Legionella: Could This Potentially Deadly Bacteria Be Lurking in Your Facility’s Water Distribution System?

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Abstract

Legionnaires’ disease is a serious, sometimes lethal pneumonia. The name of this illness originated from an outbreak of severe pneumonia among attendees at an American Legion convention in Philadelphia, Pennsylvania, in 1976. The Pennsylvania Department of Health reports one of the highest annual incidence rates by state. Numerous healthcare facilities have reported outbreaks of healthcare-acquired legionnaires’ disease, with transmission consistently linked to the hot water distribution system. Preventing healthcare-acquired legionnaires’ disease depends upon identifying possible sources where *Legionella* growth could occur and instituting control measures. Health departments and public agencies have issued infection prevention guidelines to prevent outbreaks. Proactive culturing for *Legionella* in the hot water distribution system before cases of healthcare-acquired legionnaires’ disease are discovered is an evidence-based method of prevention. Superheating and flushing or hyperchlorinating the hot water distribution system are short-term approaches to terminate an outbreak. Long-term systemic water treatment with copper-silver ionization, chlorine dioxide, or monochloramine has also been effective in controlling *Legionella*.

Introduction

Legionellosis, a respiratory infection caused by *Legionella* bacteria, can manifest as legionnaires’ disease or Pontiac fever. Legionnaires’ disease is a serious, sometimes lethal pneumonia accompanied by dry cough, fever, and myalgia. Gastrointestinal tract, central nervous system, and renal manifestations also may be associated. Pontiac fever is a less serious influenza-like, self-limiting illness.¹ Risk factors for legionellosis include advanced age, male gender, cigarette smoking, alcohol abuse, chronic pulmonary disease, and renal failure. Immunosuppressed hosts, particularly those receiving corticosteroids or those who have undergone a solid organ transplant, are most frequently involved in healthcare-acquired cases.² The incubation period for legionnaires’ disease is 2 to 10 days and 1 to 2
days for Pontiac fever. Legionnaires’ disease can be treated successfully with antibiotics in most cases.\(^1\) Case fatality ranges from 13% for community-acquired cases up to 33% for healthcare-acquired legionnaires’ disease.\(^2\) Millions of healthcare dollars are spent annually treating patients who have legionnaires’ disease.\(^3\)

Legionellosis is acquired by inhaling aerosols that contain the bacteria or aspirating drinking water that contains the bacteria. Possible sources for water droplets contaminated with \textit{Legionella} include man-made water distribution systems, such as those in buildings, that provide favorable water temperatures, physical protection within biofilms, and nutrients that promote the growth of \textit{Legionella}.\(^2\) Studies have shown that 20% to 70% of hospital hot water systems have been colonized with \textit{Legionella} bacteria.\(^4\) Numerous healthcare facilities have reported outbreaks of healthcare-acquired legionnaires’ disease with transmission consistently linked to the hot water distribution systems. Decorative water fountains have also been linked to clusters of legionnaires’ disease in healthcare facilities.\(^2\)

The Centers for Disease Control and Prevention (CDC) investigated the first outbreak of legionnaires’ disease, involving delegates to the American Legion Convention held at a Philadelphia, Pennsylvania, hotel in 1976.\(^5\) Legionellosis is a nationally reportable disease, and CDC estimates legionnaires’ disease was diagnosed in 5,000 people in 2014, a four-fold increase since 2000.\(^6\) The Pennsylvania Department of Health (PA DOH) reports between 300 and 500 total cases each year, one of the highest annual incidence rates by state.\(^7\) The true incidence of legionnaires’ disease is likely higher because of missed diagnosis and underutilization of diagnostic testing.\(^8,9\) CDC also reports 20 or more outbreaks of legionnaires’ disease nationally each year, most of which are in buildings with large water systems, such as healthcare facilities.\(^6\) CDC’s investigation of legionnaires’ disease outbreaks revealed that healthcare-acquired legionnaires’ disease was responsible for 57% of cases and 85% of deaths from legionnaires’ disease.\(^10\) The waterborne disease investigative branch of CDC also found \textit{Legionella} to be responsible for 66% of all waterborne disease outbreaks in the United States between 2011 and 2012.\(^11\)

