Health Consultation

Exposure Investigation

Blood Lead and Urine Arsenic Levels

ANACONDA CO. SMELTER
ANACONDA, MONTANA

October 17, 2019

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a health consultation may lead to specific actions such as restricting use of or replacing water supplies, intensifying environmental sampling, restricting site access, or removing the contaminated material.

In addition, health consultations may recommend additional public health actions such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes, conducting biological indicators of exposure studies to assess exposure, or providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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Prepared by the
U.S. Department of Health and Human Services
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Abbreviations and Acronyms

AAP	American Academy of Pediatrics
ADLC HC	Anaconda Deer Lodge County Health Department
AICc	2^{nd} order Akaike Information Criterion
ARCO	Atlantic Richfield Corporation
ATSDR	Agency for Toxic Substances and Disease Registry
BLL	Blood Lead Level
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
Cr	Creatinine
CSEM	Case Studies in Environmental Medicine
DHHS	Department of Health and Human Services
DLS	Division of Laboratory Sciences
DMA	Dimethylarsinic acid
EI	Exposure Investigation
EPA	(U.S.) Environmental Protection Agency
HD	Health Department
IRB	Institutional Review Board
µg/dL	micrograms per deciliter
µg/g Cr	micrograms per gram of creatinine
ml	milliliters
MMA	Monomethylarsonic acid
MTDPHHS	Montana Department of Public Health and Human Services
mg/kg	milligrams per kilogram
NIOSH	National Institute for Occupational Safety and Health
NCEH	National Center for Environmental Health
NHANES	National Health and Nutrition Examination Survey
NPL	National Priorities List
NTP	National Toxicology Program
OMB	Office of Management and Budget
OU	Operating Unit
PPE	Personal Protective Equipment
PRA	Paperwork Reduction Act
RDU	Remedial Design Unit
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
UAS3	arsenous (III)
UAS5	arsenic (V) acid
UASB	arsenobetaine
UASC	arsenocholine
UTMO	trimethylarsine oxide
WIC	Women, Infants, and Children

Executive Summary

In the fall of 2018, the Agency for Toxic Substances and Disease Registry (ATSDR), in coordination with the Montana Department of Public Health and Human Services (MT DPHHS), conducted an Exposure Investigation (EI) in Anaconda, Montana to assess lead and arsenic exposure. ATSDR tested a total of 367 people during two sampling events in September and November of 2018.

Anaconda is home to the Anaconda Smelter Superfund Site, which the U.S. Environmental Protection Agency (EPA) placed on the National Priority List (NPL) in 1983. Smelting operations occurred in Anaconda from 1884 to 1977, resulting in contamination of soils in the community. Soils contain elevated levels of lead and arsenic from the deposition of particulate from stack emissions and the disposition of slag. Some attics have accumulated contaminated dust. Under EPA oversight, the Potentially Responsible Party (PRP), Atlantic Richfield Corporation (ARCO), has conducted extensive remediation; however, the residential soil clean-up is ongoing, and slag piles covering over a hundred acres remain uncovered. Anaconda also has a significant number of older homes that may contain lead paint. As a result, the potential for exposure to lead and arsenic in the community remains.

During ATSDR-sponsored community meetings held in 2018, Anaconda citizens and local officials expressed a need for better understanding of current exposures to site contaminants. In response, ATSDR committed to an exposure investigation in Anaconda, including the community of Opportunity within the Anaconda municipality.

In August 2018, ATSDR invited all residents of Anaconda to participate in biological testing to evaluate potential exposure in the community. An invitational mailing, local media, and Anaconda social media publicized the event. Outreach also included providing health education on lead and arsenic to local physicians, daycares, and schools. The Anaconda Deer Lodge County Health Department (ADLC HD) posted flyers detailing the testing event at key locations around the community.

The ATSDR EI team collected blood (lead) and urine (arsenic) samples from participants living within the Anaconda community. Although all members of the community were invited to participate in the EI, the populations most vulnerable to the effects of lead include young children with hand-to-mouth behavior (especially children with pica behavior) and women who are pregnant or of childbearing age.

ATSDR tested 191 participants in September. Community interest was high, and approximately 150 residents were placed on a wait list. ATSDR tested 177 people in November 2018 to accommodate the wait-listed residents. For the November event, ATSDR reached out to Head Start and Anaconda preschools and elementary schools to recruit additional young children and women of childbearing age. The total sample population of 367 people over both events (one person was tested in both events).

Within 12 weeks of testing, ATSDR provided result letters to every participant and the opportunity to contact an ATSDR Medical Officer and/or ATSDR staff. ATSDR's Medical Officer called the few individuals with results near or above ATSDR levels of concern for either lead or arsenic. Results letters provided recommendations for reducing exposure to lead and arsenic both inside and outside the home regardless of testing results. Outreach and testing events increased awareness of lead and arsenic exposure prevention, especially awareness of no-cost programs available to residents that test residential soils and attic dust for contaminants.

Evaluation of Exposure Investigation Results

ATSDR adopted the Center for Disease Control and Prevention (CDC) blood lead reference value of 5 micrograms per deciliter (µg/dL) to identify children with blood lead levels (BLL) that are higher than most children's levels [CDC 2012 a,b,c]. CDC and the American Academy of Pediatrics (AAP) recommend case management to reduce BLL for children above the 5 µg/dL level of concern [CDC 2012 a,b,c, AAP 2016]. The CDC reference value is based on the 97.5th percentile blood lead distribution in children aged 1 to 5 years from data collected in the National Health and Nutritional Examination Survey (NHANES) from 2007 to 2010 [CDC 2012 a,b,c]. In 2015, the National Institute for Occupational Safety and Health (NIOSH) designated 5 µg/dL as the reference blood lead level for adults in the workplace [NIOSH 2015].

Different species of arsenic are present in food, water, and the human body, and the EI laboratory analysis distinguished these various forms in urine. The source and toxicology of organic arsenic differs from inorganic arsenic. To identify elevated levels of urinary arsenic ATSDR adopted the 95th percentile of the most recent NHANES values as a benchmark for total, organic and inorganic urinary arsenic. Following the NHANES methodology, we summed the four inorganic arsenic species (measured in NHANES) evaluated in the EI to permit comparison of the EI data set to NHANES.

The age distribution of Anaconda EI participants differed from the age distribution of the 2015-2016 NHANES study group. To ensure a relevant comparison of median values, we developed an age-adjusted NHANES median based on accepted statistical methods. The median offers insight into exposures to the community. The median (50th percentile) of the Anaconda aggregated data for BLL and urinary arsenic were compared to the age-adjusted median NHANES levels. In addition, we compared results to the expected 5th, 50th and 95th percentiles of NHANES by age.

An EI captures an exposure "snapshot in time." EI results are limited since they are only applicable to the individuals tested and cannot be generalized. EI results do not tell us when the exposure occurred or the specific source of exposure.

Blood Lead Testing Findings

There is no identified threshold or “safe” blood lead level, and some studies indicate that even very low BLLs can cause neurological, cognitive, and attention-related behavioral issues in children [CDC 2012b]. Although CDC adopted the 5 µg/dL reference value to identify elevated BLL in children aged 1 to 5 years old, ATSDR, along with the MT DPHHS and the ADLC HC, uses this value as the follow-up level for lead for participants of all ages in this investigation.

All 18 children younger than 6 years old who participated in the testing events measured a BLL < 5 µg/dL. Similarly, all 54 children ages 6-19 who were tested had BLL values < 5 µg/dL. Three of 295 adults (i.e., ages 20 and above) tested had BLL ≥ 5µg/dL (maximum of 9.14 µg/dL). The three with BLL ≥ 5µg/dL ranged in age from 58 to 72.

Aggregate Anaconda BLLs were also compared to the representative median value found in blood in the U.S. population [CDC 2019a; 2015-2016 data set] and the expected 5^{th}, 50^{th} and 95^{th} percentiles of NHANES by age. ATSDR used poststratification to match the age characteristics of the Anaconda EI group (which was generally older), as age is an important predictor of BLL. All participants tested had measurable lead in the blood (level of detection = 0.07 µg/dL). Anaconda residents had a median BLL of 1.1 µg/dL which was slightly higher than the age-adjusted median BLL in NHANES of 0.95 µg/dL (difference of 0.15 µg/dL). The difference is statistically significant but not clinically significant; no difference in clinical health effect would be discernable between these two values. In general, the BLL values measured in the Anaconda community in this EI are comparable to national values reported in the 2015-2016 NHANES [CDC 2019a].

The results of the questionnaire provided insight into potential sources of blood lead in the participants. Linear mixed effects modeling revealed that being older, being a male, entering the attic more frequently than once per month, and self-reported occupational exposure to lead were associated with higher BLL.

