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Journal Title: Journal of Public Health Management and Practice
Volume: Volume 21, Number 5
Publisher: Lippincott, Williams & Wilkins | 2015, Pages E17-E26
Type of Work: Article | Final Publisher PDF
Publisher DOI: 10.1097/PHH.0000000000000123
Permanent URL: https://pid.emory.edu/ark:/25593/ps783

Final published version: http://dx.doi.org/10.1097/PHH.0000000000000123

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Legionellosis on the Rise: A Review of Guidelines for Prevention in the United States

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Context: Reported cases of legionellosis more than tripled between 2001 and 2012 in the United States. The disease results primarily from exposure to aerosolized water contaminated with *Legionella*. **Objective:** To identify and describe policies and guidelines for the primary prevention of legionellosis in the US. **Design:** An Internet search for *Legionella* prevention guidelines in the United States at the federal and state levels was conducted from March to June 2012. Local government agency guidelines and guidelines from professional organizations that were identified in the initial search were also included. **Setting:** Federal, state, and local governing bodies and professional organizations. **Results:** Guidelines and regulations for the primary prevention of legionellosis (ie, Legionnaires' disease and Pontiac fever) have been developed by various public health and other government agencies at the federal, state, and local levels as well as by professional organizations. These guidelines are similar in recommending maintenance of building water systems; federal and other guidelines differ in the population/institutions targeted, the extent of technical detail, and support of monitoring water systems for levels of *Legionella* contamination. **Conclusions:** Legionellosis deserves a higher public health priority for research and policy development. Guidance across public health agencies for the primary prevention of legionellosis requires strengthening as this disease escalates in importance as a cause of severe morbidity and mortality. We recommend a formal and comprehensive review of national public health guidelines for prevention of legionellosis.

KEY WORDS: **Legionella, legionellosis, Legionnaires' disease, prevention, public health, water supply safety**

Legionellosis, including Legionnaires' disease, is an important public health problem that is escalating rapidly in the United States.[1,2] The number of cases reported to US public health authorities rose from 1127 in 2000 to 3688 in 2012 and 4548 cases in 2013 (preliminary data).[3-5] The Centers for Disease Control and Prevention (CDC) estimated in the 1990s that there may be 8000 to 18 000 persons hospitalized with community-acquired Legionnaires' disease.[6] Current data may lead to higher estimates. The Occupational Safety & Health Administration (OSHA) provides an estimate of up to 50 000 Legionnaires' disease cases annually in the United States.[7] In addition, other areas of the world have witnessed growth in legionellosis in the past decade (Canada, Europe).[8,9] A few areas have been relatively stable in incidence (eg, Australia) or witnessed a decline (eg, Singapore).[10-12]

Legionella bacteria were first discovered after a large outbreak of pneumonia at an American Legion convention in Philadelphia, Pennsylvania, in 1976.[13,14] Subsequent retrospective testing of banked sera revealed that *Legionella* was also responsible for several older, unsolved outbreaks as early as 1957.[15-18] In the United States, Legionnaires' disease is caused primarily by inhalation of aerosols or aspiration of water

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This work was made possible through the support of the O. Wayne Rollins Foundation. The authors are grateful to Jeffrey P. Davis, MD, chief medical officer and state epidemiologist, State of Wisconsin Department of Health Services, Bureau of Communicable Diseases and Emergency Response, Division of Public Health, for his excellent review and thoughtful comments on the manuscript.

The authors report no financial conflicts of interest.

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DOI: 10.1097/PHH.0000000000000123

contaminated with *Legionella* bacteria, primarily *Legionella pneumophila*.[13,14] Soil and potting compost contaminated with *Legionella longbeachae* also pose a risk for human infection, particularly in some geographic areas such as Australia.[19,20]

Although *Legionella* bacteria are frequently found in natural water bodies, water systems in the built environment are the primary reason for the emergence and increase in Legionnaires' disease in the United States and many other countries.[21-23] *Legionella* bacteria thrive in the biofilms of water systems and are relatively resistant to chlorine levels found in potable water supplies. Greater use of engineering products that create aerosols has increased the risk of human exposure to the pathogen. Cooling towers, spas, outdoor and indoor fountains, showers, and misters used for produce in grocery stores are among many man-made water systems that have been identified as sources of *Legionella* infection.[21,24-26]

