Canadian Committee on Indoor Air Quality

# Legionella Control in Building Water Systems: A Guide for Building Managers and Operators

## Module 16

June 2023

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First version contracted and reviewed by the Canadian Committee on Indoor Air Quality.

French translation to follow.

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# Preface

As part of a technical guidance series commissioned by the Canadian Committee on Indoor Air Quality (CCIAQ), Module 16 was created to promote awareness and provide essential information for the control and mitigation of *Legionella* in building water systems.

This module contains objective, science-based information, divided into sections and annexes, so that facility managers and decision-makers have quick access to the pertinent knowledge base. The objective of this module is to assist building managers and operators in controlling health risks associated with *Legionella* bacteria in building water systems. The references and bibliography provide additional sources of information about *Legionella* and legionellosis.

The authors would like to thank Ursula Lauper, Caroline Huot, Judy MacDonald, Hans Schleibinger, Frederik Hammes, Michèle Prévost, Marianne Grimard-Conea, Émilie Bédard and Keith Noel for providing valuable recommendations and insights for writing this module.

# Canadian Committee on Indoor Air Quality (CCIAQ)

## Disclaimer

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Indoor air quality is a broad issue, and there are gaps in knowledge of the effects of indoor air quality on the health of occupants, and the effectiveness of various air quality technologies and solutions. User discretion is advised.

## Preamble

The goal of the Canadian Committee on Indoor Air Quality and Buildings is to improve indoor air quality in buildings and, ultimately, the health of occupants, by providing a national forum and clearinghouse for "best-of-knowledge" information on the design and operations of buildings as they affect indoor air quality.

Its mandate is to:

- solicit and review relevant information;
- identify gaps and issues;
- provide a discussion forum;
- recommend studies;
- develop "best-of-knowledge" positions and best practices;
- disseminate knowledge;
- promote adoption of uniform requirements, best practices and guidelines for the design and operation of buildings; and
- provide guidance for evaluation of solutions and technologies.

The CCIAQ's initial focus was on non-specialist (e.g., not health care nor industrial) buildings, such as offices, schools, commercial spaces and residences. Many larger buildings have complex heating, ventilating and air conditioning systems that are operated and managed by knowledgeable persons; however, some buildings lack sophisticated systems. Documents produced by the CCIAQ are intended for use by building operators and facility managers, but the information contained in the Guides is meant to be helpful to anyone seeking understanding.

CCIAQ's modules are not intended to substitute for releases by Federal and Provincial/Territorial health organizations, but to support and to complement them with background and technical expert information and related insights on actionable technical solutions, backed by scientific and peer-reviewed scientific literature, and releases of cognizant authorities.

The Committee welcomes feedback on all documents and invites submission of suggestions for their improvement. The Committee is also soliciting ideas for new topics for discussion. Please contact the CCIAQ at https://iaqresource.ca/contact-us/



The Canadian Committee on Indoor Air Quality Module 16: *"Legionella Control in Building Water Systems: A Guide for Building Managers and Operators"*
https://iaqresource.ca/en/iaq-guides/


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# 1. Section 1: Introduction

## 1.1. Purpose

This module aims to provide “best-of-knowledge” information to help building owners and managers control risks associated with *Legionella* in building water systems. The objectives are the following:

- To raise awareness on the risk that airborne *Legionella-containing aerosols* can pose to building occupants.
- To guide the development of a *Legionella* water management plan.
- To provide recommendations for the operation and maintenance of building water systems with regard to the control of *Legionella.*
- To support the interpretation of results from routine *Legionella* monitoring.
- To guide the preparation of a response to a Legionnaire’s disease outbreak and outline the steps that can be taken in the event of an outbreak.

## 1.2. Scope

This module is intended to be used by facility managers in charge of managing, operating, and maintaining building water systems.

The scope of the module covers the following:

- ***Buildings***: Commercial, institutional, industrial, and multiunit-residential buildings. It does not cover hospitals, other healthcare facilities, or single-family residential buildings.
- ***Building water systems***: The module primarily focuses on building water systems, including hot and cold water systems, cooling towers, decorative fountains, humidifiers, and hot tubs and spas. However, it is important to note that other sources of *Legionella* are known, such as garden hoses and sprinkler systems, dental unit water lines and wastewater treatment plants.
- ***Building management***: The operation and maintenance of existing building water systems. The design, installation, and commissioning of new building water systems are not covered.
- ***Pathogenic microorganisms***: Although general risk management principles presented in this module can help manage risk associated with pathogens other than *Legionella*, such as *Mycobacterium*, *Pseudomonas*, and *Naegleria fowleri*, this module only focuses on managing the risks posed by the growth of *Legionella* in water systems, potentially resulting in airborne, Legionella-containing aerosols.

## 1.3. Expectations for the reader

The reader can expect to gain a general understanding of the risks posed by the growth of *Legionella* in building water systems by learning about the following:

- What is *Legionella*, and how can it pose a health risk?
- The factors contributing to *Legionella* presence and growth in building water systems
- The steps that can be taken to limit *Legionella* growth in building water systems and to minimize its transmission

- The steps that can be taken in the event of a legionellosis outbreak, including how to work with public health authorities and how to mitigate the outbreak.

The reader can also expect to find information on relevant standards, regulations, guidelines and guidance documents that apply to the risk management of *Legionella* in building water systems. This document does not require previous training in risk assessment and management.

# 2. Section 2: Legionellosis

## 2.1. What is Legionella

*Legionella* is a genus of gram-negative bacteria that compromises more than 72 species and 3 subspecies (LPSN, 2023). These bacteria are naturally found in aquatic environments such as lakes and rivers, but can also colonize human-made water systems such as cooling towers, hot tubs, fountains, and building water distribution systems.

*Legionella* bacteria have a growth temperature range of 25°C to 43°C, with optimal growth temperatures being between 30°C and 40°C. At temperatures above 60°C, these bacteria begin to die off. Favourable growth conditions for this bacterium include the presence of nutrients and biofilms, as well as stagnant water and low disinfectant levels.


**Fig. 2-1**. Scanning electron microscopic (SEM) image of a large grouping of *Legionella pneumophila* bacteria under a magnification of 8000X. Source: U.S. Centers for Disease Control (CDC)/Janice Haney Carr

## 2.2. Diseases associated with *Legionella*

At least 30 *Legionella* species are known to cause human infections (Health Canada, 2022). Pathogenic *Legionella* species can cause two respiratory illnesses: Legionnaires' disease and Pontiac Fever. The generic term "legionellosis" encompasses all diseases associated with *Legionella* species. Although various *Legionella* species can cause Legionnaires' disease, the majority of the reported cases are attributed to *Legionella pneumophila* (Benin et al., 2002). It is important to note, however, that there may be an information bias in this regard, as the urinary antigen test commonly used by clinicians detects only *Legionella pneumophila* serogroup 1. The relevant clinical aspects of these diseases are summarized in this section. The Health Canada *Guidance on Waterborne Pathogens in Drinking Water* can be consulted for more information on the health effects associated with *Legionella* (Health Canada, 2022)

### 2.2.1. Legionnaires' disease

Legionnaires' disease is a severe type of pneumonia that can develop rapidly and be life-threatening. Some relevant clinical aspects of Legionnaires' disease are:

- ***Symptoms:*** *Symptoms frequently reported for this disease include:*
  - Fever
  - Cough and difficulty breathing
  - Muscle pain
  - Headache
  - Loss of appetite
  - Confusion
  - Gastrointestinal problems (diarrhea, nausea, vomiting)

  The time interval between exposure and the appearance of symptoms (incubation period) is 2–10 days, although it may extend to more than ten days (WHO, 2007).

- ***Diagnostic***: The standard diagnostic tests for Legionnaires' disease are:
  - the urinary antigen test, which detects antigens of *Legionella pneumophila* in urine, and
  - the lower respiratory secretion culture, which can detect multiple *Legionella* species.
- ***Treatment***: Legionnaires' disease can be treated with antibiotics, and early treatment can improve the chance of a full recovery.
- ***Risk factors***: *Legionella* can infect anyone, but some groups of the population are more susceptible to Legionnaires' disease (Cunha et al., 2016). Individuals who are more susceptible to developing Legionnaires' disease include:
  - Adults older than 40 years
  - Males
  - Current and former smokers
  - Those with underlying diseases (e.g., cancer, diabetes, chronic lung disease)
  - Those who are immunocompromised

### 2.2.2. Pontiac fever

Pontiac fever is a milder respiratory illness than Legionnaires' disease and does not cause pneumonia. The following clinical aspects can be relevant:

- ***Symptoms***: This disease typically causes mild symptoms such as:
  - Fever
  - Headache
  - Muscle aches
  - Dry cough

  The average incubation period is 24–48 hrs (WHO, 2007).

- ***Diagnostic***: Pontiac fever can be diagnosed with a urine or blood test.
- ***Treatment***: Most people who develop Pontiac fever do not need medical treatment and recover within a week.

## 2.3. Incidence rate of legionellosis

The incidence rate is a measure of the number of reported cases per unit of population, usually per 100,000 individuals, during a given period, usually one year. This rate provides information on the evolution of the disease and helps prioritize interventions and research efforts.

### 2.3.1. Canadian surveillance data

Data from the Canadian Notifiable Disease Surveillance System show that annual incidence rates of reported legionellosis per 100,000 persons in Canada increased from ~0.2 in 2004 to ~1.8 in 2019 (Fig. 2-2a). Similar increases have been reported in studies from the United States (NASEM, 2020) and countries in Europe (Fischer et al., 2022; Riccò et al., 2021), Asia (Fukushima et al., 2021) and Oceania (Graham and Baker, 2022). Canadian surveillance data also show that the incidence rate of ~4.5 for people 60+ years old is much higher than for other age groups (Fig. 2-2b). Breaking down Canadian surveillance data by sex indicates that the incidence rate is about two times greater for males than for females (Fig. 2-2c). It is generally acknowledged that cases of legionellosis are underreported. This can happen for various reasons, including a lack of awareness about the disease, clinical diagnostic tests optimized to detect only *Legionella pneumophila* serogroup 1, or inadequate reporting systems (NASEM, 2020). Annex A of this module provide more information on legionellosis tracking and monitoring.

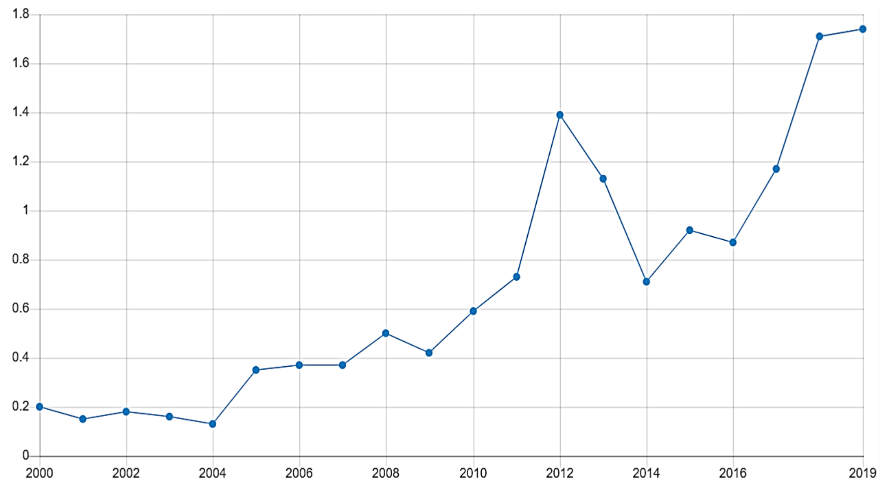
### 2.3.2. Seasonality

Seasonality in cases of legionellosis is typically observed, with a higher number of cases during the summer months (Falconi et al., 2018). Warmer months of the year may provide ideal environmental conditions for the growth of Legionella because the water temperature in some building water systems increases. In addition, some building water systems, such as cooling towers, are used more during warmer months, potentially increasing human exposure. Nevertheless, *Legionella* transmission during autumn and winter should not be overlooked because outbreaks can occur during these periods as well. For instance, a community-associated Legionnaires' disease outbreak occurred in Calgary, Canada, from November–December 2012 (Knox et al., 2017).

