Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_______________________________ _______________

Preventing Hospital-Acquired Legionnaires' Disease: Assessment of water management plans and practices in acute care hospitals in the U.S.

By

Karen M. Ehret
Master of Science in Public Health

Environmental Health, Epidemiology

____

Allison T. Chamberlain, Ph.D.
Committee Chair

____

Paige E. Tolbert, Ph.D.
Committee Member

Preventing Hospital-Acquired Legionnaires' Disease: Assessment of water management plans and practices in acute care hospitals in the U.S.

By

Karen M. Ehret

B.S.
Georgia College & State University
2016

Thesis Committee Chair: Allison T. Chamberlain, Ph.D.

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Science in Public Health
in Environmental Health, Epidemiology
2018

Abstract

Preventing Hospital-Acquired Legionnaires' Disease: Assessment of water management plans and practices in acute care hospitals in the U.S.
By Karen M. Ehret

Increased prioritization of Legionnaires' Disease (LD) has led to the development of a recently published mandate, guidelines, regulations, and in some jurisdictions, laws, around water management. However, little is known about the extent to which LD prevention initiatives and activities have been adopted within U.S. acute care hospitals. In Fall 2017, we developed and distributed an anonymous cross-sectional survey to members of the Society for Healthcare Epidemiology of America (SHEA) Research Network. The survey addressed clinical protocols for diagnosing LD, maintenance practices of potable and non-potable water systems, *Legionella*-specific prevention strategies, and knowledge of recent guidelines and regulations. Respondents from thirty of 101 (30%) hospitals completed the survey, with majority representing large facilities (more than 250 inpatient beds). Sixty-six percent reported having a water management plan for both potable and potable water, while 28% had one in development. While 72% reported the capacity to perform culture testing for LD diagnosis, only 14% reported doing so routinely. The most well-represented areas of expertise within facilities' water management teams were infection control (97%) and facilities/engineering (90%). Within this small sample of hospitals, we found variety in LD diagnostic testing and prevention practices. With many facilities relying exclusively on non-culture-based diagnostic testing, many cases of LD will be missed. While many respondents reported having a water management plan in place, it is uncertain whether these plans are adequate or comprehensive. Finally, with other areas of expertise less well-represented on water management teams, there may be a need to include a broader range of professional knowledge among those responsible for developing water management plans.

Preventing Hospital-Acquired Legionnaires' Disease: Assessment of water management plans and practices in acute care hospitals in the U.S.

By

Karen M. Ehret

B.S.
Georgia College & State University
2018

Thesis Committee Chair: Allison T. Chamberlain, Ph.D.

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Science in Public Health
in Environmental Health, Epidemiology
2018

Acknowledgements

I would like to offer my sincerest gratitude to my thesis advisor Dr. Allison Chamberlain, whose guidance and insightful perspective throughout this project were immensely valuable. I would also like to thank Dr. Scott Fridkin, Dr. Laura Cooley, and Dr. Ruth Berkelman for their participation and input in conducting this research. Finally, I would like to offer a special thank you to my parents, for supporting me through all phases of life and empowering me to pursue my aspirations.

Table of Contents

1. Introduction

Legionnaires' disease (LD) is a severe type of pneumonia caused by the bacteria *Legionella*. These bacteria thrive in water with warm temperatures (20-45°C) and stagnant flow [1]. Although sometimes found in natural water sources such as lakes and ponds, the accumulation of *Legionella* in a publicly accessed water system raises concern, as this can result in LD cases or an outbreak of the disease. Since illness occurs upon inhalation of aerosolized water droplets contaminated with *Legionella*, cooling towers, indoor decorative fountains and shower heads are features of engineered water systems that pose particular risk for inciting LD cases. Those most likely to experience complications from the disease are individuals 50 years of age or older and those with compromised immune systems.

1.1. The Problem of Hospital-Acquired Legionnaires' Disease

In recent years, outbreaks of LD have been occurring more frequently. In the United States, the incidence rate of legionellosis has increased from 0.42 to 1.62 cases per 100,000 persons between 2000 and 2014 [2]. While outbreaks have occurred in a variety of settings including hotels, offices, and cruise ships, the presence of *Legionella* in water systems is particularly concerning for healthcare facilities. Outbreaks of healthcare-associated LD have a higher fatality rate on average compared to the overall fatality rate of LD, as many hospital patients fall into the demographic at the highest risk for LD [1, 2].

