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Indicators of Exposure to and Health Effects of Lead in British Columbia, 2009-2010

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Table of Contents

Figures

Tables

1. Summary

Little information is available concerning lead exposure and lead-related illness among BC residents. In order to describe who is exposed to lead, how, and the level of their exposure, Environmental Health Services at the BC Centre for Disease Control obtained results of blood lead analyses conducted by BC laboratories during 2009 and 2010. Hospitalisation summaries, calls to the BC Drug and Poison Information Centre (DPIC), and physician visits coded for lead were also obtained in order to characterise lead-related illness. Results indicate that while lead exposure is of health concern for some BC residents, manifest lead toxicity is rare. Available data does not allow us to pinpoint which groups are at highest risk of exposure to lead, where they live, and how they are exposed.

Laboratory Testing

- Overall, 5475 BC residents had a blood lead concentration measured during 2009 and 2010 (average of 6/10,000 /year)
- The highest rate of blood lead testing per year was for children under 5 years of age (average of 9.5/ 10,000/year)
- The lowest rate of blood lead testing was for women of childbearing age (average of 3.5/ 10,000/year)
- Testing rates were comparable across BC's five regional health authorities: The highest annual level of testing was in the Northern Health Authority (average of 6.5/10,000/year) while the lowest was in the Interior Health Authority (average of 4.5/ 10,000/year)

Blood Lead Concentrations

- 291/5475 (5%) of those who had their blood lead concentration measured were above the current federal-provincial-territorial blood lead intervention level of 10µg/dL
- Persons with elevated blood lead concentrations were most commonly identified in the Interior Health Authority where 69/644 (11%) of those tested had blood lead above 10µg/dL
- Persons with elevated blood lead concentrations were least often identified in the Northern Health Authority where less than 1% of those tested had a blood lead level above 10µg/dL
- Adult males had the highest blood lead concentrations: 260/2615 (10%)had a blood lead level that exceeded 10 µg/dL, of whom 158 (6%) had a blood lead level over 15 µg/dL
- Children age 6-18 years had the lowest blood lead concentrations: less than 1% had blood lead above 10 µg/dL

Estimates of Lead-Related Morbidity

- As indicated by hospitalisations, physician visits and calls to clinical toxicology specialists at the BC Drug and Poison Information Centre, severe health outcomes related to lead are relatively rare in BC.
- There is an average of 3 hospitalisations for lead per year (2001/02-2009/10)
- There is an average of 21 lead exposure calls to the BC Drug and Poison Information Centre per year (2003-2006)
- An average of 38 physician visits are attributed to lead per 100,000 population per fiscal year (2002/03-2006/07)

2. Introduction

Objective

To characterise exposure and morbidity related to lead in BC using routinely collected health service data.

Rationale

To date, there is little information about lead exposure and lead-related illness for residents of British Columbia. Results from the 2009-2011 Canadian Health Measures Survey (CHMS) illustrate that blood lead concentrations among Canadians over three years of age are, overall, much reduced from what they were roughly 30 years ago (Statistics Canada, 2014). The CHMS, a population-based survey designed to be representative of all of Canada rather than to show provincial or regional patterns, does reveal that blood lead concentrations for Canada are highest in older adults and among males. CHMS data supports the conclusion that only a small proportion of Canadians are currently exposed to lead at levels associated with clinical disease. However, while the level of lead in the bodies of Canadians is declining, concern for lead exposure continues based on recent evidence showing that learning, behaviour and cardio-vascular health are all affected by levels of lead which at one time were both typical and thought to be without harm.

Other than on the basis of selected surveys among residents of BC communities affected by metal mining and smelting, information is scarce about the levels of and influences on blood lead of residents of British Columbia. Specifically, are there communities or population groups where blood lead levels are higher than elsewhere? Are there sources of lead which should or could be identified to protect those persons from the health effects of lead? Here we assess data collected for clinical reasons in an attempt to answer those questions. Specifically, we asked:

1. Which BC residents are being tested for blood lead through the public health care system?
2. Looked at overall, what is the distribution of blood lead levels among individuals tested?
3. Looked at demographically and geographically, do the clinical results hint at people or places where blood lead levels are atypically high?
4. Who consults physicians for health issues around lead? How many such persons consult and where do they live?

BC is considering requiring laboratories to notify the province of biometric tests of certain metals, lead among them. The intent is to identify places and population groups subject to higher levels of exposure and to identify specific individuals whose exposure to lead should be investigated for their protection as well as for others not yet tested who may be exposed to the same source(s). A review of laboratory results now collected should inform the level of activity such investigation will require and the potential gains it may bring to population health.

Background

Blood lead concentrations in Canada have decreased substantially over the past several decades. In 1978/79 27% of Canadians aged 6-79 years had blood lead concentrations exceeding the current federal-provincial-territorial (F/P/T) blood lead intervention level of 10µg/dL (Statistics Canada, 2011). By 2009-2011, few Canadians had a blood lead concentration that exceeded the intervention level (Statistics Canada, 2014). In 2009-2011, blood lead levels were higher among adults than in children, and were highest among adults age 60-79 years (Statistics Canada, 2014). This finding is largely the

result of Canada's having reduced or eliminated lead in paint, gasoline, food cans, and plumbing products, thereby reducing new exposures. Less reduction was seen in the blood lead levels of older persons, whose blood lead is affected by lead stored in bones (itself a consequence of historic exposures) which is released into the blood over time.

Blood lead concentrations are an indication of the risk of disease. At concentrations lower than those which are clearly toxic, lead present in the blood may not result in disease. However, there is evidence of subtle health effects at less-than-manifestly toxic blood lead concentrations, particularly for children. Such effects include decreased intelligence and learning ability, as well as behaviour problems (Health Canada, 2013). Recent studies conducted among adults also indicate an association between blood lead concentrations below those associated with classical lead toxicity and adverse health outcomes including neurological decline, decreased renal function, hypertension, and mortality from stroke and myocardial infarction (Health Canada, 2013).

Young children and infants are most vulnerable to the health effects of lead exposure. It is accepted that in children, health effects occur at blood lead concentrations below 10µg/dL, the current federal-provincial-territorial (F/P/T) intervention level (Health Canada, 2013; Committee on Environmental Health, 2005). In addition, health effects resulting from low level lead exposure, while largely preventable, may be irreversible. (Committee on Environmental Health, 2005). In 2012, the US Centers for Disease Control and Prevention lowered its childhood blood lead level of concern from 10µg/dL to a normative level of 5µg/dL, the value characterising the top 2.5% of blood lead among US children age 1 to 5 years.

Young children and infants are most vulnerable to lead exposure because they:

1. Are more likely to exhibit mouthing and crawling behaviours which may result in increased exposure to lead from toys, costume jewellery, soil, dust or other items containing or contaminated with lead;
2. Have increased gastrointestinal absorption of lead; and
3. Are undergoing central nervous system development, which is a target for lead toxicity (Health Canada, 2013).