Legionella infection causes 2 distinct illnesses, Legionnaires' disease and Pontiac fever, both of which have been nationally notifiable diseases since 1976.[27] Legionnaires' disease is one of the more common causes of pneumonia in the United States; the mortality rate is estimated to be 5% to 30%.[28,29] Legionnaires' disease is clinically indistinguishable from other types of pneumonia.[25] Risk is reported to be highest among those older than 45 years, smokers, men, and individuals who are immunocompromised.[1,25] Pontiac fever usually presents as a self-limiting, influenza-like illness and is likely extensively underdiagnosed and underreported.[25]

Public health efforts have largely focused on identification of outbreaks of legionellosis, followed by investigation and source control. Cases associated with an outbreak comprise only 4% of the total number of individuals reported to public health authorities, and more attention is needed to address prevention of cases not known to be associated with an outbreak.[2,30] In this study, we sought to identify guidelines for the primary prevention of legionellosis in the United States.

Methods

An Internet search for *Legionella* guidelines in the United States was conducted between March and June 2012. The search phrases such as "US *Legionella* policy," "US *Legionella* guidelines," "US *Legionella* recommendations," "US *Legionella* prevention," and "US *Legionella* control" were used. State, district, and territory government Web sites, for example, www.Georgia.gov, were searched for the terms "*Legionella*," "Legionellosis," and "Legionnaires'." Using .gov domain names allowed us to examine multiple departments, such as health, energy, and environment, as *Legionella* prevention can span multiple sectors. Additional prevention guidelines at the local level, such as counties or cities, were identified and analyzed for inclusion. Further guidelines were identified after examining the references of those found previously. For guidelines not available online, we requested copies from the appropriate organization. Guidelines were defined as any policy, law, ordinance, regulation, or recommendation put forth by governing bodies and organizations.

To be considered a *Legionella* prevention guideline, the guidelines needed to incorporate recommendations on *Legionella* primary prevention in the built environment, with detailed information on the appropriate prevention measures to take. Guidelines focusing on the detection and control of outbreaks were not included.

Results

Our study found that there is no single set of widely accepted guidelines for the primary prevention of the disease. At least 4 federal agencies have been involved in guideline or policy development for the primary prevention of legionellosis, including CDC, Environmental Protection Agency (EPA), Veterans Health Administration (VHA), and OSHA. Numerous state and local governments have also been involved in the creation of guidelines for legionellosis prevention in their area of jurisdiction. In addition, several professional organizations have developed guidelines. These efforts have resulted in guidelines for preventing the transmission of *Legionella* in hospitals, hotels, cruise ships, and other settings. These guidelines differ in the population/institutions targeted, prevention methods recommended, and the extent of technical detail.

Federal agencies

CDC has created several guidelines related to *Legionella* infection control in the health care environment, with more limited guidance for other settings.[31-34] The Healthcare Infection Control Practices Advisory Committee to CDC developed "Guidelines for Environmental Infection Control in Health-Care Facilities" published by CDC in 2003.[31] In all health care facilities, CDC recommends that health care personnel maintain a high index of suspicion for health care–associated Legionnaires' disease and that laboratory tests, such as urine antigen, culture, or direct fluorescence assay, are available to clinicians.[31] CDC's guidelines reference the American Society of Heating, Refrigeration, and Air-Conditioning Engineers' (ASHRAE) 12-2000 guidelines for engineering standards and maintenance of water systems, described later.[35] CDC has few recommendations related to routine sampling of water for *Legionella*; one exception is related to periodic

sampling in protective environments and transplant units to ensure that there is no trace of *Legionella* in the water supply.[32-34,36]

EPA's Maximum Containment Level goal for drinking water is zero organisms, and *Legionella* is specifically listed as a contaminant needing control.[37] EPA states that as long as proper treatment technique is used for removal of *Giardia* and viruses, then *Legionella* should by default also be controlled.[38] It released "*Legionella*: Human Health Criteria Document" in 1999, in which it described the microbiologic features, distribution, and health effects of *Legionella* in the United States and references Allegheny County's (Pennsylvania) recommendations for routine environmental testing (described later).[39,40]

