Assessing the risk of lead exposure to children from drinking water in Metro Vancouver child care facilities

Thomas Quach[1], Dr. Helen Heacock[2], Dr. Reza Afshari[3]

1 Lead Author, B. Tech Student, School of Health Sciences, British Columbia Institute of Technology, 3700 Willingdon Ave, Burnaby.
2 Supervisor, School of Health Sciences, British Columbia Institute of Technology, 3700 Willingdon Ave, Burnaby.
3 Contributor, Senior Scientist, Toxicology, British Columbia Centre for Disease Control, Vancouver.

Abstract

Background: Environmental lead exposure has been a concern since the early 1970's. With the reduction of airborne lead for inhalation, ingestion from food and water has become the major route of exposure leading to elevated blood lead levels. Previous research and the recent lead contamination of drinking water in Flint, Michigan demonstrate the vulnerability of young children and potential for exposure through drinking water. The purpose of this study was to assess and characterize the risk of lead contamination of drinking water for Metro Vancouver-area early childhood care facilities, and the effect of flushing fixtures as a control measure.

Method: 91 drinking water samples were collected from various fixtures at 16 child care facilities at progressive time points to observe the effects of flushing and re-stagnation on total dissolved lead content. Analysis was performed using Varian AAS-240 coupled with GTA-120 graphite furnace atomic absorption spectroscopy. Results were analysed statistically using Excel 2010 and SAS/STAT® 14.2 software with SAS Studio 3.6 interface.

Results: The mean (SD, min-max) lead concentrations of the water samples were 0.69 (2.32, 0.1-11.27) µg/L at zero minutes of flushing, 0.21 (0.44, 0.1-2.19) µg/L after one minute of flushing, 0.15 (0.17, 0.1- 0.87) µg/L after five minutes of flushing, 0.18 (0.17, 0.1 -0.64) µg/L after re-stagnation, and 0.31 (1.20, 0.1-11.27) µg/L overall. One outlier sample had a lead concentration of 11.27 µg/L, which exceeded Health Canada's maximum allowable concentration of 10 µg/L. The decrease in mean lead concentration between zero minutes and one minute of flushing was statistically significant (p=0.0020).

Conclusions: The results indicate that lead contamination of drinking water in child care facilities is present but below regulatory action levels under normal circumstances. The flushing of fixtures for at least one minute was shown to be effective in lowering lead concentrations further. Efforts should be taken to identify facilities at higher risk of lead contamination and to educate operators of flushing as an effective control measure.

Keywords: Lead, lead contamination, lead leaching, drinking water, children, daycare, child care facility, British Columbia, Metro Vancouver, Burnaby, Fraser Health Authority

Introduction

For the past five decades, environmental lead exposure has been a significant public health concern in Canada. Legislation and regulatory action throughout the 1970's to 1990's, such as the banning of leaded gasoline and changing of building codes to exclude lead-containing building materials, have served to drastically reduce the amounts of lead found in the environment available for inhalation (1–4); as a result, blood lead levels (BLL) in the Canadian population have dropped by more than 70% since 1978. (2,3)

However, ingestion of lead from food and water, while also in decline, still poses a significant public health concern. The contamination of Flint, Michigan's municipal drinking water in 2014 (5), and the detection of elevated lead levels in schools across British Columbia this past year (6) illustrate the susceptibility of drinking water to lead contamination from distribution and plumbing systems. The World Health Organization [2011] estimated that at an average of 5 parts per billion (µg/L) of lead in water, 20% of an individual's daily exposure to lead came from drinking water, representing the largest controllable source of lead. (7) In comparison, the Canadian Guidelines for Drinking Water Quality [2014] specifies a maximum allowable content of 10 µg/L for lead in drinking water. (8)