Children at higher risk for lead exposure include those who:

- Live in or frequently visit older homes or older buildings that are undergoing renovation; and
- Originate or have spent extended periods of time in a country where the level of lead exposure is higher than in Canada (Health Canada, 2013).

While lead exposure in Canada now affects a smaller proportion of people than in the past, some sub-populations may be exposed to lead in higher concentrations than others. Risk factors for lead exposure among people of all ages include, but are not limited to:

- Low income
- Living in areas contaminated by industrial emissions
- Living in areas or buildings where drinking water runs through lead pipes, pipes with lead soldering, or plumbing fixtures containing lead
- Living in homes built prior to the 1960s
- Having hobbies or occupations involving lead-based materials such as working with ceramics, stained glass, or weights used in hunting and scuba diving, or working in a smelter or foundry or living with someone who does

- Consuming lead contaminated food products (e.g. lead soldered food cans, game shot with lead pellet)
- Using folk remedies (e.g. ayurvedic medicine) or cosmetics (e.g. kohl) that contain lead; and
- Using ceramics made with a lead-based glaze or leaded crystal dishware for serving or storing food and drink (Health Canada, 2013; Statistics Canada, 2014).

As widespread sources of lead exposure have been reduced or eliminated in Canada, lead exposure has largely become an issue for specific populations whose access to lead or practices around substances containing lead are atypical. Therefore, examining indicators of exposure at finer geographic levels and time periods or in specific populations may reveal who is being exposed and how. In addition, combining exposure data with morbidity information will help quantify the burden of illness related to lead. Given that the health effects of low-level lead exposure among children (and to a degree among adults) are irreversible and preventable (Centers for Disease Control and Prevention (CDC), 2012), having a better understanding of the risk for lead exposure and lead-related morbidity in BC will allow public health authorities and other stakeholders to intervene where necessary.

3. Data Sources and Methods

Data Sources

Blood Lead Testing and Blood Lead Concentrations

Environmental Health Services at the British Columbia Centre for Disease Control obtained the results of blood lead concentration analyses conducted by BC laboratories during 2009 and 2010. These data do not include blood lead analyses performed as part of the Trail blood lead screening program, workplace hazard investigations, or for workers compensation. The data were from four sources; Vancouver Costal Health (Vancouver General Hospital Laboratory), the Provincial Health Services Authority (BC Children's and Women's Hospital Laboratory), BC Biomedical Laboratories, and Life Labs Medical Laboratory Services. The data sharing agreements for these data were for a "one-time" data exchange, and did not include provisions for sharing data with the BCCDC on an on-going basis.

Blood lead concentrations were measured by Inductively Coupled Plasma or Atomic Absorption Spectrophotometry, depending on the laboratory from which the data originated. Refer to the Technical Appendix for further details.

Morbidity

BC morbidity data were obtained from various administrative sources covering different periods in the recent past. Note that the timing intervals of the testing and morbidity data, while close, do not overlap.

Hospitalisations – A table of hospital separations between 2001/02 and 2009/10 with lead toxicity as the primary diagnosis was requested from the BC Ministry of Health Services.

Calls to Poison Control Centres – A count of lead exposure-related telephone calls to the BC Drug and Poison Information Centre (BC DPIC) per year between 2003 and 2006 was obtained from BC DPIC.

Physician Visits – A geographic and demographic breakdown of patients and services coded for lead that were billed to the provincial Medical Services Plan was requested for the period 2002/03 to 2006/07 from the BC Ministry of Heath Services.

Population Estimates

Population estimates were obtained from the British Columbia Statistics Agency's Sub-Provincial Population Projections (PEOPLE) web application (BC Stats).

Methods

Quantitative Analyses

Given that vulnerability to the health effects of lead exposure, as well as routes of exposure, varies by age (and sex among adults), blood lead test results and testing rates have been presented for five age and sex categories (demographic groups):

- Young children (0 to 5 years of age);
- Older children (6 to 18 years of age);
- Females of childbearing age (19 to 49 years);
- Females age 50 years or more; and
- Males 19 years of age or more.

Females of childbearing age have been included as a demographic group as lead can be passed from mother to child during pregnancy. However, we do not know the pregnancy status of women tested.

Some individuals in the data sets obtained had their blood lead concentrations measured more than once. If an individual had more than one test result, the test with the maximum blood lead concentration was retained. In cases where an individual had multiple test results with the same maximum value, the earliest test result with the highest blood lead concentration was retained.

Blood lead testing rates are presented in this report as the average number of individuals who have had their blood lead tested per year per 10,000 population in 2009-2010. The distribution of blood lead concentrations are presented as minimum and maximum values and 25^{th}, 50^{th}, 75^{th}, and 95^{th} percentiles. Also included are counts and proportions of individuals with blood lead concentrations <5, 5.0-9.9, 10-14.9, 15-44.9, and >45 µg/dL in the case of children and females age 19 to 49 years, and <15, 15-44.8, and >45 µg/dL in the case of females age 50 years or more and males age 19 years or more. The rate of physician consultations was calculated by dividing the number of physician consultations for lead between the 2002/03 and 2006/07 fiscal years by the average population size during the 2002, 2003, 2004, 2005, 2006, and 2007 calendar years.

Cleaning and analyses of laboratory data was done in the statistical program R (R Development Core Team, 2008). Maps were produced using the ESRI package (Environmental Systems Resource Institute), 2009. See Additional Notes section in the appendix for more detail regarding analysis and data cleaning.

Geospatial Analyses

Choropleth maps are used to illustrate the geospatial distribution of blood lead testing rates in health authorities across the province. The number of individuals who have had their blood lead concentrations measured per 10,000 population is mapped for each demographic group across health authorities. The number of individuals with blood lead concentrations that are <5, 5.0-9.9, 10-14.9, 15-44.9, and >45 µg/dL in the case of children and females age 19 to 49 years, or <15, 15-44.9, and >45 µg/dL in the case of females age 50 years or more and males age 19 years or more was mapped as well.

Estimating Numbers of Persons Subject to Mandatory Reporting of Blood Lead Concentration by Test Threshold

The number and proportion of persons tested whose potential exposures would be subject to investigation based on various potential investigation thresholds (5µg/dL, 10 µg/dL, 15µg/dL, 20µg/dL, and the 95th percentile of blood lead concentrations from a nationally representative population) was estimated by applying each threshold to blood lead test results in British Columbia. However, exact age is known for only one-quarter to one-half of individuals tested in each 1-5, 6-18, 19-49, and 50+ age groups.

Data Limitations

Testing for Blood Lead

Multiple testing could only be identified in cases where testing was done at the same laboratory. Therefore the data set may include occasional multiple tests for individuals who had their blood lead concentration tested at two or more laboratories. In addition, blood lead tests from the Trail Area Health & Environment Program and WorkSafe BC are not included. This exclusion could potentially result in an underestimation of blood lead testing rates, as well as blood lead concentrations, particularly in the Interior Health Authority.

