

# Environmental Sampling for *Legionella* Proliferation Risk in Three Long-Term Care Facilities in Vancouver, British Columbia

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## ABSTRACT:

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**Background:** *Legionella* is a pathogen that causes Legionnaires' disease in high risk populations. The pathogen is known to exist in plumbing systems that do not have preventative factors in place to prevent its growth and proliferation. *Legionella* grows between 25°C and 42°C and is killed at 60°C, yet long-term care facilities (LTCFs) reduce accessible hot water temperatures from 60°C at the hot water tank to less than 49°C at the taps in order to prevent scalding of their residents. Currently, prevention against scalding takes precedence as temperature at accessible taps is regulated within the Residential Care Regulation (RCR) of the Community Care and Assisted Living Act. It is thought that *Legionella* proliferation risk can be balanced with scalding in-part through the appropriate installation location of thermostatic mixing valves (TMVs).

**Methods:** Three LTCFs in Vancouver, British Columbia were selected for environmental sampling for *Legionella* proliferation risk. At each LTCF the author recorded the type of hot water tank, temperature of water within the hot water tank, the presence of a TMV and temperature of pipes before and after the TMV. As well, the author recorded hot water temperatures after one minute and free available chlorine concentration ([FAC]) at numerous resident-accessible taps throughout each LTCF.

**Results:** The hot water tank temperatures were set at 60.6°C, 73.0°C and 62.0°C for LTCF #1, LTCF #2 and LTCF #3, respectively. All three LTCFs had installed a TMV within the boiler room immediately after the hot water tank. It was found that LTCF #1's plumbing system water temperature was reduced from 60.6°C (at the tank) to 48.9°C after the TMV. LTCF #2's plumbing system water temperature was reduced from 73.0°C (at the tank) to 43.3°C after the TMV. LTCF #3 was an older plumbing system that did not have thermometers within the boiler room to check the drop in temperature after the TMV. Water temperatures at taps were compared to a standard of 49°C and [FAC] levels at taps to a standard of 0.2 mg/L. The mean hot water temperature and mean [FAC] residual for all three LTCFs were 40.2°C and 0.27 mg/L, respectively. For all three LTCFs, it was statistically significant that mean water temperatures were less than the comparison value of 49°C (LTCF #1 p = 0.00000, LTCF #2 p = 0.00022, LTCF #3 p = 0.00110). It was also statistically significant that the mean [FAC] of all three LTCFs were greater than the comparison value of 0.20 mg/L (LTCF #1 p = 0.00042, LTCF #2 p = 0.00000, LTCF #3 p = 0.00107).

**Conclusion:** It was found that all three LTCFs had set preventive measures in place to protect their residents. Water was heated to at least 60°C to prevent *Legionella* and lowered to less than 49°C to prevent scalding. [FAC] residual was also adequate to prevent growth of *Legionella*. However, the location of the TMV in the boiler room was suspected to be a possible contributing factor to *Legionella* growth, especially if cold water temperatures were to reach 20°C or above, as they could in warm summer months. Further research is needed to determine the significance of the TMV location and the presence of *Legionella*.

**Keywords:** *Legionella pneumophila*, Legionnaires' disease, Pontiac fever, community care facility, long-term care facility, high risk population, free available chlorine concentration, hot water temperature, hot water tank, thermostatic mixing valve

## INTRODUCTION:

The author of this report was interested in environmental conditions that may encourage the risk of *Legionella* proliferation and therefore potential for Legionnaires' disease infection in a vulnerable population. As such, the author collected environmental samples for *Legionella* proliferation risk at three long-term care facilities (LTCFs) within Vancouver, British Columbia. These samples included recording hot water tank temperatures, the location of thermostatic mixing valves (TMVs), plumbing piping temperatures where available, as well as hot water temperatures and free available chlorine concentrations ([FAC]) at accessible taps.