Hospitals affiliated with the Veterans Health Administration have been particularly plagued by LD cases. In 2008, the VHA enacted an LD prevention policy [3] applicable to all its medical centers; this policy included requirements for routine monitoring of facility water distribution systems, an action plan for *Legionella* mitigation, and annual facility evaluations for *Legionella*. With this policy, the VHA's activities for *Legionella* prevention exceeded the CDC recommendations for healthcare facilities at that time [4, 5]. Following a particularly large outbreak that occurred during 2011 and 2012 in a Pennsylvania VA hospital with an existing LD prevention program [1], the VHA revised its policy in 2014 to require both clinical testing and routine environmental surveillance [6]. The current policy has a "zero threshold" for *Legionella* bacteria in VA hospital water systems, meaning that if any *Legionella* is found at all, the facility must initiate disinfection and remediation plans.

Despite having a more stringent LD prevention policy than most other hospitals in the U.S., VA facilities are still experiencing outbreaks. Since 2015, 13 residents at a VA home in Quincy, IL have died of LD which has resulted in radical plans to redevelop the entire facility [7]. Additionally, another case of LD was diagnosed at a VA home in Fresno, CA earlier this year [8]. While not unique to VA hospitals, these outbreaks and associated investigations serve to highlight both the dangers posed by *Legionella* in hospital water systems and the need for continuous review of *Legionella* prevention methods, particularly in hospital settings.

1.2. Clinical Practices of Diagnosing Legionnaires' Disease

Definitive diagnosis of LD can occur through performance of both culture- and non-culture-based tests. The most common non-culture-based test is the urine antigen test (UAT). Using a urine sample from a suspected case, the UAT detects the presence of *Legionella* by detecting a lipopolysaccharide antigen of *Legionella pneumophila* serogroup 1 in urine [9]. It is a relatively easy test of high specificity and sensitivity [9] with results often available within 24 hours [10], thus making it a much more attractive diagnostic approach than traditional bacterial culture. A major limitation of the UAT is that it only detects *Legionella pneumophila* serogroup 1. While this species and serogroup of *Legionella* is estimated to account for more than 80% of LD cases, it is only one of multiple species that can cause human illness [11].

In contrast to the common UAT test, diagnosing LD via bacterial culture is considered the “gold standard” because it can identify exact *Legionella* species and serotype. This is beneficial for both prescribing appropriate antibiotics and linking to environmental investigations. Bacterial culture is not without its challenges however. Whereas urine is an easy clinical specimen to obtain from a suspected patient, sputum samples are needed for bacterial culture, and these can be much more challenging to collect. Additionally, the presence of viable but nonculturable cells and competing microorganisms in a sample can inhibit *Legionella* culture methods [12], and the time required to receive culture results is substantially longer—sometimes over 6 days—in comparison with the UAT test [10].

In summary, for patients exposed to *Legionella pneumophila* serogroup 1, performing UAT alone will lead to successful diagnosis and earlier recovery. But if the UAT test is the only test performed, some serogroup 1 cases will still be missed and all LD cases caused by other strains of the bacteria will be absolutely be missed. To improve clinical diagnoses, a comprehensive approach of both culture and non-culture tests is most prudent.

1.3. New Recommendations for Water Management Plans

In response to the increasing incidence of LD overall, new publications addressing the safety of water systems have been introduced. In 2015, both ASHRAE (formerly the American Society of Heating, Refrigerating and Air-Conditioning Engineers) and the American Industrial Hygiene Association (AIHA) released updated guidelines on the recognition and control of *Legionella* in water systems. The ASHRAE document, entitled "ASHRAE Standard 188, *Legionellosis: Risk Management for Building Water Systems"* [13] aims to establish minimum legionellosis risk management guidance, with a primary focus on the design and maintenance of engineered water systems through the establishment of a water management program, described in Table 1. AIHA's guideline—*Recognition, Evaluation, and Control of Legionella in Building Water Systems*—focuses on preventative approaches and provides industrial hygienists and occupational health professionals with strategies for assessing water systems to prevent illnesses [14].