The potential for deleterious health effects comes not only from acute exposure to elevated amounts of lead, but also from long-term low-level exposure. Predictive modelling by Sathyanarayana and colleagues [2006] estimated that regular exposure to lead in water at a concentration up to 49 µg/L, resulted in a BLL ranging between 1.6 and 5.0 micrograms per decilitre (µg/dL) in children but concluded that, with a BLL below guideline limits of 10 µg/dL, exposure to concentrations of lead in water up to 1500 µg/L were not likely to be hazardous. (9) Studies by Lanphear and colleagues [2005], Triantafyllidou and Edwards [2012], and Health Canada [2013a] contrast this by demonstrating that the potential for permanent and untreatable changes to behaviour and cognitive ability, including delinquency, reduced IQ, and increased risk of ADHD, were associated with BLLs <10 µg/dL and as low as 1.3 µg/dL. (3,4,10) Infants and young children were found to be especially vulnerable compared to the rest of the population due to higher gastrointestinal absorption rates, reduced ability to eliminate via excretion, and undergoing rapid and delicate neurological development. (1,3,7,11)

Given the vulnerability of young children to lead exposure from drinking water, potentially life-altering effects of prolonged lead exposure, and significant amount of time spent by children in schools and daycare facilities (12), this review aims to assess the risk of lead exposure to children from drinking water in schools and daycares, specifically in the Metro Vancouver region of British Columbia.

Evidence Review

Sources of Lead Contamination

Water leaving treatment plants and circulating through municipal distribution systems is generally unlikely to contain elevated amounts of lead (4); the exception to this is the case of Flint, Michigan, where unsuitable water chemistry caused corrosion and leaching from the city's aging lead distribution system. (5) The more common source of lead contamination begins after the water leaves municipal distribution lines and stagnates in a building's service connection line and plumbing system. (4) A study by Barn and Kosatsky [2011] identified critical factors contributing to high degrees of lead leaching: long contact time from stagnation; older plumbing systems containing lead components; longer lengths of lead pipes; smaller diameter pipes, allowing for greater surface area contact; water with lower pH; water with lower alkalinity, or hardness; and the absence of corrosion inhibitors typically added during water treatment. (13)

While changes in building requirements preclude the use of lead-containing materials in newer buildings, plumbing systems in buildings built before 1989 are likely to contain lead in the form of piping, solder, additives to polyvinyl chloride (PVC)-based components, and brass alloys. (3,4) Prior to the introduction of low-lead brass fixtures, brass devices such as flow meters could contain as much as 8% lead by weight. (4) A study by McIlwain, Park, and Gagnon [2016] found that certain models of institutional water fountain fixtures containing lead-lined cooling tanks and brass fittings released high levels of lead; one particular model with significantly high levels of lead is still in use in Canada despite being recalled in the United States. (14)

Many of the above factors can be seen in the current state of Metro Vancouver. Municipal water chemistry is slightly acidic and very low in hardness, (15) and over half of school buildings in Vancouver are over 50 years old, with 25 buildings aged 100 years or older. (16)

Current Control Measures, Effectiveness, and Gaps in Policy

Flushing of stagnant water from plumbing systems is the most commonly recommended control measure to reduce lead concentrations. (2,3,12,13,15,17) Users are advised to allow cold water to run from a single fixture for five minutes, or 10 minutes to allow fresh water to circulate into building plumbing systems, with additional flushing at other fixtures within the building as necessary. (12) The medical health officer for Vancouver Coastal Health issued a guidance document for school districts in April 2016, instructing them to implement water lead content monitoring programs and daily flushing from all fixtures. (18) A similar document was issued to day care facilities to implement monitoring and flushing programs on a case-by-case basis. (15)

While research has demonstrated the efficacy of water line flushing in bringing lead content down to acceptable limits (3,4,17), a study by Deshommes and colleagues [2016] noted that certain schools with particularly problematic stagnant lead concentrations, can return to a lead concentration of 200 µg/L, 10 times the allowable level in the Canadian Guidelines for Drinking Water Quality, in just thirty minutes of stagnation after flushing. (19) Barn and Kosatsky [2011] recommend flushing only as a temporary stop-gap measure until a permanent solution is implemented. (12)

Other possible methods of remediation include replacement of fixtures and plumbing lines with non-leaching components, altering water chemistry via addition of corrosion inhibitors or pH adjustors, and installation of point-of-use filtration units; however, these methods carry a much higher implementation cost. (12)