## BRIEF EVIDENCE REVIEW:

*Legionella* is a human pathogen that can cause two different types of illnesses: Legionnaires' disease and Pontiac fever. Collectively, these illnesses are referred to as legionellosis. Legionnaires' disease presents itself as pneumonia characterized by fever, dry cough, dyspnea, chest pain, headache, malaise and myalgia (1,2). The respiratory infection is often severe and can progress to respiratory and multi-organ failure, with death rates of up to 10% or as high as 40-80% in untreated immune-suppressed patients (3,4). Of the 50 species and 70 serotypes of *Legionella*, *Legionella pneumophili* serotype 1 causes approximately 70% of Legionnaires' disease cases (2). Those with lung conditions or compromised immune systems (e.g. transplant and chemotherapy recipients, persons with diabetes or kidney disease) are thought to be at highest risk of contracting Legionnaires' disease (5). The risk is made higher among persons aged 40 to 70 (5). Additional risk factors for Legionnaire's disease include smoking and excessive use of alcohol (5). The infectious dose (i.e. the number of *Legionellae* cells inhaled) to cause disease is not well understood (6). Pontiac fever, the second illness that *Legionellae* can cause, is a less serious respiratory illness than Legionnaires' disease. It does not involve pneumonia, but is more flu-like instead (fever, headache, chills) (7). The body is typically

capable of resolving Pontiac fever without treatment within 2-5 days of symptom onset (1,8). According to Health Canada, no known fatalities have been reported with Pontiac fever (8).

Currently, legionellosis is listed by the British Columbia Centre for Disease Control (BCCDC) as a reportable disease under Schedule B: Reportable by Laboratories only (9). This means that regular reporting of disease data occurs by passive surveillance. In other words, local laboratories report confirmed cases of legionellosis to a higher administrative level, but there is no active search for cases in the community (10). Passive surveillance contributes to the underestimation of Legionnaire's disease, along with its difficulty to diagnose (4). The most recent British Columbia Annual Summary of Reportable Disease (2016) by BCCDC indicated that legionellosis had dropped slightly from 0.5 cases per 100,000 in 2015 to 0.29 cases per 100,000 in 2016 (11). However, legionellosis continues to show an increasing trend over the last decade (11). The reasons for increased cases are unclear but could be related to increasing use of urine antigen testing in the previous few years (11,12). The majority of cases in British Columbia were reported from Fraser Health Authority (n=8) in 2016 and were likely a result of the region's higher usage of urine antigen testing (11).

*Legionella* is a gram-negative bacteria that is widespread within the natural water environment and in most soils and mud (13). It has been associated most frequently with plumbing systems, especially in larger buildings, which often have more complex water systems (14). Examples of plumbing systems include: cooling towers, hot water tanks, showers and aerators (6). When a tap from an infected source (e.g. water outlet) is used, sprays or droplets of water containing legionellae can become aerosolized (15). When this occurs, most or all of the water in the droplet evaporates quickly, leaving airborne particulate matter that is small enough to be inhaled (15). Particles of less than 5 µm in diameter can be deeply inhaled, and enter the respiratory airways to cause legionellosis (15).

Direct person-to-person transmission is not considered a risk (8). There has, however, been one case of probable person-to-person transmission reported in Portugal in 2014 (16).

In British Columbia, *L. pneumophila* caused two outbreaks between 2005 and 2016 (1). The first outbreak (5 cases) was associated with a cooling tower and the source of the 2014 outbreak (3 cases) was not confirmed, but thought to be associated with a dishwasher in a food service establishment (1). While British Columbia has not had an outbreak associated with a LTCF, the severity and consequences could prove to be quite devastating. At a Quincy, Illinois veterans' home in 2015, an outbreak of Legionnaires' disease resulted in 12 deaths and at least 54 people sickened (17). The impact of such *Legionella* outbreaks affect not only the health and wellbeing of the population, but also strains the economy as well, with an estimated cost of \$433 million a year attributed to impatient costs in the U.S. (18)

Many factors may contribute to *Legionella* growth within a plumbing system. These factors include biofilm formation, the type of disinfection system, a lack or absence of disinfection residual, a lack of thermal control, the type of hot water heater, the amount of scale/corrosion within the pipes and areas in the system with low flow (e.g. dead-ends, absence of mixing valves and point-of-use, incorrect piping diameter) (1).