Urine Arsenic Testing Findings

The various forms of arsenic found in the human body can be categorized as organic and inorganic. Organic forms of arsenic are associated primarily with diet, especially seafood; inorganic forms are generally associated with environmental exposures [ATSDR 2007c, Schoof 1999]. Inorganic arsenic is associated with industrial contamination and may enter the food chain becoming a source of dietary inorganic arsenic. For the Anaconda EI, ATSDR measured total arsenic in urine, and speciation was performed to determine the relative organic and inorganic portions. ATSDR compared levels of total arsenic, inorganic arsenic and organic arsenic in urine samples for individual participants to the age-specific 95^{th} percentile for the U.S. population reported in NHANES. We compared the median urinary arsenic values for the aggregate EI data to the representative median value in NHANES. Inorganic urinary arsenic was evaluated as the sum of four inorganic arsenic species. The results of the questionnaire were used to better understand how people may have been exposed to arsenic.

Testing results for urinary inorganic arsenic in one participant from the September testing (age 58) and two participants from the November testing (age 3 and 74) were above the age-specific 95th percentile of NHANES. The three participants were called by the EI Medical Officer to discuss their elevated results and provide recommendations to reduce exposure.

For Anaconda EI participants, the median urinary total arsenic of 6.7 micrograms per gram of creatinine (µg/g Cr) was 0.9 µg/g Cr higher than the age-adjusted NHANES median of 5.8 µg/g Cr. The median urinary total inorganic arsenic level of 4.6 µg/g Cr was 0.2 µg/g Cr lower than the age-adjusted NHANES median of 4.8 µg/g Cr [CDC 2019a]. Higher urinary organic arsenic in Anaconda EI participants compared to NHANES accounts for the difference in total urinary arsenic in the two sample populations. An evaluation of the questionnaire provides evidence for why this was found. EI participants with elevated organic arsenic had eaten food known to contain organic arsenic (e.g., seafood, chicken) in the week preceding the testing. Organic arsenic is not harmful to humans at these levels.

The results of the questionnaire provided insight into potential sources of total urinary arsenic in the participants. Linear mixed effects modeling revealed that entering the attic more frequently than once per month and eating seafood were associated with higher total urinary arsenic levels.

EI Conclusions

- The overall conclusion of the EI is that levels of blood lead and urinary arsenic measured in residents of Anaconda that participated in the EI are comparable to the U.S. population, as reported in NHANES.
- All 18 children younger than 6 years old who participated in the testing events measured a BLL below the 5 µg/dL follow-up level.
- The median BLL for all EI participants was approximately 0.15 µg/dL higher than the U.S. median, but this difference is not clinically significant.
- For arsenic, Anaconda EI participants had a slight elevation in total urinary arsenic (approximately 0.9 µg/gm Cr higher) compared to NHANES participants. The elevation in total arsenic, however, appears to be attributable to organic arsenic given that the level of inorganic arsenic was slightly lower (0.2 µg/gm Cr) than comparable NHANES values. Organic arsenic enters the body through diet and is not toxic at these levels. The organic arsenic testing results correlated to participants who reported eating foods high in organic arsenic. ATSDR would not anticipate health effects associated with urine arsenic levels measured in the Anaconda participants.
- Evaluation of the questionnaire administered at the time of the testing suggests that people can take measures to further reduce their exposure to lead. The analysis of questionnaire data in relation to BLL indicates that people who reported working in construction and maintenance jobs had higher BLLs.

- Many Anaconda attics are contaminated with lead and arsenic as a result of smelter activities in the past. Participants who reported entering their attics on a regular basis generally had higher BLL and total arsenic than other participants.
- ***The EI results do not mean that the risk of exposure to lead and arsenic in Anaconda has been eliminated; residents should continue to be proactive in preventing exposure.***

EI Recommendations

ATSDR identified specific actions, consistent with prudent public health practice that may further reduce the risk of lead and arsenic exposures in Anaconda residents. ATSDR recommends primary prevention efforts to avoid exposure to lead and arsenic in soil. ATSDR supports the following recommendations and public health actions.

- Anaconda citizens (including landlords) should participate in the Superfund Community Soils OU residential yard and attic clean-up programs as a primary mechanism for reducing potential exposure to lead and arsenic. Through the Superfund program (funded by ARCO with EPA oversight), residents may opt for soil and attic testing. Based on the results, residents can qualify for a contractor to clean contaminated attics. EPA and ADLC should make efforts to increase participation in these programs. In the meantime, ATSDR recommends that residents minimize time (or seal entryway) in untested or contaminated (but not yet remediated) attics.
- Anaconda citizens should take prudent actions to avoid contact with potentially contaminated soil. These actions include:
    - Avoid areas of known contamination (e.g., slag piles) and instruct children not to play or ride bikes there;
    - Supervise children closely to modify or eliminate risky hand-to-mouth behaviors or intentional eating of dirt (pica behavior);
    - Damp mop and damp dust surfaces;
    - Cover bare soils with vegetation (grass, mulch, etc.) and create safe play areas for children with clean ground cover;
    - Remove shoes before entering the home;
    - Bathe pets regularly to avoid them tracking contaminated soil into homes.

- Anaconda citizens should take precautions to prevent exposure to lead from lead paint during house renovations in homes build prior to 1978. Information is available at: https://www.epa.gov/lead/protect-your-family-lead-your-home.
- The EPA and ARCO should minimize risk of exposure to lead and arsenic from uncovered slag through improved signage (specifically uncapped slag piles) and Superfund remedial actions.
- The ALDC Health Department should conduct regular BLL screenings for children under age 6 based on risk identified from site contamination and the AAP recommendation [AAP, 2016] of regular BLL screenings for communities with a significant portion of

homes built before 1960. Ensure venous draws and physician follow-up for capillary BLL at or above the CDC Reference value of 5 µg/dL.

- Primary healthcare providers should continue to improve understanding of lead screening and ways to reduce exposure to site contaminants and lead paint. ATSDR's Case Studies in Environmental Medicine (CSEM) provide a self-instructional primer. The lead and arsenic CSEMs are available at:
  https://www.atsdr.cdc.gov/csem/csem.asp?csem=34&po=0
  https://www.atsdr.cdc.gov/csem/csem.asp?csem=1&po=0
- People working in jobs where lead and arsenic are present should use appropriate personal protective equipment (PPE) while on the job to reduce exposure. Regular hand washing and removing outer garments before entering the home after work reduces exposures and protects family members.

1. Background and Purpose of the Exposure Investigation

Anaconda is the county seat of Anaconda-Deer Lodge County (a consolidated city-county government) (ADLC) and is located at the southern end of the Deer Lodge Valley in southwestern Montana (Figure 1). Figure 1 provides the location of the Anaconda Smelter Superfund site in relation to other sites in the vicinity. The Anaconda Smelter Superfund Site covers approximately 300 square miles of land impacted by smelter operations and ore processing wastes. The site includes both Anaconda and the community of Opportunity located within the municipality of Anaconda (Figure 2). Smelting operations over a 100-year history led to an estimated 260 million cubic yard deposition of heavy metals from mill tailings, furnace slag, and flue dust [EPA 1996]. Over 20,000 acres of soils (both residential and commercial) were contaminated by emissions [EPA 2015].

In the 2010 census, the population of ADLC was 9,139 with 28% of the population living with an income below the poverty level (Appendix A). Lead exposure may also result from lead in house paint since 80% of the homes in Anaconda were built before 1980, when lead was allowed in house paint (Appendix A). Homes built before 1960 are more likely to contain lead paint [DHHS, 2011], and approximately 55% Anaconda homes were built before 1960 [Census Bureau 2013-2017]. Older homes in this area may have copper water pipes joined with leaded solder. Testing of tap water in nearby Butte in 1994 indicated that lead leaching from older plumbing may be a source of lead exposure [EPA, 1994].

