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Association of Local
PUBLIC HEALTH
Agencies

alPHa RESOLUTION A22-3

TITLE: **Provincial Cooling Tower Registry for the Public Health Management of Legionella Outbreaks**

SPONSOR: **Simcoe Muskoka District Health Unit Board of Health**

WHEREAS Legionella can cause fatal disease and cases of Legionellosis remain underreported in the province of Ontario;

WHEREAS The burden of Legionellosis is increasing and is expected to continue to increase in the context of climate change;

WHEREAS Most non-healthcare-associated Legionellosis deaths are attributable to spread of Legionella from cooling towers by aerosolization;

WHEREAS Public health units must search for and identify cooling towers for environmental sampling and possible remediation in the context of community Legionella outbreaks, which delays remediation actions and causes considerable resource expenditure by public health units;

WHEREAS Legionella outbreak investigation and control could be streamlined if a province-wide cooling tower registry existed, yet no such registry exists;

THEREFORE BE IT RESOLVED that the Association of Local Public Health Agencies (alPHa) write to the Minister of Municipal Affairs and Housing recommending the creation of a province-wide mandatory cooling tower registration system and mandating a risk management plan for cooling towers to operate;

AND FURTHER that the Minister of Health, the Minister of Environment Conservation and Parks, and the Chief Medical Officer of Health of Ontario be copied.

CARRIED

BACKGROUND:
PROVINCIAL COOLING TOWER REGISTRY FOR THE PUBLIC HEALTH MANAGEMENT OF LEGIONELLA OUTBREAKS

1. The burden of Legionella

Legionella bacteria are gram-negative aerobic bacilli that are ubiquitous in freshwater environments such as ponds, rivers, and lakes (1). Their ability to survive in biofilm and to reproduce within certain protozoa makes them resistant to chlorination and other traditional water disinfection protocols, enabling replication within plumbing systems (2), hence their designation as opportunistic premise plumbing pathogens. Most human infections are caused by Legionella pneumophilia serogroups, though other legionellae species have been involved in human disease (3).

Legionella infection occurs primarily through inhalation of aerosolized water droplets and manifests as two distinct clinical syndromes in humans (1). Pontiac fever is generally mild in nature, self-resolving, involving febrile illness and muscle aches. Symptoms generally begin within 24 to 72 hours post exposure (4). Legionnaire's disease is a type of pneumonia that often manifests with overlapping systemic symptoms and can be severe. Hospitalization is common, and up to 10% of community-acquired cases (non-healthcare associated) are fatal (4). Risk factors for severe disease include age over 50, smoking, chronic lung disease, immunize system compromise, malignancy, or other chronic illness such as diabetes, renal failure, or hepatic failure (5). Cases of Legionnaire's disease are underreported because symptoms are non-specific, overlap significantly with those of other bacterial pneumonias, and Legionella testing is not performed routinely (6,7).

Transmission of Legionella is determined by the presence or absence of conditions that promote growth of Legionella, aerosol generation, and human exposure to aerosolized water (8). Aerosolization of contaminated water particles may occur through potable water systems (e.g., shower), cooling towers, whirlpool spas, or through other water sources such as decorative fountains, sprinkler systems, safety showers and eyewash stations, humidifiers, and nebulizers (2). Water stagnation, temperatures between 25°C and 45°C, and plastic and rubber plumbing materials favor the colonization and growth of Legionella (2).

Sources of Legionella infections can be difficult to determine, but cooling towers have been identified as significant contributors to the burden of Legionella. A cooling tower is an evaporative heat transfer device that places warm water from a building water system into direct contact with atmospheric air. The water is cooled upon contact, and the heat rejected into the atmosphere via evaporation (8). Legionella bacteria present in the cooling tower can be aerosolized via this process and spread to distances of over six kilometers away (9). In a large database that compiles published Legionella outbreaks worldwide, an infectious source for Legionella outbreaks was identified 68% of the time. While potable water systems account for a greater proportion of outbreaks (63%) relative to cooling towers (34%), the overall number of cases attributable to cooling towers is larger than the number of cases attributable to potable water systems (10). A separate review attributed 60% of Legionella outbreak-related deaths to cooling towers (11).