Blood Lead Concentrations

The majority of blood lead concentrations were found to be below a particular laboratory's lowest level reported/limit of detection, which results in an inability to utilise measures commonly used to describe blood lead concentrations, such as geometric mean (Table A-1). We also have little information at a geographic level finer than Health Authority.

Morbidity

Currently, we do not have specific information on blood lead concentrations for individuals admitted to hospital or who consulted a physician for lead. Unlike hospital discharges and calls to BC DPIC which can capture multiple diagnostic codes or substances, data pertaining to physician consultations incorporate only one diagnosis code per patient visit and therefore may underestimate lead exposure as the basis for consultation.

Estimating Numbers of Persons Subject to Mandatory Reporting of Blood Lead Concentration by Test Threshold

The exact age for each individual tested is not complete in the blood lead testing data received from the four BC laboratories which analyse blood lead. Therefore the numbers of individuals whose potential exposures would be subject to investigation based on various potential test thresholds in age categories finer than 0-5 years of age, 6-18 years of age, 19-49 years of age, or 50 years of age or more are underestimates. Individuals for whom exact age is known are from two of four laboratory sources and may not be representative of all individuals tested.

4. Laboratory Testing

Total Population Tested for Blood Lead

During 2009 and 2010, 6,779 blood lead concentration analyses were conducted in BC. Ninety-seven percent of tests were recorded as having been billed to the provincial health insurance program

(Medical Services Plan, or MSP), while 1% were billed to federal sources such as the Public Service Health Care Plan (health care coverage for the Royal Canadian Mounted Police and other designated groups) or the Interim Federal Health Program (coverage for refugees) for example. Billing information for 2% of tests was unknown. The 6,779 blood tests were conducted for 5,475 individuals.

Overall, 12 individuals per 10,000 population had their blood lead concentrations measured during 2009 and 2010 (average of 6 per 10,000 per year). Blood lead concentrations were tested more frequently among children under five years of age than for any other demographic group (average of 9.5/10,000 per year), followed by males over 19, children between 6 and 18, females over 50, and females 19 to 49 (Table 3.1). The highest frequency of blood lead testing occurred in the Northern Health Authority (6.5/10,000 per year), followed by the Fraser, Vancouver Coastal, Vancouver Island, and Interior Health Authorities (Table 3.1).

Young Children

During 2009-2010, the highest level of blood lead testing for children 0-5 occurred in the Fraser Health Authority (average of 11.5/ 10,000 per year), followed by the Vancouver Coastal, Vancouver Island, Northern, and Interior Health Authorities (Figure 3.1, Table 3.1).

Older Children

During 2009 and 2010, the highest level of blood lead testing for children 6-18 occurred in the Vancouver Coastal Health Authority (average of 7.5/10,000 per year), followed by the Northern, Vancouver Island, Fraser and Interior Health Authorities.

Females of Childbearing Age

The highest level of blood lead testing for females of child-bearing age (19-49 years) was in the Vancouver Coastal Health Authority (average of 3.5/10,000 per year), followed by the Interior, Northern, Fraser, and Vancouver Island Health Authorities.

Older Females

Females over the age of 50 years were most frequently tested in the Vancouver Coastal Health Authority (average of 5.5/10,000 per year), followed by the Northern, Vancouver Island, Fraser, and Interior Health Authorities.

Adult Males

Similarly, blood lead tests for males over the age of 19 were most frequently performed in the Northern Health Authority (average of 9/10,000 per year) followed by the Fraser, Interior, Vancouver Island, and Vancouver Coastal Health Authorities.

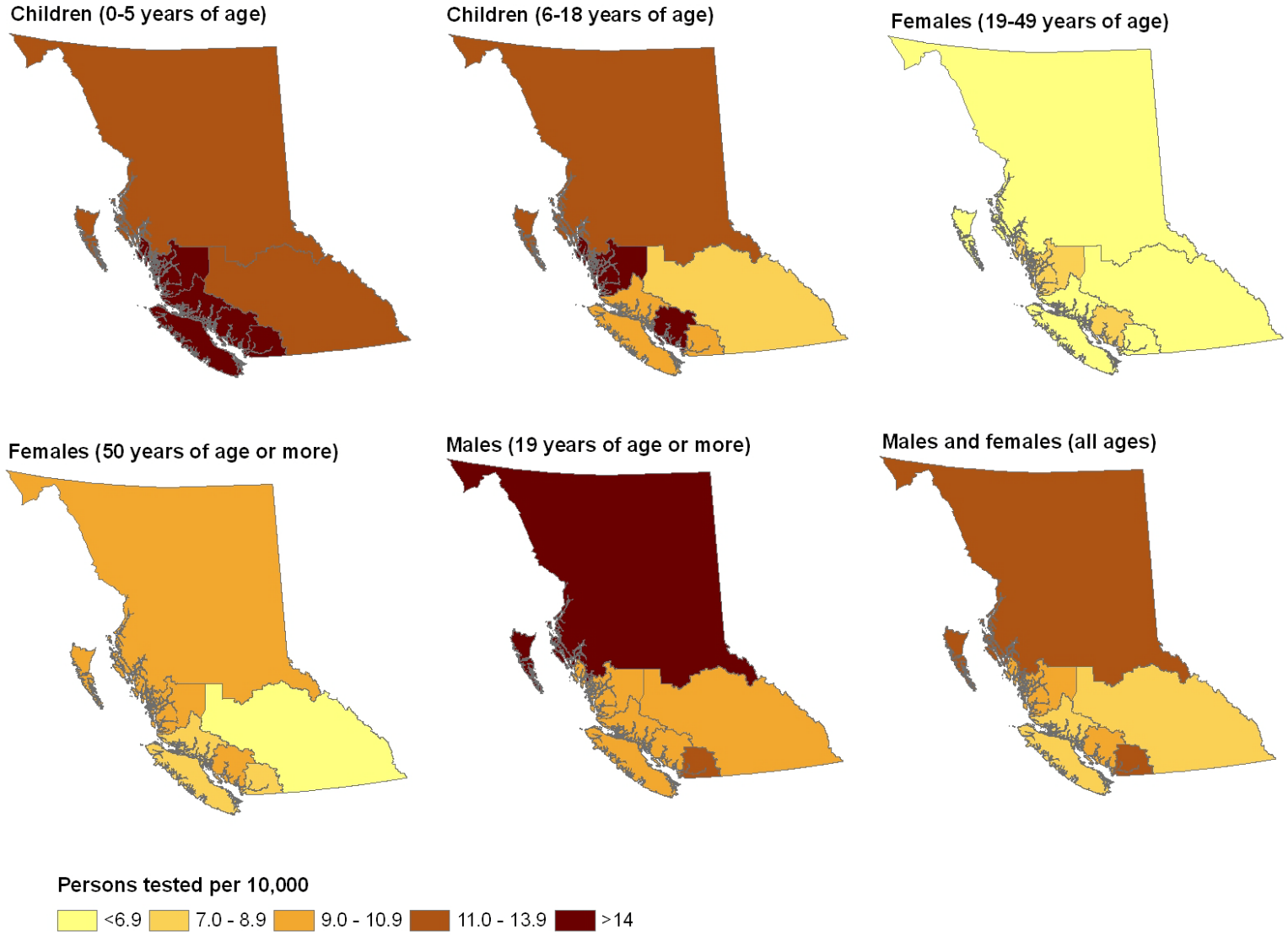
Table 4.1: Blood lead testing counts and proportions, by age, sex, and Health Authority, 2009-2010, over the two years