Figure 1. Anaconda Co. Smelter NPL Site (Montana): Site Location Map

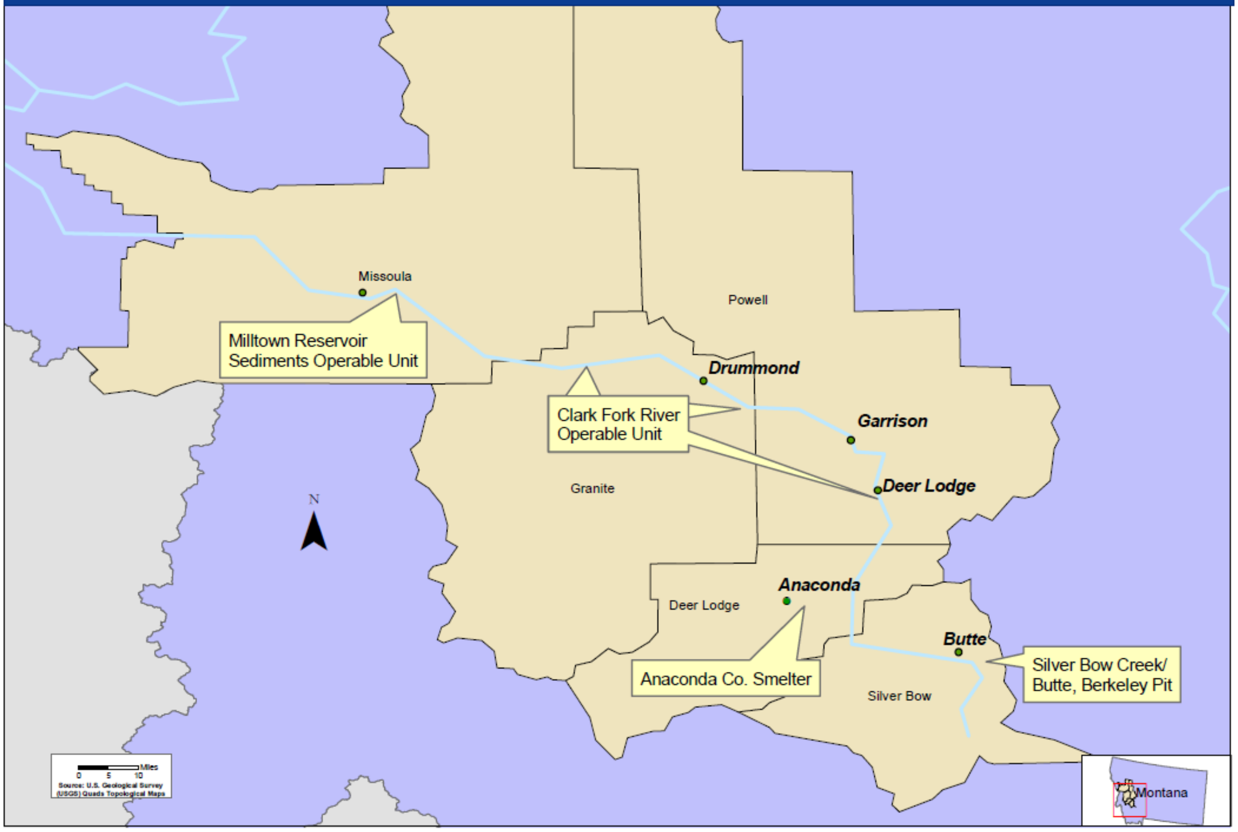

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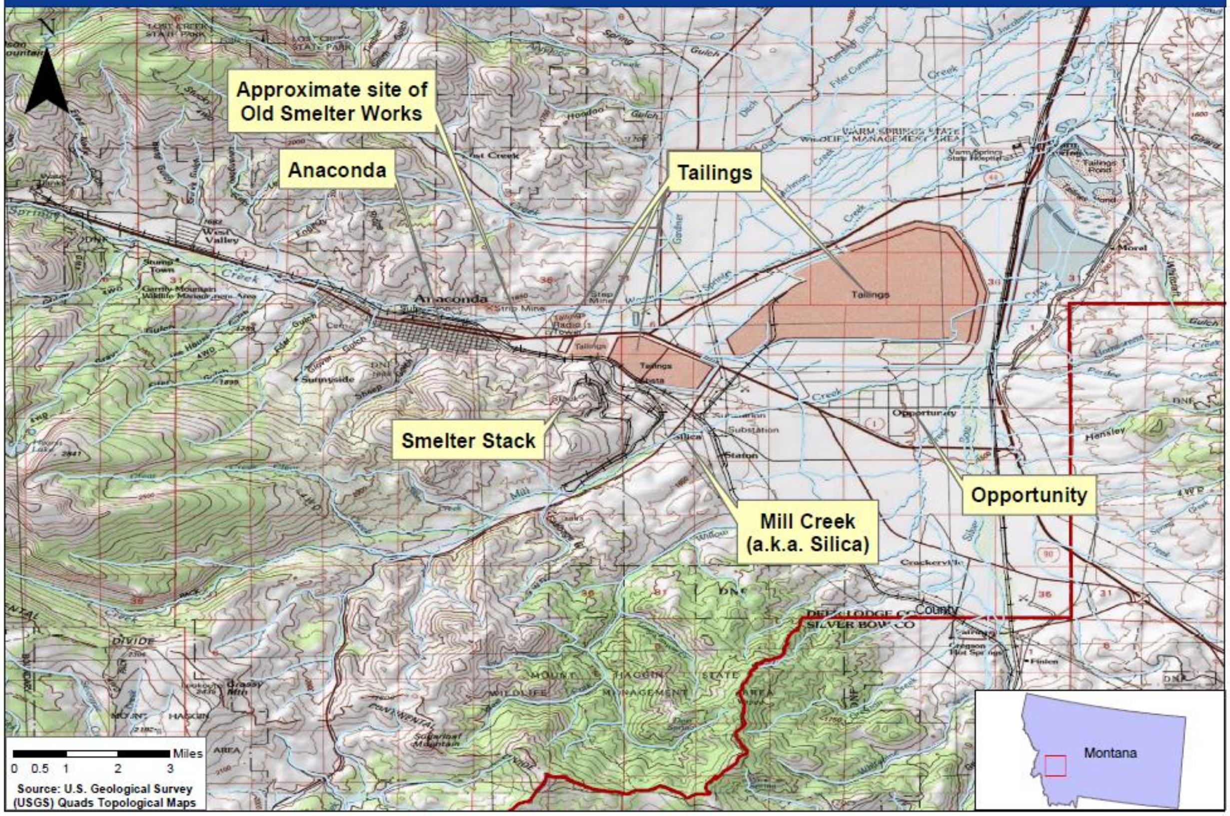
Figure 2. Anaconda Co. Smelter NPL Site (Montana): Site Features Map



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1.1 Environmental Sampling Data

ARCO, under EPA oversight, has conducted extensive environmental sampling over the course of the site's Superfund history. The information presented here provides an overview of historic sampling followed by recent data that informs our understanding of present exposure pathways. EPA often portions a site into smaller units, or Operable Unit (OU), to assist in site management and ultimate cleanup of a site.

Residential Soils Overview

Through the Superfund process, ARCO and EPA together completed approximately 21 soil investigations between 1985 and 1995. Analytic results from the 1997-1998 Remedial Investigation/Feasibility Study (RI/FS) established the Community Soils OU as the focus of residential clean ups. This OU includes residential yards in Anaconda, Opportunity, and rural areas in the Anaconda vicinity. This focus area of remediation encompasses the population at greatest current risk for exposure to arsenic and lead. Though ARCO has completed many remedial activities for residential soils, EPA's Fifth Five Year Review Report in 2015 [EPA 2015] concluded "the remedy for the Community Soils OU is not protective because exposure to … contamination in residential soil and dust is not currently controlled."

In 2006, ARCO sampled over 1,400 residential yards in Anaconda and the surrounding rural area [EPA 2008]. Of these, 300 yards exceeded the 250 mg/kg action level for arsenic. Analysis of the sampling indicated that arsenic contamination was more widespread than indicated in previous decision documents. Also in 2006, ARCO evaluated residual lead concentrations in yards where arsenic concentrations measured below the 250 mg/kg cleanup benchmark. The results indicated that lead concentrations in residential soils posed a significant exposure pathway for lead even where the arsenic level was below 250 mg/kg [EPA 2008]. A total of 347 of 554 soil samples exceeded the EPA 400 mg/kg lead clean up benchmark [EPA 2008]. The lead and arsenic in community soils do not appear to be correlated; the reason is not known but may be associated with differing deposition of lead and arsenic when the smelter was in operation.

Recent Residential Yard Sampling

Remediation actions continued from 2015 to 2017 for the Community Soils OU with the action levels set at 250 mg/kg and 400 mg/kg for arsenic and lead, respectively. Data collected in 2015 and 2016 data confirmed continued risk for community exposure to lead and arsenic through residential soil [ATSDR 2018].

Dust in Attics and Home Interiors

The higher than anticipated soil arsenic concentrations prompted ARCO to sample attic dust for arsenic and lead in 52 homes [ARCO 2008]. Environmental sampling of attic dust has established that historic smelter emissions settled in home attics. In its analysis of the correlation of contaminant levels found in residential interior, exterior, and attic dust, EPA concluded that "attic dust may be a secondary source of interior dust arsenic and lead contamination" [EPA 2008]. In 49 attics sampled, the mean arsenic and lead values (496 mg/kg and 721 mg/kg, respectively) were above the remedial action levels for soils [ARCO 2008].

The Community Soils Record of Decision [EPA 2013] established an attic remediation program for residences located in the Community Soils OU. Testing and remediation of attic dust is an ongoing process, though initial results indicate that approximately half of sampled attics require remediation. Attic dust is a current pathway of exposure to lead and arsenic.

Uncovered Waste in Place

EPA's most recent Superfund Five-Year Review identified areas with uncovered wastes left in place. The remedy included some slag piles intentionally left in place for historic preservation recognizing Anaconda's history in processing copper ore [EPA 2015]. Some of these areas are accessible to trespassers resulting in potential exposures through inhalation of airborne particulates and contact with contaminated soils near the pile.

An area known as the Old Works Historic District, located in the Old Works/East Anaconda Development Area Operating Unit, contains ore processing waste from smelter operations dating from 1884-1902. In 2010, EPA estimated that 60,000 to 75,000 cubic yards of contaminated waste remained [EPA 2015]. Previous sampling has indicated that portions of this waste exceed the 1,000 mg/kg remedial action level for arsenic established for recreational/open space/agricultural areas [EPA 2015].