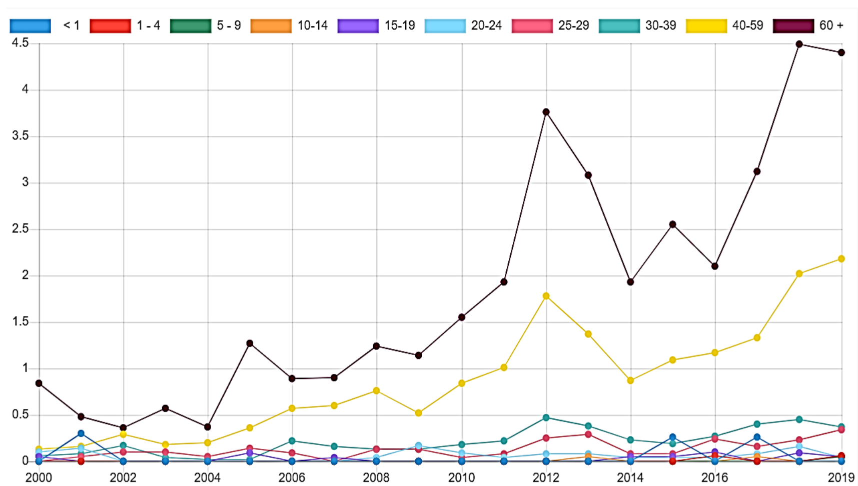
### 2.3.3. Increase in incidence rates

The rise in incidence rates of legionellosis is believed to have multiple contributing factors. The aging population and the rising prevalence of immunocompromised individuals potentially contribute to the increase in incidence rates, as these individuals are particularly susceptible to the disease. As healthcare improves and life expectancies increase, more people live with weakened immune systems, making them more vulnerable to legionellosis. Climate change may also play a role, as longer and increased use of air conditioning could facilitate the proliferation of *Legionella*. Additionally, changes in water quality due to climate change, such as increased water temperatures, can promote *Legionella*'s growth in building water systems. Moreover, aging infrastructure may increase the risk of main breaks and leaks, which could introduce *Legionella* bacteria into the distribution water system, leading to building water system colonization. Therefore, effective water management programs and proper maintenance of water distribution systems become increasingly important in controlling *Legionella* in building water systems, particularly amidst an aging population, increasing temperatures due to climate change, and aging infrastructure.

(a) Incidence rate for all legionellosis cases




(b) Incidence rate for legionellosis cases by age



(c) Incidence rate for legionellosis cases by sex

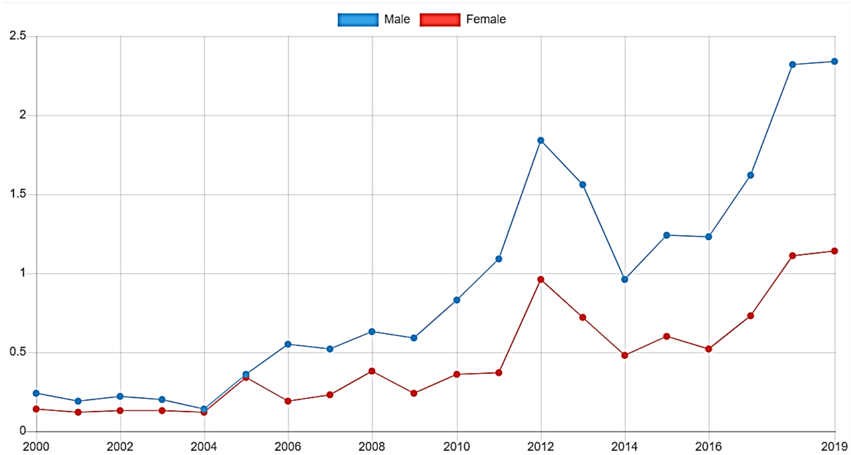



**Fig. 2-2**. Annual incidence rates of legionellosis in cases per 100,000 persons in Canada (all provinces and territories) from 2000 to 2019 for (a) all legionellosis cases, (b) legionellosis cases by age, (c) legionellosis cases by sex. SOURCE: diseases.canada.ca

## 2.4. Transmission of *Legionella* to humans

### 2.4.1. Inhalation of *Legionella*-containing aerosols and infection

*Legionella* is most commonly transmitted through the inhalation of contaminated aerosols generated by various building water systems, including but not limited to cooling towers, decorative water features like fountains, hot tubs and showers. Equipment and maintenance of these building water systems can create aerosols when water is splashed, sprayed, dripped, misted, bubbled or jetted. This means that any location where water is used in this way poses a risk. These aerosols can also travel long distances through air currents, potentially exposing vulnerable individuals far from the source.

Inhalation transmission occurs when *Legionella* are transported within aerosols generated by water devices and enter the respiratory tract through the mouth or nose. Aerosols of size <10 µm can deposit into the lungs (Heyder et al., 1986), where a dose of *Legionella* can initiate infection (Box 2-1). Transmission can occur in indoor and outdoor environments. Once *Legionella* contained in these aerosols deposit into the deep regions of the lungs, they can be ingested by macrophages, a type of human immune cell. *Legionella* can then replicate within these cells and interfere with normal lung functions by causing inflammation and damage, resulting in pneumonia.

**Box 2-1** Dose–response models for *Legionella pneumophila*

Dose–response models have been developed to describe the relationship between the dose of *Legionella pneumophila* inhaled and the likelihood of infection (Armstrong and Haas, 2007; Armstrong and Haas, 2008). These models have been derived from animal experiment data and validated against human outbreaks. These dose–response models indicate that the likelihood of infection increases as the dose increases, but there is no dose at which the infection risk is zero. In other words, any *Legionella* bacterium is expected to act independently and carries some risk of infection, no matter how small the dose may be.

It is important to note that testing results for *Legionella* or *Legionella pneumophila* cannot guarantee the absence of these bacteria in a system. This is because sampling and testing methods have limitations for detecting bacteria, which provide incomplete information about their presence (see Section 5). Hence, the risk cannot be zero but can be reduced to an acceptable level.

Therefore, a chain of transmission must occur for *Legionella* to cause human disease (Fig. 2-3). The main steps in the chain are the following:

1. *Legionella* are in the building water system due to conditions favouring their persistence or growth.
2. The capacity of the building water system to generate aerosols containing *Legionella.*
3. Presence of an individual inhaling these contaminated aerosols.
4. The ability of bacteria to deposit into the lungs and initiate infection in a susceptible human host.

This chain of transmission of *Legionella* can be interrupted by controlling the concentration of bacteria in water, preventing and reducing the formation and release of contaminated aerosols, and minimizing human exposure to these aerosols.

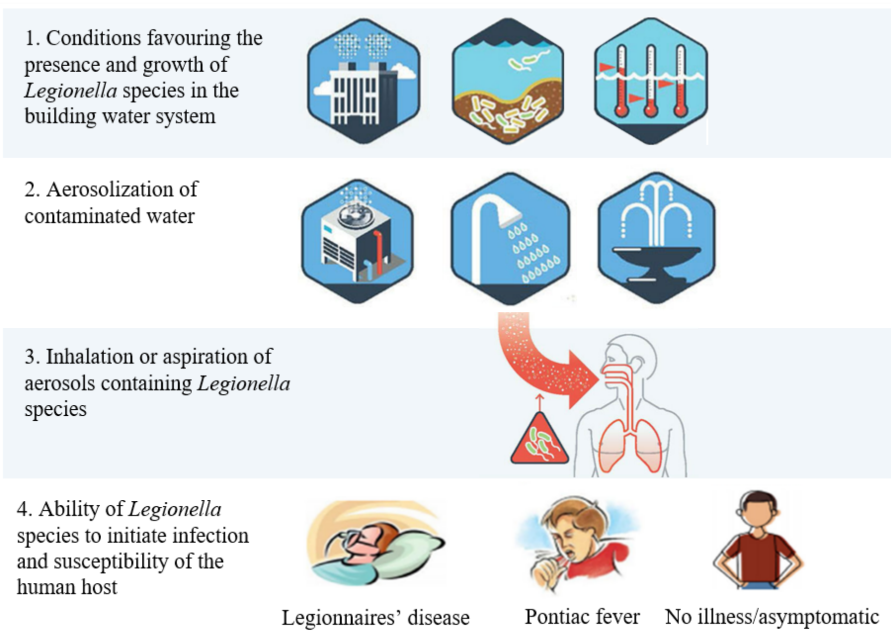



**Fig. 2-3.** Chain of transmission for *Legionella* to cause human disease. Adapted from an infographic produced by the U.S. Centers for Disease Control (CDC) available here: https://www.cdc.gov/legionella/infographics/legionella-affects-water-systems.html

### 2.4.2. Other transmission routes

*Legionella* are not transmitted by normal consumption of contaminated drinking water (Percival and Williams, 2014), and person-to-person contact has been suspected only once (Correia et al., 2016). In rare cases, exposure can occur through aspiration (inhaling water into the lungs) or contact with contaminated water on the skin (Padrnos et al., 2014)or with potting soil/compost (van Heijnsbergen et al., 2015). Although these sources have been recognized, inhalation of aerosols is the most common transmission route, leading to legionellosis (NASEM, 2020).

Guidance on precautions for potting soil/compost can be found on the following webpage: Minimising the risk of a Legionella infection at home.

## 2.5. Approach to control *Legionella* in building water systems

Developing a water management plan is central to prevention. This plan provides a step-by-step approach for identifying locations where *Legionella* can grow and be transmitted to building occupants; developing control measures to prevent growth; monitoring these control measures, and taking corrective action(s) when control limits are exceeded. Section 4 describes the development of a water management plan. It is important to note that effective responses to legionellosis outbreaks are crucial when prevention measures fail. Section 6 addresses this topic.

Annex B provides information on control measures to reduce aerosol formation and exposure.

# 3. Section 3: *Legionella* in building water systems

## 3.1. Entry of *Legionella* into building water systems

*Legionella* bacteria are commonly found in natural environments, including surface and groundwater sources, as well as soils. Despite their widespread presence, their risk to human health is considered low under normal circumstances because they are not readily aerosolized, and their concentrations are usually low. However, *Legionella* can enter and colonize building water systems providing favourable growth conditions for the bacterium.

*Legionella* can enter a building through two main routes: direct and indirect. Direct entry occurs through the water utility distribution system after passing through drinking water treatment (Loret and Greub, 2010) or due to intrusion during disruptions in the water distribution system due, for example, to construction activities (Mermel et al., 1995) and watermain breaks. This can lead to the transport of low concentrations of *Legionella* into building plumbing systems and associated equipment, such as cooling towers, humidifiers, and decorative fountains.

Indirect entry involves a connection between different building water systems within the same building. For example, if *Legionella* colonizes a decorative fountain, the bacteria could spread to other building water systems via the connection to the building plumbing. As another example, contaminated aerosols could be transported from a cooling tower into the HVAC systems of another building, where they can proliferate.

## 3.2. The role of protozoa and biofilms in *Legionella* colonization

The presence of protozoa and biofilms within building water systems can provide an ideal environment for the growth of *Legionella*. The replication of *Legionella* is known to occur predominantly within protozoa (i.e., single-celled organisms such as amoebae and ciliates) that reside within biofilms (NASEM, 2020). A biofilm is a complex aggregation of microorganisms held together by an extracellular matrix composed of various biological molecules (Fig. 3-1). This matrix provides adherence to surfaces and protects microorganisms from physical stress, such as shear forces, chemical disinfectants and, to some extent, high water temperatures (Abdel-Nour et al., 2013). The protozoa hosting *Legionella* can create an additional protective layer against thermal and chemical stressors. The aerosolization of *Legionella* bacteria can occur when a piece of the biofilm is disrupted by the physical forces exerted by the water flow velocity (Shen et al., 2015).

(a) Biofilm inside a shower hose

(b) Free-living and biofilm-associated *Legionella* bacteria

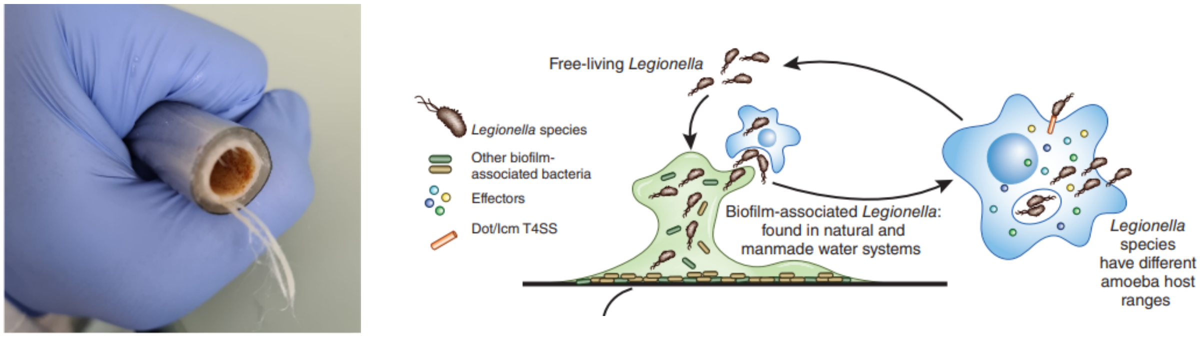



**Fig. 3-1**. Biofilm in water pipes. (a) Photo: A. Cavallaro, Eawag. (b) drawing from Comas (2016)

## 3.3. Preventive measures to control *Legionella* growth in a building

Control of *Legionella* in a building water system is a complex task requiring a comprehensive approach. This section briefly describes factors affecting the growth of *Legionella* in building water systems.