Since freshwater and man-made water systems are variable, generally low-nutrient environments, *Legionella* spp. developed mechanisms to acquire nutrients by residing in biofilms (6). Biofilms are capable of covering the interior of pipe walls, in-premise plumbing fixtures and heating, ventilation and air-conditioning systems (6). Biofilms not only allow *Legionella* spp. access to nutrients, but provide a niche and protection against adverse conditions like chlorine and elevated water temperatures (8).

Thriving growth temperature for *Legionella* lies between 25°C and 42°C, with an optimal growth

temperature of 35°C (19). The bacteria, however, have also been isolated in water systems at temperatures up to 60°C and below 20°C (20,21). The National Plumbing Code of Canada (NRCC) includes requirements for maintaining domestic hot water tank temperature at a minimum of 60°C to address the growth of *Legionella* (8,22). One study found that if the water heater temperature was 60°C and maintained at least at 55°C across the network, there was no risk for *Legionella* based on negative culture or qPCR results (23). Taking these temperatures into consideration, it is reasonable to require that LTCF licensees maintain their heater temperature at 60°C and the network at 55°C across. According to the World Health Organization (WHO), maintaining circulating hot water at >50°C and cold water <25°C is sufficient (24). There is, however, a balancing act between risk of *Legionella* proliferation and risk of scalding (25). Water at 60°C can result in a second-degree burn after three seconds, and a third-degree burn after five seconds in adults (26). As such, the water accessible to a person in care should be lowered to 49°C according to the Residential Care Regulation (RCR) Section 17 under the Community Care and Assisted Living Act (27). To reduce the risk of scalding, thermostatic or pressure-balanced mixing valves should be installed to control the water temperature at the tap (28). Instead of inserting thermostatic or pressure-balanced mixing valves directly at taps, buildings may lower the water temperature coming directly out of the hot water tank. This may lead to conditions that facilitate the growth for *Legionella* if the water in the pipes is circulating at less than 50°C, and especially if near 35°C.

The type of water heater system a building uses can make a difference for *Legionella* growth. After studying hot water plumbing systems in Quebec homes in 1991, researchers Alary and Joly found *Legionella* in 39% (69/178) of hot water tanks with electric heaters and 0% (0/33) of tanks with oil-fired or gas-fired heaters. The reason for *Legionella* detection in electric tanks was determined to be due to the location of the heating elements, which were above the bottom

of the heaters. This could allow for bottom sediments and a stratification in temperatures, such that water below the heating element remain at lower temperatures capable of *Legionella* growth (29).

In addition to temperature control, a number of disinfection strategies have been shown to be effective in reducing *Legionella*, including chlorine, monochloramine, chlorine dioxide, ozone and ultraviolet (UV) radiation (30). A disinfectant residual is important however, and UV does not provide one and chlorine dioxide and ozone are not effective at maintaining a residual (30). A free chlorine concentration of 0.25 mg/l is capable of maintaining non-biofilm associated *Legionella* under levels capable of causing disease (31). This is close to the typical free chlorine concentration required in distribution systems (0.2 mg/L) (32). However, Cervero-Aragó et al. (2015) found that when comparing five different *Legionella* strains, *L. pneumophila* serotype 1 was the most resistant to the free available chlorine concentrations typical of drinking water systems (0.2mg/L and 0.5 mg/L). Additionally, when *Legionella* was co-cultured with an amoeba (protozoan host), the effectiveness of chlorine treatments on the associated bacteria was reduced between 2.5 and 4 times at 0.5 mg/L (33). Some plumbing systems of hospitals and large buildings employ routine thermal disinfection either on its own or in conjunction with chemical disinfection as a means of a temporary control strategy (34).

Since there is uncertainty about what concentration of *Legionellae* cells is required to cause infection (35) and no private labs in western Canada are currently engaged in environmental sample analysis [note: BCCDC Public Health Laboratory is working towards a quicker and improved method of *Legionella* detection in water and on swabs (36)], it does not make sense to gather water samples to test for *Legionella*. In the end, it is the factors for growth discussed above that will contribute to *Legionella* growth in a water system and testing for its presence only confirms that.