The reported incidence of Legionnaire's disease has been increasing provincially. From 2015 to 2019, the annual incidence rate for Legionellosis in Ontario more than doubled, from 0.9 cases per 100 000 population in 2015 to 2.6 cases per 100 000 in 2019 (12). Rates in Simcoe Muskoka have also increased in recent years and have exceeded provincial rates. In 2019, Simcoe Muskoka reported 3.5 cases per

100, 000 population. There have been two recent Legionella outbreaks in the Simcoe Muskoka region. On September 4, 2019, the Simcoe Muskoka District Health Unit (SMDHU) received a report of a confirmed case of Legionellosis in the City of Orillia. This single case was later associated with a cluster of cases. In all, ten confirmed cases of Legionellosis were identified, with symptom onset ranging from August 9, 2019 to October 2, 2019. The investigation was completed on November 19, 2019. All ten cases required hospitalization and one death was reported. Thirty-nine locations were investigated for cooling towers within the Orillia area. Ten cooling towers in eight different locations were identified and sampled for Legionella. Of these, three cooling towers tested positive for Legionella, but only one of these samples matched the genetic sequence of Legionella found in two of the confirmed cases. As the cluster investigation in Orillia was being finalized, SMDHU received a report of a confirmed case of Legionellosis in the City of Barrie. Five cases were identified, with symptom onset between November 9, 2019 and December 12, 2019. All five cases required hospitalization, and two required admission to the intensive care unit. Twenty-eight cooling tower locations were identified by the SMDHU team as potential sources for the cases. Ultimately, ten cooling towers from 8 distinct locations were sampled for Legionella. Of the ten cooling towers sampled, three tested positive for Legionella spp. Further laboratory analysis with genomic sequencing showed no relation between the Legionella samples from the three cooling towers and confirmed cases.

Both clusters highlight the challenging nature of Legionella investigations. A necessary and time-consuming step in both investigations was the identification of operational cooling towers within a defined geographic area. A significant amount of time was spent in the search for potential cooling tower sites through a variety of means (including field assessments), which caused considerable delay in sampling of the potential sources of aerosolized Legionella and remediating towers with contamination.

The threat of Legionella is likely to increase in the context of climate change (13). Several empirical studies investigating the relationship between sporadic, community acquired Legionnaires Disease (LD) and meteorological variables were identified (14, 15, 16, 17, 18, 19, 20, 22, 23). Overwhelmingly, these studies found that increases in temperature, humidity, and precipitation increased the incidence of LD. Furthermore, Beaute et al. (2016) suggest that higher temperatures are linked with behaviours that can increase the risk of potentially hazardous sources of Legionnaires (22). For example, higher outdoor temperatures are linked to increase use of air conditioning, taking showers, and using fountains (and air conditioning units, shower heads, and fountains are all potential sources of Legionnaires).

Finally, the COVID-19 pandemic may increase the risk of Legionella. Many buildings have been closed or have reduced their water usage in the past year in the context of public health measures, creating stagnant water conditions favorable to Legionella. The Ministry of the Environment, Conservation and Parks (23), Public Services and Procurement Canada (24), and the Canadian Water and Wastewater Association (25) have all issued statements to alert of or provided guidance to mitigate risks linked to Legionella in the context of building re-opening. The staged nature of our provincial re-opening plan and the increase in remote work arrangements mean these risks are likely to persist through 2021 and into next year.

2. Mitigating risks of Legionella outbreaks from cooling towers: Rapid review of the literature

SMDHU performed an environmental scan of jurisdictions in early 2020 to determine existing policies used to mitigate the risk of Legionellosis in buildings. It is useful to organize findings by jurisdictional level, namely national, provincial, and municipal.

The Federal role in mitigating the risk of Legionella is outlined in a joint 2018 report by the National Research Council of Canada (NRC), Health Canada, and Public Services and Procurement Canada (PSPC). The NRC publishes the National Model Construction Codes with oversight by the Canadian Commission on Building and Fire Codes. Included in the National Model Construction Codes are the National Building Code of Canada and the National Plumbing Code of Canada. Each contain provisions specific to the control of Legionella in building systems to be implemented in the design and construction of cooling towers (26).