Table 1. Summary of ASHRAE 188: Purpose and Components of a Water Management Program (WMP)

Purpose of a WMP: to prevent and remediate bacteria growth within a facility water system
Components of WMP: -A water management team: a team consisting of professionals with relevant expertise (i.e. engineering, facility maintenance, environmental health, etc.) -Risk assessments: performance of a risk assessment for areas susceptible to bacteria growth -Prevention and monitoring measures: established prevention measures and routine monitoring of water quality (i.e. pH and temperature measurements, disinfectant, etc.) -Regular testing for *Legionella* and other premise plumbing bacteria -Acceptable limits for routine testing and a plan for corrective actions

With LD cases rising and revised industry standards circulating, but likely not broadly enough, the Centers for Disease Control and Prevention (CDC) published a toolkit in June 2016 to help building owners implement the guidance set forth in ASHRAE 188. While the ASHRAE standard establishes the principal needs for *Legionella* prevention, CDC aims to assist in the execution of these preventions, particularly in healthcare facilities [15]. As an example, the toolkit provides sample water system plans and possible scenarios of identifying issues and performing remediation, with separate textboxes of special considerations for healthcare facilities. Also following the release of ASHRAE 188, the Centers for Medicare and Medicaid Services issued a directive in June 2017 for healthcare facilities specifically, requiring all Medicare-certified healthcare facilities to establish a water management plan [16].

1.4. Regional Policies on *Legionella*

In addition to these guidelines, limited regions in the United State have adopted legislation applicable to facilities within their jurisdictions to prevent *Legionella* growth. In 2005, the city of Garland, TX passed an ordinance requiring annual inspection and maintenance of all cooling towers, becoming the first city in the United States to implement such policy [17]. The State of New York followed Garland, TX with similar cooling tower regulations in 2016, plus additional guidance on surveillance for *Legionella* in healthcare facilities [18]. After a 2015 outbreak of LD traced to a hotel cooling tower in the Bronx, New York City also imposed local regulations requiring the registration, inspection, and cleaning of cooling towers within the city [19]. And most recently, the state of Illinois has introduced two bills in response to recent outbreaks: HB

5784, which requires quarterly reports from the Department of Veterans Affairs on resident welfare in Illinois facilities, and HB 4278, which requires Veterans Home administrators to notify patients, families, and the public health department of an outbreak via written notification and posted information at the facility's front entrance [20, 21].

Since release of these guidance documents and mandates, the extent to which hospitals nationally have adopted or revised their LD prevention strategies is unknown. In a 2017 study among 81 Minnesota hospitals, 27% reported having a water management plan in place, with participant awareness of ASHRAE 188 and the CDC toolkit at 53% and 41%, respectively [22]. Building upon these state-specific findings, this study focuses on assessing the status of water management plans and awareness of recent guidelines through a national survey of acute care hospitals in the United States. Additionally, this study aims to assess current clinical practices for diagnosing LD.

2. Methods

For this study, we designed a cross-sectional survey for U.S. members of the Society for Healthcare Epidemiology of America (SHEA) Research Network. The SHEA research network consists of hospital epidemiologists from around the country who participate in important research-related activities pertinent to their field and facilities. The 24-question survey included multiple choice and open-ended questions. Topics addressed in the survey included clinical protocols for diagnosing cases of LD, maintenance practices of potable and non-potable water systems, *Legionella*-specific prevention strategies, and knowledge of recent guidelines and regulations for preventing LD.

While the survey questions were written for a target audience of hospital epidemiologists, respondents were encouraged to print the survey and consult with colleagues involved in designing their facility's water management plan on questions requiring non-epidemiologic expertise (e.g., clinical or engineering-based questions). On October 17, 2017, an email requesting participation in the online survey was sent by the SHEA RN administration team to 101 U.S.- based SHEA RN facilities. Facility names and locations were not disclosed to the research team. Non-respondents were sent up to 3 reminder emails by SHEA RN administration until the survey closed on November 30, 2017. Responses were limited to one per facility. Results were analyzed using descriptive statistics in SAS version 9.4 (Cary, North Carolina). The project was deemed non-human subjects research by the Emory University Institutional Review Board.