Substantial progress in remediation has been made in the Anaconda Regional Water, Waste, and Soil Operating Unit; however, remediation is not complete for multiple remedial design units (RDUs) covering thousands of acres of contaminated land located within this OU. Three slag piles covering approximately 197 acres and consisting of approximately 25.5 million cubic yards of smelter slag are located within this OU. Wind and erosion control measures are in place; however, particulates are entrained in air during high wind events [EPA 2015].

1.2 Previous Biomonitoring

In the past, several biomonitoring investigations have been conducted evaluating potential exposure to residents exposed to environmental contaminants from smelting activities. The ATSDR Health Consultation [ATSDR 2007a] provides information on the past biomonitoring events in the Anaconda area; they are summarized in Table 1.

Table 1. Past (1977-1997) Arsenic Biomonitoring Events in Anaconda*		
Reference	Testing	Conclusion
Baker et al. 1977	Arsenic in hair and urine	Nationwide survey of children living around copper, lead or zinc smelters, including Anaconda. • Both hair and urine arsenic levels (total) in Anaconda were above levels found in comparison towns without smelters.
Hartwell et al. 1983 (testing completed from 1978-1979)	Arsenic in hair, blood and urine (also evaluated air, soil, dust, and tap water)	Nationwide survey of children living around copper, lead or zinc smelters, including Anaconda. • Dust arsenic levels correlated best with hair arsenic levels for all age groups; urine arsenic (total) correlated with air, water and dust arsenic levels for 1 to 5 year old children.
Anaconda Smelter closed in 1980		
Binder et al. 1987 (testing completed in 1985)	Arsenic urine (total) (also soil and house dust)	Four locations were evaluated and compared to each other. In the Mill Creek neighborhood (downwind of smelter and adjacent to the stack): higher mean arsenic in soil and urinary arsenic in children vs Eastern Anaconda (upwind of stack), Opportunity (4 miles downwind of smelter) and the control town. Eight children relocated from Mill Creek based on this investigation.
Hwang et al. 1997 (testing completed in 1992-1993)	Total and speciated arsenic in children in Anaconda	Speciated urine arsenic concentration correlated with soil arsenic level in bare yards.

* ATSDR (2007a)

In 2013, ARCO contracted with ENVIRON International Corporation in consultation with ADLC HD to conduct a baseline blood lead and urinary arsenic biomonitoring study to evaluate potential exposures of residents in the Anaconda area. Blood lead levels (BLL) and urine arsenic sampling was offered to community members and results are presented in Table 2 [ARCO 2014].

Table 2: Biomonitoring Results by Age [ARCO 2014]				
Blood Lead Levels				
	< 7 years		≥ 7 years	
Number detections (DL = 1.0 µg/dL) /number tested	7/18		26/84	
Concentration range (µg/dL)	1-3.8		1-5.4	
Urine Arsenic Results				
	<12 years		≥12 years	
	Number of participants	Concentration Range of detections	Number of Participants	Concentration Range of Detections
Total Arsenic (µg/L)	32	4.24-39.5	74	1.36-363
Speciated Arsenic (µg/L) *	32	4.61-25.4	74	1.15-90.6
Speciated Arsenic, Specific Gravity-Corrected (µg/L)	29	4.56-22.5	61	1.87-77.5
Speciated Arsenic, Creatinine-Corrected (µg/g)	30	4.69-33.4	66	1.83-63.7

* Combined inorganic species, arsenous (III) acid and arsenic (V) acid, and their methylated metabolites [monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA)] results.
DL = Detection Limit

1.3 Risk Factors for Lead Exposure in Anaconda

In addition to the potential exposure to contaminated soil, people living in the area have multiple factors associated with increased risk of lead exposure. The census tract has a large percentage of homes built before 1980 (80%) that may have lead-based paint and lead pipes that may impact drinking water [Census Bureau 2010] (Appendix A). In addition, approximately 28% of residents in Anaconda were below the poverty line in 2015 [American Fact Finder 2018] (Appendix A). Poverty is an additional risk factor for increased BLL [Dixon et al. 2009, Jones et al. 2009, Bernard et al. 2003].

1.4 Community Concern in Anaconda

In community meetings held in 2018, Anaconda citizens and local officials expressed a need for a better understanding of current exposures to site contaminants. One of the outcomes of the meetings was the identification of the need to conduct biomonitoring for lead and arsenic in the community as a result of long-term exposure to products of the smelting process.

The MT DPHHS provided a summary of cancer incidence in ADLC (Appendix B). The results of the analysis indicated that the rate of new cancer cases remains the same among ADLC residents when compared to all Montana residents, and cancer in ADLC is not occurring at rates higher than the rest of Montana.

2.0 Agency Roles

Many activities are conducted during an EI. ATSDR, the lead agency for the EI, collaborated with EPA, the Montana Department of Public Health and Human Services (MT DPHHS), the Anaconda Deer Lodge County Health Department (ADLC HD), and the CDC National Center for Environmental Health (NCEH) Division of Laboratory Sciences (DLS) to complete these activities. The roles of each agency are described in Table 3.

Table 3. Exposure Investigation Activities and Agency Roles		
Activity	**Agency**	**Agency Role**
EI protocol and PRA/OMB submittal	ATSDR	Completed the EI protocol which included Fact Sheets, Flyers, Posters, Questionnaire, Parental Permission, Consent and Assent Forms, Sampling and Analysis Plan Submitted the Paperwork Reduction Act (PRA) forms to the Office of Management and Budget (OMB) for approval to administer the questionnaire and consent forms. This package also included an Institutional Review Board (IRB) exemption since the EI is not considered to be research.
Identification of area with risk for lead and arsenic exposure	EPA, ADLC HD, ATDSR	Provided information regarding soil lead levels and the status of remediation in the Community Soils OU to identify a mailing list for recruitment materials.
Provided ATSDR with BLL for Anaconda Residents	EPA and MT DPHHS	Both agencies provided ATSDR with historical BLL data for children in Anaconda. The agencies continue to engage the community regarding potential lead contamination in Anaconda.
Participant recruitment	ATSDR, ADLC HD	Sent informational postcards, and scheduled appointments.
Blood sample collection	ATSDR, MT DPHHS, ADLC HD, DLS	Administered parental permission/assent/consent forms to participants and their parent/guardian. Hired or provided licensed phlebotomists to draw blood from participants.
Blood and urine sample analysis	NCEH/DLS	Used approved laboratory methods to analyze biological samples for lead and arsenic. Provided results to ATSDR.

Table 3. Exposure Investigation Activities and Agency Roles		
Activity	**Agency**	**Agency Role**
Reporting of results	ATSDR, MT DPHHS, ADLC HD	Prepared and mailed letters with results to all participants. Contacted EI participants who had BLL ≥ 5 µg/dL to recommend follow-up with their physician. Contacted EI participants with inorganic arsenic levels greater than NHANES to discuss reducing exposure to arsenic. Evaluated data and prepared the Exposure Investigation (EI) report.
Abbreviations: ATSDR, Agency for Toxic Substances and Disease Registry; EPA, Environmental Protection Agency; MT DPHHS, Montana Department of Public Health and Human Service; ALDC HD, Anaconda Deer Lodge County Health Department; NCEH/DLS, National Center for Environmental Health/Division of Laboratory Services		

3.0 Methods

The goal of the EI was to implement sample collection in September 2018 when contact with soil (and therefore exposure to arsenic and lead) was expected to be high due to increased outdoor activity by residents. Exposure to soil is expected to be highest during months with good weather. Given high community participation, an additional round of testing was completed in November 2018.

3.1 Criteria for Participation

All members of the Anaconda municipality, including those living in the Opportunity community, were eligible to be included in the Exposure Investigation (EI). The EI was initially conducted to test up to 200 persons in the Anaconda community (September 2018). The first effort was very successful (191 participants), and an additional 150 people were put on a waiting list for a second round of testing. For the second round of testing (November 2018), testing was offered to those on the waiting list and others who approached the ADLC HD to ask about testing. In addition, given the low number of young children and women of childbearing age that were tested in September, outreach to Head Start and the preschools/elementary schools in Anaconda was conducted to recruit participants from these groups. Young children (younger than 6 years old) and women who are pregnant or of childbearing age are most susceptible to the effects of elevated BLL.

3.2 Participant Recruitment

Table 4 provides the goals, recruitment strategy and participant profile for the two testing events.