After construction, responsibility for mitigating Legionella risk at the Federal level is shared between Health Canada, the Treasury Board of Canada Secretariat (TBS), and PSPC. Health Canada creates drinking water guidelines, and Legionella is mentioned in its guidance document on waterborne bacterial pathogens, though the section on treatment technologies for Legionella offers a review of evidence for the relative effectiveness of various agents and technologies rather than firm recommendations (27). TBS indirectly mandates requirements for the investigation, risk assessment and control of Legionella as it relates to the health of federal employees (27). PSPC is responsible for mitigating the risk of Legionella on Government of Canada property and has developed the MD-15161 Control of *Legionella* in Mechanical Systems standard. Chapter 3 of the standard outlines design, construction, maintenance, and sampling requirements for mitigating the risk of Legionella in all crown-owned buildings (28). Different maintenance requirements are mandated on a weekly, monthly, and annual basis. Readers are directed to table 3.1 of the standard for a summary of mandated maintenance and testing requirements and to Appendix D for detailed cooling tower bacterial test protocols.

Finally, the Public Health Agency of Canada supports provinces by providing a national case definition for Legionellosis and by aggregating surveillance data (26).

Provinces and territories are responsible for development of their own protocols to prevent, investigate, and control Legionella-related outbreaks (26). The Ontario Public Health Standards (OPHS) Infectious Diseases Protocol puts forth high level principles for the prevention and control of Legionellosis. Section 6.2 of the disease-specific chapter on Legionellosis recommends implementation of a preventive maintenance program with hazard control measures, making specific reference to the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard 188-2015 – Legionellosis: Risk Management for Building Water (29).

The British Columbia Center for Disease Control guidelines for the management of Legionella outbreak investigation and control offer more comprehensive prevention recommendations (30). These include i) minimizing risk via design and installation recommendations, operational considerations, water temperature control and flushing, and regular disinfection protocols; and ii) implementation of a monitoring plan that may include testing routine parameters with heterotrophic plate count, weekly dipslide count, and testing at start of season and after disinfection (30).

Quebec has imposed the most stringent requirements for the control of Legionella. These include mandatory registration of all cooling towers with the Régie du bâtiment du Quebec. Cooling tower operators must also provide the name of third-party professionals hired for implementation of a maintenance program, and the name and contact details of the laboratory to whom routine samples are sent for analysis (31).

Several municipalities in Canada have adopted local strategies for mitigating the risk of Legionellosis. The City of Hamilton, Ontario, passed the Cooling Tower Registry By-Law in 2011 that requires all cooling towers to be registered with the city with an accompanying risk management plan (32). The City of Vancouver, BC, has enacted a similar by-law mandating operating permits for cooling towers, decorative water features, alternate water systems, and building water treatment systems (33). The Middlesex-London Health Unit (MLHU) has also identified cooling tower registration as a key risk mitigation strategy for Legionella. The MLHU Cooling Tower Registration Project allows voluntary registration of cooling towers and assists cooling tower operators with their risk management plans.

The environmental scan also identified 13 guidelines for mitigating the risk of Legionella in cooling towers. The content of the guidelines was variable, though most (nine of the 13 guidelines) recommend a risk management plan. One of the more comprehensive guidelines is the ASHRAE Standard 188-2018, recently supplemented with Guidelines 12 (8), which offers operational considerations specific to cooling towers for implementing components of a risk management plan as outlined in Standard 188. Basic elements of a risk management plan include, but are not limited to (8):

- Documented system maintenance requirements, including scheduled inspection
- Specified routine water treatment protocols, including chemical treatment or other specialized treatment equipment. The goals of a water management plan are to extend equipment life, minimize energy consumption, minimize water consumption, and maintain a safe environment.
- System standby and shutdown protocols
- Disinfection protocols to remedy deviations from expected standards on routine monitoring, including when disinfection is urgently required
- Contingency response plan in the event of known or suspected cases of Legionellosis

Other risk mitigation strategies discussed in the guidelines include recommendations specific to risk assessment, testing, reporting and remediation actions. Auditing was only mentioned in two guidelines, and cooling tower registries was only mentioned in the BCCDC guideline. It is beyond the scope of this document to provide an in-depth review of the relative merits of each guideline.

