The National Academies of SCIENCES ENGINEERING MEDICINE

Management of *Legionella* in Water Systems

CONCLUSIONS AND RECOMMENDATIONS FOR HEALTHCARE PROFESSIONALS

Legionnaires' disease is on the rise. Below are recommendations from this report to advance understanding of the causes, incidence, detection, and diagnosis of the disease, which is caused by Legionella bacteria.

Legionella bacteria may grow on virtually any surface that contacts water. Although the bacteria reside naturally in many rivers, lakes, and soils, *Legionella* can flourish in the pipes, tanks, and other components of humanmade water systems, where the combination of stagnant water, warm temperatures, and loss of residual disinfectants can lead to explosive bacterial growth. When contaminated water from those systems is aerosolized, for example, by showerheads, people can be exposed to *Legionella* when they breathe in the mist.

Legionella infections (legionellosis) can lead to Legionnaires' disease, a pneumonia characterized by fever, cough, shortness of breath, aching muscles, gastrointestinal symptoms and altered mental state. Those at greatest risk of developing the disease are the immuno-compromised, the elderly, men, and smokers. Between 3 and 33 percent of cases of Legionnaires' disease lead to death. Exposure can also result in a milder, flu-like condition called Pontiac fever. Most reported cases of Legionnaires' disease in the U.S. are found to be caused by *Legionella pneumophila*, although many other species of *Legionella* are known to be pathogenic.

INCIDENCE OF LEGIONELLOSIS AND OCCURRENCE OF *LEGIONELLA*

Rates of reported Legionnaire's disease have risen six-fold in the United States and Europe in the past 20 years, and current reported incidence is likely a substantial underestimate of the actual disease burden. **This report estimates that the true incidence is 52,000 to 70,000 cases of Legionnaires' disease in the United States each year, about ten times the reported incidence.** The incidence is likely to rise each year until more effective prevention measures are in place.

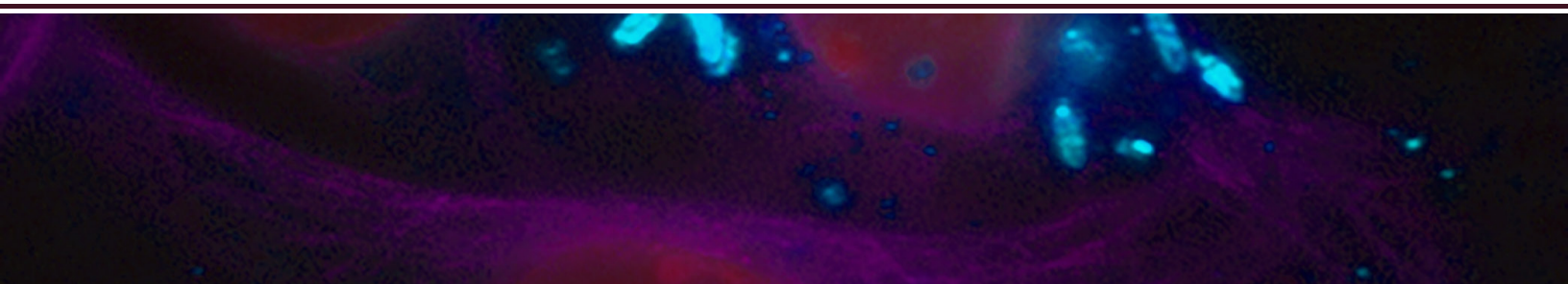
There are many sources of *Legionella* risk in engineered water systems, from cooling towers to building plumbing to hot tubs. Most of the *Legionella* occurrence data gathered from these sources are highly variable and sparse, making comparisons among studies difficult and detection of spatial and temporal trends almost impossible. In only a few outbreak investigations have clinical and environmental data been linked to definitively show that a particular water system was the source of a Legionnaires' disease cluster.