<table>
<tr><th colspan="2">Table 4: Goals, Recruitment Efforts and Participants for the Anaconda EI</th></tr>
<tr><th colspan="2">Testing Event</th></tr>
<tr><th>September 14-17, 2018</th><th>November 3-6, 2018</th></tr>
<tr><td colspan="2"><u>Goal</u></td></tr>
<tr><td>Given community concern, all members of the Anaconda community were invited to participate.</td><td>Individuals who were on the waiting list after the first testing round were offered testing. In addition, young children and women of childbearing age were specifically recruited.</td></tr>
<tr><td colspan="2"><u>Recruitment Effort</u></td></tr>
<tr><td>• Invited all Anaconda residents to be tested for BLL and urine arsenic
• Mailed approximately 5000 recruitment postcards inviting residents to be tested approximately 3 weeks prior to testing. Approximately 20% of the letters were returned as undeliverable.
• Provided and distributed fact sheets and recruitment posters within the community by ADLC HD and ATSDR Region 8 personnel
• Provided a Grand Rounds presentation and information packets for lead and arsenic information to local physicians in Butte and Anaconda
• Announced the testing event in a press release in the local Anaconda newspaper (Anaconda Leader and Montana Standard)
• Used local resources and contacts, including the ADLC HD and the MT DPHHS, to publicize the EI testing event.</td><td>• Invited all Anaconda residents that were on the waiting list to participate
• Recruited young children and women of childbearing age to participate
• Provided information to Head Start and preschools and elementary schools in the community to recruit young children and women of childbearing age
• Used local resources and contacts, including the ADLC HD and the MT DPHHS, to publicize the EI testing event.</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Table 4: Goals, Recruitment Efforts and Participants for the Anaconda EI	
Testing Event	
September 14-17, 2018	**November 3-6, 2018**
Participants	
• 191 participants ○ 1 child younger than 3 yrs ○ 2 children aged 3-5 yrs ○ 12 children aged 6-11 yrs ○ 13 children aged 12-19 yrs ○ 163 adults aged 20 yrs and older • 184 tested for blood lead† • 185 tested for urine arsenic†	• 177 participants ○ 5 children younger than 3 yrs ○ 10 children aged 3-5 yrs ○ 19 children aged 6-11 yrs ○ 10 children aged 12-19 yrs ○ 133 adults aged 20 yrs and older* • 175 tested for blood lead† • 173 tested for urine arsenic†

EI = Exposure Investigation; BLL = Blood Lead Level; ATSDR = Agency for Toxic Substances and Disease Registry; ADLC HD = Anaconda Deer Lodge County Health Department; MT DPHHS = Montana Department of Public Health and Human Services

* One adult participant was tested for BLL in both testing events

† Not all participants were tested for both lead and arsenic.

3.3 Biologic Sample Collection and Analytic Procedures

ATSDR completed the biological sample collection at the Anaconda Community Service Center, located at 118 East 7th Street in Anaconda, from September 14-17, 2018 and November 3-6, 2018. We offered weekend and early evenings testing times for the convenience for Anaconda residents.

Prior to the testing date, participants were asked to obtain a urine collection kit from the ADLC HD. The urine collection kit included a urine collection cup and instructions on how to obtain a first morning urine sample. Once the urine sample was collected, the participant was asked to put it directly into their freezer and bring it with them to their blood collection appointment.

At the blood collection location, the participants signed in and provided their frozen urine sample to ATSDR personnel, who logged it into a hard copy and electronic data collection log. To maintain privacy, the samples were labeled with a unique identification number. No personal information was sent to the laboratory. The EI team then administered the appropriate Consent/Assent/Parental Permission form and OMB-approved questionnaire (OMB # 0923-0048) to each participant. The household questionnaire included questions on demographics, characteristics and age of residences, and activities that might result in exposure to lead and arsenic. Federal rules require that ATSDR maintain confidentiality of the information gathered through interviews as well as the results of laboratory tests.

Blood Collection

After the consent forms were administered and the questionnaire completed, the participant provided a blood sample for analysis. Licensed phlebotomists (medical professionals who draw blood from a vein) were obtained from the MT DPHHS, DLS and from local sources.

Blood lead sampling is the most reliable method for measuring lead exposure from all sources [Barbosa et al. 2005]. Whole blood samples were obtained by venous puncture. A phlebotomist collected 3 milliliters (ml) of blood from each participant who provided consent. The collection tubes and supplies were provided by the NCEH/DLS. As with the urine samples, the blood samples were logged on a hard copy and electronic collection log and were labeled with a unique identification number.

After collection, blood samples were maintained near 4ºC throughout the week and during overnight shipment. Samples were delivered for analysis to the NCEH/DLS laboratory in Atlanta, Georgia.

The NCEH/DLS laboratory performed blood lead testing in Atlanta, Georgia using NHANES Method 2009-2010 [CDC 2009-2010] and Quality Assurance/Quality Control for lead according to NHANES 2007-2008 [CDC 2007-2008a,b].

Urine Collection

Urine arsenic is the most reliable method for measuring arsenic exposures occurring within a few days prior to the sample collection. A 24–hour urine collection is considered the optimal method to collect urine for arsenic sampling due to fluctuations in excretion rates. However, most studies use a first morning void or random spot sample because it is convenient for the participant and improves their compliance. These methods appear to correlate well with 24-hour collection results [Orloff et al. 2009, Hinwood et al. 2002]. Participants were provided a urine collection kit that included the urine collection cups (provided by DLS for quality control) and instructions for urine collection and freezing of the sample.

Frozen urine samples brought to the collection location were placed on dry ice and shipped frozen by FedEx overnight to NCEH/DLS in Atlanta for analysis. DLS analyzed the urine for total arsenic by DLS method 3031.1 and DLS method 3000.15-02 for speciated arsenic by high performance liquid chromatography inductively coupled plasma dynamic reaction cell mass spectrometry (HPLC ICP-DRC-MS).

All urine specimens were analyzed for total arsenic, speciated arsenic, creatinine and specific gravity. Seven arsenic species were analyzed: three methylated metabolites (organic) [arsenobetaine (UASB), arsenocholine (UASC) and trimethylarsine (UTMO)] and four inorganic arsenic species [arsenic (V) acid (UAS5), arsenous (III) acid (UAS3), dimethylarsinic acid (DMA) and monomethylarsonic acid (MMA)]. The urine test results were creatinine-corrected, as age appropriate. The organic arsenic species were evaluated individually while the four inorganic arsenic species were summed and evaluated as a total inorganic arsenic value. To maintain privacy, the samples were labeled with a coded identification number so no personally identifiable information was provided to the laboratory.

Statistical Methods

Results for lead, total creatinine corrected urinary arsenic, and inorganic creatinine corrected urinary arsenic were compared to NHANES 2015 – 2016 [CDC 2019a] after post stratification to adjust for differences in ages between the NHANES 2015 – 2016 population and the Anaconda EI participants. Similarly, organic creatinine corrected urinary arsenic results were compared to post stratified NHANES 2015-2016 data for UASB and UASC; UTMO was evaluated using data from the 2011-2012 NHANES data set since that was the last year UTMO was evaluated [CDC 2019a].

We assigned the limit of detection divided by the square root of two for results less than the limit of detection for inorganic arsenic results, consistent with the approach taken in NHANES. We calculated 50^{th} and 95^{th} percentiles for the age-adjusted NHANES and betaWald 95% confidence intervals using R software package [Lunley 2019, R Core Team 2019]. To compare how the Anaconda EI participants compared to the U.S. population, we compared boxplots for the Anaconda EI results to the age-adjusted 2015-2016 NHANES. In addition, we compared results to the expected 5^{th}, 50^{th} and 95^{th} percentiles of NHANES by age.

For the EI participants, one participant gave biological samples in both the September and November events, so the results were averaged. To compare the NHANES results to the Anaconda EI participants, we developed boxplots and calculated median estimates of blood lead and urinary arsenic and calculated bootstrap 95% percentile confidence intervals (1,999 replications) for these parameters [Manly 2007]. We also compared the logs of blood lead to the logs of urinary total and inorganic arsenic levels using Pearson's correlation coefficient. Anaconda results were evaluated using linear mixed effects modeling. Further details are discussed in Appendix E.

4.0 Results

4.1 Participants in the Exposure Investigation

There were 367 participants in the Anaconda EI: 191 participants in the September testing event and 177 participants in the November testing event (one participant was tested in both the September and November testing event for BLL). Table 5 below presents the break down by age as reported by participants.

Table 5. Summary of Participants by Age			
Age Group	**Total number of participants tested**		
	September	**November**	**Total**
Less than 3 years	1	5	6
3 to 5 years old	2	10	12
6 to 11 years old	12	19	31
12 to 19 years old	13	10	23
≥ 20 years old	163	133	295*
TOTAL	**191†**	**177‡**	**367**

* one participant was tested in both the September and November sampling round for BLL

†184 were tested for blood lead and 185 were tested for urine arsenic

‡ 175 were tested for blood lead and 173 were tested for urine arsenic

The demographics of the sampled population and the demographics of the community based on the 2010 US Census is presented in Appendix C. The table in Appendix C presents the demographic data for each testing event as well as a summation for both efforts. The results indicate that the demographics were similar between testing events and were consistent with the results from the 2010 Census.

Based on information gathered from the questionnaire, the majority of the homes in the community are single-family homes (93%) with most being built prior to 1980 (77 to 85%). Lead paint, a risk factor for children for lead exposure, ceased being manufactured in 1978, so homes built prior to 1980 may contain lead paint.

The most sensitive population groups associated with the potential impacts of lead exposure are young children (younger than 6 years) and pregnant women or women of childbearing age. For the second round of testing in November 2018, ATSDR recruited additional participants in these groups. ATSDR tested 18 children younger than 6 years old in the EI, which represents approximately 5% of the population tested during the EI (18/367 participants tested). The percentage of children younger than 6 years old tested in the EI is comparable to the percentage of children in this age group identified in the 2010 Census (348/9,139 residents; approximately 4%) [Appendix C].