OSHA addresses occupationally acquired legionellosis in its 1999 "OSHA Technical Manual, Section III, Chapter 7: Legionnaires' Disease."[41] It outlines specific environmental sample culture action levels that focus on the quantity of *Legionella* colony-forming units (CFUs) per milliliter (CFU/mL) of water.[42,43] Specific disinfection procedures differ on the basis of the number of CFUs/mL, recognizing that risk depends on potential for exposure and concentration of the pathogen. OSHA heavily references the Wisconsin Protocol on proper maintenance of cooling towers, described later.[44]

VHA has at least 2 directives in place regarding *Legionella* disease. In 2008, it created the comprehensive VHA Directive 2008-010: "Prevention of *Legionella* Disease" for VHA inpatient facilities across the nation.[45] This directive presents 2 specific and detailed algorithms for monitoring *Legionella*, depending on the type of facility. One algorithm focuses on acute care (nontransplant) and nursing home care units (including long-term care units) and the other is for transplant and posttransplant facilities. Differences in monitoring procedures depend on a facility's history of health care–associated Legionnaires' disease and whether a facility uses monochloramine for water treatment. Each facility is required to conduct a risk assessment, involving a combination of environmental testing, which is similar to Allegheny County's protocol described later, and *Legionella* urine antigen testing for a specific number of patients.[40] VHA Directive 2009-009: "Domestic Hot Water Temperature Limits for *Legionella* Prevention and Scald Control" details the water temperature policies within VHA patient care facilities with the goal of reducing the risk of scalding while reducing the risk of *Legionella* exposure.[46]

State/territory level

States and territories differ in the amount of guidance posted on their Web sites that is related to primary prevention of legionellosis. Several states mention *Legionella* in their drinking and surface water regulations, which are the same as those of EPA's described earlier.[39] We found 10 states that have developed *Legionella* prevention guidelines that met our inclusion criteria.

During 1987, the Wisconsin Division of Health (now the Wisconsin Division of Public Health [DPH]) took the lead in developing one of the first guidelines for controlling *Legionella* in cooling towers after the occurrence of several notable *Legionella* outbreaks in the state.[44] They collaborated with experts from CDC, ASHRAE, other Wisconsin state agencies, local health departments, the University of Wisconsin, the Cooling Tower Institute, and other agencies, and the final product was distributed widely throughout Wisconsin and to all state health departments in the United States (Jeffrey P. Davis, MD, State of Wisconsin Department of Health Services, Bureau of Communicable Diseases and Emergency Response, Division of Public Health, e-mail communication, December 4, 2012). Referred to as the "Wisconsin Protocol," these guidelines were used for many years but were not formally revisited or updated by Wisconsin DPH or other public health agencies and accordingly are no longer actively distributed (Thomas E. Haupt, MS, Wisconsin Department of Health Services, e-mail communication, June 12, 2012). The Wisconsin DPH developed an interim guideline pertaining to water and decorative fountains in hospitals following an outbreak of Legionnaires' disease that was associated with an indoor water fountain in 2010.[24,47] In this guideline, Wisconsin DPH advised health care facilities with decorative fountains to establish strict maintenance procedures and conduct periodic bacteriologic monitoring for *Legionella*, if they continued to operate them.

In 2000, the Maryland Scientific Working Group, commissioned by the Maryland Department of Health and Mental Hygiene, released a set of *Legionella* prevention and control guidelines for the acute care hospital setting.[48] They recommended routine environmental testing for *Legionella* and advised hospitals to conduct their own risk assessment to determine the frequency of testing. They offered no recommendation on action levels for remediation because they deemed there was not enough evidence to support any and recommended each hospital determine its own levels via risk assessment. In addition, the working group suggested that other health care facilities, such as nursing homes, should be aware of the risks in their institutions and offered a scenario for *Legionella* monitoring in a 100-bed licensed nursing home.