Although there are more than 60 species in the \textit{Legionella} family, \textit{Legionella pneumophila} causes 80% to 90% of legionnaires’ disease in the United States, with 75% caused by \textit{Legionella pneumophila} serogroup 1. Only about half of the more than 60 other \textit{Legionella} species have been implicated in human disease and some species are quite common in the environment but rarely cause infection. Some \textit{Legionella} organisms are among a group of species that fluoresce blue-white under long-wave ultraviolet light. They are referred to as blue-white fluorescing species and include \textit{Legionella anisa}, \textit{Legionella bozemanii}, \textit{Legionella dumoffii}, and \textit{Legionella gormanii}. To read more about \textit{Legionella} species, visit \url{http://www.specialpathogenslab.com/legionella-species.php}. The most commonly used diagnostic test is the \textit{Legionella} urinary antigen test, which is specific for \textit{Legionella pneumophila} serogroup 1.\(^8\)

Analysts sought to evaluate the incidence of definite and possible healthcare-acquired legionellosis cases and healthcare-acquired legionellosis outbreaks in Pennsylvania from 2007 through 2016.

\textbf{Methods}

Analysts used data from Pennsylvania's version of the National Electronic Disease Surveillance System (PA-NEDSS) to review the incidence of legionellosis cases identified and reported in the state. PA-NEDSS receives legionellosis reports from laboratories and healthcare facilities, which is more comprehensive than the Pennsylvania Patient Safety Reporting System or the National Healthcare Safety Network databases that receive legionellosis reports from healthcare facilities only.

PA-NEDSS case definitions are as follows:\(^12:\)

http://patientsafety.pa.gov/ADVISORIES/Pages/201709_Legionella.aspx

9/20/2017
1. A “case” is defined as healthcare-acquired legionellosis if a patient, employee, visitor, or volunteer spent any amount of time in a healthcare facility (i.e., inpatient or outpatient visits, emergency departments, doctor offices, or long-term care facilities) in the 10 days prior to onset of illness.

   a. A case is defined as “definite” healthcare-acquired legionellosis if the individual spent the entire 10 days in a healthcare facility before symptom onset.

   b. A case is defined as “possible” healthcare-acquired legionellosis if the individual spent a portion of the 10 days in or at a healthcare facility before symptom onset.

A healthcare-acquired legionellosis “outbreak” is defined as the occurrence of two or more cases that are epidemiologically linked (i.e., time, location, and illness characteristics).\(^{13}\)

**Results**

Pennsylvania’s healthcare-acquired legionellosis cases have trended upward over the past 10 years. The numbers of definite healthcare-acquired and possible healthcare-acquired legionellosis cases reported to PA-NEDSS are shown in Figure. The number of healthcare-acquired legionellosis cases doubled from 45 in 2007 to 91 in 2016. Thirteen healthcare-acquired legionellosis outbreaks were reported to PA-NEDSS from 2007 through 2016.

**Figure. Healthcare-Acquired Legionellosis Cases in Pennsylvania**

![Bar chart showing healthcare-acquired legionellosis cases in Pennsylvania from 2007 to 2016.](http://patientsafety.pa.gov/ADVISORIES/Pages/201709_Legionella.aspx)

**Source:** The Pennsylvania version of The National Electronic Disease Surveillance System.
The incidence of healthcare-acquired legionellosis is increasing in Pennsylvania. The reason for the increase is unknown, but many factors play a role. A true increase in the frequency of disease includes human factors of more people at risk due to an aging population and people with weakened immune systems due to underlying illness or immunocompromising medications; and environmental issues of aging plumbing infrastructure and climate change. Increased diagnostic testing and more reliable reporting to PA-NEDSS are also factors.8

The prevention of healthcare-acquired legionnaires’ disease depends on identifying possible sources where Legionella growth could occur and instituting control measures.14 The Allegheny County Health Department in Pittsburgh, Pennsylvania, published the first guideline for preventing healthcare-acquired legionnaires’ disease in the 1990s, based in part on the experience of Pittsburgh investigators at the Veterans Affairs Medical Center. This guideline, “Approaches to Prevention and Control of Legionella Infection in Allegheny County Health Care Facilities,” reviews diagnostic testing for Legionella infection, advocates for proactive environmental surveillance culturing for Legionella in hot water systems, and recommends options for controlling Legionella in water distribution systems.15,16 Routine annual environmental monitoring of water distribution systems—or more often if transplant surgery is performed at the facility—followed by implementation of disinfection methods if indicated, was later shown to significantly reduce healthcare-acquired legionnaires’ disease in Allegheny County and Western Pennsylvania.17 In July 2016, New York passed the first statewide regulation addressing building-associated legionnaires’ disease by mandating proactive culturing of healthcare facility water systems. Hospitals and residential healthcare facilities in New York are required to implement an environmental assessment, develop a Legionella sampling and management plan for their cooling towers and potable water systems, and take necessary responsive actions.18