The environmental scan also identified two synthesis documents that review control strategies for Legionella in plumbing systems. The first was produced by the US Environmental Protection Agency (EPA) and focuses exclusively on potable water plumbing systems (34). The second review was authored by Public Health Ontario (PHO), is more general in scope, and follows a question-and-answer format (2). The overarching findings from both documents were largely overlapping. In both documents, the challenges posed by Legionella's ability to survive in amoeba and biofilms is highlighted. Techniques for reducing Legionella contamination are extensively discussed, particularly in the EPA review. There is consensus that thermal control is effective, but that temperatures are hard to regulate consistently in complex water systems. The reviews identify monochloramine and chlorine dioxide as superior to chlorine for Legionella-containing biofilm penetration, but optimal concentrations of all chemical biocides are difficult to determine and depend on several system-specific variables including water pH, temperature, pipe material and condition, water turnover rate and turbidity. Moreover, chemical biocides may compromise integrity of the water system and come with a risk of disinfection by-products. Non-chemical biocides such as UV disinfection and ozone appear effective a decreasing Legionella counts that are associated with biofilms and amoebae but must be used in conjunction with other agents or techniques given their lack of a residual effect.

Both reviews also highlighted existing knowledge gaps concerning routine environmental sampling, and the large variation seen in guidelines recommending routine sampling. The PHO review cautions that interpretation of Legionella culture results can be challenging and lead to underestimation of risk. Culture of the organism, which is considered the gold standard for identification purposes, can be difficult on standard culture media and competing microorganisms may mask Legionella growth. Furthermore, Legionella contained within an amoeba host will not show up on culture (2).

Similarly, an evidence-based threshold of Legionella counts for remediation has not yet been determined. Some standards suggest using numerical cut offs based on colony-forming units per water volume. Others suggest a relative trigger for remediation, whereby remediation is performed when a sample exceeds average counts from historical samples by a certain margin. Neither are based in evidence.

To supplement the environmental scan, a rapid review of the evidence for various mitigation strategies to reduce the risk of spread of Legionella from cooling towers was performed. Seven observational studies met inclusion criteria. Of these, one was discarded due to poor methodological quality. Two reports were from the province of Quebec, where a province-wide mandatory cooling tower registry, documentation of mechanical maintenance and water treatment programs and regular cooling tower sampling and culture were implemented following a significant outbreak in Quebec City in 2012. A decreasing trend in the number of samples exceeding a threshold of 10 000 colony-forming units per litre (cfu/L) was reported, though the level of significance for this observation was not clear and the association to human-cases of Legionella not discussed (35, 36). Similarly, France has required mandatory registration of all cooling towers since 2004 (also following a substantial outbreak), with obligatory sampling every two years. Findings from a cross sectional study suggest a decreasing trend in the number of Legionella cases since 2005 (37). A decrease in the number of yearly outbreaks was also reported (37).

The impact of routine sampling of plumbing systems and cooling towers was also described in Greece, where routine monitoring for Legionella was introduced in preparation for the Athens 2004 Olympic games. Greek authorities selected a threshold of 10 000 cfu/L for cooling towers and water distribution systems to trigger remediation. In hospitals specifically, a significant decrease in the contamination of potable plumbing systems was noted over the monitoring period, but no decrease in the proportion of cooling towers requiring remediation was noted (38). In community settings where the same measures were introduced, an inverse association was noted between Legionella contamination levels and the presence of a risk assessment and management plan with trained staff (39). The impact on Legionella cases was not discussed.

Finally, one mixed-methods study based in Texas investigated the impact of a requirement for owners of multi-family dwellings with cooling towers to perform annual testing for Legionella (40). Qualitative findings suggest that the testing requirement was effective in raising awareness of the potential risks of Legionella and enhancing overall controls, a finding that was also reported in Racine, 2019 (35). The low cost of testing (and possible remediation) was also identified as enabling by study participants. During the ten-year observation period from 2005 to 2015, the proportion of cooling towers with samples positive for Legionella decreased significantly. Trends in human cases were not noticeably different.

3. Policy options

To articulate policy recommendations, it is useful to discuss the expected real-world effects of the various risk mitigation strategies discussed above, while also accounting for implementation considerations.

The effectiveness of a mandatory cooling tower registry, and specifically, the impact of having a cooling tower registry on the number of human cases of Legionellosis, is difficult to assess because this intervention was never applied in isolation in the cross sectional studies we encountered in our rapid literature review. Mandatory registration was most often accompanied by routine sampling requirements and reporting. While the effectiveness of this intervention in reducing the burden of Legionella, therefore, cannot be commented on, there are several anticipated operational benefits to such a policy. First, having such a registry would improve the comprehensiveness and speed of public health response in the context of a suspected Legionella outbreak linked to a cooling tower. If a comprehensive list of cooling towers in each geographic area is readily available for reference by public health unit investigators, the task of identifying cooling tower locations is eliminated, and shutdown and remediation of potential sources of the outbreak can occur more rapidly, potentially saving lives. Procedures and processes that enable rapid detection and risk assessment during suspected Legionella outbreaks are essential (6) and SMDHU's own experience attests to this. Moreover, the human resources and other costs involved in a cooling tower outbreak response would also be diminished, because field investigations (for identification of potential cooling tower sites specifically) would be significantly reduced. Finally, mandatory registration of cooling towers would be necessary for other risk mitigation strategies such as routine environmental sampling, reporting, and auditing to be effectively implemented.