There are several entities in the state of California with *Legionella* prevention recommendations directed toward the use of recycled water by industries or power plants. The California Code of Regulations, Title 22,

Section 60306, requires the use of biocides in recycled water used by industrial or commercial cooling towers to limit *Legionella* transmission and growth.[49] An additional draft guideline specific to *Legionella* prevention and control in power plant's recycled water was developed in 2004 by the State of California Energy Commission.[50] This draft guideline encourages the creation of a cooling tower management plan that tests power plant cooling tower water for *Legionella* either at least every 6 months or more frequently after routine testing reveals the system is "out of microbial control."[50] Disinfection procedures are initiated on the basis of the number of *Legionella* CFUs/mL.

The South Dakota Department of Health in 2005 commissioned *Legionella* Risk Management, Inc, a Pennsylvania-based company, to develop jointly a guideline for the control of *Legionella* in ornamental water features in the community, such as hotels, restaurants, offices, and conference centers.[51] This guideline describes the different risk factors for *Legionella* growth in ornamental water features, such as submerged lights, design, and location, and includes a sample risk management plan. It focuses on proper maintenance of water features and keeping accurate maintenance logs. For ornamental indoor water features in health care facilities, the guideline advises compliance with other national guidelines. South Dakota also recommends testing quarterly to ensure that *Legionella* levels are below 1 CFU [*sic* CFU/mL]; testing can then be reduced to annual testing after levels are consistently maintained below 1 CFU/mL for 1 year. In addition, the South Dakota legislature adopted administrative rules for temperature and chlorine levels in health care facility water supply systems.[52]

In response to hospital-associated *Legionella* outbreaks in 2005, the New York State Department of Health distributed a letter detailing *Legionella* prevention and control guidance to hospital administrators.[53] This letter contained recommendations for clinicians, information on surveillance and outbreak investigation, and environmental and engineering prevention measures. In the letter, the New York State Department of Health recommends quarterly *Legionella* environmental sampling in transplant units and states a multidisciplinary team must determine if their health care facility should do routine environmental testing in nontransplant units based on a review of current empiric literature and the risk assessment of their facility. The guidance offers detailed information on temperature ranges, scalding precautions, disinfection procedures, and sampling techniques.

The New Jersey Department of Health and Senior Services (now New Jersey Department of Health) developed guidelines for *Legionella* prevention in hospitals with assistance from the New York State Department of Health.[54] New Jersey Department of Health recommends that general hospitals organize a multidisciplinary team to determine if nontransplant units should conduct routine environmental cultures. It recommends transplant units, at a minimum, conduct quarterly environmental sampling and culture of potable water sources for *Legionella*.

The Texas Department of State Health Services formed a task force in 1999 to create a *Legionella* prevention guideline for health care settings. After the release of the Maryland Scientific Working Group's recommendations, the Texas Legionnaires' Disease Task Force incorporated many elements of Maryland's plan, with some modifications.[48,55] The task force recommended that acute care hospitals form a team headed by a hospital epidemiologist or infection control professional to evaluate the risk of nosocomial *Legionella* transmission by assessing patient population characteristics as well as environmental and engineering factors, including results of previous testing of the water, to determine whether their facility is at significant risk.[55] If the team determines that the risk of legionellosis is significant, routine culturing for *Legionella* in hot water tanks, distal sites, and faucets, and in some cases showerheads, is recommended. The task force recommended testing in long-term care facilities with confirmed or probable nosocomial cases. For both hospitals and long-term care facilities, the task force recommended primary prevention strategies, such as education of clinicians, to maintain a high level of suspicion for nosocomial cases and how to diagnose cases. They also recommended education of engineering and patient staff about proper maintenance of equipment and remediation of *Legionella* colonization in the facility's water system.