The available data suggest that cooling towers, hot tubs, building plumbing and its fixtures such as showerheads and faucets, and wastewater treatment plants can be hot spots for growth of *Legionella* and for inhalation exposure. Most of these data were collected during outbreaks of Legionnaires' disease, which comprise only 4 percent of all reported cases. In order to better understand the sources of sporadic disease (not associated with an outbreak), improved environmental monitoring methods that facilitate temporal and spatial assessment of changes in *Legionella* levels within buildings will be needed to better understand background levels, potential exposure, and ultimately risk. A collaborative, widespread national survey of *Legionella* that included distribution systems, premise plumbing in various types of buildings, and cooling towers would be useful for further understanding the *Legionella* concentrations of concern and the risks of sporadic Legionnaires' disease.

EPIDEMIOLOGY

The CDC should strengthen the National Notifiable Disease Surveillance System and the Supplemental Legionnaires' Disease Surveillance System to include environmental exposures as feasible, including both the potential exposure setting and the type of related building water systems. Although all cases will not receive thorough environmental investigations, at a minimum it should be discerned whether a case may be associated with a healthcare facility, accommodation site, hot tub, or other well-recognized potential source, as well as some information about the building water system and any known deficiencies (e.g., water main breaks) during the incubation period. Similarly, within the National Outbreak Reporting System (NORS), the Centers for Disease Control and Prevention (CDC) should consider housing *Legionella* outbreak data in a separate database from enteric pathogens to make NORS more useful for legionellosis prevention and control. In addition, timely analyses by setting and type of water system, with more frequent updating of publicly available data, would improve the usefulness of NORS for assessment of *Legionella* prevention efforts.

An improved understanding of sporadic, community-acquired cases of Legionnaires' disease is critical to reducing the rising rates observed over the last 20 years. **Determining the most common sources of sporadic disease will require well-funded, population-based studies in multiple jurisdictions (e.g., cities, counties, states).** Such studies would require the recruitment of multiple medical centers with an adequate number of *Legionella* cases each year, willingness and capacity to collect clinical samples for *Legionella* culture, environmental personnel with knowledge of how to sample the most likely sources of exposure for legionellosis patients, and laboratory capacity to reliably grow *Legionella* from clinical and environmental samples. In the United States,



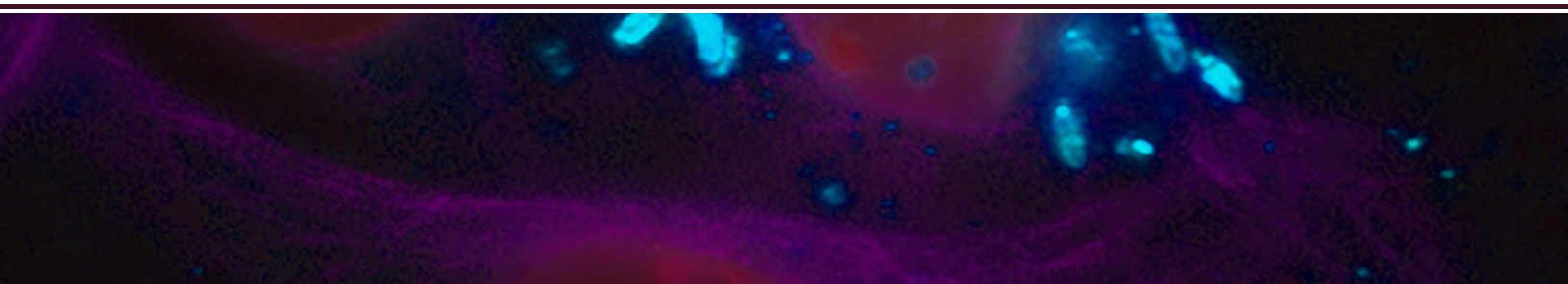
clinical cultures are currently utilized for less than 10 percent of cases; thus, an effective study would have to dramatically improve on the current capacity to obtain cultures from patients. Enhanced clinical culture capacity is also essential to accurately assess the contribution to disease from non-*pneumophila Legionella*, and *L. pneumophila* that is not serogroup 1.