Health Authority	Children 0-5 years		Children 6-18 years		Females 19-49 years		Females 50+ years		Males 19+ years		Total	
	n	Per 10,000	n	Per 10,000	n	Per 10,000	n	Per 10,000	n	Per 10,000	n	Per 10,000
Fraser Health	242	23.1	383	9.6	188	5.3	197	7.3	733	12	1743	11
Interior Health	46	11.2	77	7.4	98	6.9	110	6.9	313	10.8	644	8.8
Northern Health	25	11.7	65	13.0	37	6.1	40	9.1	202	18.3	370	12.9
Vancouver Coastal Health	115	19.5	212	15.3	205	7.3	206	10.6	418	9.23	1156	10.3
Vancouver Island Health	56	14.3	97	9.7	79	5.2	127	7.6	309	10.4	668	8.9
Total	512	19.3	946	14.7	685	6.9	715	8.6	2615	14.9	5,475	12.2

Note:

- There were 3 adults for whom sex was unknown
- There were 894 individuals for whom Health Authority was unknown

Figure 4.1: Blood lead tests/10,000, by age, sex, and Health Authority, 2009-2010 together



*Age category is known for 100% of individuals tested

5. Blood Lead Concentrations

Total Population Tested for Blood Lead

Overall, 291 (5%) of the 5,475 individuals tested were found to have blood lead concentrations above the current F/P/T blood lead intervention level of 10µg/dL. The maximum blood lead concentration and 95th percentile were 61.1 and 10.9µg/dL respectively. Individuals with blood lead concentrations above 10µg/dL were most commonly identified in the Interior Health Authority, where 11% (n=69) of those tested had a blood lead concentration above the F-P-T intervention level. Individuals with blood lead concentrations above 10µg/dL were least commonly identified in the Northern Health Authority where less than 1% had blood lead concentrations above this level. In the Fraser, Vancouver Coastal, and Vancouver Island health authorities, the proportion of individuals tested who had a blood lead concentration above 10µg/dL was 4% or less.

Young Children

512 children 0-5 years of age had their blood lead concentration measured during 2009 and 2010. The maximum blood lead concentration and 95th percentile were 34 and 3.9 µg/dL respectively. 491 (96%) had blood lead concentrations below 5µg/dL (Table 4.1). 21 young children (4%) had blood lead concentrations above 5 µg/dL; 8 (1.6%) had blood lead concentrations between 5 and 10 µg/dL, 11 (2.1%) had blood lead concentrations between 10 and 15 µg/dL, and two had blood lead concentrations between 15 and 45 µg/dL (Table 4.2).

Children 0-5 years of age with blood lead concentrations above 5 µg/dL were most commonly identified in the Interior Health Authority, where 11 (24%) tested above 5µg/dL. Four (9%) had blood lead concentrations between 5 and 10 µg/dL, 6 (13%) had blood lead concentrations between 10 and 15 µg/dL, and less than 1% had blood lead concentrations between 15 and 45 µg/dL (Figure 4.1). Young children with blood lead concentrations above 5 µg/dL were least commonly identified in the Northern Health Authority where in this group, all blood lead concentrations were below 5µg/dL. In the Fraser, Vancouver Coastal, and Vancouver Island health authorities, the proportion of young children tested that had blood lead concentrations above 5µg/dL was 2% or less.

Older Children

Older children had the lowest blood lead concentrations of all demographic groups. 946 children between 6 and 18 years of age had their blood lead concentrations measured during 2009 and 2010. The maximum blood lead concentration and 95th percentile among older children were 11.6 and 2.3 µg/dL respectively. 939 (99.2%) had blood lead concentrations below 5µg/dL (Table 4.1). Seven children of 6-18 years (less than 1%) had blood lead concentrations above 5 µg/dL (Table 4.2).

Children ages 6-18 with blood lead concentrations above 5 µg/dL were most commonly identified in the Interior Health Authority, where 2 (2.6%) had blood lead concentrations above 5µg/dL (Figure 4.1). Older children with blood lead concentrations above 5 µg/dL were least commonly identified in the Northern, Vancouver Island, and Vancouver Coastal Health Authorities where all blood lead concentrations in this demographic group were below 5µg/dL. One percent of children 6-18 tested in the Fraser Health Authority had blood lead concentrations above 5µg/dL.

Females of Childbearing Age

685 females between 19 and 49 years had their blood lead measured during 2009 and 2010. The maximum blood lead concentration and 95th percentile among females of childbearing age were 35.8 and 4.3 µg/dL respectively (Table 4.1). 654 females of childbearing age (95%) had blood lead concentrations below 5µg/dL. 31 females had blood lead concentrations above that; 18 (2.6%) had blood lead concentrations between 5 and 10 µg/dL, 6 (0.9%) had blood lead concentrations between 10 and 15 µg/dL, and 7 (1.0%) had blood lead concentrations between 15 and 45 µg/dL (Table 4.2).

Females age 19 to 49 years with blood lead concentrations above 5 µg/dL were most commonly identified in the Interior Health Authority where 10 (10%) had blood lead concentrations above 5µg/dL. Of these females, 4 (4.1%) had blood lead concentrations between 5 and 10 µg/dL, 2 (2.0%) had blood lead concentrations between 10 and 15 µg/dL, and 4 (4.1%) had blood lead concentrations between 15 and 45 µg/dL (Figure 4.1). Females 19 to 49 years of age with blood lead concentrations above 5 µg/dL were least commonly identified in the Northern Health Authority where no blood lead concentration in this demographic group was found to be above 5µg/dL. In the Fraser, Vancouver Coastal, and Vancouver Island Health Authorities, the proportion of females age 19 to 49 years tested that had blood lead concentrations above 5µg/dL was 5% or less.

Older Females

715 females over the age of 50 years had a blood lead tested during 2009 and 2010. The maximum blood lead concentration and 95th percentile were 38.3 and 4.2 µg/dL respectively (Table 4.1). Nearly 100% of females over the age of 50 years had blood lead concentrations below 15 µg/dL (Figure 4.2).

Adult Males

Males over the age of 19 years were more likely to have elevated blood lead concentrations as compared to other demographic groups. 2,615 males 19 years of age or older had their blood lead measured in 2009 and 2010. The maximum blood lead concentration and 95th percentile were 61.07 and 17.59 µg/dL respectively (Table 4.1). 2457 (94%) had blood lead concentrations below 15 µg/dL (Table 4.3). 150 had blood lead concentrations between 15 and 45µg/dL, while 8 (less than 1%) had blood lead concentrations that exceeded 45µg/dL.