For monitoring policy, only the Province of Ontario legally requires regular testing of school and daycare water for lead in Canada, though only specifies the need to test a single fixture; Health Canada recommends screening all fixtures, with focused follow-up testing on problematic fixtures. (12)

In an article dated May 21, 2016, the Vancouver Sun reported inconsistencies in action among various school districts in British Columbia: only a few school districts, such as New Westminster, were performing annual lead content analysis, while others only performed testing in response to complaints regarding sensory characteristics; the Richmond school board claimed that Vancouver Coastal Health audited their water every three years, which the health authority denied.(6) Daycare facilities, operating independently of school districts, may have to retain testing services from private laboratories to satisfy recommended monitoring. (15)

Conclusion

This review summarizes the published knowledge for the risk of lead exposure via drinking water to children in schools and daycares. The existing evidence of low-level lead exposure effects, aging condition of Vancouver schools, water chemistry conducive to leaching, and lack of enforceable, uniform policy in British Columbia suggests that lead exposure from drinking water in schools and daycares in Metro Vancouver has the potential to pose a long-term health risk to young children. Further research to accurately quantify the risk and develop control measures, especially to fill the gap in knowledge regarding daycares, should be undertaken.

Methodology

Drinking water samples were collected from child care facilities licensed by Fraser Health Authority during the three-month period between January and March 2017. Sample collection was to take place during mornings of regular operation starting at 8:00 am. Eight 250 mL portions were to be collected using high-density polyethylene bottles per facility between two specific types of fixtures: taps or faucets intended for drinking water consumption, and water fountains. Sample portions were collected at four sequential time points: prior to any flushing or use of fixtures (t=0), immediately following a one-minute flushing period (t=1), immediately following a five-minute flushing period (t=1), and immediately following a 120-minute re-stagnation period (t=120).

Samples were acidified using 5% v/v nano-pure nitric acid to pH <2 within 48 hours of collection in their collection bottles, and stored at room temperature at BCIT until testing. Sample digestion prior to analysis was not required (20–22).

Analysis was performed at BCIT using a Varian AA240 atomic absorption spectrometer with GTA 120 graphite thermal atomizer. Samples were transferred into appropriate containers and loaded onto the automated sampling carousel as per the manufacturer's instructions. Proprietary control software was used to control testing parameters, automated operation, and data recording. (23,24)

Results

Study Participation Rate

From the list of 35 candidate childcare facilities provided by Fraser Health Authority, 9 consented to participation. An additional 17 facilities were randomly selected and contacted from Fraser Health Authority's registry licensed childcare facilities, of which 7 consented to participation. In total, 52 daycare facilities were contacted with 16 providing consent to participation for an overall participation rate of 31%.

Sampling and Additional Data Collection

Ninety-one water samples were collected from 23 fixtures in the participating facilities. Of these fixtures, 13 (57%) were countertop sink faucets located outside of food preparation areas, eight (35%) were countertop sink faucets located within food preparation areas, one (4%) was a stand-alone water fountain, and one (4%) was a washroom sink faucet. For facility type, five (33%) of the facilities were in-home child care facilities with the remaining eleven (67%) being institutional facilities. For facility age, operators were able to provide information for only eleven (69%) of the sixteen facilities. Tables 1 and 2 in the on the following page summarize this data.

AAS analysis results for lead concentration were recorded in units of micrograms per litre (µg/L), while facility age was recorded in years, both of which are continuous numerical forms of data. Results below the detection limit of 0.1 µg/L were treated as concentrations of 0.1 µg/L for statistical analysis. Facility type was recorded as nominal dichotomous data, and fixture type as nominal multichotomous data. Statistical analysis was performed using a combination of Microsoft Excel and SAS/STAT® 14.2 software with SAS Studio 3.6 computer interface (25,26,27).