Plumbing systems are frequently old and complex, favoring amplification of *Legionella* bacteria; and water temperatures are often reduced to prevent scalding of patients (37). While the VCH's Residential Facility Inspection Checklist requires the Licensing Officer to check water temperatures that are accessible to people in care (38), the responsibility to maintain water temperatures actually falls under the care facility licensee according to the Residential Care Regulation under the Community Care and Assisted Living Act (27). Since maintaining water system temperatures and chlorine residual minimizes the likelihood of Legionnaires' disease transmission, the purpose of the author's research study is to determine whether LTCFs are abiding by temperatures and disinfection conditions nonconductive to the growth of *Legionella*. While temperature and chlorine residual are not the final indicators of *Legionella* presence, they offer insight into the current maintenance of the water network. It is thought that prevention efforts may be inadequately implemented in the majority of health care facilities, especially if the facility is old and/or not measuring risk of scalding against risk of *Legionella*.

## METHODOLOGY

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Three LTCFs housing senior residents within the city of Vancouver were selected for testing based on accessibility. At each LTCF, the following methods were conducted, which were split into two stages: Hot water tank and piping temperatures within the boiler room, and temperature and chlorine measurements at faucets.

### **A. Hot Water Tank and Piping Temperatures within Boiler Room**

With maintenance personnel for access and reference, the LTCF's boiler room was visited. The following information was recorded: the type of hot water heater the facility used (gas or electric), the temperature output at the hot water tank, the water holding tank temperature (if available) and the temperature of any plumbing

lines by reading plumbing line thermometers (if available). It was also determined whether there was a TMV located within the boiler room or elsewhere. If there was a TMV in the boiler room, the temperature of the water entering and existing the TMV were both recorded by reading plumbing line thermometers (if possible).

### B. Temperature and Chlorine Measurements at Faucets

30 resident-accessible taps were chosen to give a good representation of the entire LTCF building (e.g. taps on every floor or every other floor, either end of the floor and the middle of the floor) for temperature and chlorine measurements. For statistical validity, measurement at 30 taps was sought after.

At each tap, it was recorded whether the tap had a TMV. The TMV could be discovered by looking under the sink. A clean (rinsed with distilled water), double-cupped 16 oz Solo cup was placed under the faucet and the hot water was turned on for one minute. The water overflowed the cup. Time was recorded with a stop watch. After one minute, the hot water was turned off and the temperature of the water within the Solo cup was immediately recorded using a calibrated, clean BIOS DT130 pocket digital thermometer. Following temperature measurement, the [FAC] of the hot water in the Solo cup was recorded using a LaMotte ColorQ PRO 7 kit by following the kit's instruction manual for [FAC]. After temperature and chlorine measurements at each tap, the thermometer, Solo cup, and LaMotte ColorQ PRO 7 equipment were rinsed with distilled water to remove any chlorine residue.

### RESULTS:

The LTCFs varied in size from two floors (LTCF #3) to four floors (LTCF #2) to 15 floors (LTCF #1).

The author found that all three LTCFs had domestic gas-fired hot water tanks installed to supply hot water to residents. The hot water tank temperatures were set at 60.6°C, 73.0°C and

62.0°C for LTCF #1, LTCF #2 and LTCF #3, respectively.

The author found that all three LTCFs had installed a TMV within the boiler room immediately after the hot water tank. There were no TMVs directly at accessible taps within the facility, except where a resident-accessible tap may be connected to a kitchen plumbing line where hot water was needed for regular kitchen duties. The hot water tank heated incoming municipality-treated water to 60°C and sent it through the TMV, where the water temperature was cooled to less than 49°C by mixing in cold water. Where there was a thermometer to read the temperature of the water in the pipes coming out of the TMV, it was recorded by the researcher. It was found that LTCF #1's plumbing system water temperature was reduced from 60.6°C (at the tank) to 48.9°C after the TMV. LTCF #2's plumbing system water temperature was reduced from 73.0°C (at the tank) to 43.3°C after the TMV. LTCF #3 was an older plumbing system that did not have thermometers within the boiler room to check the drop in temperature after the TMV. Instead, the maintenance staff routinely checked hot water temperature directly at the taps

The author compared water temperatures at taps to a standard of 49°C, water temperatures at hot water tanks to 60°C, and [FAC] levels at taps to a standard of 0.2 mg/L (39).