### 3.3.1. Control of water temperature

In laboratory-controlled conditions, *Legionella* can grow at water temperatures between 25–43°C, with an optimal range of 30–40ºC (NASEM, 2020) (Fig. 2-3). In building water systems, various environmental conditions can affect this range, including water quality parameters and the protection of the bacteria by the biofilm. Maintaining temperatures above 60°C at hot water heaters and above 55°C at distal points across hot-water systems, and below 25°C across cold-water systems is recommended to limit colonization and growth (NASEM, 2020). Higher water temperatures required to prevent *Legionella* growth are associated with an increased risk of scalding for sensitive populations, such as young children and older people. For some building water systems, thermostatic mixing valves (i.e., temperature valves) may be needed to prevent scalding by blending hot and cold water close to fixtures.

Operating outside a range of 25–43°C may not be feasible for some building water systems, such as cooling towers, or when implementing energy conservation measures (Box 3-1). In such cases, other control measures, such as on-site disinfection, may be needed to control *Legionella* growth.

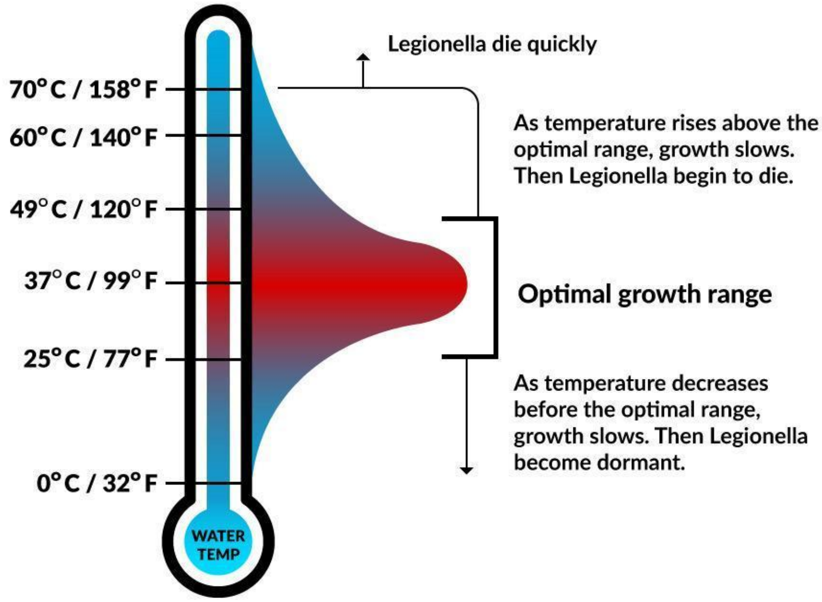



**Fig. 3-2.** Temperature effects on survival and growth of *Legionella pneumophila* in laboratory-controlled conditions (ASHRAE, 2020).

**Box 3-1 Unintended consequences of energy and water conservation**

***Energy conservation***: Implementing strategies to reduce energy consumption or water use from a building water system can create an environment favourable for *Legionella* growth. Some well-known energy conservation measures are reducing the temperature of stored hot water and reducing the use of hot water. Lowering the stored hot water temperature has been shown to significantly increase the likelihood of detecting *Legionella* in a large building (Blanc et al., 2005).

***Water conservation***: The primary approach to reducing water use is implementing water-saving equipment, such as low-flow showerheads, faucets and dual-flush toilets. While this equipment reduces water consumption, it also has the potential to promote the growth of *Legionella*. Such water-saving devices extend water age, leading to stagnation, as discussed in Section 3.3.3. Alternative water sources, such as greywater and rainwater, can also be used to reduce water use. In addition to the fact that these alternative systems often have an extended water age, these water sources can contain *Legionella* and high levels of organic matter, which can contribute to *Legionella* growth. Therefore, on-site filtration or disinfection, such as chlorination or UV disinfection, may be necessary to ensure the safe use of these alternative waters in building water systems.

The report "Management of *Legionella* in Water System" from the National Academies of Science, Engineering, and Medicine (NASEM) provides a more extensive review of the impact of energy and water conservation measures on *Legionella* in building water systems (NASEM, 2020).

### 3.3.2. Maintaining a disinfectant residual concentration

Chlorine and monochloramine are the primary disinfectants added to potable water before distribution. These disinfectants can prevent biofilm formation from the centralized treatment plants to the entry of the buildings when present at sufficient concentration. However, it is important to note that disinfectant residual concentrations can be significantly depleted when water enters the building plumbing system. The disinfectant residual can be consumed within the building water system due to biofilm growth, stagnation and increased water temperature. Due to the rapid depletion of disinfectant residuals at high water temperatures, it should not be assumed that disinfectant levels will be maintained in hot water systems without implementing in-building disinfection measures (Grimard-Conea and Prévost, 2022).

For large buildings, on-site disinfection may be needed to control the risk associated with *Legionella*. The decision to conduct on-site disinfection is typically made in consultation with a water treatment specialist or public health authority. Types of on-site disinfection include chlorine, monochloramine, chlorine dioxide, and copper-silver ionization (USEPA, 2016).

Cooling towers require supplemental water treatment to prevent scaling, corrosion, and microbial growth. Typical disinfectants used in cooling towers are metal ions (copper and silver), oxidizing agents (e.g., chlorine, bromine), and non-oxidizing agents (e.g., 2,2-dibromo-3-nitro propionamide (DBNPA), glutaraldehyde). The type and dosage of a chemical disinfectant are specific to a system and depends on water quality parameter such as pH, temperature, and concentration of organic and inorganic matter (Kim et al., 2002).

### 3.3.3. Control of water age

Controlling water age (the residence time of the water in the system) is essential for maintaining water temperature, disinfectant residuals, and preventing the growth of biofilms. Stagnation or low flow conditions can cause changes in water temperature — decreases in hot water systems or increases in cold water systems. These changes can move the temperature toward *Legionella* spp.'s optimal growth range. Additionally, stagnation can reduce the level of disinfectant residuals and promote the development of biofilms. Inefficient water circulation due to poor mixing in storage tanks and reservoirs or inactive pipe sections (dead-end or dead legs) can make it challenging to control water age effectively. Recirculation lines are commonly used to decrease hot water stagnation; however, even with recirculation, temperature losses that can promote *Legionella* growth can occur at distal points (Bédard et al., 2015; Boppe et al., 2016).

### 3.3.4. Control of sediments

The buildup of sediments, such as mineral deposits, debris, and organic matter, provides a source of organic material and nutrients essential for the growth and survival of *Legionella* and other microorganisms. Over time, these sediments can accumulate and contribute to the formation of biofilms.

Sediment accumulation on surfaces, pipes and fixtures from building water systems can result from poor control of scale and corrosion. Scale is a buildup of mineral deposits caused by hard water. Corrosion is the deterioration of metal surfaces due to their interaction with water. As corrosion occurs, metal particles are released into the water and can accumulate in the system. The deterioration of metal surfaces due to corrosion and the buildup of corrosion deposits can provide a suitable habitat for *Legionella* by consuming disinfectant residuals, providing nutrients to the bacteria, and enabling the protection of the biofilm (Brazeau and Edwards, 2013; Proctor et al., 2017).

**Box 3-2 Impact of construction activities and other water system disruptions**

Disruption to the normal functioning of a building water system can be due to numerous external factors, including construction activities, water main breaks or shut off, power outages and natural disasters. These disruption events are known risk factors for the growth and spread of *Legionella* spp. in building water systems (Garrison et al., 2016; Scanlon et al., 2020).

For instance, re-pressurizing the water distribution system during startups and shutdowns can dislodge biofilm containing *Legionella*, which can then be transported to building areas adjacent to construction activities (Cooksey et al., 2008; Mermel et al., 1995). Construction activities can also increase stagnation, leading to fluctuations in water quality parameters, such as water temperature and disinfectant residual (Cooksey et al., 2008). Furthermore, excavation and demolition can lead to the intrusion of *Legionella* or sediments into the building plumbing system.

Current standards and guidance documents on *Legionella* water management planning do not explicitly address the risk associated with construction activities.

## 3.4. Building water systems supporting *Legionella* growth

The main characteristics of building water systems frequently identified as sources of legionellosis cases are described in this section.

### 3.4.1. Hot and cold water systems

Hot and cold water systems in buildings are typically used for domestic purposes such as drinking, cooking, personal hygiene, and washing. These systems include the water piping and all system components, from the point-of-entry of the supply water to the points-of-use. Hot water systems are generally supplied by a pressurized source connected to a water heater and can be distributed using either a recirculating or non-recirculating system. Storage tanks or reservoirs can be used to regulate water pressure and ensure a constant supply of water.

If a hot or cold water system becomes colonized by *Legionella*, occupants may be exposed to contaminated aerosols produced by its components, including showerheads, faucets, aerators, and spray nozzles (ASHRAE, 2020).

Premises plumbing systems have a high surface-area-to-volume ratio, which can facilitate the development of biofilms that can impact a significant portion of the water flowing through the pipes. Stagnation can further promote the growth of biofilms and reduce the level of disinfectant residuals (NASEM, 2020). Other risk factors associated with *Legionella* growth in premises plumbing systems include:

- Water temperatures below 55°C at distal points across hot-water systems and above 25°C across cold-water systems;

- No or low disinfectant residual at the point of entry;
- High nutrient concentrations
- Highly variable flow velocities, and
- Potential for cross-connections between different plumbing systems, such as between potable water and non-potable water systems.

### 3.4.2. Heating, ventilation, and air conditioning air distribution systems

Heating, ventilation, and air conditioning (HVAC) systems are essential for maintaining indoor environmental comfort in Canada. However, under certain conditions, these systems can spread *Legionella*-containing aerosols. The HVAC-associated sources of *Legionella* may include cooling towers and evaporative condensers (for more detail, refer to Section 3.4.3), evaporative coolers, humidifiers (Section 3.4.4), and leaks from pipes, coils, and heat exchangers.

Serving as transmission channels, HVAC systems can circulate *Legionella*-containing aerosols from a source inside and outside the building. Moreover, the HVAC system itself might be the source of *Legionella* growth and aerosolization. While some wet regions or leaks within an air-conditioning unit may not have the appropriate water temperature to support *Legionella* growth, certain locations and conditions, such as hot air systems, dual duct systems or heating coils leakages, could operate at temperatures suitable for *Legionella* growth. Some of these areas might not directly generate aerosols, but the turbulence present in specific regions could contribute to *Legionella* aerosolization. The effect of turbulent conditions on such aerosolization is not yet fully understood. To prevent the spread of *Legionella*, facility managers must consider that all wet areas in air handling systems might generate *Legionella*-containing aerosols under suitable conditions. It is recommended to eliminate these wet areas, particularly following periods of stagnation during shutdowns and outbreak investigations.

For in-depth information on HVAC contamination sources and guidelines for preventing exposure to HVAC air distribution systems during a legionellosis outbreak, refer to the U.S. Occupational Safety and Health (OSHA) legionellosis webpage: https://www.osha.gov/legionnaires-disease/

Additional modules published by the CCIAQ offer valuable information on microbial growth prevention and control in HVAC systems. These include:

- Module 3: Custodial Activities, Maintenance, Repair and Renovation
- Module 5: Hygienic Operation of Air-Handling Systems
- Module 10: Management Strategies for Moulds and Microbiologic Agents

### 3.4.3. Cooling towers

Cooling towers circulate water to remove heat from a building, which is first collected by equipment such as water-cooled chillers, heat pumps, compressors, condensers, and heat exchangers. The process involves rejecting heat from the circulating water to the atmosphere through evaporation.

There are two main types of cooling towers: open-circuit and closed-circuit. Open-circuit cooling towers are designed to transfer heat from water to the air through evaporation (Fig. 3-2a). They work by spraying water onto a fill material that increases the surface area for evaporation. As the water evaporates, it cools down and is recirculated back to the heat source. Closed-circuit cooling towers operate similarly to open-circuit cooling towers, but the water is contained within a closed loop (Fig. 3-2b). Closed-circuit cooling towers that cool a refrigerant are often referred to as evaporative condensers.

In Canada, some cooling towers are operated year-round, while others are shut down during winter.