Table 1: List of Participating Facilities with Type and Age

Facility Number	Facility Type	Facility Age (years)
000	In-Home	c. 20
001	In-Home	c. 30
002	In-Home	c. 30
003	Institution	c. 50
004	Institution	c. 60
005	Institution	c. 40
006	Institution	92
007	Institution	Unknown
008	Institution	Unknown
009	Institution	Unknown
010	In-Home	c. 15
011	Institution	c. 10
012	Institution	c. 5
013	Institution	c. 10
014	Institution	21
015	Institution	Unknown

Table 2: List of Participating Facilities with Fixtures and Lead Concentration[1]

Facility Number	Fixture Number	Fixture Type	Lead Concentration (µg/L)			
			T=0	T=1	T=5	T=120
000	1	Kitchen Sink	<0.10U	<0.10U	<0.10U	<0.10U
000	2	Washroom Sink	<0.10U	<0.10U	<0.10U	<0.10U
001	3	Kitchen Sink	<0.10U	<0.10U	<0.10U	<0.10U
002	4	Kitchen Sink	<0.10U	<0.10U	<0.10U	<0.10U
003	5	Countertop Sink	<0.10U	<0.10U	<0.10U	<0.10U
004	6	Countertop Sink	1.17	0.5	0.37	0.64
004	7	Countertop Sink	11.27	2.19	0.87	n/a[2]
004	8	Water Fountain	0.32	0.11	0.13	0.19
005	9	Kitchen Sink	0.81	<0.10U	<0.10U	0.51
006	10	Kitchen Sink	0.2	<0.10U	<0.10U	<0.10U
007	11	Kitchen Sink	0.21	<0.10U	<0.10U	0.34
008	12	Kitchen Sink	<0.10U	<0.10U	<0.10U	<0.10U
009	13	Kitchen Sink	0.11	<0.10U	<0.10U	0.64
009	14	Countertop Sink	<0.10U	<0.10U	<0.10U	<0.10U
010	15	Countertop Sink	<0.10U	<0.10U	0.21	<0.10U
011	16	Countertop Sink	0.15	0.11	0.12	<0.10U
012	17	Countertop Sink	0.16	0.13	<0.10U	<0.10U
013	18	Countertop Sink	<0.10U	<0.10U	<0.10U	<0.10U
014	19	Countertop Sink	<0.10U	<0.10U	<0.10U	<0.10U
014	20	Countertop Sink	<0.10U	<0.10U	<0.10U	<0.10U
014	21	Countertop Sink	<0.10U	<0.10U	<0.10U	<0.10U
015	22	Countertop Sink	<0.10U	<0.10U	<0.10U	<0.10U
015	23	Countertop Sink	<0.10U	<0.10U	<0.10U	<0.10U

[1]Values below the detection limit are expressed as "<0.10U".
[2]Sample collection was not performed due to lack of sampling capacity.

Descriptive Statistics

The mean (SD, min-max) lead concentrations of the water samples were 0.69 (2.32, 0.1-11.27) µg/L at zero minutes of flushing, 0.21 (0.44, 0.1-2.19) µg/L after one minute of flushing, 0.15 (0.17, 0.1- 0.87) µg/L after five minutes of flushing, 0.18 (0.17, 0.1 -0.64) µg/L after re-stagnation, and 0.31 (1.20, 0.1-11.27) µg/L overall. The mean (SD, min-max) facility age was 37 (24, 5-95) years. The mean age of in-home facilities was 23 years while the mean age of institutional facilities was 42 years. Table 3 and Figures 1 to 4 below and on the following page summarize and further illustrate the data.

Table 3: Summary table of descriptive statistics

Group	*n.*	Mean	Mode	SD	Min	Max	Range	Skewness	Kurtosis
Overall	91	0.31	0.10	1.20	0.10	11.27	11.17	8.81	81.02
By Time Point:									
T=0	23	0.69	0.10	2.32	0.10	11.27	11.17	4.70	22.35
T=1	23	0.21	0.10	0.44	0.10	2.19	2.09	4.55	21.16
T=5	23	0.15	0.10	0.17	0.10	0.87	0.77	4.01	16.92
T=120	22	0.18	0.10	0.18	0.10	0.64	0.54	2.04	2.83
By Facility Type:									
In-Home	20	0.11	0.10	0.02	0.10	0.21	0.11	4.47	20.00
Institution	71	0.37	0.10	1.35	0.10	11.27	11.17	7.79	63.27
By Fixture Type:									
Countertop Sink	51	0.43	0.10	1.59	0.10	11.27	11.17	6.66	45.95
Kitchen Sink	32	0.17	0.10	0.17	0.10	0.81	0.71	2.85	7.64