### A. Descriptive Statistics

The data recorded from temperature and [FAC] measurements at each LTCF were input into Microsoft Excel to determine measures of spread (dispersion) and measures of central tendency. The author was interested in the mean, range, minimum, maximum and standard deviation. The results from the statistical tests can be seen in Table 1 and Table 2 below:

**Table 1: Tap Hot Water Temperatures (°C)**

Group	(n) Samples	Mean	Range	Min	Max	Std. Deviation
LTCF #1	9	43.2	4.9	39.9	44.8	1.4
LTCF #2	16	38.1	21.4	22.3	43.7	6.1
LTCF #3	12	40.9	2.4	39.3	41.7	0.8
ALL	37	40.2	22.5	22.3	44.8	4.5

**Table 2: [FAC] Residual at Taps (mg/L)**

Group	(n) Samples	Mean	Range	Min	Max	Std. Deviation
LTCF #1	6	0.31	0.11	0.26	0.37	0.04
LTCF #2	17	0.26	0.14	0.21	0.35	0.04
LTCF #3	12	0.27	0.07	0.22	0.29	0.02
ALL	35	0.27	0.16	0.21	0.37	0.04

## B. Inferential Statistics

Four inferential statistical tests were employed. A one sample t-test compared mean water temperatures at each LTCF to a standard of 49°C. Another one sample t-test compared mean [FAC] at each LTCF to a standard of 0.20 mg/L. Two ANOVA tests were employed to first, compare the difference of mean hot water temperature between all three LTCFs, and second, compare the difference of mean [FAC] between all three LTCFs.

### One Sample T-test Comparing Mean Hot Water Temperature

H <sub>0</sub>	There is no statistical difference between mean hot water temperature at taps and the comparison value of 49°C
H <sub>a1</sub>	Mean hot water temperature at taps will be statistically greater than the comparison value of 49°C
H <sub>a2</sub>	Mean hot water temperatures at taps will be statistically less than the comparison value of 49°C

For all three LTCFs, the null hypothesis was rejected and it was deemed statistically significant that mean water temperatures were less than the comparison value of 49°C (LTCF #1 p = 0.00000, LTCF #2 p = 0.00022, LTCF #3 p = 0.00110).

### One Sample T-Test Comparing Mean [FAC]

H <sub>0</sub>	There is no statistical difference between mean FAC concentration at taps and the comparison value of 0.20 mg/L
H <sub>a1</sub>	Mean FAC concentration at taps will be statistically greater than the comparison value of 0.20 mg/L
H <sub>a2</sub>	Mean FAC concentration at taps will be statistically less than the comparison value of 0.20 mg/L

For all three LTCFs, the null hypothesis was rejected and it was deemed statistically

significant that mean [FAC] were greater than the comparison value of 0.20 mg/L (LTCF #1 p = 0.00043, LTCF #2 p = 0.00000, LTCF #3 p = 0.00107).

### ANOVA Comparing Mean Hot Water Temperature

H <sub>0</sub>	There is no statistical difference in mean hot water temperature at taps between the three LTCFs
H <sub>a1</sub>	There is a statistical difference in mean hot water temperature at taps between the three LTCFs

The null hypothesis was rejected and it was deemed statistically significant that there was a difference in mean water temperature between the three LTCFs. The p-value was 0.00292. Based on the post hoc Tukey-Kramer Multiple-Comparison Test, the mean hot water temperature of LTCF #1 was statistically different than LTCF #2 (p = 0.01342) but not statistically different than LTCF #3 (p = 0.43073). LTCF #2 was also not statistically different than LTCF #3 (p = 0.17829).

### ANOVA Comparing Mean [FAC]

H <sub>0</sub>	There is no statistical difference in mean [FAC] at taps between the three LTCFs
H <sub>a1</sub>	There is a statistical difference in mean [FAC] at taps between the three LTCFs

The null hypothesis was rejected and it was deemed statistically significant that there was a difference in mean [FAC] between the three LTCFs. The p-value was 0.03481, indicating a potential alpha error. Reducing the p-value cut-off to 0.01 would minimize this error. Power was 0.75488, indicating some chance that the null hypothesis could be true. Based on the post hoc Tukey-Kramer Multiple Comparison Test, LTCF #1 was statistically different than LTCF #2 (p = 0.01562) and LTCF #3 (p = 0.02785), but LTCF #2 and LTCF #3 were not statistically different (p = 0.99238).