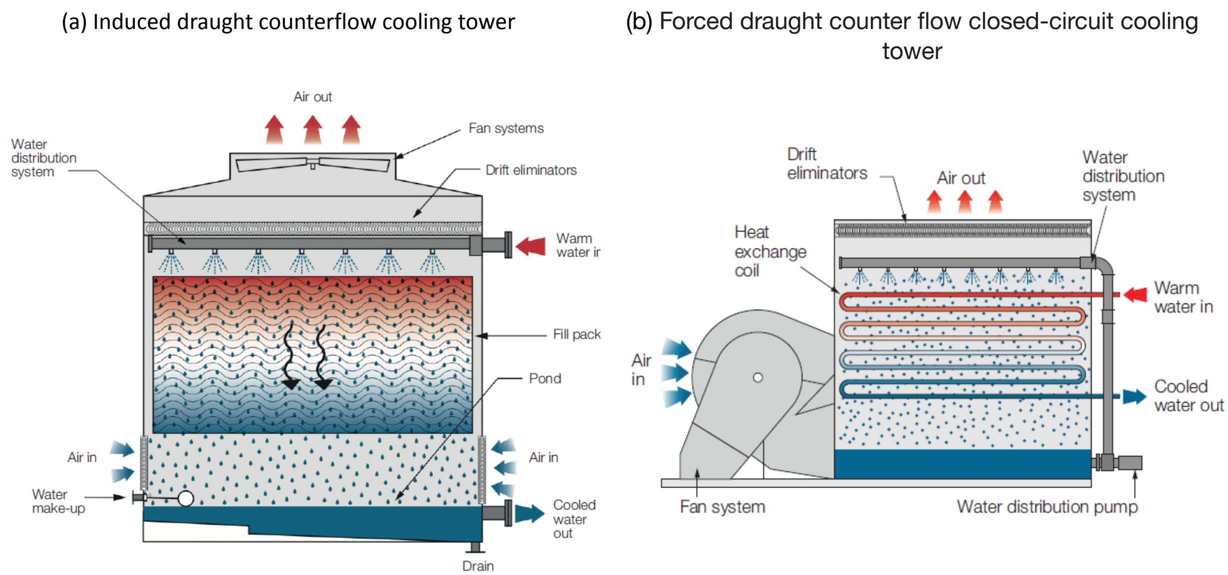



**Fig. 3-3.** Typical configuration and components of an open-circuit cooling tower (a) and a closed-circuit cooling tower (b). Reference: HSE (2013)

Cooling towers produce water droplets, known as “drift,” that can potentially transport *Legionella* bacteria and infect individuals exposed to them. Drift can be dispersed outdoors or enter building interiors through air intakes or infiltration, leading to indoor exposure. Therefore, *Legionella* growth in water and the generation of contaminated aerosols should be controlled to minimize the risk of legionellosis associated with these building water systems.

*Legionella* growth can occur in water from cooling towers having certain risk factors, including standing water in the cooling tower, operation within a temperature range that provides optimal conditions for growth, nutrient-rich water, formation of biofilm on the internal surfaces of cooling tower components, and inadequate maintenance, such as infrequent cleaning, disinfection, and insufficient water treatment (NASEM, 2020; SPX, 2009).

Cooling towers incorporate drift eliminators to reduce water droplets from the exhaust air. While drift eliminators can effectively reduce the production of *Legionella*-containing aerosols, they may become less effective over time due to fouling, damage, or inadequate maintenance

(ASHRAE, 2020). In addition, the efficiency of drift eliminators can vary depending on the design of the cooling tower (SPX, 2009).

#### 3.4.4. Humidifiers

Humidifiers add moisture to the air to increase humidity levels, which can help prevent dry skin, nasal congestion, and respiratory problems. They are available in various sizes, from small residential units to large commercial systems integrated into the building's HVAC system. *Legionella* can grow and multiply in water tanks, pipes, and other components of humidifiers if the temperature range is adequate to foster *Legionella* growth, especially when these components are not cleaned and maintained correctly (Sahai, 2017).

There are several types of humidifiers. Steam humidifiers are generally considered low risk, as the high temperature required to generate steam makes it unlikely for viable *Legionella* to survive (AIHA, 2022). However, humidifiers that atomize potable water, such as impeller and ultrasonic humidifiers, that have not been heated to a temperature high enough to inhibit *Legionella* growth can be a transmission source.

#### 3.4.5. Decorative water features

Decorative water features like fountains, waterfalls, and green walls are artificial structures designed to create aesthetic effects. These features can vary in size, configuration, and complexity but generally involve water being sprayed into the air or cascading over a medium before returning to a basin. Without proper cleaning and maintenance, microbial growth can occur due to factors such as water age, heat gain, and loss of disinfectant residual (ASHRAE, 2020). These conditions can lead to the amplification of *Legionella* bacteria and their dissemination via aerosolization. Indoor and outdoor decorative water features have been associated with Legionnaires' disease outbreaks (AIHA, 2022).

#### 3.4.6. Water-using devices in buildings

Many water-using devices have been identified as a source of legionellosis cases. Those include ice machines, drinking fountains, fire suppression sprinklers, emergency eyewash and safety showers, dental unit water lines, and healthcare devices (nebulizers, ventilators, heater-cooler units) (AIHA, 2022).

For emergency eyewash and safety showers, periodic flushing, which involves running water through the system for a set period to ensure fresh water is introduced into the system, can prevent *Legionella* growth by reducing water age, as discussed in Section 3.3.3. For drinking fountains and ice machines, regular cleaning and replacement of filters per manufacturer recommendations can help minimize *Legionella* growth in the system. Insulating heat exhaust pipes of ice machines can also be an effective option to reduce the possibility of water temperatures reaching the range that supports *Legionella* growth (ASHRAE, 2020).

# 4. Section 4: *Legionella* water management program

## 4.1. Background

A *Legionella* water management program applies Hazard Analysis and Critical Control Points (HACCP) principles to prevent *Legionella* growth in building water systems. The HACCP is a widely used risk management approach to control foodborne and waterborne illnesses (Mortimore and Wallace, 2013). The HACCP principles have been adapted and applied to prevent *Legionella* growth and transmission in building water systems (WHO, 2007; 2011). The World Health Organization (WHO) refers to these as "water safety plans". In this module, we refer to these as *Legionella* water management plan (WMP).

A WMP outlines a range of measures the building manager, the building operator or another responsible individual takes to identify, assess, and control risks that *Legionella* can pose for building occupants and visitors. The WMP approach is most effective when it considers the site-specific characteristics of a building. In some jurisdictions, other terms are used. For example, "Legionella Bacteria Control Management Program" is used in the Public Services and Procurement Canada (PSPC) Standard MD-15161 (PSPC, 2016).

Although *Legionella* WMPs are recommended by various industry standards and guidance documents, such as WHO (2007) and ASHRAE (2018), the factors influencing the successful development and implementation of WMPs are not yet fully understood (Ambrose et al., 2020; Clopper et al., 2021; van der Lugt et al., 2019). Several guidelines and guidance documents outline approaches to developing and implementing a *Legionella* water management plan (WMP). Information from various sources was compiled in this section to provide facility managers with an overview of best practices and guidelines.

## 4.2. Building water systems that should prioritize the development of a WMP

A water management plan can be developed for building water systems that have a high potential for *Legionella* growth and transmission. According to ASHRAE (2018), building water systems that should prioritize the development of a WMP are:

- Potable building water systems from the following buildings:
  - Buildings primarily housing people older than 65 years (like a retirement home or assisted-living facility)
  - Buildings having multiple housing units and a centralized hot water system (like a hotel or high-rise apartment complex)
  - Buildings having more than ten stories (including basement levels)
  - Healthcare facilities or other buildings that house or treat individuals who are more susceptible to developing Legionnaires' disease (see Section 2.2.1)
- Open- and closed-circuit cooling towers or evaporative condensers
- Hot tubs, whirlpools and spas

- Ornamental fountains, misters, atomizers, air washers, humidifiers or other nonpotable water systems or devices that release water aerosols

The yes/no worksheet from the U.S. Centers for Disease Control and Prevention (CDC) toolkit *Developing a Water Management Program to Reduce Legionella Growth and Spread in Buildings* can be used to determine whether a building or specific building water systems need a WMP.

## 4.3. Development and implementation of a *Legionella* water management plan

### 4.3.1. Structure of a WMP

The key steps to develop a *Legionella* WMP are described in Box 4-1 (WHO, 2007; 2011). Each step is further described in the following sections.

### 4.3.2. Step 1: Assemble the WMP team

The first step in developing a WMP is to assemble a WMP team responsible for its establishment. Clear roles and responsibilities should be determined for each team member. The team should consist of local personnel involved in the operation and maintenance of the building water system. The planning and execution of a plan should only be carried out by individuals with the appropriate training and experience. The necessary training depends on the complexity of the building water system and the knowledge of the individual involved. If the team lacks expertise in a specific area, then bringing in external specialists as contractors may be necessary.

The *Technical Framework: Legionella*, published by the American Industrial Hygiene Association (AIHA), outlines the essential roles, knowledge, and skills necessary for developing and implementing a successful *Legionella* WMP (AIHA, 2020). This framework can be used to evaluate the training needs of each team member based on their specific roles and responsibilities. Table 4-1 provides an overview of this framework.

**Table 4-1**. Roles and core knowledge and skills required by an individual for effectively developing and implementing a WMP (adapted from AIHA (2020))

| | Competent Technician | Program Professional | Responder Professional |
|---|---|---|---|
| **Role** | • Everyday monitoring of building water systems under the guidance or direction of a Program Professional<br>• Assisting with the investigation of potential sources in an outbreak or suspected case of disease | • Developing and overseeing the *Legionella* water management plan<br>• Establishing control measures and monitoring strategies, supervising or reviewing results, and directing corrective actions<br>• Examining results from *Legionella* analysis | • Developing an outbreak investigation strategy<br>• Directing or carrying out sample collection and water parameter measurements during the investigation of potential sources in an outbreak or suspected case of disease |
| **Knowledge and skills** | • Knowledge of building water systems | • Advanced knowledge of *Legionella* transmission, sources, building water | • Outside expert when a case or cluster of legionellosis is suspected |

| | | | |
|---|---|---|---|
| | • Skills in collecting measurements and samples<br>• Ability to ensure the implementation of corrective actions | systems, and potential amplification sites<br>• Ability to anticipate, recognize, evaluate, and control *Legionella* exposure in water systems and develop water management programs | to be associated with the system<br>• Typically local, state, or federal public health professionals, including industrial hygienists, epidemiologists, and environmental health specialists |
| **Cooperation** | • With Program Professional for day-to-day decisions on system management | • With Responder Professional to investigate possible environmental sources of *Legionella*. | • With Program Professional during the post-remediation monitoring |

**Box 4-1 Key steps in developing a *Legionella* water management program**

**Assemble the WMP team**

**System assessment**

Describe the potable and nonpotable water systems within the building and develop water-system schematics

Identify which hazardous conditions can occur and where

Evaluate the risk associated with hazardous conditions

**Monitoring**

Determine location where *control measures* should be applied and maintained in order to stay within established control limits

Establish *critical limits* for each control measure to ensure that the risk is controlled

Establish *operational monitoring procedures* to evaluate whether control measures are operating within established control limits

Establish *corrective actions* to correct deviations from critical limits and limit exposure

**Confirmation**

Validate whether the WMP controls the hazardous conditions

Verify whether the WMP is implemented as designed

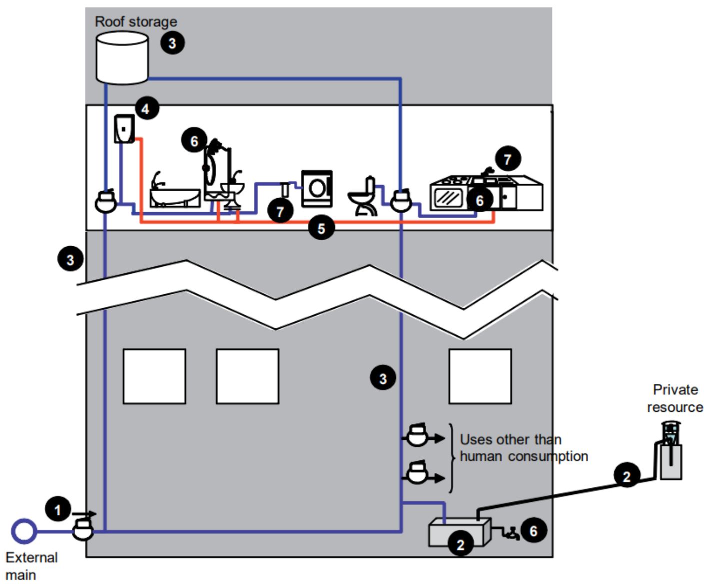
**Documentation:** Establish documentation and communication procedures for all activities of the Program

### 4.3.3. Step 2: System assessment

***Document and describe the system***

The WMP team begins by creating a description of the building water system, which includes text and flow diagrams (CDC, 2021a). The description should cover various aspects, such as the layout and design of the building water system, the entry and distribution of water, the circulation and recirculation of water, storage, heating, cooling, treatment, and monitoring (Fig. 4-1). The existing documentation should be verified on-site to confirm its accuracy (WHO, 2011).