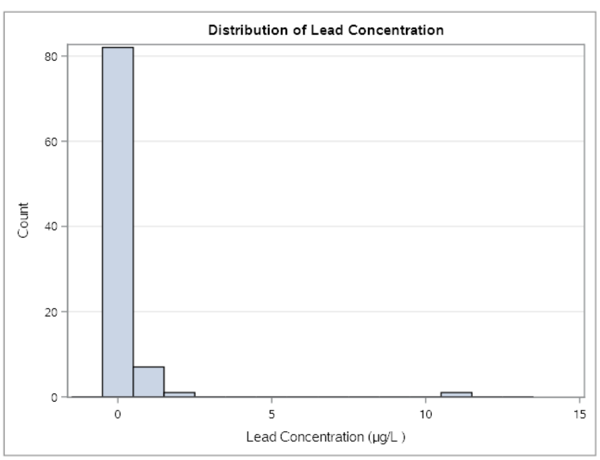

Figure 1: Distribution of lead concentration for all samples (*n*=91).

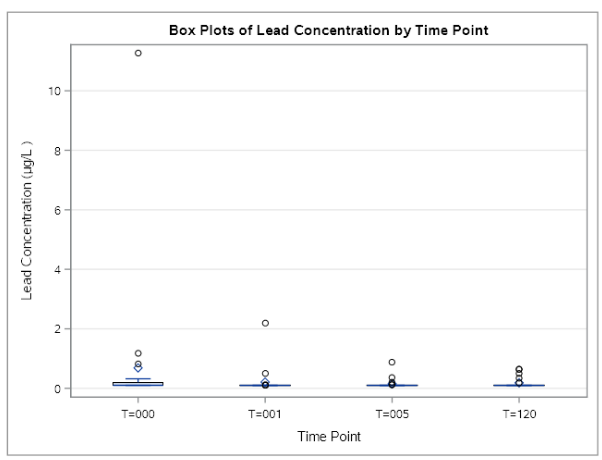

Figure 2: Box plot of lead concentration for samples at separate time points (*n*=91).

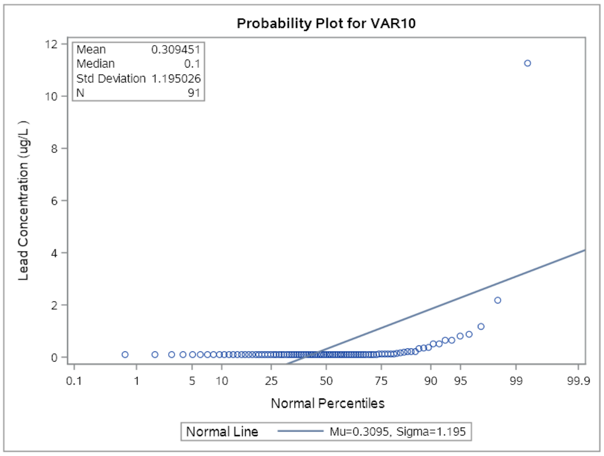

Figure 3: Normal probability plot of lead concentration (*n*=91).

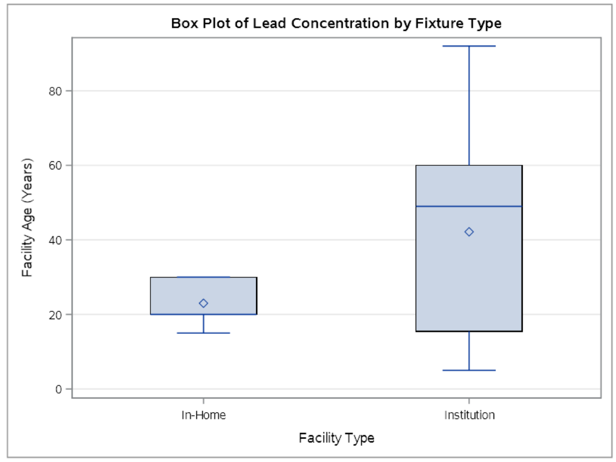

Figure 4: Box plot of facility age by facility type (*n*=12).