## DISCUSSION:

All three LTCFs had domestic gas-fired hot water tanks installed to supply hot water. *Legionella* is much less likely to be detected in gas-fired hot

water tanks as opposed to electric heaters (29). This is because gas-fired water tanks can heat the water more evenly, whereas electric tanks may experience a stratification of temperatures such that the water below the heating elements remains at a lower temperature that promotes *Legionella* growth (29). The hot water tanks were set at 60.6°C, 73.0°C and 62.0°C for LTCF #1, #2 and #3, respectively. The reason why LTCF #2's tank was set higher than LTCF #1 and LTCF #2 was unknown, but is thought to be an extra precaution taken by the facility. Water that is heated to 70°C rapidly kills *Legionella* in 0 minutes, whereas water that is heated to 60°C kills 90% of bacteria in two minutes (40). Often times, 70°C is the temperature used to pasteurize and flush an already-infected system (40). However, the National Plumbing Code of Canada (NRCC) requires only that domestic hot water tanks be maintained at 60°C to address the growth of *Legionella* (8,22). As such, at the times of inspection, all three LTCF's hot water tanks were meeting the requirements to prevent *Legionella* growth.

All three LTCFs were found to have met the typical [FAC] (0.2 mg/L) that is required in City of Vancouver distribution systems (32), with the overall LTCF average having been 0.27 mg/L (n = 35). According to Dalaedt et al. (2008), a concentration of 0.25 mg/L is capable of maintaining non-biofilm associated *Legionella* under levels capable of causing disease (31). As such, non-biofilm associated *Legionella* should not be a concern with the residual levels found in the LTCFs at the times of inspection. However, since *Legionella pneumophila* serotype 1 is often associated with a biofilm, it is more resistant to the free available chlorine concentrations typical of drinking systems and so other environmental factors must be regulated to prevent *L. pneumophila* growth (33). This is why chlorine is not the only factor to consider when it comes to the presence of *Legionella* in the water system.

A total of 37 (n = 37) accessible taps were measured for hot water temperature at all three LTCFs. The average hot water temperature at accessible taps was 40.2°C, with a minimum of 22.3°C and a maximum of 44.8°C. As well, the

statistical results (one sample t-tests) confirmed that the hot water temperature at each tap of each LTCF was less than 49°C. Accordingly, all three LTCFs were in compliance with the RCR Section 17 under the Community Care and Assisted Living Act which states that any water accessible to a person in care be lowered to 49°C (27). While temperature reduction is important to prevent scalding in LTCF residents, there is concern as to where in the system the temperature is lowered since high temperature (at least 55°C) across the entire plumbing network is important to prevent *Legionella* growth (23). To determine where in the system the temperature was lowered to meet the RCR, maintenance personnel were asked where TMVs were installed.

As was mentioned, the average temperature at all accessible taps for all three LTCFs was 40.2°C, which is significantly lower than the temperature requirement by the RCR. This indicated that the hot water temperature in the pipes dropped significantly after the TMV. At 40.2°C, the hot water temperature in the plumbing systems is optimal for thriving *Legionella* growth (19). Since the water was previously heated to 60°C, there should not be a problem. However, since cold water is mixed in, it has the potential to contain *Legionella* as the bacteria can grow in cold water that is above 20°C (20,21). During the winter months, this is not a concern, but during the summer months, exceptionally warm weather could increase the temperature of incoming cold water above 20°C. If water above 20°C is mixed in to the heated water via the TMV and reduced to less than 49°C (or to the 40.2°C average for the three LTCFs), the temperature becomes optimal for *Legionella* growth if other preventative conditions are not in place. Those preventative measures include appropriate disinfection and residual, a closed loop system with no dead ends or stagnant zones and well-maintained piping. For this reason, to ensure that *Legionella* does not have any conditions to grow, it is best to heat incoming water at the hot water tank to 60°C and maintain the plumbing distribution system at 55°C across. To do this, it is suggested that instead of installing TMVs after the hot water tank in the boiler room, that they instead be installed directly at accessible taps before hot

water is dispensed. That way, the hot water is maintained throughout the facility and lowered where needed.