Additionally, the WMP team should identify the point(s) of potential human exposure to *Legionella*. It is also important to collect information on water-use patterns as this information can help identify low-flow areas and locations where water can become stagnant (WHO, 2011).




1. Point-of-entry to the building
2. Source of water
3. Water piping, storage systems, and connections
4. Devices for heating and supplying hot water
5. Hot-water piping systems
6. Equipment installed at point-of-use
7. Water treatment systems at point of use

**Fig. 4-1.** Typical components of water systems inside buildings (WHO, 2011)

The WHO guidance document *Water Safety in Buildings* can be consulted for more detailed information on system description (WHO, 2011).

***Identify hazardous conditions***

After completing the preliminary tasks, the WMP team should identify locations within the building where hazardous conditions may occur and characterize them (CDC, 2021a). In the context of this module, the hazard is the growth of *Legionella* in building water systems. Hazardous conditions are, therefore, conditions that can lead to the growth of *Legionella*.

Hazardous conditions can occur at multiple locations within a building, including at points-of-use (e.g., showers, sinks), at water-using devices (e.g., cooling towers, decorative fountains, humidifiers, etc.) and within the building plumbing system (e.g., water heaters, storage tanks). The WMP team should then consider the factors that may affect the growth of

*Legionella* (introduced in Section 3.3) to determine which hazardous conditions could occur at identified locations.

Common hazardous conditions for building water systems include low water flow or pressure, water temperatures in the optimal range for *Legionella* growth, plumbing age and low disinfectant residuals. The document *Developing a Building Water Management Plan* from the New York City Health Department provides examples of hazardous conditions (NYC Health Department, 2020). The WHO guidance document *Water Safety in Buildings* can also be consulted for detailed examples (WHO, 2011).

***Evaluate hazardous conditions***

Once hazardous conditions are identified, the WMP team evaluates their risks to identify and prioritize the control of unacceptable risks (WHO, 2011). Following this evaluation, the team should be able to determine if risks are adequately controlled with existing control measures or if alternative or additional controls are required.

The risk can be interpreted as the likelihood that an exposed individual becomes ill due to exposure to *Legionella*. Factors contributing to the risk include the vulnerability of the individual to legionellosis and the concentrations of *Legionella* in water and aerosols produced by the building water system. The risk can then be controlled by ensuring that efficient control measures are in place to limit growth and transmission.

There is a continuum of approaches to conducting a risk assessment. Simple qualitative methods, such as a WMP team decision based on assumptions or experience, may be appropriate to evaluate the risk of some hazardous conditions. In other cases, more detailed approaches, such as risk matrices or quantitative microbial risk assessment (QMRA), may be needed. Examples of risk-scoring matrices can be found in WHO (2011). NASEM (2020) can be consulted for more information on applying the QMRA framework to quantify risk and evaluate the benefits of control measures for *Legionella pneumophila* in buildings.

Evaluating the severity and likelihood of a microbiological hazard can be challenging without knowing whether the microorganism is present in the system (Schmidt et al., 2019). To inform hazard evaluation, *Legionella* or *Legionella pneumophila* testing can initially be conducted to determine whether these bacteria are present at the identified locations (NASEM, 2020). It is important to note that the *Legionella* testing should be performed by qualified individuals, and the results should be interpreted in the context of the building water system and relevant guidance and regulations (as discussed in Section 5). The WMP team should also consider how the results will be used to inform the hazard evaluation, as the presence of *Legionella* in a building water system does not necessarily mean it is causing a health risk. Similarly, values below the detection limit do not necessarily mean the absence of *Legionella*.

### 4.3.4. Step 3: Monitoring

***Determine control measures***

Control measures refer to activities or processes aimed at preventing, eliminating or reducing the hazard to an acceptable level. While control measures can be applied at any step in the chain of *Legionella* transmission, within the context of a WMP, they are generally used to control concentrations of *Legionella* in water. Typical control measures can be categorized as follows (WHO, 2011):

- Preventive (e.g., system design, construction, and commissioning)
- Mechanical (e.g., temperature control, flushing, cleaning and maintenance procedures)
- Treatment (e.g., filtration, chemical disinfection)

Many buildings may already have control measures in place. These measures should be validated regularly to ensure their effectiveness. The need for additional control measures depends on the hazard evaluation. The number of control measures typically increases with the complexity of the building water system.

During operation, the efficacy of some control measures, such as temperature, should be monitored at critical control points. A critical control point can be located at points-of-use or specific locations within the system, such as the points-of-entry in the building, water heaters, distribution piping, water storage tanks, and water-using devices (e.g., cooling towers, decorative fountains, humidifiers) (CDC, 2021a).

***Establish control limits***

A control limit is a criterion used to determine the safe and unsafe operation of a control measure. It can be a maximum or minimum value or a range of values for a chemical or physical parameter (ASHRAE, 2018). For example, a control limit can be defined by the numerical value of parameters such as water temperature, pH, or the concentration of a chemical disinfectant. Alternatively, it can be a frequency at which an activity, such as cleaning and maintenance, is performed. When these limits are not met, corrective action should be taken immediately.

Established control limits may depend on the type of building water system and can draw upon various sources of information, such as standards, guidelines, experimental results, and scientific literature. For instance, the water temperature in a hot water storage system should typically be set above 60 $^{o}$C to control growth. Similarly, a minimum concentration of disinfectant residual may be required at the point-of-use.

It should be noted that recommended control limits can vary depending on the guidelines and standards being followed. As such, seeking the assistance of a specialist may be beneficial to ensure that proper control measures are in place.

***Establish operational monitoring procedures***
Monitoring involves a planned sequence of measurements or observations to ensure that individual control measures remain within the established control limits (ASHRAE, 2018). Monitoring can also reveal trends that suggest a potential loss of control, allowing corrective action to be taken before a deviation from the control limit occurs (WHO, 2007). Operational monitoring can involve measuring water quality parameters (e.g., temperature, pH, turbidity) as well as regular inspection and maintenance procedures.

Operational monitoring frequencies should be defined to ensure that corrective actions can be implemented rapidly enough to prevent hazardous conditions. Ideally, the monitoring of parameters should be automatic and continuous (WHO, 2007). This is often achievable for physical and chemical parameters. The feasibility of operational monitoring for microbiological parameters, such as *Legionella pneumophila*, depends on the quantification methods used (refer to Section 5.4). Traditional cultivation methods can take several days to yield results, limiting their real-time application. However, recent advancements in molecular technologies, such as online qPCR monitoring devices, can deliver rapid results that may be used to enhance operational control.

The person responsible for the monitoring procedures should be adequately trained in the monitoring procedure, including instrument calibration and maintenance, and result interpretation. ISO 5667 can be consulted for guidance on the design of water sampling programs and water sampling techniques (ISO, 2006).

***Establish corrective actions***
When monitoring results indicate that the established control limits have been exceeded, corrective actions must be taken to return control values to within control limits (Fig. 4-2). The system should be inspected at the locations the violation occurred to identify any malfunction that may explain the deviation from the control limit. An investigation of the root cause of the problem should always be carried out, and this investigation should be documented in the WMP. This will help prevent similar deviations and promote continuous improvement of the WMP.

The implementation of corrective actions and exposure prevention may also be needed to control risks during this period. Corrective actions generally recommended in guidance documents are (CDC, 2021b):

- Disinfecting and flushing the whole system or an affected section of it using an elevated concentration of a disinfectant, like chlorine, for a limited duration
- Cleaning of the system

In some situations, testing for *Legionella* or *Legionella pneumophila* may help verify the effectiveness of corrective actions.

Standard operating procedures for all corrective actions should be developed, in advance, for each control measure. The communication procedures and individuals responsible for implementing these actions should be documented in the WMP.

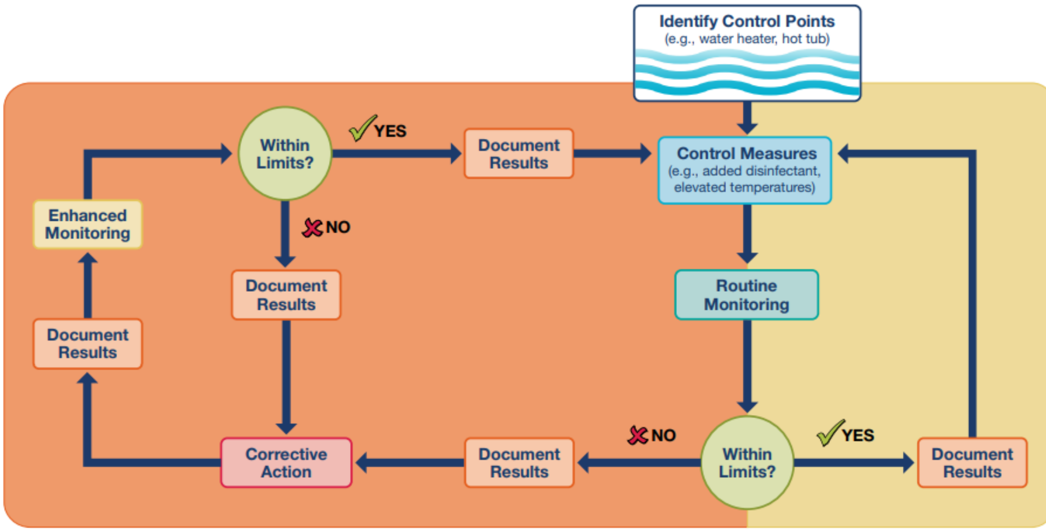



**Fig. 4-2**. Diagram of the process of implementing and monitoring control measures. SOURCE: CDC (2021a)

### 4.3.5. Step 4: Confirmation

Confirmation ensures both validation – ensuring the system performs in alignment with the WMP – and verification – ensuring compliance with an effective WMP.

***Validation***

The validation step confirms that the WMP, when implemented as designed, controls hazardous conditions throughout the building water systems (ASHRAE, 2018). Testing water samples for concentrations of *Legionella* or *Legionella pneumophila* may be an appropriate measure for validating the WMP (ASHRAE, 2020; WHO, 2007). If the control of the concentration is found to be inadequate, testing results will provide some evidence to support a revision of the WMP and a re-evaluation of the control measures. The critical concentration for validation should be established to ensure that the risk of legionellosis is acceptably low. Action levels for *Legionella pneumophila* are discussed in Section 5.5

***Verification***

Verifying the WMP involves an initial confirmation and ongoing monitoring to ensure that all steps of the plan are implemented as intended. The verification can be carried out with regular internal reviews and audits by independent experts. Several factors should be considered during this process, including the identification of all significant hazardous events, the selection of appropriate control measures, the establishment of operational monitoring and verification procedures, the definition of control limits, and the identification of corrective actions (WHO, 2011).

### 4.3.6. Step 5: Documentation

***Establish record-keeping and a documentation procedure***

Generally, the records maintained for the *Legionella* WMP should include the following (NACMCF, 1998; NYC Health Department, 2020; WHO, 2007):

1. A summary of the hazard analysis, including the rationale for determining hazard conditions and control measures.

2. The WMP including:
    - List of all individuals on the WMP team and their assigned responsibilities
    - Description of the building water system(s), including a current schematic diagram of the system
    - Summary table(s) that includes information for:
        - Critical control point
        - Hazard condition(s) of concern
        - Control measure
        - Control limit
        - Control monitoring (means, method, frequency)
        - Corrective actions procedure
        - Verification procedures and schedule
        - Record-keeping procedures
    - Actions to be taken as part of routine periodic maintenance of the system
    - Interventions to be undertaken when monitoring or verification data suggest loss of control

3. Support documentation for developing the WMP, including validation
4. Records that are generated through operational monitoring, validation monitoring and verification

# 5. Section 5: Routine monitoring of *Legionella*

## 5.1. Purpose of monitoring

Routine monitoring is a systematic process of sample collection and analysis to determine the concentration of *Legionella* in a building water system. The primary objective of routine monitoring is to validate the effectiveness of the water management program (ASHRAE, 2020; NASEM, 2020; WHO, 2007). More specifically, this process can help (CDC, 2021b):

- Evaluate potential growth and transmission sources
- Establish a baseline measurement for performance indicators
- Confirm the success or failure of corrective actions
- Demonstrate compliance with a regulation

The NASEM (2020) (p. 129) recommends that *Legionella* sampling should serve as the foundation for validating the effectiveness of any WMP as follows:

"*Legionella* sampling should be the basis for validating any water management plan, regardless of building size, configuration, or even building population composition, which are risk factors secondary to plan development. Initial samples will define the extent or even if *Legionella* is present and the extent to which the plan should be developed."