Inferential Statistics

The data were analysed using SAS/STAT software to determine if statistically significant conclusions could be drawn regarding the project's research questions. The results of the hypothesis testing are described in the following sections.

Comparison of Fixture Types for Overall Mean Lead Content

Null Hypothesis*: No difference exists in the overall mean lead content between kitchen sink fixtures and countertop sink fixtures.*
Alternate Hypothesis*: There is a difference in overall mean lead content between kitchen sink fixtures and countertop sink fixtures.*

Data for the kitchen sink group (*n*=32) and countertop sink group (*n*=51) were tested for normality using the Shapiro-Wilk, Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling tests. All tests for both sample groups returned *p* values of less than 0.05, allowing for the rejection of normality and indicating that a non-parametric T test was required.

The Wilcoxon Rank-Sum test was selected and yielded a two-tailed probability level of 0.6898. From this, we fail to reject the null hypothesis and can conclude that no difference exists in overall mean lead content between the sampled kitchen and countertop sinks with a power of 13%. Figure 5 illustrates this result.

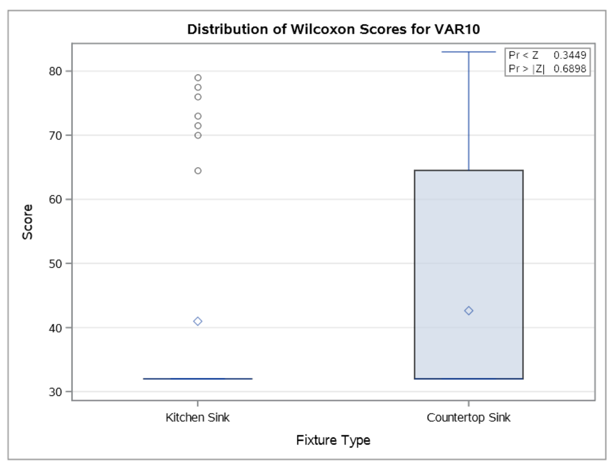

Figure 5: Distribution of Wilcoxon scores for lead concentration of kitchen sinks and countertop sinks.

Comparison of Facility Types for Mean Lead Content

***Null Hypothesis**: No difference exists in the overall mean lead content between in-home and institutional child care facilities.*
***Alternate Hypothesis**: There is a difference in overall mean lead content between in-home and institutional child care facilities.*

Data for the in-home facility group (*n*=20) and institutional facility group (*n*=71) returned *p* values of less than 0.05 in all normality tests, allowing for the rejection of normality and indicating that a non-parametric T test was required.

The Wilcoxon Rank-Sum test was selected and yielded a two-tailed probability level of 0.0159. From this, we can reject the null hypothesis and conclude that the overall mean lead content was significantly greater in institutional facilities than in-home facilities, with a power of 100%. Figure 6 below illustrates this result.

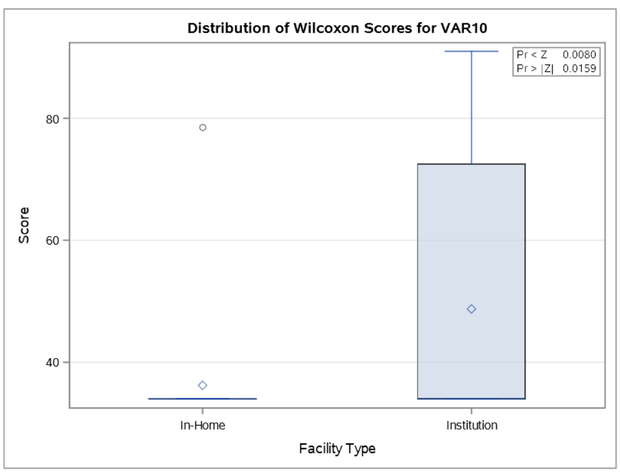

Figure 6: Distribution of Wilcoxon scores for lead concentration from institutional and in-home facilities

Comparison of Mean Lead Content between Time Points

Given that the characteristics of each sampled fixture were not expected to drastically change during sampling, the lead content data from each fixture can be compared across time points in a paired t-test.