The CDC should work with states to gain closer to real-time reporting and investigation of travel-associated cases. Many outbreaks of travel-associated disease can be best detected at the national level, since many of the patients who report staying in a hotel or other accommodation during the incubation period have crossed state lines. Currently, reporting of travel-associated cases from many states is neither timely nor complete. Better understanding travel-associated cases is an easy target for intervention, as these data are often readily available from patient interviews, can help to link individual cases to larger clusters, and may help to identify opportunities to limit further exposures.

Although *Legionella* program efforts are underway in some states, most state health departments are severely lacking (both in resources and expertise) in their programs of surveillance, prevention, and control for Legionnaires' disease. **Regional Centers of Excellence for prevention and control of legionellosis could serve as a backbone to strengthen the capacity of state health departments to detect and investigate cases of Legionnaires' disease.** These centers could be modeled on the Integrated Food Safety Centers of Excellence and the Centers of Excellence for Vector-Borne Diseases, modified to include the relevant disciplines needed for *Legionella* applied research and control. The Centers could undertake critical applied research (e.g., optimizing culture methods and comparing them to new methods as discussed below, as well as coordinating the in-depth, multiple-jurisdiction studies of environmental exposures, recommended above). By building a cadre of experts in *Legionella* prevention and control that includes industrial hygienists and engineers, these centers could promulgate best practices for control, assist building managers as they create water management plans, and initiate certification programs for those responsible for building water safety.

BETTER CLINICAL TOOLS

T**here is an urgent need to develop better clinical tools that will capture more Legionnaires' disease cases and identify pathogenic *Legionella* beyond *L. pneumophila* serogroup 1.** The increasing rates of legionellosis, combined with its associated morbidity and mortality, demand improved diagnostics. First, hospitals in both rural and urban areas should have access to on-site urinary antigen testing to facilitate more targeted antimicrobial therapy and to increase disease recognition. Second, efforts to develop standardized molecular methods for *Legionella* diagnoses (including non-*pneumophila* species and *pneumophila* serogroups other than serogroup 1) should be prioritized by research laboratories and federal agencies. Such methods could increase understanding of the extent of the underestimate of reported disease rates and should be accessible outside of research and academic institutions. Finally, the U.S. Department of Health and Human Services should fund multi-center prospective studies of clinical respiratory samples using these new assays to better understand prevalence and diversity of the *Legionella* spe-



cies and serogroups causing clinical disease. There is also a need for education and a cultural shift from empiric treatment to use of available and future diagnostic tools for *Legionella* to better characterize the true incidence of legionellosis in the community.

RECOMMENDED MEDICAL RESEARCH

There is a need to better understand the mechanistic pathways for the development of Pontiac fever, and what roles the pathogen, endotoxins, *Legionella*-harboring amoebae, or other exposures play in disease pathogenesis. Additional studies aimed at understanding the differences in *Legionella* species characteristics associated with Pontiac fever are also needed. Because Pontiac fever is associated with less mortality, focused studies examining this clinical entity have been limited. Pontiac fever reporting occurs primarily through outbreak investigations, which limits assessments of true incidence, population risk, and an understanding of the relationship between certain *Legionella* species and serotypes and disease manifestations. There is a need to develop improved diagnostic tools for Pontiac fever (including molecular methods) that would enhance overall *Legionella* epidemiology and outbreak investigation and detection.

There is a need to better characterize legionellosis among neonates, young children, and adolescents, who may have varied epidemiologic risk factors for exposure to *Legionella* and differing risk for disease manifestations. There have been limited studies of Legionnaires' disease among children. The majority of current guidelines and recommendations focus on adult disease or target high-risk patient populations (e.g., immunocompromised hosts). Studies of community-acquired pneumonia, fever and non-respiratory viral influenza-like illnesss among pediatric populations that assess *Legionella* are needed.

Studies that further assess the contribution of aspiration of potable water as a mechanism for clinical legionellosis both in community outbreaks and among sporadic cases are needed. Inhaled respiratory droplets are thought to be the primary mode of exposure to *Legionella*, but other water-based exposure routes are poorly characterized. Aspiration, including microaspiration and silent aspiration, is thought to be potentially linked to legionellosis. Links between feeding tubes and among conditions that increase risk for aspiration, together with studies demonstrating potential short-term oral colonization, suggest potential risks from this pathway.

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