While it was found that the three LTCFs inspected had TMVs located only within the boiler room, it is uncertain whether this is representative of all LTCFs in Vancouver. As well, it is possible for some facilities to install boosters throughout their distribution system to re-heat the water as it moves further away from the main hot water heater. There are many factors that are involved in a well-maintained plumbing distribution system to prevent *Legionella* proliferation, and as such, it is difficult to extrapolate results from this study to other LTCFs in Vancouver.

#### KNOWLEDGE TRANSLATION:

With climate change and increasing summer temperatures on the rise, it is possible that cold water in summer months may reach above 20°C. Whether this poses a concern in terms of the location of the TMV remains to be investigated fully. This area in the plumbing system deserves more attention, especially in LTCFs where susceptible people are living. If, after more research, it is found that the location of the TMVs poses a concern for *Legionella* growth in some systems, it could be suggested as an extra precaution that TMVs instead be installed directly at accessible taps. As such, it may become common practice for any future renovations and LTCF developments to require that TMVs be located directly at accessible taps so that the distribution system remains heated to at least 55°C throughout to prevent *Legionella* proliferation.

#### LIMITATIONS:

This research project was primarily limited by time. Each LTCF was inspected and sampled within a few hours. This required the attendance of at least one maintenance personnel as well as the accompaniment of a Vancouver Coastal Health Vancouver district EHO. Since the EHO had to continue their day with regular inspections, only

one LTCF could be inspected each day. As well, with the researcher having only four Thursdays available to conduct her research, one of those having been used for her pilot study, this left three dates, and therefore only three LTCFs to be inspected and sampled.

To improve the study, it would be recommended that less time be spent measuring hot water temperature and chlorine residuals at taps, and instead more time be spent visiting additional LTCFs to collect information. It was found that temperature and chlorine residual did not vary drastically across the LTCFs, and so it would only be necessary to measure temperature and chlorine at even intervals throughout to represent the size and layout of the facilities. With the time saved, more LTCFs could be visited and information such as location of TMVs could be focused on. As a result, the research would have more external validity in being able to generalize what may be found at other LTCFs in Vancouver.

As well, it would have been desirable to take samples for *Legionella* throughout the water systems that could be analyzed by BCCDC. This would have provided solid evidence to support the temperature and chlorine measurements, and therefore improved internal validity. However, this would have added to both the time factor as well as the cost factor. As such, this research project intended to focus on the conditions for *Legionella* growth, rather than the presence of *Legionella* in the system.

#### FUTURE RESEARCH:

Future student projects based on *Legionella* and LTCFs could include:

- Conducting a survey to determine how many LTCFs in Vancouver (or another municipality) have thermostatic mixing valves installed primarily in the boiling room versus at accessible taps
- Conducting a survey to determine how many LTCFs in Vancouver (or another municipality) have water cooling towers and determining how those facilities are maintained



## CONCLUSIONS:

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It was found that all three LTCFs had set preventive measures in place to protect their residents. Water was heated to at least 60°C to prevent *Legionella* and lowered to less than 49°C to prevent scalding. [FAC] residual was also adequate to prevent growth of *Legionella*. However, the location of the TMV in the boiler room was suspected to be a possible contributing factor to *Legionella* growth, especially if cold water temperatures were to reach 20°C or above, as they could in warm summer months. It is concluded that further research is needed to determine the significance of the TMV location and the presence of *Legionella*. If it is confirmed to be a problem, it would be suggested that it become common practice to install TMVs directly at accessible taps instead of within the boiler room to prevent *Legionella* proliferation and therefore incidences of Legionnaires' disease in a vulnerable population base.

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## ABBREVIATIONS:

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BCCDC	British Columbia Centre for Disease Control
EHO	Environmental Health Officer
[FAC]	Free Available Chlorine Concentration
LTCF	Long Term Care Facility
RCR	Residential Care Regulation
TMV	Thermostatic Mixing Valve

## COMPETING INTEREST:

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The author declares that there were no competing interests in the study.

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