Adult males with blood lead concentrations above 15 µg/dL (35 or 11%) were most commonly identified in the Interior Health Authority; 30 (9.6%) had blood lead concentrations between 15 and 45 µg/dL, while 5 (1.6%) had blood lead concentrations exceeding 45 µg/dL (Figure 4.2). Adult males with blood lead concentrations above 15 µg/dL were least commonly identified in the Northern Health Authority. In the Fraser, Vancouver Coastal, and Vancouver Island health authorities, the proportion of adult males tested that had blood lead concentrations above 15 µg/dL was 5% or less.

Table 5.1: Minimum, maximum, 25th, 50th, 75th, and 95th percentiles for blood lead concentrations (µg/dL), by age and sex, 2009-2010

Demographic Group	Children 0-5 years	Children 6-18 years	Females 19-49 years	Females 50+ years	Males 19+ years
Minimum	*<2.07 **	*<2.07 **	*<2.07 **	*<2.07 **	*<2.07 **
25th Percentile	*<2.07 **	*<2.07 **	*<2.07 **	*<2.07 **	*<2.07 **
50th Percentile	*<2.07 **	*<2.07 **	*<2.07 **	*<2.07 **	*<2.07 **
75th Percentile	*<2.07 **	*<2.07 **	*<2.07 **	2.5	3.5
95th Percentile	3.9	2.3	4.3	4.1	17.6
Maximum	34.2	11.6	35.8	38.3	61.1

**Below 2.07 µg/dL (see table A-1 in the technical appendix for more detail about limits of detection).*

Table 5.2: Blood lead concentrations in BC, children and females of childbearing age, 2009-2010

Blood Lead Concentration	Children 0-5 years		Children 6-18 years		Females 19-49 years	
	n	%	n	%	n	%
<5µg/dL	491	95.9	939	99.2	654	95.5
5 µg/dL - 10 µg/dL	8	1.6	4	0.4	18	2.6
10 µg/dL - 15 µg/dL	11	2.1	3	0.3	6	0.9
15 µg/dL - 45 µg/dL	2	0.4	0	0	7	1.0
>45 µg/dL	0	0	0	0	0	0.0
All	512	100	946	100	685	100

Table 5.3: Blood lead concentrations in BC, older females and adult males, 2009-2010

Blood Lead Concentration	Females 50 Years or More		Males 19 Years or More	
	n	%	n	%
<15µg/dL	714	99.9	2457	94.0
15 µg/dL - 45 µg/dL	1	0.1	150	5.7
>45 µg/dL	0	0.0	8	0.3
Total	715	100	2615	100

Figure 5.1: Blood lead concentrations among children 0-5, and 6-18 years of age and females 19-49 years of age by Health Authority, 2009-2010

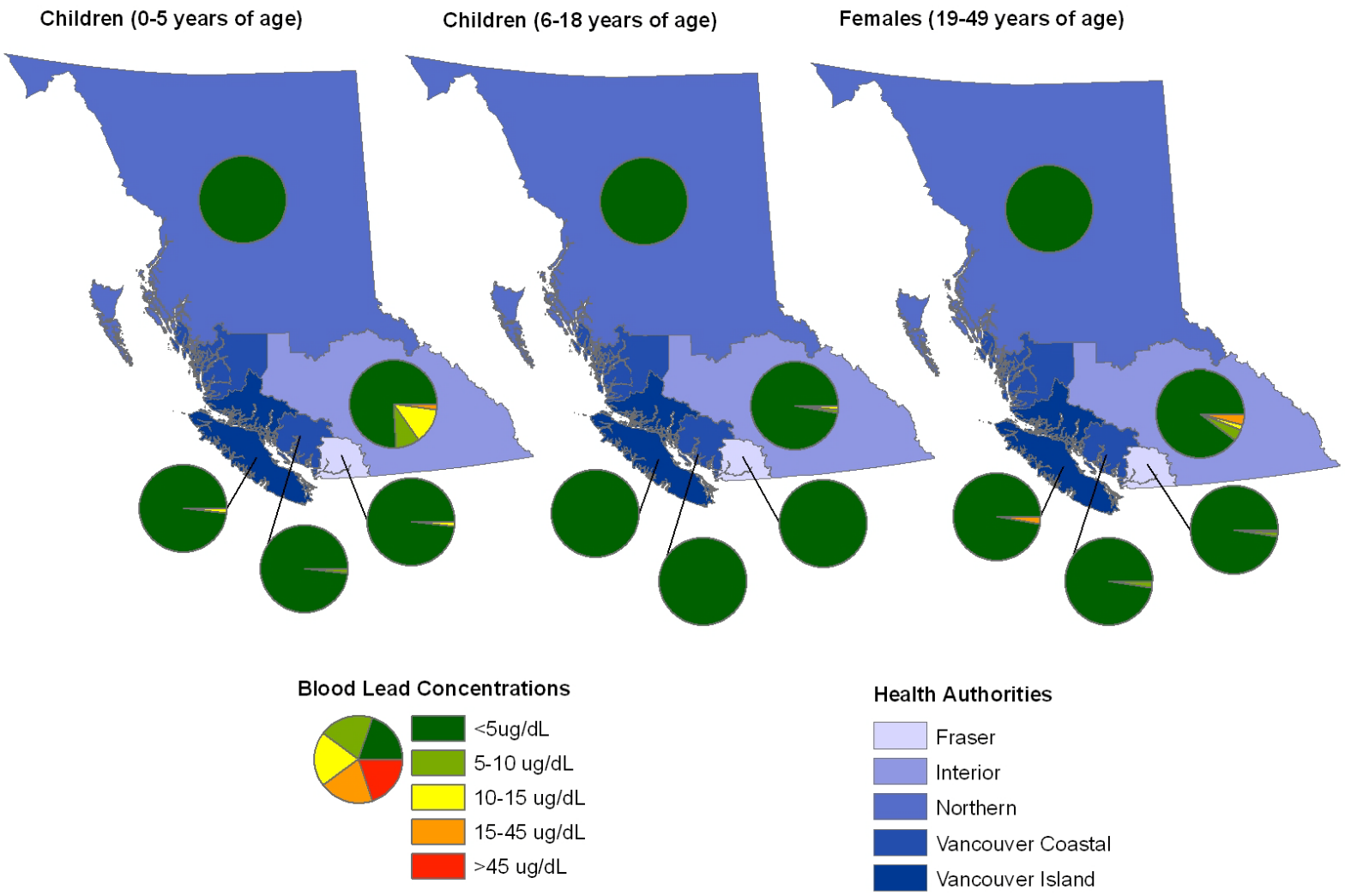
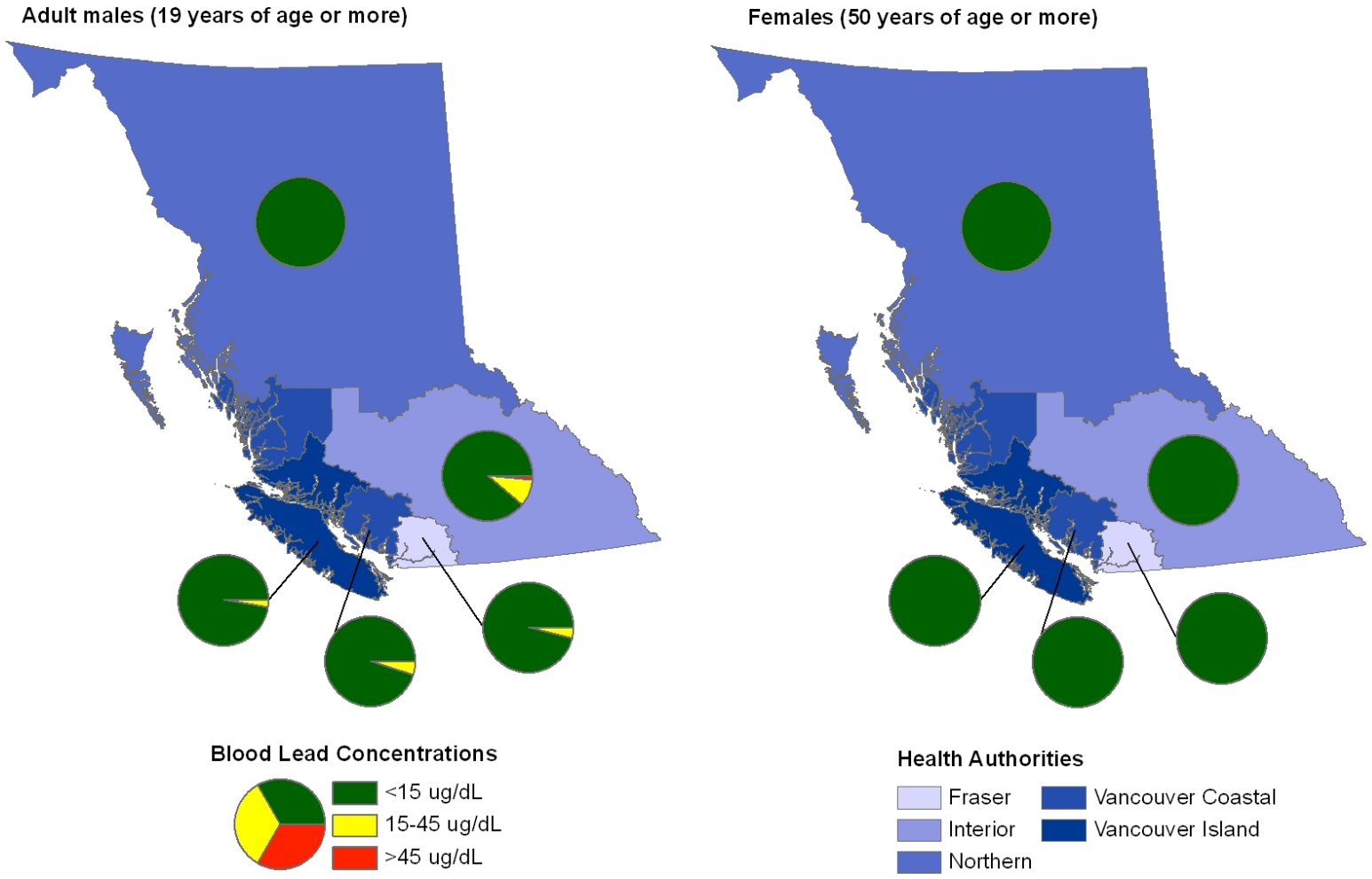