The process to develop the first national standard for preventing legionellosis in the United States began in 2005. This process culminated in 2015 with the approval of a new industry standard developed by the American Society for Heating, Refrigerating and Air-conditioning Engineers (ASHRAE). This standard, titled ANSI/ASHRAE Standard 188-2015, Legionellosis: Risk Management for Building Water Systems, is a risk management approach to the control and prevention of building-associated legionnaires’ disease. ASHRAE Standard 188 applies to buildings with any of the following: (1) multiple rooms served by a centralized water heater, (2) 10 or more stories, (3) healthcare facility where patient stays exceed 24 hours, (4) housing immunocompromised individuals, (5) cooling towers, ornamental fountains, and/or whirlpools, and (6) housing occupants older than 65 years. To comply with ASHRAE Standard 188, facility managers need to assess the potential risk in their buildings by performing a survey for devices and building characteristics that have been associated with increased risk for legionnaires’ disease. A program team makes many of the decisions for implementing the standard requirements, including when, where, and how to test for Legionella. This decision-making responsibility can also be a source of liability, including litigation and unfavorable publicity, should the team not seek advice from knowledgeable partners such as water treatment providers and consultants. CDC recognizes this potential gap in knowledge for those implementing ASHRAE Standard 188 and has written “A Practical Guide to Implementing Industry Standards.”4,19

Most recently (in June 2017), the Centers for Medicare and Medicaid Services (CMS) issued a policy memorandum for hospitals and long-term care facilities to raise awareness about facility requirements to prevent Legionella infections. CMS expects Medicare-certified healthcare facilities to develop and adhere to policies and procedures that reduce the risk of growth and spread of Legionella and other opportunistic pathogens in building water systems. CMS surveyors will review policies, procedures, and reports documenting water management implementation results to verify that facilities have taken the following steps:

1. Conduct a facility risk assessment to identify where Legionella and other opportunistic waterborne pathogens could grow and spread in the facility water system.
2. Implement a water-management program that considers the ASHRAE industry standard and the CDC toolkit and includes control measures such as physical controls, temperature management, disinfectant level control, visual inspections, and environmental testing for pathogens.

3. Specify testing protocols and acceptable ranges for control measures, and document the results of testing and corrective actions taken when control limits are not maintained.

CMS expects healthcare facilities to comply with the new requirements to protect the health and safety of its patients. Noncompliance with the requirements will be cited accordingly.²⁰

Detection of *Legionella*

**When to Test**

Environmental testing can be proactive as described above or can follow identification of a case or outbreak. According to CDC, environmental testing should be performed if a single case of definite healthcare-acquired legionnaires’ disease has been diagnosed (the individual spent the entire 10 days in a healthcare facility before symptom onset) or two or more cases of laboratory-confirmed possible healthcare-acquired legionnaires’ disease (the individual spent a portion of the 10 days in or at a healthcare facility before symptom onset) occur within six months of each other.²¹

**How to Test**

Both the ACHD guideline and the New York regulations, for a 500-bed hospital, recommend selecting and testing a minimum of 10 distal sites, faucets or showers, that roughly represent the water distribution system (i.e., sites on multiple floors and wings, and include high-risk units such as hematology and oncology, transplant, medical/surgical, intensive care, and neonatal intensive care).¹⁵,¹⁸ Note that for sampling potable water systems, testing only hot water systems can be sufficient. The concentration of *Legionella* recovered from a given outlet has not been shown to correlate with disease risk. Rather, a distal-site positivity rate of 30% or greater for *Legionella* in a hospital water system has been shown to be a better indicator of risk for healthcare-acquired legionellosis.¹⁶,²²,²³

Routine surveillance can be performed using either swab or water samples. The results will be affected by the type of sample collected and the method of sample collection. Stout and Yu recommend collecting swab samples before water samples and after removal of the faucet aerator to achieve maximum recovery of *Legionella* from the biofilm within the fixture. If aerators are not removed, biofilm cannot be adequately sampled and the results can show a false negative. Water samples should be collected from the initial flow of hot water with no flushing of the outlet prior to sample collection. Flushing can reduce the recovery of *Legionella*. A volume of 250 mL is collected in a sterile bottle. Sample collection supplies are usually provided by the laboratory at no charge. In the context of a case investigation, Stout and Yu recommend that both swab and water samples should be collected from the water outlets in the immediate environment of the suspected case, to optimize sensitivity.²⁴