3. Results

3.1. Facility Demographics

Of the 101 eligible facilities that received the survey, we received 30 responses (30% response rate). Demographic information from SHEA indicated that 41% of respondents represented academic medical centers, and 59% represented hospitals with no academic affiliation. Most respondents (80%) represented facilities with 250 or more beds; none of the facilities had fewer than 100. Nineteen (63%) hospitals featured both transplant and inpatient dialysis units; 6 (20%) had only a dialysis unit. A majority of hospitals (80%) reported having cooling towers as part of their non-potable water system.

Only 8 (27%) hospitals featured operational indoor decorative fountains or aesthetic water features, and fewer (13%) featured whirlpool therapy spas.

3.2. Clinical Diagnostic Practices

Within the past five years, 24 facilities (69%) reported having had at least one case of LD, with 38% of those cases suspected or confirmed to be healthcare-associated. To diagnose LD, 25 (86%) reported an ability to test for LD in-house using urine antigen tests (UAT), 21 (72%) using respiratory culture, and 8 (28%) using multi-pathogen molecular assays. Despite the high prevalence for capability of in-house culture testing, nineteen (63%) indicated that routine LD testing for hospital-acquired pneumonia is usually limited to non-culture-based tests (e.g., urine antigen tests, molecular assay).

Four (14%) facilities reported always conducting bacterial culture in conjunction with non-culture tests. Among the 24 who reported performing culture confirmation sporadically, 22 (92%) reported provider discretion as the primary circumstance for initiating culture-based testing. Other circumstances included patient risk factors and concern of outbreak. For patients suspected of having hospital-acquired pneumonia, only 4 (13%) facilities have a policy requiring performance of any type of diagnostic testing for LD.

3.3. Water Management Plans

Nineteen facilities (66%) reported having a water management plan in existence for both potable and non-potable water at the time the survey was administered; 8 (28%) had one in development, 1 (3%) had a plan for potable water only, and 1 (3%) had no plan. To monitor potable water quality, 18 (64%) routinely measured chlorine levels, 17 (61%) reported routinely measuring temperature, and 15 (54%) measured pH level.

Seventeen (61%) reported routinely testing for presence of *Legionella* as part of their water management plan. For those who test for *Legionella* presence, testing included specific bacteria count of *Legionella*. Twenty-two (76%) facilities reported having conducted a risk assessment to identify areas within their water system infrastructure susceptible to *Legionella* growth, 17 of which occurred within the past three years.

Respondents were also asked about personnel engaged in water management plan development at their facility. Occupations were categorized into six areas of expertise. Within these teams, the most well-represented areas of expertise were infection control (97%) and facilities/engineering (90%). Other areas of expertise including microbiology (52%), compliance/administration (45%), risk management (38%) and public health (10%) were less well-represented. Thirty-four percent included specific expertise in environmental microbiology, all of which was provided by external consultants.

3.4. Knowledge of Guidelines and Regulations

Most facilities were aware of ASHRAE 188 (97%) and the CDC tool kit (89%). Both guidelines were also frequently cited as having been used to develop their facility's water management plan. Other materials with high percentages of awareness and use included ASHRAE Guideline 12-2000 and *Water Management in Healthcare Facilities: Complying with ASHRAE Standard 188* produced by ASHRAE. Awareness of regulations in the state of New York, New York City, and Garland, TX were low.

4. Discussion

In this small sample of acute care hospitals across the U.S., LD diagnostic and prevention practices varied, but the reported prevalence of established water management plans and awareness of key LD-prevention guidance documents was substantially higher than recent state-based reports [22]. Few hospitals surveyed require culture-based tests for diagnosing LD, instead choosing to perform such tests at the discretion of the care provider rather than under defined circumstances. For diagnosing LD, the UAT test was the most prevalent diagnostic, with 86% of respondents indicating the capacity to conduct UAT tests at their facility.

While UAT testing may be the easiest diagnostic test to perform, as mentioned previously, its biggest limitation is that only detects infections caused by *Legionella pneumophila* serogroup 1. With other serogroups and species of Legionella responsible for more than 80% LD cases [11], testing with UAT leaves many potential cases undiagnosed, especially if other diagnostic tests (e.g. culture) are not performed. With 72% reporting the capacity to perform culture confirmations in-house, but only 14% doing so routinely, this may be an area for additional guidance and promotion. If more hospitals can routinely culture pneumonia patients, more cases of LD can be accurately diagnosed or ruled out, leading to more appropriate treatment regimens and environmental investigations.