***Null Hypothesis**: No difference exists in the water lead content between time points t=0 and t=1 within the same fixture.*
***Alternate Hypothesis**: The water lead content decreases between time points t=0 and t=1.*

Data for the difference in lead levels between zero minutes of flushing and one minute of flushing (*n*=23) were tested for normality using the Shapiro-Wilk, Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling tests. All tests returned *p* values of less than 0.05, allowing for the rejection of normality and indicating that a non-parametric T test was required.

The Wilcoxon Signed Rank test was selected and yielded a one-tailed probability level of 0.0020. From this, we can reject the null hypothesis and conclude that decrease in lead concentration between zero minutes and one minute of flushing was statistically significant with a power of 100%.

This paired T-test was repeated for the difference in data between one minute and five minutes of flushing, and the difference between five minutes of flushing and re-stagnation. However, none of these differences were statistically significant.

Discussion

General Project Results

Overall mean lead concentrations were found to differ significantly between institutional and in-home child care facilities, and the mean lead concentrations of fixtures were observed to significantly decrease between the start of use and after one minute of flushing. No statistically significant differences were observed between the types of sampled fixtures and between other sampling time points.

Of 91 samples analysed, only 1 was found to have a lead concentration higher than Health Canada's maximum allowable concentration of 10 μg/L. This outlier sample was collected from an institutional facility fixture that had been left stagnant for several months, which was reflected in the elevated lead concentration from all time points when compared to samples from other fixtures in the same facility. Even when seen as a worst-case scenario of lead contamination, lead levels in water collected from this fixture dropped to an acceptable level within one minute of flushing as seen in Figure 7 below.

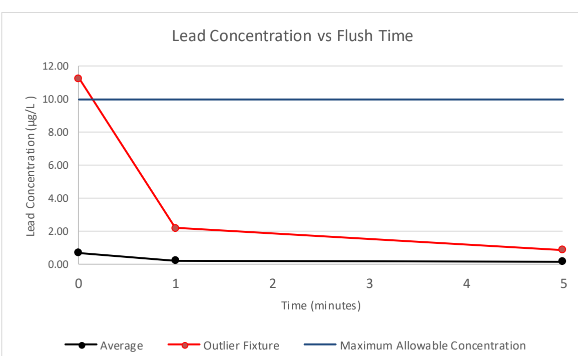

Figure 7: Graph illustrating decline in lead concentration over time with flushing.

A component of the original project design aimed to identify and assess any difference in lead content and leaching potential between faucets and water fountains. However, this was not possible due to the scarcity of water fountains encountered during sampling. Of the sixteen participating facilities only two had water fountains installed, and of those two fountains one was decommissioned and not in use. In response to this lack of water fountains, the difference between faucets in food preparation areas and faucets outside of food preparation areas providing drinking water became the focus, though no significant difference in lead concentrations was found.

Another potential focus identified later in the study was the difference between in-home and institutional child care facilities. As demonstrated in the previous section, institutional child care facilities had a statistically significantly higher overall lead concentration than in-home child care facilities. Despite this difference, lead levels in institutional facilities were well below 10 μg/L except for the outlier fixture mentioned above.

Other Observations

The author observed that several institutional child care facilities were located in or converted from older commercial buildings or places of worship, and a few located within school district property. The average age of these institutional buildings was also greater than the age of in-home facility properties.

Operators demonstrated varying degrees of knowledge regarding the effects of lead in drinking water and the potential for lead exposure in their own facilities. Four operators reported that they boiled all the drinking water at their facilities to ensure its safety. The operators of two facilities reported providing only bottled water for children to drink, citing concerns of the potential presence of lead in their plumbing. One operator in particular was able to provide a full history of their facility from its initial construction, including details of plumbing renovations. This disparity in knowledge regarding lead and drinking water may be a potential subject for a future study.