For laboratories performing *Legionella* testing, the standard for environmental microbiology and laboratory quality management is International Organization for Standardization (ISO) 17025. Microbiological culture for *Legionella* on selective media remains the gold standard for detection per ISO 11731 Water quality - Enumeration of *Legionella* or ISO 11731-2 Water quality - Detection and enumeration of *Legionella*.¹⁸,²⁵ No other methods, such as direct fluorescent antibody (DFA or DFA) or polymerase chain reaction (PCR), have proven more sensitive or specific for detecting *Legionella* pneumophila.²

Disinfection of Water Systems
More than one method can be used to disinfect hot water systems, such as the following: (1) chemical disinfection, such as copper-silver ionization, chlorine dioxide, and monochloramine and (2) physical, such as point-of-use filters placed in high-risk units such as neonatal intensive care or transplant.

**When to Disinfect**

Healthcare facilities can consider the following questions to decide whether to install a disinfection system:

1. How extensive is the colonization? (Are >30% of outlets positive?)
2. Is *Legionella* pneumophila serogroup 1 present?
3. Have cases of healthcare-acquired legionnaires’ disease (definite or possible) been diagnosed?
4. Is the facility housing at-risk individuals?

If the answer is yes to one or more of these questions, then consider disinfection. Finding species other than *Legionella pneumophila* would warrant continuous disinfection if found in a high-risk unit such as bone marrow or solid organ transplant units.16,23,25

The decision regarding selection of the disinfection method for a healthcare facility is best made by a task force consisting of administrators, infection preventionists, and hospital engineers. Input from the facility’s Infection Prevention and Control Department will help ensure that there will be an evidence-based approach to selection and will include review of relevant literature. Pitfalls exist for choosing a disinfection system based solely upon a vendor’s recommendation. Evaluation of disinfection efficacy can include both *Legionella* distal site positivity and disinfectant concentrations at select locations. Issues to consider include the necessity for maintenance, regular monitoring, and possible permitting requirements. Objective assessments from other hospitals’ infection preventionists and engineers that have used the systems being evaluated may provide information to help facilities make decisions about what type of disinfection system might be appropriate for their facility.27 Four standard criteria have been recommended to evaluate disinfection methods:

1. Documentation of efficacy in vitro against *Legionella*
2. Anecdotal reports of efficacy in controlling *Legionella* contamination in individual facilities
3. Peer-reviewed and published reports based on controlled studies of prolonged duration (years) demonstrating the efficacy of controlling *Legionella* growth and preventing cases of healthcare-acquired legionnaires’ disease in individual facilities
4. Confirmatory reports from multiple hospitals with prolonged duration of follow-up as validation

**How to Disinfect**

The most common methods for controlling *Legionella* in the water distribution system of hospitals and other large buildings are listed in Table. The United States Environmental Protection Agency offers a literature review document of *Legionella* control measures at: https://www.epa.gov/ground-water-and-drinking-water/technologies-legionella-control-premise-plumbing-systems (https://www.epa.gov/ground-water-and-drinking-water/technologies-legionella-control-premise-plumbing-systems). Preference is given to application to the hot water only because this has been shown to be effective in preventing illness, does not add additional chemicals to the drinking water, and requires less chemical addition because the volume of treated hot water is a fraction of the cold water used in a facility.26,27,29
<table>
<thead>
<tr>
<th>Disinfection Method</th>
<th>Intermittent or Emergency Short-Term Applications</th>
<th>Continuous Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal shock treatment (superheat and flush)</td>
<td>√</td>
<td></td>
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<tr>
<td>Shock chlorination (&gt;10 mg/L residual, may require water tanks to be at a level of 20 to 50 mg/L)</td>
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<tr>
<td>Continuous chlorination (2 to 4 mg/L)</td>
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<tr>
<td>Copper-silver ionization</td>
<td>√</td>
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<td>Chlorine dioxide</td>
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<td>Monochloramine</td>
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<tr>
<td>Point-of-use filtration</td>
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Conclusion

The increasing incidence of legionnaires’ disease, the millions of healthcare dollars spent annually in treating these patients, and the high morbidity and mortality associated with legionnaires’ disease provide compelling arguments for a focus on prevention. Evidence-based risk reduction strategies may control and proactively prevent healthcare-acquired legionellosis. Implementation of prevention strategies may save lives and healthcare dollars and control litigation and unfavorable publicity. Healthcare facilities are encouraged to renew their focus on prevention in an attempt to reverse the trend of increasing rates of legionnaires’ disease and devastating outbreaks.

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