Figure 5.2: Blood lead concentrations among females age 50 years or more and males age 19 years or more by Health Authority, 2009-2010



6. Lead-Related Morbidity

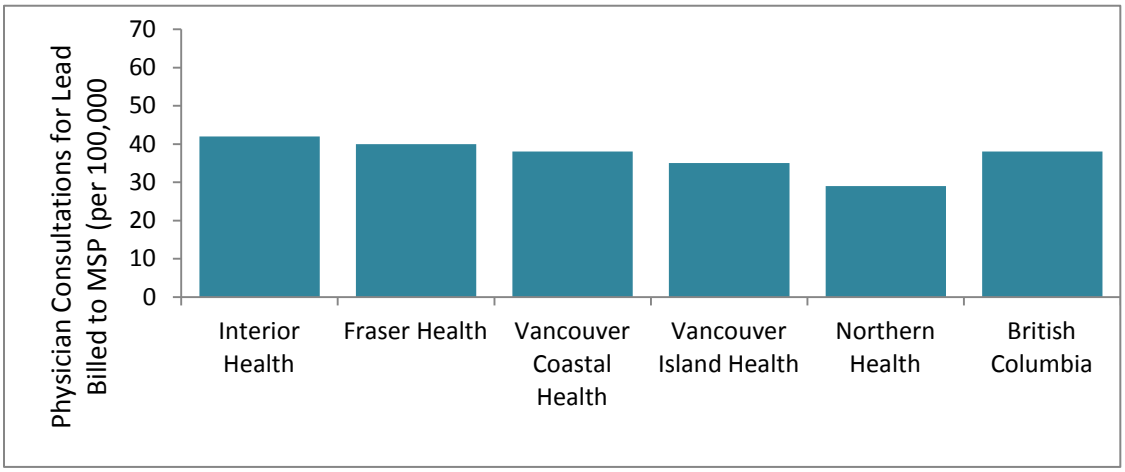
Hospitalisations, physician consultations, and calls to the provincial Drug and Poison Information Centre for lead occur infrequently in BC. Hospitalisation data indicate that between 2001/02 and 2009/10 there was an average of 3 hospitalisations per year with a primary diagnosis of lead toxicity. Between 2002/03 and 2006/07 there was an average of 1,612 physician consultations per fiscal year where lead was noted (38 physician consultations for lead/ 100,000 in BC per fiscal year). Thirty-two percent (n=2,602, or 502 per year) of consultations were for children age 16 years or less. The rate of physician consultations was similar in each health authority, with the exception of Northern Health which had a rate of 29 visits per 100,000 population (Figure 5.1).

In 2012 there were approximately 30 exposure calls to the BC Drug and Poison Information Centre(DPIC) pertaining to lead. During 2003-2006, there was an average of 21 calls to DPIC per year.

While these data are not from the same time periods as the blood lead testing data, they do indicate that the burden of severe illness for lead toxicity is low in BC. However, as they would not appear in physician billing codes or hospitalisation records, the sub-clinical health effects of low level lead exposure among children are not represented in these data.

We were unable to access records of the blood lead concentrations of individuals captured in DPIC, hospitalisation, or physician consultation data. As these individuals might be expected to have particularly high blood lead levels, our estimate of the distribution of blood lead levels in the BC population as indicated by clinical test results may underestimate the high end. Nor are we currently able to follow individuals with elevated blood lead concentrations identified in this report to characterise burden on the health care system due to lead exposure.