There were a greater number of male children (63%) than female children (38%) tested and a greater number of female adults (57%) than male adults (43%) tested. Close to 100% of those tested identified as white (97%) and few identified as being of Mexican descent (2 to 7%). These results are comparable to the results from the 2010 census (93% white and 3% of Mexican descent) [Appendix B].

The questionnaire results indicate that the community is stable with 75% of adults living in their home for 10 years or longer. Approximately 27% of participants indicated that the soil in their yards had been replaced by EPA, indicating that the lead or arsenic levels in their yard soil warranted cleanup in the past but only 10% have had their attics professionally cleaned [Appendix C].

Questions associated with resident's lifestyle included questions about occupational exposure, whether participants remove their shoes prior to entering their home and questions about their diet to provide context for arsenic exposure. Approximately 24% of participants lived in a home where a family member worked in a profession associated with potential exposure, such as construction work. About half of the participants never or seldom take off their shoes before entering their home, thereby tracking in soil that may become dust in the home. It was clear that many participants consumed food items that are associated with potential exposure to arsenic, including seafood (36%), rice (45%) and chicken (83%) [Appendix C].

4.2 Evaluation of Exposure Investigation Results

The CDC assesses the health and nutritional status of adults and children in the general U.S. population through the National Health and Nutritional Examination Survey (NHANES). NHANES evaluates health and nutritional status by applying a survey that includes interviews and physical examinations in people across the U.S. The testing of BLL and urinary arsenic is included in NHANES: data from the 2015-2016 testing events were used to evaluate BLL and all urinary arsenic species except for UTMO, which was evaluated using the 2011-2012 data set because NHANES did not test for urinary UTMO after 2012 [CDC 2019a].

For the Anaconda EI, ATSDR used the CDC blood lead reference value of 5 micrograms per deciliter (µg/dL) to identify children who require case management [CDC 2012a]. The CDC reference value is based on the 97.5th percentile of the NHANES's 2012 blood lead distribution in children aged 1 to 5 years [CDC 2019a]. Each participant's BLL was compared to the reference value of 5 µg/dL and reported directly to the participant. Similarly, the arsenic results (total and speciated) for each participant were compared to the 95th percentile of the NHANES for each species and reported directly to the participant. When the aggregate data from the EI testing was compiled, the median (50th percentile) results for BLL and urinary arsenic were compared to the age-adjusted median NHANES levels for BLL and urine arsenic.

4.3 Blood Lead Levels

Lead and Health Effects

Lead is a naturally occurring metal. Typically found at low levels in soil, lead is processed for many industrial and manufacturing applications, and it is found in many metallic alloys. Lead was banned as an additive to gasoline in 1996 and from paint in 1978. Lead can be found in all parts of our environment because of past and current human activities including burning fossil fuels, mining, and manufacturing processes [ATSDR 2007b]. Because of this, lead is often found in the body at low levels. Lead exposure occurs primarily via the oral route, with some contribution from the inhalation route. The toxic effects of lead are the same regardless of the route of entry into the body.

Lead has no physiological value, and if it gets into the blood, lead can affect various organ systems and be stored in the bones. Lead that is not stored in bones and teeth is excreted from the body in urine and feces. About 99% of the amount of lead taken into the body of an adult will leave the body in urine or feces within a couple of weeks, while about 30% of the lead taken into the body of a child will leave the body in urine or feces [ATSDR 2007b]. Lead can stay in bones for decades. Lead can leave bones and re-enter the blood and deposit in organs under certain circumstances: during pregnancy and lactation, after a bone is broken, and during menopause in women due to osteoporosis [ATSDR 2007b].

Depending on the level of exposure, lead can adversely affect the nervous system, kidney function, immune system, reproductive system, development, and cardiovascular system. Lead exposure also affects the oxygen carrying capacity of the blood. The lead effects most commonly encountered in the current population are neurological effects in children, and cardiovascular effects (e.g., high blood pressure and heart disease) in adults. Lead can be passed from a mother's body to negatively affect the health of her unborn child.

Exposure investigations that evaluate BLL usually emphasize the testing of pregnant women and children younger than 6 years. Epidemiologic cohort studies suggest that prenatal lead exposure, even with maternal BLLs <10 µg/dL, is inversely related to fetal growth and neurodevelopment independent of the effects of postnatal lead exposure. Lead exposure can also cause a miscarriage. Infants and young children are especially sensitive to even low levels of lead, which may contribute to behavioral problems, learning deficits, and lowered IQ (intelligence quotient) [Lanphear et al. 2005, Crump et al. 2013]. The exact mechanism(s) by which low-level lead exposure, whether prenatal or postnatal, may adversely affect child development remains uncertain [DHHS, 2010].

It is not known for certain if lead causes cancer in humans. Rats and mice fed large amounts of lead in their food developed kidney tumors. The U.S. Department of Health and Human Services classifies lead as "reasonably anticipated" to cause cancer and EPA considers lead a "probable" cancer causing substance [ATSDR 2007b]. Because of the absence of any clear threshold for some of lead's more sensitive health effects, ATSDR has not established guidelines for a low or no risk lead intake dose.

Currently a blood lead level of 5 µg/dL is used to identify children with blood lead levels greater than most children in the U.S. These levels are known to have adverse effects. As a result, blood lead levels should be kept as low as possible since no safe blood lead level in children has been identified. In Montana, the reportable blood lead level is ≥ 5 µg/dL for all age groups.

An elevated level of lead in a person's blood is an indication that an exposure has occurred. In general, BLL correlates well with adverse health effects [ATSDR 2007b]. Young children and the developing fetus are particularly sensitive to the effects of lead. The Pediatric Environmental Health Specialty Units (PEHSU) provide recommendations for medical management of children exposed to lead at all BLLs (Appendix D). CDC also provides a guide for recommended actions based on BLL (https://www.cdc.gov/nceh/lead/advisory/acclpp/actions-blls.htm).

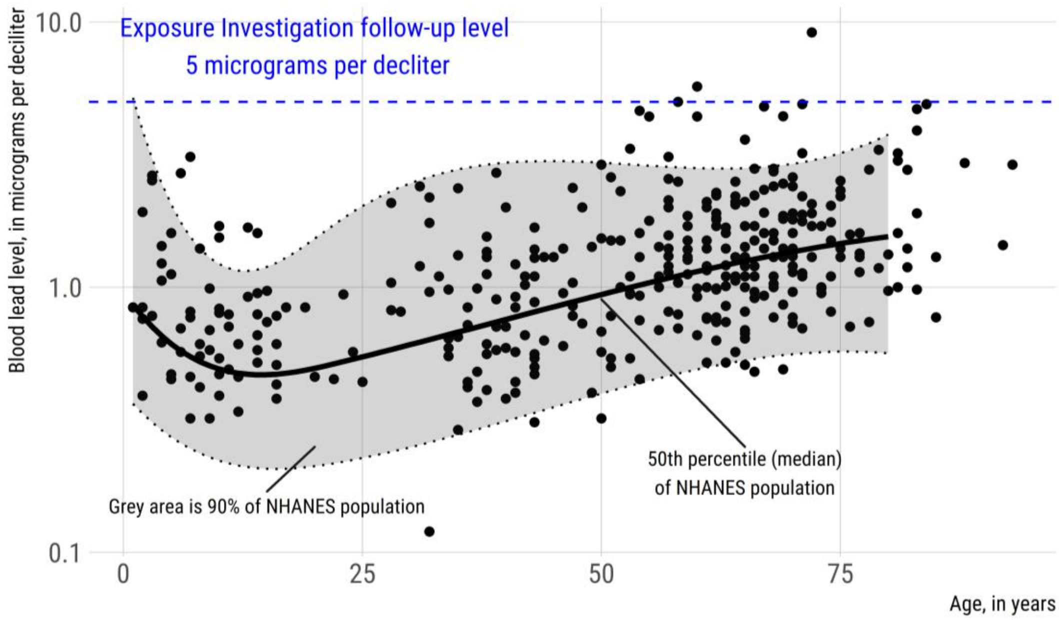
Some characteristics contribute to susceptibility (e.g., age, race, sex) and others to vulnerability (e.g., socio-economic status and living in older housing). Living in older housing [CDC 2013, Bernard et al. 2003], and poverty [CDC 2013, Jones et al. 2009] and being non-Hispanic black [Bernard et al. 2003, CDC 2013, Jones et al. 2009] are risk factors for higher blood lead levels. In Anaconda, living in poverty (28% below the poverty line) and living in older homes (80% of homes were built before 1980) may indicate vulnerability of the Anaconda community to lead exposure in addition to risk associated with site contamination.

Blood Lead Results

All 18 children younger than 6 years old who participated in the testing events measured a BLL < 5 µg/dL. Similarly, all 54 children ages 6-19 who were tested had BLL values < 5 µg/dL. Three adults (ages 58, 60 and 72) had BLL ≥ 5µg/dL (maximum of 9.14 µg/dL) with one participant being tested in both events and having elevated results in both events. The results of the questionnaire provided insight into the potential source of the BLL in the participants (e.g., participants lived in older homes for over 10 years, had hobbies associated with lead exposure, or had their yard soil and attics tested and remediated). In addition to receiving a letter with their results, the three participants were called by the EI Medical Officer to discuss their elevated results and to provide recommendations to reduce exposure.