The implementation of routine monitoring of *Legionella* in building water systems poses various challenges. These include resource constraints in cost, personnel, and laboratory capacity, technical difficulties, challenges in designing monitoring strategies for complex buildings, and difficulties in interpreting results. Given these considerations, some jurisdictions in Canada refrain from advocating routine monitoring as part of a *Legionella* risk management strategy. Consequently, facility managers are encouraged to consult with local authorities to clarify whether routine monitoring is recommended in their region. When monitoring is considered, several considerations should be balanced, such as potential health risks to building occupants and visitors, the cost and feasibility of implementing a monitoring program, and compliance with local guidelines and regulations.

In Canada, routine monitoring of *L. pneumophila* is mandatory in Quebec for cooling towers (Gouvernement du Québec, 2013), in New Brunswick for cooling towers (New Brunswick, 2023), and in Vancouver for cooling towers, decorative water features and non-potable systems (City of Vancouver, 2020). Furthermore, for federally owned buildings managed by Public Services and Procurement Canada, routine monitoring of *L. pneumophila* is mandatory for cooling towers and evaporative condensers, decorative water features, humidifiers, and hot water systems (PSPC, 2016).

## 5.2. Legionella pneumophila vs Legionella species

Selecting the type of *Legionella* to measure in a building water system is important to evaluate risks accurately. *Legionella* species and *Legionella pneumophila* (*L. pneumophila*) have been used for routine monitoring of building water systems. *Legionella* species refer to all species within the genus *Legionella*, whereas *L. pneumophila* refers to a specific species of *Legionella* (Box 5-1).

**Box 5-1 Legionella Diversity: Species, Serogroups, and Sequence Types**

The *Legionella* genus includes a range of species, such as *L. pneumophila*, *L. longbeachae*, *L. bozemanii*, and *L. anisa*. *L. pneumophila* is the most frequently identified species. Within the *L. pneumophila* species, different serogroups exist, which are based on the types of antigens on the surface of the bacteria. *Legionella* sequence type refers to the specific DNA sequence of several regions of the genome of a particular strain of *Legionella*. During an outbreak investigation, sequence typing can be an essential tool for identifying the environmental source of infection by comparing the sequence type of *Legionella* bacteria found in clinical samples to those found in environmental samples. A strain is a more general term used to distinguish bacterial isolates. *Legionella* strains are given different names until additional information on species, serogroup, or sequence type is obtained.

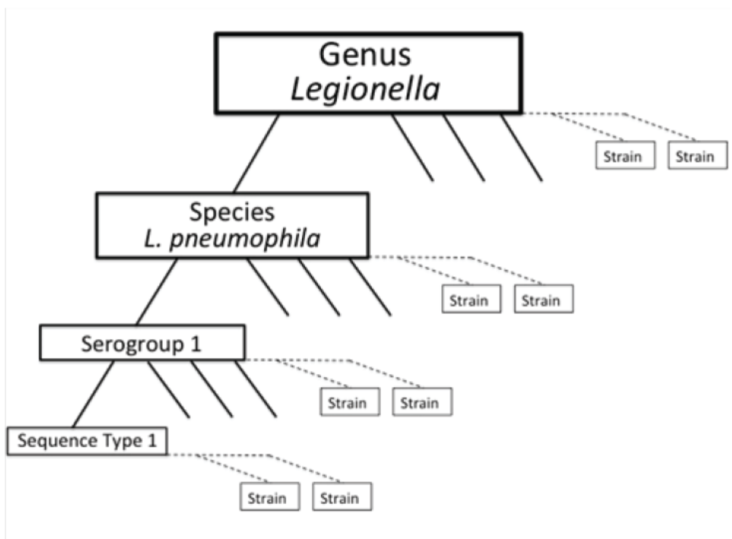



**Fig. 5-1.** Nomenclature of *Legionella.* Reference: NASEM (2020)

It is generally recommended to measure concentrations of *L. pneumophila* in building water systems (van der Wielen et al., 2021), primarily because this species is responsible for the vast majority of all reported Legionnaires' disease cases (Beauté, 2017; Benin et al., 2002). In Canada, the selection of *L. pneumophila* is consistent with the Quebec Cooling Tower Regulation (Gouvernement du Québec, 2013), the Standard MD 15161 (PSPC, 2016), and the New Brunswick Technical Guidelines for Water Circulation Systems (New Brunswick, 2023). Legionnaires' disease can be caused by other *Legionella*, such as *L. longbeachae*, *L. micdadei*, and *L. bozemanii*; however, these species typically cause Legionnaires' disease in individuals with weakened immune systems (Chambers et al., 2021). This section only addresses *L. pneumophila*.

## 5.3. Establishing a monitoring program

A routine monitoring strategy requires the development of a sampling plan that targets the most relevant sample sites within the water system. The choice of sampling locations will be influenced by factors such as the piped system schematics, the vulnerability of the location to *Legionella* colonization, and potential human exposures. It should also reflect an optimization of the number of samples due to the complexity and cost of sampling and analysis.

### 5.3.1. Sampling approach

Concentrations of *L. pneumophila* can be measured in bulk water, biofilm, or aerosols, but routine monitoring strategies typically focus on bulk water for sampling (AIHA, 2022; NASEM, 2020). A comprehensive sampling plan for *L. pneumophila* in building water systems involves the following steps (AIHA, 2022):

1. Identification of building water systems to be sampled
2. Selection of appropriate sampling locations based on vulnerability to *L. pneumophila* growth and potential for human exposure
3. Development of a sampling schedule to specify the frequency of sampling
4. Planning of standard operating procedures for proper transport and storage of samples
5. Establishment of corrective actions for responding to test results
6. Regular review and update of the sampling plan.

The following references can be consulted for more information on the environmental sampling of *Legionella* and *L. pneumophila*:

- CEAEQ (2013) for cooling towers
- NASEM (2020) for cooling towers and premises plumbing in large buildings
- ASTM International (2015) for premises plumbing

When sampling a building’s plumbing system, it is recommended to consult with a specialist. A water treatment specialist or a certified industrial hygienist can help a facility manager develop and implement a customized sampling plan. It is important to choose a specialist with experience in *Legionella* sampling and testing who is familiar with relevant regulations and guidelines. Several factors can influence the selection of sampling locations and frequencies, including the size and usage of the system. It is important to carefully consider the water sample collection method, as choosing between “first draw” (pre-flush) or “flushed” (post-flush) samples can significantly impact the magnitude of the results obtained (Cristina et al., 2014; Grimard-Conea et al., 2022).

### 5.3.2. Monitoring frequency

The selection of a monitoring frequency is a critical step when designing a monitoring strategy because it affects the ability to detect changes or trends in the concentration of *L. pneumophila* over time. For instance, a low monitoring frequency may not be sufficient to detect intermittent peaks in *L. pneumophila* concentrations or to evaluate the effectiveness of control measures over time. On the other hand, a high monitoring frequency may be costly and may not provide additional information beyond what could be obtained with an ideal monitoring frequency. The chosen monitoring frequency should offer an up-to-date understanding of the system's status, allowing for the identification of potential growth conditions and timely implementation of control measures.

Monitoring frequencies specified in regulations and guidelines are largely empirical and typically range from monthly to annual (NASEM, 2020; Wang et al., 2017). In Canada, monthly monitoring of *L. pneumophila* in bulk water from cooling towers is mandatory as per the Quebec Cooling Tower Regulation (Gouvernement du Québec, 2013) and the Standard MD 15161 (PSPC, 2016). Factors that can influence the selection of a monitoring frequency include a history of *Legionella* contamination or recent construction work on the water system. In these cases, more frequent monitoring may be necessary to ensure early detection of contamination. More research is needed to determine optimal monitoring frequencies to identify periods of *Legionella* growth in building water systems (NASEM, 2020).

## 5.4. Analytical methods

### 5.4.1. Selecting a laboratory

*L. pneumophila* analyses need to be done with a certified laboratory. In Canada, laboratories certified for culture testing can be found on the following web pages:

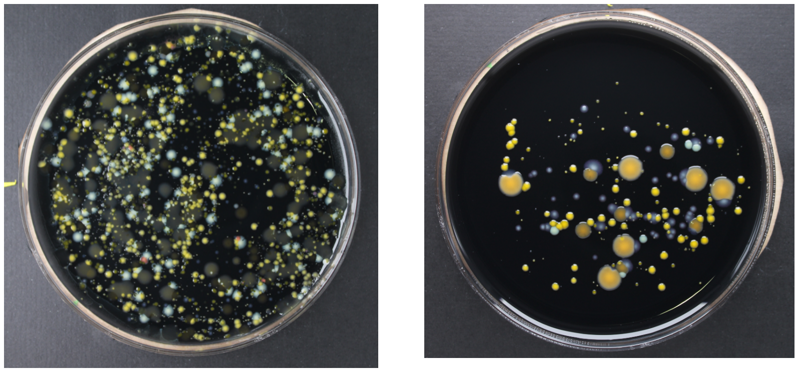
- Canadian Association for Laboratory Accreditation (insert Legionella in the search field)
- Accreditation | Standards Council of Canada - Conseil canadien des normes (scc.ca) (enter Legionella in the search field).

### 5.4.2. Culture-based methods

The International Organization of Standardization (ISO) has developed a culture method (ISO 11731-2) to standardize the enumeration of *Legionella* in water samples (ISO, 2004). The ISO 11731-2 method involves inoculating the water sample onto a medium, typically buffered charcoal yeast extract (BCYE) agar, supporting the growth of *Legionella* colonies. A water sample or a filtered concentrated water sample is inoculated onto the medium. The sample can also be diluted or pretreated with heat or acid before inoculation. The pretreatment can facilitate the enumeration of *Legionella* by reducing the number of interfering microorganisms growing on the plate (Fig. 5-2), but it can also reduce the number of *Legionella* bacteria. The sample is incubated for seven days. Suspected colonies are then inoculated on a new plate and incubated for seven days. The number of *Legionella* colonies that form can therefore be counted after 14 days. Results are typically reported as colony-forming units (CFU) per unit volume (e.g., CFU/L).

ISO 11731-2 method does not inform on whether *Legionella* colonies are *L. pneumophila*. For this, an additional step, such as the latex agglutination test, can be used to determine if colonies are *L. pneumophila* serogroup 1 or *L. pneumophila* serogroups 2-14.

a. Sample b. Tenfold diluted sample



c. Sample pretreated with heat d. Sample pretreated with acid

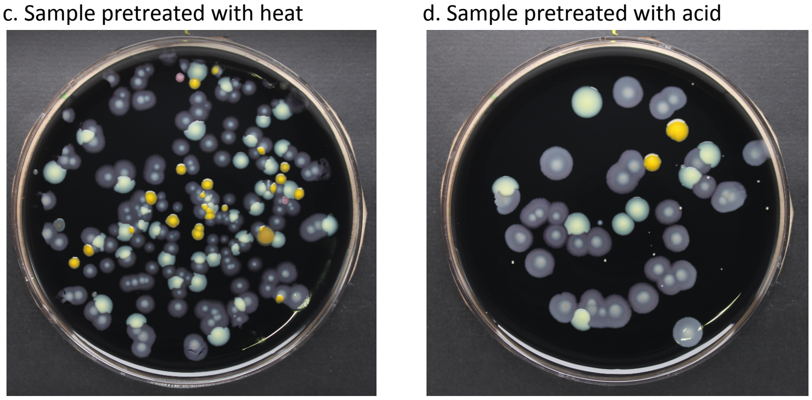


**Fig. 5-2.** Impact of a tenfold dilution and pretreatments with heat and acid for enumerating *Legionella* colonies (in blue-gray) from a shower water sample inoculated on a buffered charcoal yeast extract (BCYE) agar. Credits: N. Roser, SwissLEGIO/LeCo project.

There are alternative approaches to the ISO 11731-2 method. For example, the Legiolert™/Quanti-Tray™ method is a standardized approach for enumerating *L. pneumophila* (ASTM, 2021). This method utilizes a liquid-based most-probable-number (MPN) approach for quantification, considerably simplifying laboratory analyses. The technique involves inoculating a series of wells with the water sample, then incubating them for seven days. A bacterial enzyme detection technology signals the presence of *L. pneumophila* through a colour change. The concentration is estimated using a most probable number method based on the proportion of coloured to uncoloured wells in the Quanty-Tray.

### 5.4.3. Quantitative polymerase chain reaction (qPCR) methods

An alternative to culture-based methods for detecting *L. pneumophila* in water samples is quantitative polymerase chain reaction (qPCR). Unlike culture-based methods, qPCR does not require the incubation of the sample. qPCR detection and quantification approaches require concentration and extraction of the DNA from a water sample. This is often conducted by filtering water samples to concentrate the *L. pneumophila*, and extracting the DNA directly from the filter. qPCR amplifies specific DNA regions from *L. pneumophila* DNA in the water sample. Amplification is done using fluorescent probes. The timing of the increase in fluorescence in the sample is used to estimate the concentration of *L. pneumophila* in the sample by comparison to the timing of samples with known concentrations. The set of these samples is known as a standard curve.