Figure 6.1: Five-year average of the number of physician consultations where lead was noted billed to MSP per 100,000 population, by Health Authority, 2002/03-2006/07



7. Estimating Public Health Workload as a Result of Mandatory Reporting

BC is considering mandating the reporting of analyses of blood lead by laboratories operating in the province as part of the notifiable disease provisions of the provincial *Public Health Act*. As yet, Quebec is the only Canadian province to require notification of blood lead tests.

Mandatory notification would serve three main purposes:

1. Better understanding of the circumstances (by which physicians, for which patients, under which circumstances) that blood lead analyses are ordered;
2. The ability to identify patterns in person, time and place which lead some BC residents to have atypically high levels of blood lead; and
3. Identification of individuals who should be assessed to identify the source of their exposure and to allow for blood lead testing and exposure management in others connected to them who may also have been atypically exposed.

In order to estimate the workload to public health authorities under point 3, we posited a series of potential intervention thresholds that would trigger public health investigation. These include the new US children's' blood lead action level, the current F/P/T intervention level, and the 95th percentile by age group from the Canadian Health Services Measures Survey.

Table 6.1 shows the number and proportion of persons tested in British Columbia in 2009 and 2010 who would have been followed up by public health authorities at target blood lead test concentrations including 5, 10, 15, 20 µg/dL, and the 95th percentile blood lead level of the Canadian Health Measures Survey by age group.

The current F/P/T blood lead intervention level is 10µg/dL.

- Over a two year period, 9 (2.5%) of children under the age of five years, 3 (under 1%) of children age 6 to 18 years, 171 (7.9%) adults age 19 to 49 years (mostly adult males), and 104 (5.6%) of adults age 50 years or more tested in BC had a blood lead concentration above the F/P/T blood lead intervention level.

The US Centres for Disease Control and Prevention presently uses a childhood blood lead level of concern of 5µg/dL.

- 4.1% (n=21) of children under the age of five and 4.5% (n=31) of females of childbearing age tested in BC exceed the US CDC threshold.
- The 95th percentile blood lead is less than 5µg/dL across Canadian demographic groups. The 95th percentile ranges from 1.6 µg/dL for children age 6 to 11 years of age to 4.2µg/dL among adults over the age of 50 years. In some cases, this is lower than the laboratory limits of detection in BC (see table A-1 in the technical appendix for more information).
- The proportion of individuals tested in BC whose blood lead concentration exceeds the 95th percentile Canadian population level for their age group ranges from 4.7% (n=24) among children less than 5 years of age to 35.5% (n=523) among males between 19 and 49 years.
- Individuals can be tested more than once. If considering tests as opposed to individuals, the number of tests that exceed a particular threshold will likely be higher.

Table 7.1: Estimates of the number and proportion of persons tested who would potentially be subject to mandatory reporting of blood lead concentration by test threshold, BC, 2009-2010

Age Group	Individuals Tested	Test Thresholds									
		≥5µg/dL		≥10 µg/dL		≥15 µg/dL		95th Percentile			
		n	%	n	%	n	%	Source	µg/dL	n	%
1-5†	512	21	4.1	13	2.5	--	--	St. John's, Bell (2010); Montreal, INSPQ (2009-2010) [1]	3	42	8.2
								NHANES; CDC (2007-2008) [2]	4.10	24	4.7
6-18†	946	7	0.7	--	--	--	--	*CHMS, Statistics Canada (2009-2011)*[3]	1.6	76	8.0
3-5‡	*300*	*14*	*4.7*	*8*	*2.7*	--	--	*CHMS, Statistics Canada (2009-2011)*[3]	2.1	*47*	*15.7*
6-11‡	*293*	--	--	--	--	--	--	*CHMS, Statistics Canada (2009-2011)*[3]	*1.7*	*24*	*8.2*
*12-18‡**	*131*	--	--	--	--	--	--	*CHMS, Statistics Canada (2009-2011)*[3]	*1.6*	*9*	*6.7*
Both Males and Females		≥10 µg/dL		≥15 µg/dL		≥20 µg/dL		95th Percentile			
		n	%	n	%	n	%	Source	µg/dL	n	%
19-49†	2160	171	7.9	104	4.8	67	3.1	*CHMS, Statistics Canada (2009-2011)*[3]	2.2	651	30.1
50+†	1857	104	5.6	62	3.3	43	2.3	*CHMS, Statistics Canada (2009-2011)*[3]	4.2	272	14.6
*19-39‡**	*265*	*19*	*7.2*	*14*	*5.3*	*11*	*4.2*	*CHMS, Statistics Canada (2009-2011)*[3]	*2.2*	*60*	*22.7*
40-59‡	*456*	*35*	*7.7*	*22*	*4.8*	*17*	*3.7*	*CHMS, Statistics Canada (2009-2011)*[3]	*3.2*	*101*	*22.1*
60-79‡	*221*	*9*	*4.0*	*5*	*2.3*	--	--	*CHMS, Statistics Canada (2009-2011)*[3]	*4.2*	*32*	*14.5*
Males											
19-49‡	1474	158	10.7	97	6.6	61	4.1	*CHMS, Statistics Canada (2009-2011)*[3]	2.4	523	35.5
*19-39†**	*180*	*17*	*9.4*	*12*	*6.7*	*9*	*5.0*	*CHMS, Statistics Canada (2009-2011)*[3]	*2.4*	*48*	*26.7*
Females		≥5µg/dL		≥10 µg/dL		≥15 µg/dL		95th Percentile			
		n	%	n	%	n	%	Source	µg/dL	n	%
19-49†	685	31	4.5	13	1.9	7	1.0	*CHMS, Statistics Canada (2009-2011)*[3]	1.8	114	16.7
*19-39‡**	*84*	--	--	--	--	--	--	*CHMS, Statistics Canada (2009-2011)*[3]	*1.8*	*10*	*11.9*

†Data from all four laboratory sources (Lifelabs, BC Biomed, Vancouver General Hospital, BC Children's and Women's Hospital)
‡Partial data from two laboratory sources (Vancouver General Hospital, BC Children's and Women's Hospital). Exact age is known for 22% to 70% of individuals tested in each 1-5, 6-18, 19-49, and 50+ age groups. Exact age used to assign individuals to CHMS age groups.
* CHMS age group is slightly different, altered in this case to be consistent with sub-setting BC data.
-- Indicates where data are suppressed in order to prevent residual disclosure

[1] (Health Canada, 2013)
[2] (Centers for Disease Control and Prevention (CDC), 2013)
[3] (Statistics Canada, 2013)

8. Discussion

This first surveillance report on exposure to lead among BC residents is timely, given ongoing consideration that blood lead test results be made reportable under the *Public Health Act* by laboratories operating in BC.

The analytic results presented here are complementary to, but do not take the place of population lead surveys, in particular the Canadian Health Measures Survey (CHMS). The blood lead analyses presented here were collected in clinical settings where, presumably, lead would have been a concern in order for the patient to be tested.

We found that the overall distribution of BC blood lead test concentrations is low as compared to what would have been found 20-30 years ago. However, there do appear to be some groups and geographic areas at higher risk for exposure.