Figure 3 provides the blood lead levels found in the EI participants versus age. The dots in the figure represent each of the participants in the EI where blood lead was analyzed. The figure shows the age of each participant and the BLL in comparison to NHANES and the follow-up level of 5 µg/dL. The black line indicates the 50th percentile (median) of the NHANES population and the grey area outlines the area that reflects 90% of the NHANES population (bordered on the top by the 95th percentile and on the bottom by the 5th percentile). The swish pattern in the grey outline indicates higher lead concentrations at an early age due to greater susceptibility of young children to lead exposure, including in utero, lower concentration in adolescents resulting from rapid growth, and an increase of lead body burden in adults. This pattern is consistent with current understanding of BLL distribution by age.

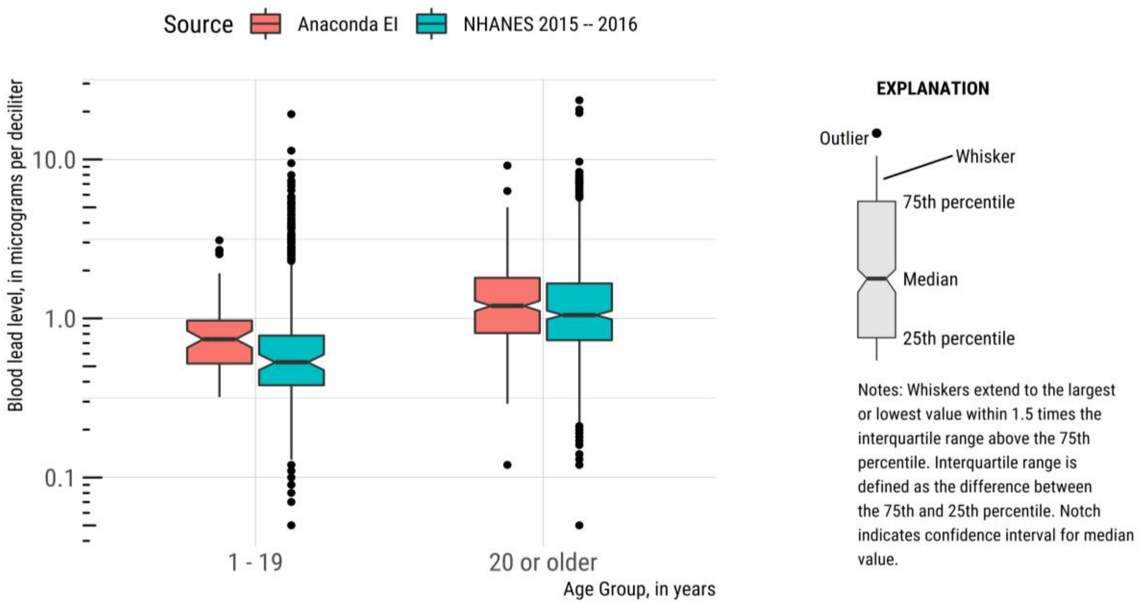
Figure 3: Anaconda Blood Lead Levels Compared to NHANES Values*



*NHANES 2015-2016 data set

Figure 3 provides the median estimates for Anaconda BLL compared to NHANES within boxplots of the overall distribution of the EI and NHANES. ATSDR used post stratification to match the age characteristics of the Anaconda EI group (which was generally older), as age is an important predictor of blood lead levels. All participants tested had measurable lead in the blood (level of detection = 0.07 µg/dL). In addition to comparing BLLs to the blood reference level of 5 µg/dL, BLLs were also compared to values that are representative of the median value found in blood in the U.S. population (Figure 4). ATSDR used post stratification to match the age characteristics of the Anaconda EI group (which was generally older), as age in an important predictor of blood lead levels. The Anaconda residents had a median BLL of 1.1 µg/dL (95% confidence interval [CI] 1.0 – 1.2 µg/dL) which was slightly higher compared to the median BLL in age – adjusted NHANES of 0.95 µg/dL (95% CI 0.86 – 1.0 µg/dL) (difference of 0.15 µg/dL) [CDC 2019a]. The difference is not clinically significant.

Figure 4: Boxplots of Anaconda blood lead levels compared to NHANES Values*



*NHANES 2015-2016 data set

Linear regression of the log transformed BLL values with the questionnaire results suggest that occupational exposure to lead may be a contributing factor in BLL (Appendix E). After controlling for the effects of age, diet and being male, we found that having a household member employed in a construction or maintenance job, and entering their attic more than once per month, were associated with higher BLLs.

4.4 Urinary Arsenic Levels

Arsenic and Health Effects

Arsenic is a naturally occurring element that is found in combination with either inorganic or organic substances to form many different compounds. Arsenic often occurs naturally with lead. Arsenic is also released into the environment from mining, ore smelting, and industrial use. Inorganic arsenic compounds are of greater concern for toxicity than organic arsenic compounds and are found in soils, sediments, groundwater, and some foods. People are most likely exposed to excessive amounts of inorganic arsenic through drinking water. Other potential sources of inorganic arsenic exposure can include contact with contaminated soil or with wood preserved with arsenic. [ATSDR 2007c].

Fish and shellfish commonly contain organic arsenic compounds that can lead to organic arsenic exposure in people consuming seafood. Chicken may also be a dietary source of organic arsenic. Rice may be a source of dietary inorganic arsenic **[**CDC 2019b]. Organic arsenic is less toxic than its inorganic form, which is generally associated with environmental exposures [Schoof 1999; ATSDR 2007c].

Inorganic arsenic is well absorbed from the gastrointestinal tract and, to a lesser degree, from inhalation. Inorganic arsenic and its metabolites are rapidly metabolized and excreted from the body with elimination half-lives of around 2-4 days. Therefore, urinary arsenic testing measures only recent exposures [ATSDR 2007c; Orloff et al. 2009]. Inorganic arsenic crosses the human placenta [ATSDR 2007b]. Inorganic arsenic is found in trivalent (arsenite) and pentavalent (arsenate) forms. Trivalent arsenic is substantially more toxic and carcinogenic than pentavalent arsenic [ATSDR 2007b]. Inorganic arsenic has been used as an outdoor wood preservative, as a semiconductor in dopant materials, in some pesticides and in certain medicines.

Inorganic arsenic has been linked to skin, liver, bladder, and lung cancer, and the Department of Health and Human Services (DHHS) has designated it as known to be a human carcinogen [ATSDR 2007c].

Arsenic also induces a wide variety of non-cancer effects in humans. Unusually large doses of inorganic arsenic can cause symptoms ranging from nausea, vomiting, and diarrhea to dehydration and shock. Swelling of the face and cold-like symptoms which go away and are followed by a rash or numbness are also associated with acute exposure [Mizuta 1956]. Long-term exposure to high levels of inorganic arsenic in drinking water has been associated with skin disorders (e.g., hyperkeratosis and hyperpigmentation) and increased risks for diabetes and high blood pressure [ATSDR 2007c].

All participants were tested for total arsenic as well as speciated arsenic in order to differentiate organic from inorganic arsenic. Creatinine was also evaluated to correct for dilution variation. For each participant, the total arsenic results were creatinine-corrected, as age-appropriate, and compared to the 95^{th} percentile NHANES values (2015-2016 data set for all species except UTMO (2011-2012 data set); CDC 2019). For inorganic arsenic, ATSDR uses a conservative approach by comparing the total of the participant's inorganic arsenic species results (sum of UAS5, UAS3, DMA and MMA) to NHANES values [CDC 2019]. Participants who exceed the 95^{th} percentile NHANES value for total arsenic and total inorganic arsenic were contacted by the ATSDR Medical Officer to discuss whether further evaluation may be warranted. The results of the questionnaire were used to evaluate organic arsenic exposure, since most exposure to organic arsenic is dietary.

Urine Arsenic Results

As indicated above, all urine specimens were analyzed for total arsenic, speciated arsenic, creatinine and specific gravity. Seven arsenic species were analyzed: three methylated metabolites (organic) [UASB, UASC and UTMO] and four inorganic arsenic species [UAS5, UAS3, DMA and MMA]. The urine test results were creatinine-corrected, as age appropriate. To evaluate urinary inorganic arsenic, the four inorganic arsenic species were combined because the NHANES values provide comparison to the sum of the inorganic species.

Each participant's creatinine-corrected, total urinary arsenic level and speciated arsenic levels were compared to the 95th percentile value reported in NHANES [CDC 2019], as indicated in Table 6.