The primary disadvantage of mandating cooling tower registration is the additional costs for multiple stakeholders. First, cooling tower operators will need to cover the cost of operating permits, though these are generally low (frequently under $100 per annum) and some jurisdictions have provided operating permits at no cost in the initial phases of roll-out (41). Moreover, the processing of operating permit applications and maintenance of a cooling tower database will require administrative and technical staff support in government agencies at the local and provincial levels.

Implementation of a cooling tower registry can be done via various legal channels. While the examples of Hamilton and Vancouver demonstrate that cooling tower registries can be enacted through municipal by-laws, this approach is impractical for public health units who have jurisdiction over several distinct municipalities, as each would require its own by-law. A provincial approach, such as the one adopted in Quebec, could be implemented much more rapidly and with considerable savings (both in time and labour) for municipalities and their associated public health units across the province.

The cross-sectional articles we identified in our rapid review largely focused on frequent sampling and remediation. The overall impact on human cases of Legionella was largely equivocal. The benefits of routine sampling in a non-outbreak context remain unclear given the uncertain link between Legionella counts and likelihood of dissemination and human disease. Moreover, given the knowledge gaps that persist about interpretation of culture results and altogether arbitrary thresholds recommended in various guidelines, the effect of implementing a sampling protocol is difficult to forecast. In addition, a frequent sampling process imposes additional human resource demands on cooling tower operators and laboratories tasked with sample analysis. Therefore, a case for strong recommendation of routine sampling cannot be made at this time. Additional strategies, such as mandated reporting and preventive remediation would rely on routine environmental sampling being in place, and therefore cannot be recommended.

Most of the guidelines encountered in the environmental scan recommended implementation of a risk management plan, as described in the previous section. While the literature is equivocal on the association between implementation of a risk management plan and reduction of human cases of Legionellosis, the general principles of a risk management plan align with current understanding of factors that promote the growth of Legionella and how to mitigate these. A properly implemented risk management plan should decrease the presence of biofilm, monitor for, and remediate the presence of disinfectant residual, and control water age and water temperature. How to best achieve control of these factors, however, depends on a host of factors that may be unique to each facility. These include average temperature water, water replacement rate, plumbing system materials, turbidity level, and pH. Therefore, generalizable recommendations on the use of specific chemical biocides, their concentration, and potential supplementation with other effective decontamination techniques such as ozone or UV disinfection, are difficult to make. Instead, these decisions should be made by cooling tower owners for their specific system in consultation with manufacturers or third-party experts as they design their risk management plan and consider the potential for unwanted effects of various technologies including damage to plumbing infrastructure. Cooling tower operators should be directed to well-established guidelines for the formulation of risk management plans, such as the ASHRAE standard 188 (2018) and Guideline 12-2020 supplement, and the CDC Controlling Legionella in Cooling Towers resource. If testing is being considered by a cooling tower operator, Appendix D of the Mechanical design 15161-2013 control of Legionella in mechanical systems produced by the PSPC can be referenced (42).

4. Conclusion

The burden of Legionella is underestimated and rising. To protect Ontarians from potentially fatal disease, strategies mitigating the risk of Legionella spread from cooling towers must be adopted. Given operational considerations and the knowledge gaps that persist in the literature, the implementation of a province-wide mandatory cooling tower registry is recommended as a first step towards improving the control of Legionella in the province. Additional provisions could be made for cooling tower operators to have a risk management plan in place, though beyond general principles, decisions on the use of chemical biocides or other techniques should be made by cooling tower operators in consultation with experts familiar with the unique characteristics of their water system. Additional risk mitigation strategies, such as sampling, reporting, and auditing, could be added to the registration requirement if stronger evidence of their effectiveness becomes available. Finally, new technologies providing alternatives to wet cooling towers that would remove the risk of Legionella aerosolization entirely should be considered in the construction of new buildings.

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