Regarding water management plans, nearly two-thirds reported already having a plan in place that covers both potable and non-potable water. This is substantially more than the 27% of hospitals in Minnesota that reported having a water management plan in place as of spring 2017. It is important to note that while many facilities appear to have a plan, we do not know the adequacy or comprehensiveness of these plans beyond the limited information we obtained through the survey questions. Close to 60% of our respondents reported having conducted a risk assessment for *Legionella* since 2014, yet some of these risk assessments likely occurred before publication of new guidelines for

Legionella prevention. As facilities continue refining their water management plans, conducting periodic facility risk assessments with an emphasis on *Legionella* prevention will be a continued priority.

Since comprehensive water management planning requires participation by many types of professionals, examining the composition of expertise represented on water planning teams can help guide selection of other appropriate representatives. While infection control and facilities/engineering appear to be well-represented, other domains of expertise like compliance/administration and risk management are less likely to be represented. There may be a need to promote inclusion of a broader range of expertise in the planning process since so much of LD prevention involves non-traditional infection control expertise like environmental microbiology and industrial hygiene.

4.1. Conceptualizing a Comprehensive LD Prevention Strategy

As observed most acutely by the VA hospitals that continue to struggle with healthcare-associated LD cases despite enacting more stringent *Legionella* prevention and control measures, there may be a need to consider extending hospital water management policies even further. Developed initially as an industry standard, ASHRAE 188 is the most widely-accepted standard for building water management programs. It could therefore serve as the generic and minimum requirements for a given building or facility. But for facilities that primarily care for the most at-risk populations, such as acute care hospitals or nursing homes, a more comprehensive approach that more actively links the clinical diagnostic practices for LD with water system safety is needed.

4.2. Requirements for a Comprehensive LD Prevention Strategy

While the ASHRAE standard provides a solid foundation for any water management program, a comprehensive LD prevention (LDP) strategy is one that covers both the clinical and the environmental capacities of a facility, connecting more directly the diagnostic practices with water management program activities. Both ASHRAE 188 and the CDC toolkit attempt to create a comprehensive approach to *Legionella* prevention, but neither of these documents address clinical methods or protocols for diagnosing LD. Therefore, further progress in LD prevention may rely on focused improvements outside of the water system.

Performing LD testing for pneumonia patients with greater frequency and earlier in the hospital stay will improve detection and accuracy of hospital case counts for LD. This may also contribute to better patient outcomes by virtue of identifying the disease earlier and through more tailored and prudent use of antibiotics. These diagnostic tests and hospital-wide case counts in turn provide feedback to the water management team on the effectiveness of the water management plan. By improving the regularity of LD testing—and by identifying hospital-acquired versus community-acquired cases—water management teams can monitor case rates over time to confirm that the facility's water management plan is sufficient. An increase or lack of improvement in case rates over time can also prompt an exploration of possible water management plan improvements. Furthermore, identifying the *Legionella* species from patient culture samples and linking it to samples obtained from premise plumbing will aid the water management team in finding a source should an outbreak ever occur. By incorporating better LD testing policies, diagnostic practices can work synergistically with water management programs to create a safer hospital environment.

5. Conclusion

It is important to consider that the response rate for this survey was very low. We suspect it was low because some questions in this survey addressed aspects of LD prevention that may have extended beyond the expertise of a hospital epidemiologist. Despite encouraging collaboration with knowledgeable colleagues, reaching out to others to obtain accurate or complete answers to certain questions may have discouraged participation. Additionally, we did not have the ability to offer any incentive to participate, a strategy that may have increased survey response rates.

Another important consideration is the likelihood of selection bias. Given the relatively high proportion of respondents that indicated having a water management plan either in place or in development, we suspect that facilities not currently working on revising or creating a plan chose not to respond. However, this implies that the facilities that did respond may be the hospitals most knowledgeable about *Legionella* prevention. Even among these hospitals, there is room for improvement both in terms of clinical diagnosis practices and protocols and for water management programs. Despite these limitations, the results presented here offer an important national snapshot of LD diagnostic capacity and water management planning at a time when LD cases are rising and pressures to improve LD prevention are increasing.