Five percent of BC residents tested were found to have blood lead concentrations above 10µg/dL, the current federal-provincial-territorial (F/P/T) blood lead intervention level. This is higher than what has been observed in the Canadian Health Measures Survey where less than 1% of the population tested had a blood lead concentration above 10µg/dL (Statistics Canada, 2014). The greatest divergence between CHMS survey data and the collection of clinical laboratory results presented here is for adult males in Interior BC. Interestingly, for children of 6-18 in BC overall, the clinical results do not differ markedly from CHMS, while results for children under the age of 5 appear to be slightly elevated in BC relative to CHMS but similar to survey results reported for St. John's, NL, Montreal, QC, and the United States (Health Canada, 2013; Statistics Canada, 2013; Centers for Disease Control and Prevention (CDC), 2013).

It is unknown how differing testing practices across the province impact the distribution of analytic results. We found a discrepancy between testing rates and blood lead concentrations. Notably, individuals with elevated blood lead concentrations were most likely to be identified in the Interior Health Authority and least likely to be identified in the Northern Health Authority. Conversely, Interior Health had some of the lowest blood lead testing rates while Northern Health had some of the highest. However, we do not know how many people in the Interior Health Authority are tested via WorkSafe BC or through the Trail Area Health and Environment (THE) Program.

Given that the data presented in this report offer few details pertaining to the characteristics of individuals exposed, hospitalised, or who have consulted a physician for lead, a more detailed examination is warranted in order to identify factors influencing lead exposure in British Columbia. Having a solid understanding of factors related to lead exposure in British Columbia will allow for public health authorities to intervene where necessary and inform environmental and health promotion-based interventions to lower lead exposure.

Future activities for lead surveillance activities in British Columbia should include:

1. Requests for testing data from all four laboratories from 2005-2008 and after 2010 to assess trends over time;
2. Examination of blood lead concentrations at a finer level of geography, particularly within the Interior Health Authority;

3. Incorporation of environmental monitoring data to identify areas where populations may be more likely to be exposed to lead in the environment, and comparison of these environmental measures with blood lead results;
4. Incorporation of socio-demographic data to identify potential vulnerabilities for exposure;
5. Explore linkages with other data sources, such as establishing an administrative cohort using health services utilisation data, in cases where blood lead concentrations are observed to be higher than acceptable. Such linkages would allow us to further examine the burden of lead exposure on health care service utilisation in BC;
6. Comparison of blood lead test results and population testing rates between billing sources, for example comparing blood lead test results billed to the provincial health insurance program (Medical Services Plan or MSP) with those billed to WorkSafe BC or testing performed by targeted screening programs such as the Trail Health and Environment (THE) Program;
7. Comparison with BC Drug and Poison Information Centre data. This will allow for an examination of blood lead concentrations in specific areas of British Columbia from which lead exposure calls to BC DPIC originate;
8. This review of results from all BC laboratories analysing blood lead, suggests that at a threshold for investigation of 10µg/dL, an average of six children under the age of 5 years would be followed-up annually in order to assess the likely sources of their exposure. At a threshold of 15µg/dL, 83 adults over 18 years of age would be followed-up while at 20µg/dL, 55 adults over 18 would be followed-up, with most of these elevated blood lead levels presumably being related to exposure at work.

9. Technical Appendix

Additional Notes

Data Cleaning

- All blood lead results obtained were in SI units (µmol/L). As blood lead concentrations are not commonly reported in µmol/L, values were converted to µg/dL[4] prior to analysing the data;
- Data pertaining to individuals from out-of-province and a lead screening program in Trail, BC are not included. The data were requested in this manner so that the influence of targeted screening on blood lead concentration and blood lead testing rates for the Interior Health Authority and the province of British Columbia overall would be limited;
- If an individual has more than one test result, the test resulting in the maximum blood lead concentration was kept in the 2005-2010 dataset;
- If an individual has multiple test results with the same maximum value, the earliest test result with the highest blood lead concentration was kept in the dataset;
- The highest limit of detection across all laboratory sources is 0.10µmol/L (2.07 µg/dL). In order to be consistent in analyses and in compiling blood lead levels all four laboratories, all blood lead values below 0.10µmol/L (2.07 µg/dL) were converted to 0.05µmol/L (1.03µg/dL) or one-half the highest limit of detection;

[4] *1 µg/dL = 0.048 µmol/L*

- The proportion of blood lead tests with a concentration less than 2.07 µg/dL is above 40% for all four laboratories (Table A-1); and
- Blood lead testing rates were computed by dividing the number of individuals who had their blood lead concentrations measured between 2009-2010 by the average of the population in 2009 and 2010.

Billing Information

- 97% (n=6798) of tests were known to be billed to the provincial health insurance plan (Medical Services Plan, or MSP)
- Billing information for 2% (n=144) of tests were unknown
- 1% (n=55) of tests were known to be billed to the Public Service Health Care Plan (coverage for the Royal Canadian Mounted Police) or the Interim Federal Health Program (coverage for refugees)

Estimating Numbers of Persons Subject to Mandatory Reporting of Blood Lead Concentration by Test Threshold

- Exact age is known for 70% (n=357) of children less than 5 years of age
- Exact age is known for 45% (n=424) of children 6-18 years of age
- Exact age is known for 23% (n=502) of adults 19-49 years of age
- Exact age is known for 26% (n=487) of adults 50 years of age or more
- Exact age is known for 24% (n=350) of adult males 19-49 years of age
- Exact age is known for 22% (n=151) of adult females 19-49 years of age
- There is one individual where gender is unknown in the 19-49 age group

Table A-1: Sample analysis methods, limits of detection, and lowest level reported for each laboratory for blood lead tests in British Columbia, 2009-2010.

Laboratory	Method	Units of Measurement	Limit of Detection	Recorded as	Lowest Level Reported[5] µmol/L (µg/dL)	Handling	Percentage of results below 0.10 µmol/L (2.07 µg/dL)
BC Biomedical Laboratories	Inductively Coupled Plasma	µmol/L	0.10	"<0.10"	"<0.10"/0.10 (2.07)	Values less than 0.10 µmol/L were converted to 0.05 µmol/L	67.1%
BC Children's and Women's Hospital	Inductively Coupled Plasma	µmol/L	0.00049 (0.49 nmol/L)	N/A	0.01 (0.207)	Values less than 0.10 µmol/L were converted to 0.05 µmol/L	80.24%
Life Labs Medical Laboratory Services	Inductively Coupled Plasma	µmol/L	0.009	"<0.05"	"<0.05"/0.05 (1.03)	Values less than 0.10 µmol/L were converted to 0.05 µmol/L	59.8%
Vancouver General Hospital	Atomic Absorption Spectrophotometry	µmol/L	0.05	"<0.05"	"<0.05"/0.05 (1.03)	Values less than 0.10 µmol/L were converted to 0.05 µmol/L	67.6%

[5] *Lowest level reported in the raw data (2009-2010)*

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