Louisiana Department of Health and Hospitals provides engineering and water management procedures for cooling towers, hot water systems, and spas that focus on hyperchlorination and temperature regulation.[56] This manual references the American Society of Healthcare Engineers Technical Document that details how to implement the Joint Commission for the Accreditation of Healthcare Organizations (JCAHO) standards (described later).[57]

The Northern Nevada Adult Mental Health Services, under the purview of the Nevada Department of Health and Human Services, developed a *Legionella* prevention and control policy for its mental health facilities.[58] It references some of CDC's recommendations including (1) maintenance of a high level of suspicion for legionellosis, (2) implementation of active surveillance if a nosocomial case is identified, and (3) implementation of ASHRAE's biocide recommendations. The Northern Nevada Adult Mental Health Services policy also discusses prevention techniques

for water fountains and specific ice machines in their buildings, as well as how to control increased aerosols during facility renovation.

Utah's Bureau of Epidemiology in the Department of Health released *Legionella* guidelines intended for businesses, especially hotels, and referenced ASHRAE's prevention guidelines with emphasis on control through temperature regulation, periodic inspection of the water system infrastructure, and thermal disinfection or shock chlorination.[35,59] Its guidelines focus on water distribution systems and HVAC (heating, ventilation, and air-conditioning) systems and provide guidance on recommended water temperatures and chlorination levels.

Local level

Several cities and counties have developed their own guidelines for legionellosis prevention.[40,60-62] In 1992, Allegheny County Health Department in Pennsylvania led a task force consisting of medical, public health, and water professionals to establish a guideline for *Legionella* infection prevention.[40] Revised in 1997, this guideline advocates a proactive approach to controlling legionellosis in health care settings. The guideline encourages annual environmental testing in hospitals (unless transplants are performed, in which case, they should sample more often), specifies the number of sites that should be tested depending on hospital size, and offers guidance on when and how to disinfect potable water systems. The guideline states that if 30% of the distal sites cultured are positive for *Legionella*, then appropriate disinfection measures should be considered. As previously mentioned, several other state and federal *Legionella* prevention guidelines reference the Allegheny County recommendations.[39,45,48,55]

The Code of Ordinances implemented by the city of Garland, Texas, mandates routine testing of cooling towers for *Legionella* in certain settings.[62] City ordinance section 32.04, adopted in 2005, requires annual testing specifically for the presence of *L. pneumophila* in cooling towers serving multifamily homes. If the specimen is culture positive (>4 CFUs/mL), then the owner must sanitize the tower and continue to test until results are culture negative (Ashton J. Tassin, REHS, Garland Health Department, e-mail communication, May 18, 2012).

Private industry/professional organizations

ASHRAE first developed recommendations for prevention of legionellosis in 2000. Guideline 12-2000: "Minimizing the Risk of Legionellosis Associated With Building Water Systems" is intended for "designers, owners, operators, users, maintenance personnel, and equipment manufacturers" of nonresidential buildings and multifamily homes.[35] It contains comprehensive information on the different types of water systems, such as potable water, heated spas, fountains, cooling towers, and evaporative air coolers, and specifies how each system operates, the average temperature ranges, whether it produces water droplets, possible contamination with nutrients, any history of Legionnaires' disease associated with it, and the recommended treatment procedures. ASHRAE Guideline 12-2000 suggests environmental testing to either evaluate a water treatment or determine a potential source of contamination after a *Legionella* case has been detected and reported to public health authorities. The guideline emphasizes the importance of water system maintenance and treatment in the control of *Legionella*.

A committee formed by ASHRAE plans to develop a revised standard, "BSR/ASHRAE Standard 188P: Prevention of Legionellosis Associated With Building Water Systems."[63,64] The proposed standard will make recommendations for prevention practices for *Legionella* associated with building water systems and applies to human-occupied buildings with centralized industrial or commercial building water systems; it does not apply to single-family homes.[63] The draft revised standard has been through several iterations; a version released for public comment in 2011 recommended conducting an annual risk characterization for each building and then developing a plan based on the principles of Hazard Analysis and Critical Control Points (HACCP).[65] The draft standard does not provide guidance on environmental monitoring for *Legionella* and defers to individual building teams the decision as to whether routine *Legionella* environmental culturing will be performed.[65]