6. References

1. Demirjian, A., et al., The Importance of Clinical Surveillance in Detecting Legionnaires' Disease Outbreaks: A Large Outbreak in a Hospital With a Legionella Disinfection System—Pennsylvania, 2011–2012. *Clinical Infectious Diseases*, 2015. **60**(11): p. 1596-1602.
2. Garrison, L.E., et al.;Vital Signs: Deficiencies in Environmental Control Identified in Outbreaks of Legionnaires' Disease—North America, 2000–2014. *American Journal of Transplantation*, 2016. **16**(10): p. 3049-3058.
3. Veterans Health Administration. *VHA Directive 2008-010: Prevention of Legionella Disease,* Department of Veterans Affairs, Editor. 2008.
4. Sehulster, L.C., RYW, Guidelines for environmental infection control in healthcare facilities: Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). *MMWR Recomm Rep*, 2003. **52**(RR10): p. 1-42.
5. Gamage, S.D.K., S.M.; Roselle, G.A., The case for routine environmental testing for Legionella bacteria in healthcare facility water systems - reconciling CDC position and guidance regarding risk. *Clinical Infectious Diseases*, 2015. **61**(9): p. 1487-1488.
6. Veterans Health Administration. *VHA Directive 1061: Prevention of healthcare-associated Legionella disease and scald injury from potable water distribution systems.* Department of Veterans Affairs, 2014.
7. O'Connor, J. Rauner Now Plans to Raze Vet Dorms Where Legionnaires' Found. *U.S. News and World Report*, 2018.
8. Anderson, B. Legionnaires' disease investigated at Veterans home in Fresno. *The Fresno Bee,* 2018.
9. Kazandjian, D., R. Chiew, and G.L. Gilbert, Rapid diagnosis of Legionella pneumophila serogroup 1 infection with the Binax enzyme immunoassay urinary antigen test. *J Clin Microbiol*, 1997. **35**(4): 954-6.
10. Formica, N., et al., The impact of diagnosis by legionella urinary antigen test on the epidemiology and outcomes of Legionnaires' disease. *Epidemiology and Infection*, 2001. **127**(2): 275-280.
11. Yu, V.L., et al., Distribution of Legionella Species and Serogroups Isolated by Culture in Patients with Sporadic Community-Acquired Legionellosis: An International Collaborative Survey. *The Journal of Infectious Diseases*, 2002. **186**(1): 127-128.
12. Collins, S., et al., Real-time PCR to supplement gold-standard culture-based detection of Legionella in environmental samples. *Journal of Applied Microbiology*, 2015. **119**(4): 1158-1169.
13. American Society of Heating Refrigerating and Air-Conditioning Engineers, *Standard 188-2015 -- Legionellosis: Risk Management for Building Water Systems*. 2015: Atlanta, GA p. 18.
14. Stewart, K.R.C., *AIHA Provides Preventative Guidance in New Legionella Guideline*. 2015.

15. Centers for Disease Control and Prevention. *Developing a water management plan to reduce Legionella growth and spread in buildings: A practical guide to implementing industry standards.* 2016.
16. Centers for Medicare and Medicaid Services. Requirement to reduce Legionella risk in healthcare facility water systems to prevent cases and outbreaks of Legionnaires' disease. 2017, US Department of Health and Human Services, Centers for Medicare & Medicaid Services, Center for Clinical Standards and Quality/Survey and Certification Group: Baltimore, MD.
17. Whitney, E.A., S. Blake, and R.L. Berkelman, Implementation of a Legionella Ordinance for Multifamily Housing, Garland, Texas. *Journal of Public Health Management and Practice*, 2017. **23**(6): p. 601-607.
18. New York Codes, Rules, and Regulations, Title 10. (2016).
19. City of New York Local Law 77 (2015).
20. *HB 5784*. Illinois General Assembly (2018).
21. *HB 4278*. Illinois General Assembly (2018).
22. Danila, R.N., et al., Hospital Water Management Programs for Legionella Prevention, Minnesota, 2017. *Infect Control Hosp Epidemiol*, 2018: p. 1-3.