Results are reported as genomic units (GU) per unit volume (e.g., GU/L) and can be obtained within 2-48 hours. The ISO has developed a standard qPCR method (ISO 20395:2019) to enumerate *L. pneumophila* in water samples. This method includes a protocol for standard curve generation and use that should be followed.

qPCR is often less expensive than culture methods and may be suitable for screening for the presence or absence of *Legionella* DNA or evaluating the effectiveness of corrective actions. It is important to note that standard qPCR detects all DNA in the sample, including the DNA from non-viable *L. pneumophila* bacteria. Thus, GU can be higher than CFU when *L. pneumophila* viability is impacted by environmental factors such as heat and chemical disinfection (Delgado-Viscogliosi et al., 2009; Lee et al., 2011).

Emerging viability qPCR methods, which aim to quantify only *L. pneumophila* within membrane-intact cells, may provide further insights into the relationships between qPCR and culture results. These methods use pretreatment with ethidium or propidium monoazide to destroy DNA in membrane-compromised cells, leaving only DNA from viable cells intact. However, these methods must be standardized before they can be routinely employed to detect viable *L. pneumophila* in building water systems (NASEM, 2020).

### 5.4.4. Limits of detection and quantification

The reported concentration of *L. pneumophila* in water samples can be expressed as a numerical value, such as CFU/L and MPN/L in the case of culture-based methods or GU/L in the case of qPCR-based methods, or they may be "censored."

Censored results obtained with culture-based methods are typically reported as below the limit of detection (LOD) or "non-detect", or as "too numerous to count" (TNTC) when they are above the quantification limit. In such cases, the laboratory will indicate that the concentration is below or above a specified threshold, such as a minimum of 1 CFU per analyzed water volume. In other cases, reported results can indicate that an interfering flora affected the results, meaning that the presence of other bacteria interfered with the growth and identification of *L. pneumophila*.

Similarly, censored results obtained through qPCR-based methods are reported as below the limit of detection (LOD) and the limit of quantification (LOQ). For qPCR, upper limits of detection are rarely encountered because a standard curve can be designed such that the highest concentration is well above what would be expected to measure. The LOD refers to the lowest concentration that can be accurately detected, while the LOQ represents the lowest concentration that can be accurately quantified (Borchardt et al., 2021). These limits may vary depending on the efficiency of the assay and the quality of the sample. Laboratories typically indicate a concentration below the LOD or LOQ per processed water volume.

### 5.4.5. Selection of methods for routine monitoring

To ensure reliable results, NASEM (2020) recommended employing a combination of technologies, such as culture-based and qPCR methods. qPCR methods can be used first for screening, i.e., to rapidly determine whether *L. pneumophila* is above the detection limit and, if so, at which concentration (NASEM, 2020; PSPC, 2016). This information can then guide the development of a more comprehensive monitoring program focusing on areas of the water system where *L. pneumophila* is most likely to be found. Culture-based methods are more time-consuming and costly, but they can provide more detailed information about the viability of the bacteria and their strain type. It is important to consult local guidelines and regulations as they can provide specific requirements on *L. pneumophila* monitoring that must be followed to ensure compliance.

## 5.5. Interpretation of monitoring results with action levels

Interpreting monitoring data for *L. pneumophila* requires a comprehensive understanding of the factors involved. As discussed previously, the choice of a sampling method, sampling location, monitoring frequency, and analytical method all play a role in the accuracy and precision of the results and must be carefully considered.

An action level is a threshold triggering a corrective action based on results obtained by monitoring the concentration of *L. pneumophila*. Action level exceedances indicate the need to identify potential factors that promote the growth of *L. pneumophila*, such as stagnant water, water temperature conducive to growth, or insufficient water treatment. This helps guide the implementation of corrective measures to address the identified issues.

Action levels can be specific to the building water system because they pose different exposure risks. In Canada, the Quebec Cooling Tower Regulation (Gouvernement du Québec, 2013) and the Standard MD 15161 (PSPC, 2016) define concentration-based action levels for *L. pneumophila* in cooling towers. The Standard MD 15161 also set action levels for domestic hot water systems, decorative water features, and humidifiers. In the U.S., similar action levels have been recommended for cooling towers, domestic cold and hot water systems, decorative water features and humidifiers (AIHA, 2022; ASHRAE, 2020).

It is important to note that the action levels mentioned above are mostly established through practical considerations and expert opinion rather than a formal human health risk assessment. Risk-based action levels have been defined for indoor water uses (faucets, toilets, and showers) using quantitative microbial risk assessment (QMRA) (Hamilton et al., 2019). These risk-based action levels align with the action levels established by the Standard MD-15161, except for showers, for which Hamilton et al. (2019) determined a low critical concentration of $10^1$ CFU/L. This concentration is equal to the detection limit of analytical methods of many laboratories using ISO (2017).

# 6. Section 6: Response to a legionellosis outbreak

Clusters and outbreaks of legionellosis (Legionnaires' disease or Pontiac fever) can occur in buildings, often from cooling towers, hot tubs, decorative features, humidifiers and water used for drinking and showering. This section provides an overview of the role and responsibilities of individuals responsible for identifying and containing a community-associated outbreak. It also describes the main steps of a cluster or outbreak investigation. Responses to travel and healthcare-associated outbreaks are not covered in this module.

## 6.1. Definitions of cases, clusters and outbreaks

A confirmed case of legionellosis is defined as a clinical illness (Legionnaires' disease or Pontiac fever) with laboratory confirmation of infection (BC CDC, 2018). Legionellosis cases are typically identified when an ill individual is diagnosed by a healthcare provider who then reports the case to the local health department via laboratories. Legionellosis is a nationally notifiable disease in Canada (National Research Council Canada et al., 2018). This means that by law, any instances of the disease must be reported to the Public Health Agency of Canada (PHAC).

Every individual case has the potential to be the first case of a cluster or an outbreak. Public health authorities consider clinical, epidemiological, and microbiological criteria to define cluster and outbreak cases. Clinical criteria involve confirming pneumonia, while epidemiological criteria involve identifying whether a case has visited a location common to other cases within a certain period before the onset of the disease (ranging from a few days to months, depending on the context). Microbiological criteria require laboratory evidence of an infection caused by *Legionella*, such as the presence of *Legionella pneumophila* urinary antigen or isolation of *Legionella* from respiratory secretions (Phin et al., 2014).

A cluster refers to two or more cases with onsets of symptoms close in time (within days or months) and location, and may suggest a common source of infection. Following an investigation, a cluster may be redefined as multiple sporadic cases or point towards a common source, suggesting an outbreak.

The declaration of a legionellosis outbreak occurs when at least two medically confirmed cases are confirmed to have been infected by the same *Legionella* species, and there is epidemiological or microbiological evidence pointing to a common source (BC CDC, 2018; MSSS, 2015).

## 6.2. Roles and responsibilities for identifying and managing an outbreak

To identify and manage a legionellosis outbreak, various roles and responsibilities must be fulfilled. Critical roles and responsibilities are briefly described in this section.

### 6.2.1. Public health authorities

Provincial and regional public health authorities play the leading role in detecting and responding to legionellosis outbreaks. Their primary responsibility is to track and investigate disease cases, with the ultimate goal of identifying the source of the outbreak for taking appropriate actions to prevent new cases (ECDC, 2017). To accomplish this, public health authorities typically interview cases and perform environmental sampling in various building water systems. In certain cases, public health authorities may request building owners to perform environmental sampling, particularly when multiple rounds of follow-up sampling are necessary. When an outbreak source is identified, public health authorities will either directly implement or guide the implementation of appropriate remediation measures according to roles and responsibilities.

Additionally, public health authorities are responsible for communicating about the situation with the general public and healthcare professionals to promote testing. They generally provide information on how the disease is spread, the symptoms to look for, and what actions individuals can take to prevent exposure. Depending on the context of the outbreak, this role may be fulfilled by the Responder Professional, as defined in Table 4-1.

### 6.2.2. Building owners

In the event that two or more cases are linked to a particular facility (such as a hotel where guests have used the hot tub), public health officials will reach out to a facility. They will then initiate environmental sampling at the facility to identify any common source of exposure. If a specific source (such as the hot tub) is found to be responsible, public health officials or partners, according to roles and responsibilities, may direct the facility to close to the public and implement standard cleaning and disinfection procedures once samples have been collected. Before recommending a broad announcement to occupants, public health officials typically wait until preliminary results have been received.

Upon being informed about an outbreak, it is recommended that building owners inform their tenants and employees about the situation and the steps taken to address it. Section 6.4 provides template messages that can help inform the public during an outbreak. This includes guidance on seeking medical attention if necessary. It is also important for building owners to inform vulnerable populations, such as older people and individuals with weakened immune systems, of their potentially elevated risks because they are within a high-risk group. To limit exposure to a domestic water system, temporary provisions may include supplying drinking water bottles, shutting down water heaters to eliminate access to hot water, and installing terminal filters, often referred to as point-of-use (POU) filters, at faucets and showerheads (OSHA, 2023).

It is also recommended that building owners work closely with public health officials to aid in investigating an outbreak. This may involve granting full access to buildings as well as providing building records, the building's Legionella Environmental Assessment Form (LEAF) (Box 6-1) and *Legionella* Water Management Plan(s) (WMP, if available), and allowing inspections of building water systems. If no prior LEAF or WMP is developed, the building owner may have to work closely with public health officials to complete a LEAF.

Depending on the applicable legislation, the owner whose building water system is identified as the source of the outbreak may be required to take immediate actions, such as shutting down or disinfecting and cleaning cooling towers or other water systems identified as potential outbreak sources (see Section 6.4). Failure to do so can result in serious public health consequences and legal liability. It is, therefore, crucial for building owners to understand their legal obligations in the event of an outbreak.

The owner may also be responsible for developing and implementing a remediation plan reviewed and approved by public health authorities (BC CDC, 2018). To ensure that the remediation plan is effective, it is recommended that the facility manager works with a water treatment professional. Together, they can develop and implement the remediation plan and establish long-term system monitoring.

**Box 6-1 Proactive measures to facilitate the response to a legionellosis outbreak**

**Environmental assessment**: This assessment involves reviewing building characteristics and history (e.g., recent construction or disruptions to the water distribution system) to discover any vulnerabilities that would allow for the growth of *Legionella* species. During an outbreak, public health officials use the Legionella Environmental Assessment Form (LEAF) to determine the need for environmental sampling and develop an effective sampling plan. The U.S. Center for Disease Control and Prevention (CDC) offers resources, such as the Legionella Environmental Assessment Form and the Legionella Assessment Form Marking Guide, that can aid in developing a LEAF. By utilizing these resources, public health officials can obtain comprehensive information about the water system and identify potential risk factors that may contribute to *Legionella* growth, ultimately helping to prevent legionellosis cases.

**Water management plan**: By outlining the hazard evaluation, critical control points, a response plan, and control measures, a *Legionella* Water Management Plan (WMP) can help facilitate a rapid investigation and response. In addition, the WMP should include key personnel roles and responsibilities, a *Legionella* sampling plan, detailed records of water quality, treatment procedures, and maintenance activities. These records should be made available for investigators to identify potential changes or anomalies that may have contributed to the outbreak. For more information about the *Legionella* WMP, refer to Section 4.

**Routine *Legionella* monitoring**: Routine monitoring can be instrumental in identifying the possible source of an outbreak. For instance, if an outbreak or cluster is reported in a building with a cooling tower, routine monitoring results can facilitate investigators in swiftly assessing the potential role of the cooling tower. More information on *Legionella* monitoring can be found in Section 5.

### 6.2.3. Healthcare providers

Healthcare providers are responsible for monitoring patients for signs and symptoms of legionellosis. Healthcare providers should be able to diagnose legionellosis and distinguish it from other respiratory infections. To achieve this, they use laboratory tests, such as urine antigen tests or cultures of respiratory secretions, to confirm the diagnosis. Cultures of respiratory secretions are carried out as often as possible because they allow for genotypic matching with environmental samples.

## 6.3. Outbreak investigation and control

When a legionellosis cluster is detected and an outbreak is suspected, public health authorities establish an outbreak team. The team's composition may vary based on the specific role of public health agencies within each province. For example, it can be led by a local medical health officer and include an environmental health officer, an epidemiologist, and a microbiologist with experience in clinical and environmental sample testing, according to the BC CDC (2018). Additional specialists may also be included in the team, depending on the complexity of the investigation, as outlined in Table 4 from BC CDC (2018). This investigation involves conducting epidemiological, environmental, and microbiological investigations and implementing outbreak control measures, as shown in Figure 6-1.