Under section EC 1.7 of the JCAHO Environmental Care standards, all JCAHO-accredited facilities are required to reduce the potential for "organizational-acquired illness" by creating management programs for cooling towers, hot water systems, and other utility systems that aerosolize water.[66] In 2001, JCAHO partnered with American Society of Healthcare Engineers to release guidance on how to comply with these requirements as well as a *Legionella* executive brief.[57] They cautioned that although JCAHO Standard EC 1.7 does not specifically mention *Legionella*, *Legionella* transmission through utility systems is well documented; therefore, the standard is presumed to cover *Legionella* environmental control. The JCAHO and American Society of Healthcare Engineers guidance follows CDC guidelines and states that there is no recommendation to routinely culture for *Legionella* in water systems.[57]

Additional professional organizations such as the Association of Water Technologies, Cooling Technology Institute, and the American Industrial

Hygiene Association have documents to help their members address *Legionella* in their respective built environments.[67-69] The Association of Water Technologies released a position statement in 2003 conveying that all water systems with the possibility of *Legionella* colonization would benefit from a risk assessment to determine the need for routine sampling. The position statement supports *Legionella* sampling in water systems that have been evaluated to pose a disease risk and supports using quantitative *Legionella* colony counts (CFU/mL) as a guide for when to implement remediation treatment.[67] The Cooling Technology Institute provides technical information for its members on control of *Legionella* in cooling towers through disinfection techniques, temperatures, and biocides; and it references CDC, ASHRAE, OSHA, and agency guidance from other countries, including Japan, the United Kingdom, and Australia.[68] Guidance to industrial hygienists is also provided in an American Industrial Hygiene Association journal article that advocates systematic microbiological testing for *Legionella* coupled with appropriate interpretation as an important part of prevention.[70]

Discussion

Legionnaires' disease continues to increase in importance as a public health issue in the United States, and legionellosis has one of the most rapidly increasing rates among nationally notifiable diseases. Surveillance artifacts should be considered as a possible reason for the increase; however, there is no evidence that there have been significant improvements in reporting, physician education, or diagnosis for this disease in the past decade.[1-4,71-73] The disease is markedly underdiagnosed, even among hospitalized patients with community-acquired pneumonia.[71,72]

Numerous prevention guidelines have been developed by federal, state, and local governmental and nongovernmental agencies as well as by national professional organizations. These guidelines vary in scope, and the recommendations do not always align with one another across agencies or jurisdictions. For example, with the exception of very limited circumstances (eg, transplant units and protective environments), CDC recommendations do not include routine monitoring for *Legionella* either qualitatively or quantitatively in the absence of an outbreak, nor does CDC recommend using counts to determine a need for remediation.[31-34] Alternatively, OSHA provides detailed guidance for prevention of occupationally-acquired legionellosis based on environmental sampling for *Legionella* and quantitative counts.[41] Some states recommend quarterly testing of hospital water systems serving protective environments and transplant units; others leave the frequency of testing to the hospital's judgment based on individual risk assessment. Guidelines also vary as to what should be tested (eg, cooling towers, water fountains, and ice makers), frequency of testing, and threshold for action. Discrepancies between guidelines were also noted by Fields and Moore[74] in a report to ASHRAE in 2006. Outside of limited health care settings, there has been considerable disagreement among public health experts as to the use of routine monitoring of environmental levels of *Legionella* as a guide to hazard reduction (eg, remediation).[34,75] In addition, relatively little public health attention in the United States has been given to registration of cooling towers and/or their routine testing for *Legionella*. At the local level, the city of Garland, Texas, requires annual testing of cooling towers for multifamily dwellings; a proposed draft regulation amendment would also include testing of cooling towers for lodging establishments.[76]

Perhaps, the most comprehensive public health guidance on primary prevention was developed by the Wisconsin Division of Health in collaboration with many other private and public partners in the late 1980s.[44] This guidance has not been updated. A limited number of states and localities have convened task forces to develop guidelines for primary prevention of legionellosis.