Limitations

Numerous factors acted as limitations on the implementation of the project as originally designed. The factors commonly seen in other projects included budget and time; other factors, such as participation, sampling logistics, and analysis capacity, were more specific to this project.

In regard to material cost, the majority of reagents and analysis equipment were already available for use courtesy of the BCIT Chemistry Department, and so did not act as a limitation. The availability of sample collection bottles, however, was limited due to supply chain issues and demand from other projects. Throughout the months of January and February sampling and analysis capacity was limited by a fixed number of bottles, even resulting in the incomplete sample collection for one facility – the facility with the outlier fixture.

Obtaining consent to participation was a major limiting factor for the early stages of the project. Attempts at initial contact with facility operators by telephone and email often failed. Of the thirty-five candidate facilities referred by Fraser Health Authority, only eighteen confirmed or rejected participation, with the rest deferring their decisions over numerous follow-up communications. The change to site visits as the primary means of initial contact with telephone and email being supplementary greatly increased the participation rate in the later stage of the project.

Time and scheduling were other significant limiting factors for this project. Taking into account the varying business hours for the child care facilities, the original project plan of collecting samples immediately after a weekend stagnation period was not possible. Instead, sampling was performed on a convenience basis between 9:00 AM and 5:00 PM during weekdays to accommodate regular facility operation. While this change in methodology effectively precluded the original intent to measure the highest possible lead concentrations after stagnation, it did provide a sampling that was much more representative of lead concentrations and exposure during normal day-to-day operations; the exception to this was the outlier fixture noted above.

Finally, the limiting factor affecting the study was the usage of the sampled fixtures by operators and facility staff. The author was unable to control usage of the fixtures prior to sampling and during the re-stagnation period; for many of the facilities, the sampled fixture was both the only source of drinking water and sole handwashing sink. This calls into question the validity of the samples, especially those taken after the re-stagnation period, but also lends support to the notion that the sampling was more representative of normal operations.

Knowledge Translation

The results of this study demonstrate that drinking water from Burnaby child care facilities contains lead at levels well below the 10 µg/L limit outlined by Health Canada during normal daily operation, that periods of extended stagnation can result in lead concentrations reaching unacceptable levels, and that flushing out stagnant water for at least a minute lowers lead concentration back to acceptable levels. With these three findings in mind, the author proposes a double policy approach of education and testing on the part of health authorities to minimize lead exposure.

For education, current and prospective child care facility operators should be fully informed of the harmful effects of lead exposure to children as well as ways to control or eliminate exposure, such as switching to alternative water sources, using effective filtration technologies, or simply flushing water from fixtures at regular intervals and after prolonged periods of disuse.

For testing, a water sample from all current and prospective child care facilities should be collected and analysed to determine if lead is present. Once identified, operators of facilities with lead present can work closely with their licensing officers on ways to control exposure.

Recommendations for Future Research

The author recommends the following as potential areas of study to build on and fill in knowledge gaps from the findings of this project:

- In-depth analysis of lead concentrations, ages, and various building types of institutional child care facilities
- Targeted sampling and analysis of lead concentrations for in-home child care facilities built before 1989
- Sampling and analysis in other municipalities, such as Vancouver, Surrey, Delta, White Rock

Conclusion

The mean lead level in drinking water from Metro Vancouver-area child care facilities was found to be 0.31 (SD 1.20, min 0.1, max 11.27) µg/L. Aside from one outlier case, lead levels during normal operating hours were much lower than Health Canada's maximum allowable concentration of 10 µg/L. The effect of flushing fixtures for at least one minute to reduce lead concentrations was statistically significant at a probability level of 0.0020, while the type of fixture had no effect on lead.

Environmental health officers working with operators of child care facilities should note that while lead contamination of drinking water at these facilities may be present, it can be easily controlled with flushing prior to use.

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Competing Interests

The authors declare that they have no competing interests.

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