### 6.3.1. Descriptive epidemiological information

To establish hypotheses for the source of the outbreak and search for other cases, public health authorities conduct interviews with cases to gather descriptive epidemiological data. This data can include contextual information about patients, their location, and the timing of infection. A template for a trawling questionnaire is available here: https://legionnaires.ecdc.europa.eu/?pid=215 (ECDC, 2017). This information can be continually updated as the investigation progresses. Geographic information systems can be used to analyze the locations of multiple cases and provide insight into potential exposure patterns in the outbreak. This analysis can help pinpoint the potential source of the outbreak and inform targeted interventions.

### 6.3.2. Environmental investigation

Public health authorities and their partners, such as environmental laboratories, conduct environmental investigations to identify the potential source of the outbreak. These investigations involve various techniques, including site assessments, system inspections, environmental sampling, and microbiological testing (BC CDC, 2018). To guide their investigation, the authorities can use descriptive epidemiological information and the *Legionella* Environmental Assessment Form (LEAF). This data can help them focus on sampling the high-risk building water systems. Water samples and swabs of the biofilms found on the surface of the targeted building water systems are typically collected. Specific indications to guide environmental investigations of cooling towers, domestic hot water systems and public and private spas can be found in MSSS (2015).

### 6.3.3. Microbiological investigation

The ultimate objective of the environmental investigation is to find evidence linking the outbreak to the source by comparing genotypes of *Legionella* isolates from environmental samples to those from patients (WHO, 2007). Therefore, potential sources should be sampled *before* remediation actions occur unless remediation cannot be delayed (BC CDC, 2018). Even in cases where *Legionella* isolates from clinical samples are unavailable, analyzing environmental samples remains valuable for assessing the extent of *Legionella* contamination in suspected building water systems.

### 6.3.4. Implement control to prevent additional exposure

If the source of the outbreak is identified, public health officials will take or request the building owner to take immediate steps to implement control measures. The shutdown of the entire building may not be necessarily required if the suspected or confirmed source of the outbreak can be adequately isolated (OSHA, 2023). In cases where the source is not identified, but *Legionella* bacteria are measured in the environmental samples, the decision to implement control measures or not will be based on applicable legislation or decided by the public health authorities.

Remediation measures for controlling *Legionella* in water systems are specific to each outbreak. They often involve a chemical shock treatment, which uses an elevated disinfectant level for a limited time throughout the water system (CDC, 2021b). In addition to chemical treatment, physical cleaning, system shutdown, and point-of-use water filters are other remediation methods that can help control human exposure in response to an outbreak. Thermal shock, which uses very high water temperatures for remediation measures, is not recommended due to its inefficiency and the potential to rapidly recolonize the water system (ASHRAE, 2020).

The following references provide system-specific treatment protocols for the remediation of domestic cold and hot water systems, cooling towers, decorative features and humidifiers:

- British Columbia Center for Disease Control (2018). Communicable Disease Control Chapter I – Management of Specific Diseases Legionella outbreak investigation and control
- *ASHRAE* Guideline *12-2020*, Managing the Risk of Legionellosis Associated with Building Water Systems.
- U.S. Occupational Safety and Health Administration, Legionellosis (Legionnaires' Disease and Pontiac Fever): Outbreak Response

### 6.3.5. Restarting the building water system

After a legionellosis outbreak, it is critical to restart the building water system carefully to prevent the further spread of *Legionella*. Before restarting the water system, it is recommended to retest the water to confirm that the remediation measures have effectively reduced the concentration of *Legionella* species (BC CDC, 2018). Moreover, once the system has been restarted, there may be a need for routine *Legionella* monitoring for a certain period. The monitoring frequency and duration can be based on applicable regulations or decided by public health authorities.

Effective risk management practices should be implemented to prevent future legionellosis outbreaks. When water systems experience persistent issues, it may be necessary to consider implementing a secondary treatment system. Facility managers are encouraged to discuss available options with a water treatment consultant. For buildings with a history of legionellosis cases, developing or updating a *Legionella* WPM is recommended. Refer to Section 4 for more information on *Legionella* WPMs.

### 6.3.6. End of the outbreak investigation

The end of the outbreak investigation can be determined by the absence of new cases over a certain period or decided by public health authorities (MSSS, 2015).

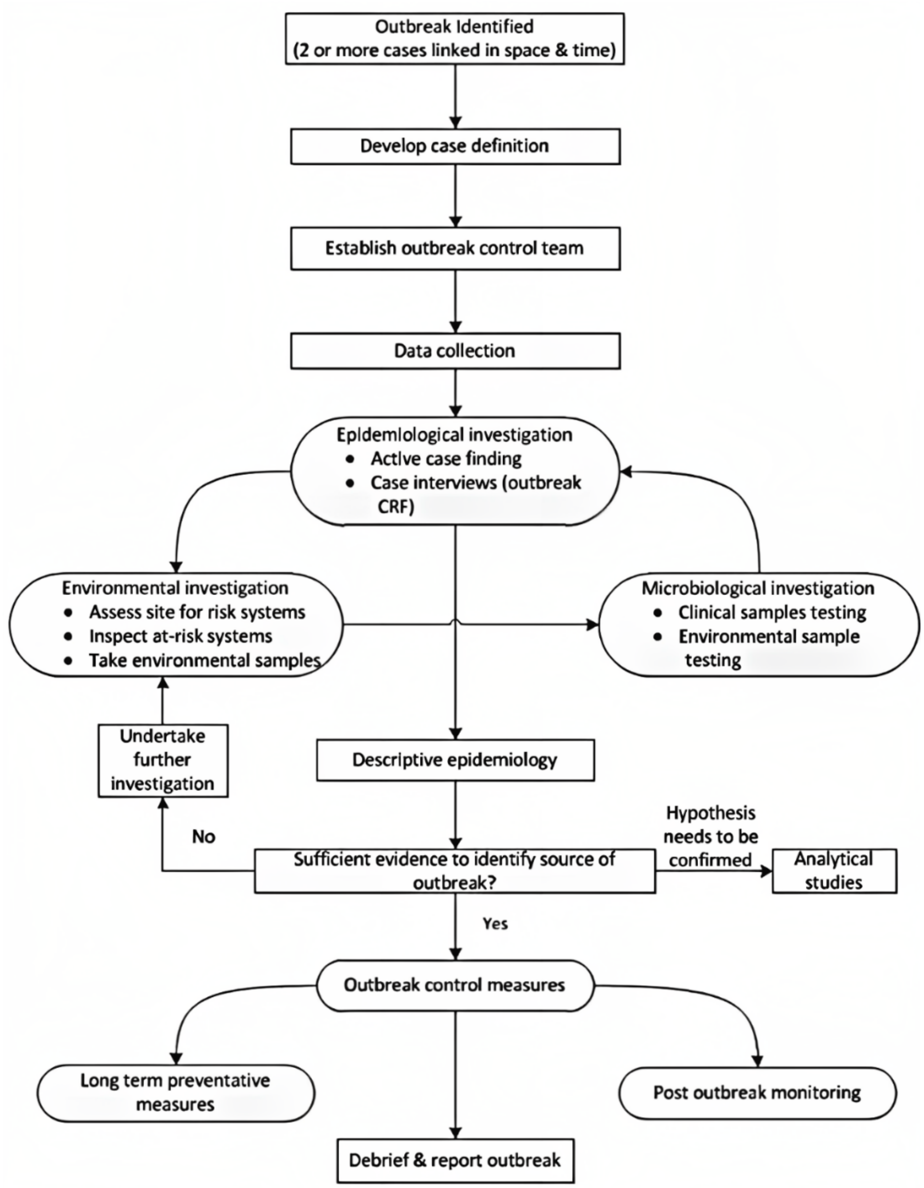



**Fig. 6-1**. *Legionella* outbreak investigation flowchart from BC CDC (2018).

## 6.4. Communication

During an outbreak response, new and updated information on cases may arrive erratically. Therefore, it is recommended that building owners establish and maintain communication with public health officials to respond effectively to the outbreak. The owner may also have to collaborate with public health officials to ensure that building occupants receive clear and accurate information about the risks of exposure to *Legionella* species and measures to take to minimize exposure. Template messages that can help inform the public during an outbreak can be found below.

- U.S. Centre for Disease Control and Prevention (2021). Legionella (Legionnaires' Disease and Pontiac Fever): Communications Resources.
- European Centre for Disease Prevention and Control (2017). Legionnaires' disease outbreak investigation toolbox: Developing Communications.

## 6.5. Provincial and territorial reference documents

National Research Council Canada et al. (2018) listed the following guidelines and guidance documents providing provincial and territorial-specific information on legionellosis outbreak investigation and control in Canada. The authors of this module updated this list on March 2023.

- **Alberta**: Public health disease management guidelines: legionellosis (2021)
- **British Columbia**: Communicable Disease Control Chapter 1 – Management of Specific Diseases *Legionella* outbreak investigation and control (2018)
- **Manitoba**: Communicable Disease Management Protocol: Legionellosis (2015)
- **Newfoundland and Labrador**: Disease Control Manual – Section 3 – Diseases transmitted by respiratory routes (2013)
- **Ontario**: Infectious Disease Protocol, Appendix A: Disease-Specific Chapters: Legionellosis (2022)
- **Québec** : Guide d'intervention - La légionellose (2015, ongoing update)
- **Saskatchewan**: Communicable Disease Manual – Respiratory and Direct Contact – Legionellosis Section 2-70 (2011)

No published documents were identified for **New Brunswick, Northwest Territories, Nova Scotia, Nunavut, Prince Edward Island, and Yukon.**

Guidelines from British Columbia (BC CDC, 2018) and Québec (MSSS, 2015) were used as reference documents to develop this Section.

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## Annex A: Legionellosis tracking and monitoring

Legionellosis cases can be classified by exposure scenarios to help public health officials identify potential sources of exposure to *Legionella*. The exposure classification is the following:

- ***Community-acquired***: a case where the potential source is in the community, typically defined as cases without evidence of healthcare or travel-associated exposures. Community-acquired cases can occur in various buildings, including hotels, office buildings, schools and universities, convention centers, gym and fitness centers, and residential buildings.
- ***Healthcare-associated***: a case where the potential source was healthcare-associated, typically defined as cases where the individual has had significant exposure to healthcare-associated premises, including hospitals and hospices, for some or all of the 2 to 10 days (the incubation period) before the onset of symptoms.
- ***Travel-associated***: a case where travel (or associated) accommodation is the potential source, typically defined as cases who have travelled and visited or used other overnight accommodation at any time 2 to 10 days before the onset of symptoms.

Public health officials also use the following epidemiological classification to help determine whether cases are linked to a common source that should be controlled or not:

- ***Sporadic case***: isolated case or cases occurring in a community with no clear temporal or spatial patterns.
- ***Cluster***: two or more cases with onset of symptoms close in time (within days or months) and location. Following an investigation, a cluster may be redefined as multiple sporadic cases or point towards a common source, suggesting an outbreak.
- ***Outbreak***: two or more cases meet the criteria for a cluster (symptom onset close in time and location) and with epidemiologic or microbiological evidence of a common source of exposure.

Linking cases of legionellosis to specific sources is often challenging as *Legionella* can proliferate in different building water systems and natural environments. Moreover, only certain water systems or specific sections of a building may provide optimal growth conditions for *Legionella*, further complicating the process of identifying the origin of the infection.

Furthermore, contamination of a system does not mean it was the source, and more information is needed. Molecular biology techniques can be used to analyze the DNA sequence of the bacteria obtained in clinical and environmental samples. Comparing clinical and environmental sequences can help identify the environmental source that caused the cases.

Legionnaire’s disease outbreaks are commonly associated with cooling towers, domestic cold and hot water systems and hot tubs (Hamilton et al., 2018; NASEM, 2020). However, it is important to note that most cases of Legionnaires’ disease are not associated with outbreaks. Vigilance is always required since sporadic cases can occur without any apparent connection to an outbreak. Unfortunately, limited information is available on sporadic cases acquired in the community. Therefore, appropriate measures should be taken in all settings to minimize the risk of *Legionella* contamination.

# Annex B: Control measures to reduce aerosol formation and exposure

Control measures to prevent transmission of *Legionella* primarily focus on minimizing the proliferation of the bacterium in building water systems. However, control measures have also been proposed to reduce the formation and exposure to aerosols for faucets and showerheads (EnHealth, 2015; Falkinham III, 2013; Succar et al., 2023). These measures include removing aerators from taps, avoiding mist-generating devices such as humidifiers, and selecting showerheads that produce streams rather than a fine mist. To minimize the emission of aerosols by cooling towers, high-efficiency drift eliminators are recommended (ASHRAE, 2020).

When significant aerosol exposure is possible, such as during sampling or maintenance procedures in an outbreak investigation, personal protective equipment (PPE), such as high-efficiency particulate air (HEPA)-filtered respirator, can be used by workers to avoid the inhalation of contaminated aerosols (AIHA, 2022).