National professional organizations that have tackled the issue of primary prevention of legionellosis have largely been industry- and manufacturer based. ASHRAE is continuing to work on updating its guidance.[77,78] The fourth draft guidance from ASHRAE, scheduled for release in 2014, is likely to remove HACCP terminology, include considerations for environmental monitoring, and provide guidance on evaluation of design and operation of building water systems to reduce the risk of amplification of *Legionella*.[78]

Our study has several limitations; it was conducted at a single point in time and only looked for publicly available, Internet-based, *Legionella*-related guidelines. Our search engine algorithms may not have captured all of the *Legionella* documents available, and our summaries may not be comprehensive. Guidelines may have been missed, removed, or updated since the time the review was conducted. For example, VHA has been devoting considerable attention to this disease and has been closely examining its policies (eg, a 2013 information letter from the Undersecretary of Health of VHA prohibits the use of open decorative fountains within a VHA health care facility).[79]

Prevention of legionellosis has garnered much attention globally. The World Health Organization has published documents addressing *Legionella* prevention in man-made water systems, including potable water, health care facilities, cruise ships, hotels, and

swimming pools.[80,81] As part of an effort to monitor *Legionella* control measures, it recommends that the levels of *Legionella* be checked regularly to examine trends in *Legionella* concentration and be used to verify and validate water safety plans.[80]

The European Union has multiple directives in place protecting people from bacterial contaminants in drinking and bathing water, with some member states specifically listing *Legionella* as a pathogen to monitor in selected water systems.[82] A study conducted by the European Working Group for *Legionella* Infections concluded in 2008 that most outbreaks associated with wet cooling systems are preventable and that "there is enough evidence to suggest that developing water safety plans for wet cooling systems, including system assessment, monitoring and management, is the preferred approach for managing the health risks associated with exposure to *Legionella* spp."[83(p4)] The report noted that many countries require cooling towers to be registered with local authorities (eg, Andorra, Belgium, France, Malta, the Netherlands, Norway, Singapore, Spain, the United Kingdom, and the Russian Federation).[83] The authors recommended that the European Union give consideration to requiring registration and monitoring of wet cooling systems by health systems.[83] In 2011, Germany decided there was a need for a proactive approach to the primary prevention of *Legionella*; the country began requiring regular testing of water systems that supply water to the public, including apartment buildings, and instituted minimum thresholds for levels of *Legionella*.[84-86]

Singapore enacted and implemented the Environmental Public Health (Cooling Towers and Water Fountains) Regulations nationwide in 2001.[87] This legislation specifies the frequency of inspection, maintenance, and quantitative testing of water samples for *Legionella* spp bacteria. Singapore reported declining rates of legionellosis from 2000 to 2009 and suggested that the regulations may have contributed to the decline.[11]

As the population ages, the burden of legionellosis is likely to continue to increase in the absence of more effective prevention measures and/or improved implementation of prevention measures. Increasingly, more individuals are immunosuppressed, with immunosuppressive treatment used more widely for a range of problems from cancer to skin conditions to arthritis. In addition, the expansion of the number and complexity of water systems is resulting in newly recognized sources of outbreaks such as indoor decorative water fountains.[24] Public health practitioners should be aware of legionellosis as a growing problem and the controversies surrounding its prevention.

There have been few resources devoted to the study of microbiology in the built environment, including applied research for the prevention of legionellosis.[88] Research on environmental monitoring may be beneficial to evaluate methods to quantify *Legionella* levels in water systems as well as to define more clearly the role of routine environmental monitoring as a guide to remediation. Application of advances in molecular techniques to environmental and clinical *Legionella* isolates may improve insights into disease prevention. Of note, the Sloan Foundation awarded funds to several universities to begin work on microbiology in the built environment, with the stated goal of gaining the federal government's interest in investing more research into this field.[88]

No comprehensive public health review of legionellosis prevention guidelines at the national level has been conducted in the United States for more than 2 decades. We recommend that CDC, in its public health leadership role as the nation's prevention agency, undertake a formal and comprehensive review of national public health guidelines for the prevention of legionellosis. We suggest that public health authorities evaluate the available evidence for proactive prevention measures and identify and support needed research. Such a review would benefit from inclusion of experts in legionellosis at the local, state, federal, and international levels as well as leaders from industry and academia with environmental, microbiologic, epidemiologic, engineering, and industrial hygiene expertise related to prevention of legionellosis. Legionellosis deserves a higher public health priority.

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