBT <sup>a</sup> Result
Clinical isolate, resident of Building 1	<i>Legionella pneumophila</i> serogroup 1, MAb-2 positive	ST222 <sup>a</sup>
Building 1	<i>L. pneumophila</i> serogroup 3	ST995
	Blue-white <i>Legionella</i> species	N/A <sup>a</sup>
Building 2	<i>L. pneumophila</i> serogroup 1, MAb-2 positive	ST222
Building 3	No <i>Legionella</i> isolated	N/A
Condominiums	No <i>Legionella</i> isolated	N/A
Cooling tower	<i>L. pneumophila</i> serogroup 1, MAb-2 positive	ST222
	<i>L. pneumophila</i> serogroup 1, MAb-2 negative	ST1
	<i>L. dumoffi</i>	N/A
Fountain	No <i>Legionella</i> isolated	N/A

<sup>a</sup>SBT = sequence-based typing; ST = sequence type; N/A = not applicable; SBT can only be performed on *L. pneumophila*.

obtaining respiratory specimens from these patients, conclusively determining whether their illness was caused by an infection with *Legionella*, another etiology of pneumonia, or another disease process is impossible.

**Conclusion**

This investigation has important implications for cooling tower design in preventing LD outbreaks. Cooling towers that rely on a timed delivery of biocide only when the system is actively being used can become a reservoir for amplification and dissemination of *Legionella*. This is a particular concern during season changes, when cooler or warmer than expected temperatures can lead to variations in cooling demand, causing automated systems to turn on and off and creating environments more conducive to the growth of *Legionella*. Manu-

facturers should consider other alternatives to this design, and building facilities managers and treatment contractors should be knowledgeable about the methods of biocide delivery and measurement in cooling towers that they maintain. Public health should partner with hospitals and long-term care facilities, experts in facility construction and maintenance, and the heating, cooling, and plumbing industries to ensure that recommendations for the prevention of *Legionella* in water systems will protect vulnerable populations. 🦠

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