Table 6. NHANES Levels (95th percentile) Used for Urinary Arsenic Comparison for Individual Results

	NHANES Level (µg/g Creatinine)*				
Age	**Total Arsenic**	**Inorganic Arsenic†**	**Organic Arsenic**		
			UASB	**UASC**	**UTMO**
Less than 3 yr	NA	NA	NA	NA	NA
3 to 5 yrs	40.90	23.70	20.5	1.06	NA
6 to 11 yrs	28.10	17.70	17.1	0.571	1.06
12 to 19 yrs	22.30	12.90	12.3	0.421	<0.17
≥ 20 yrs	56.20	16.1	36.6	0.533	<0.17

* - Data from the 2015-2016 data set (CDC 2019); Data for UTMO was from the 2011-2012 data set
† - Inorganic arsenic includes a sum of UAS5, UAS3, DMA and MMA
NHANES = National Health and Nutritional Examination Survey; UASB = arsenobetaine; UASC = arenochloine; UTMO = trimethylarsine; UAS5 = arsenic (V) acid; UAS3 = arsenous (III) acid; DMA = dimethylarsinic acid; MMA = monomethylarsonic acid

The following conclusions were drawn based on this comparison for individual participants:

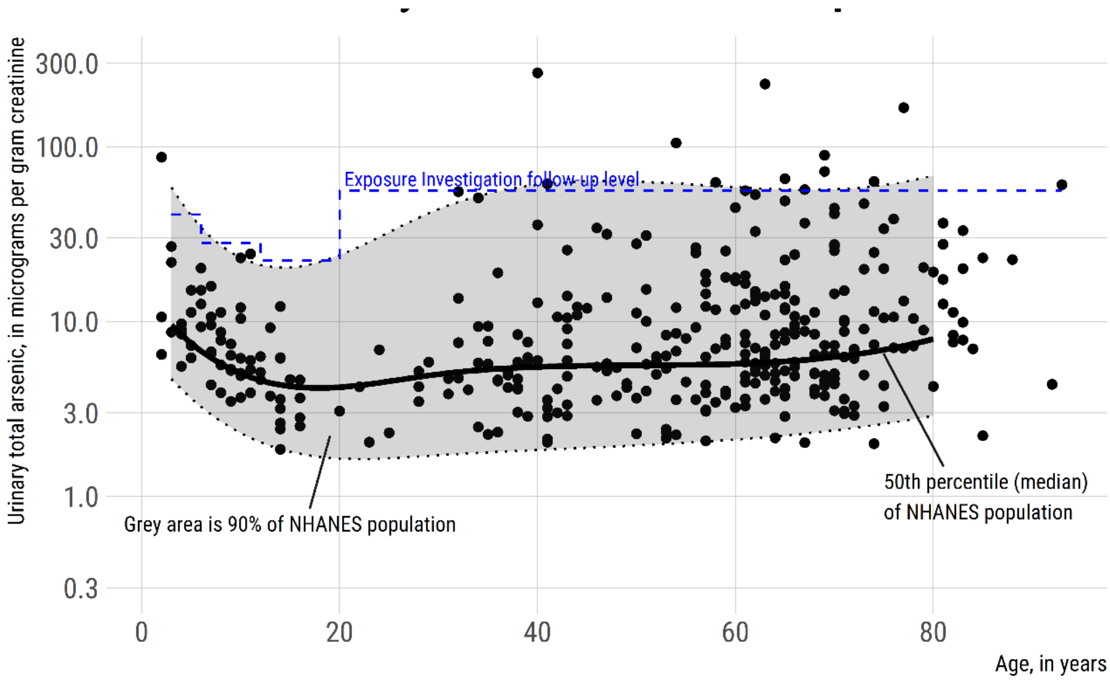
- Total arsenic: four adult participants from the September testing and eight adult participants from the November testing had total arsenic results greater than the age-specific NHANES values provided in Table 6.
    - NHANES values are only provided for children 3 years or older. There was one child younger than 3 years that had a higher-than-expected total urinary arsenic result (87.1 µg/gm Cr), but there is no NHANES value that can be used for comparison. Given the level, the child's parents were called by the EI Medical Officer to discuss the elevated results and to provide recommendations to reduce exposure.
- Inorganic arsenic: one adult participant from the September testing and one adult and one child participant from the November testing had inorganic arsenic results greater than the age-specific NHANES value provided in Table 6. The results of the questionnaire provided insight into the potential source of the inorganic arsenic in the participants (e.g., participants have remodeled their home, including their attic or lived with a family member that is employed in an occupation associated with metals exposure). In addition to the standard results letter, the three participants were called by the EI Medical Officer

to discuss their elevated results and provided recommendations to reduce exposure.

- Organic arsenic: approximately 5% of tested participants had organic arsenic that was above the age-specific NHANES value provided in Table 9. The questionnaire provided information that these residents had eaten a diet consisting of arsenic-containing foods (e.g., fish, chicken, rice) in the week prior to testing.

Figure 5 provides the urinary levels for total arsenic found in all the EI participants versus age. The urinary total arsenic levels include both organic and inorganic forms of arsenic with the inorganic forms of arsenic being of potential health concern and the organic forms being associated with exposure to arsenic in the diet. The dots in the figure represent each of the participants in the EI where urinary total arsenic was analyzed. Figure 5 shows the age of each participant and the urinary total arsenic level in comparison to NHANES and the age-specific follow-up level for urinary total arsenic. The black line indicates the 50^{th} percentile (median) of the NHANES population and the grey area outlines the area that reflects 90% of the NHANES population (bordered on the top by the 95^{th} percentile and on the bottom by the 5^{th} percentile). Several participants had urinary total arsenic levels above the follow-up level, especially adult participants.

Figure 5: Anaconda Urinary Total Arsenic Compared to NHANES*



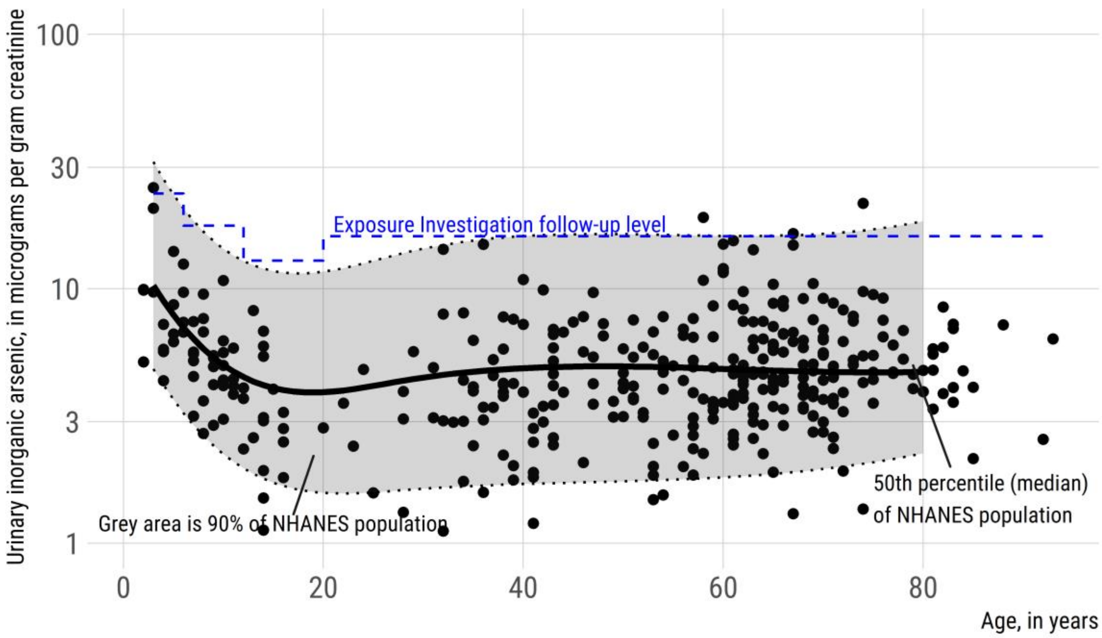
*NHANES 2015-2016 data set

As noted above, there were several participants that had an elevated level of total arsenic in their urine sample. Speciation of all urine samples was completed to determine whether urinary total arsenic levels were associated with inorganic or organic forms of arsenic. Figure 6 provides the urinary levels for inorganic arsenic, the more toxic form of arsenic, found in the EI participants versus age. The dots in the figure represent each of the participants in the EI where urinary inorganic arsenic was analyzed. The black line indicates the 50th percentile (median) of the NHANES population and the grey area outlines the area that reflects 90% of the NHANES population. Two adult and one child participants had slightly elevated urinary inorganic arsenic levels. The EI Medical Officer discussed ways to reduce potential arsenic exposure with these participants.

For urinary inorganic arsenic, one participant from the September testing (age 58) and two participants from the November testing (age 3 and 74) had inorganic arsenic results greater than the age-specific 95th percentile of NHANES. For perspective, if there were no differences between the Anaconda EI participants and the U.S. population, we would have expected about 18 participants to be higher than the 95% due to chance alone. The EI Medical Officer called the three participants were to discuss their elevated results and provide recommendations to reduce exposure.

For organic arsenic, 16 EI participants had UASB greater than the 95th percentile of NHANES, and four EI participants had UASC levels greater than the 95th percentile of NHANES. UTMO was detected in four EI participants (detected values range from 0.276 – 7.2 µg/gm Cr). In the NHANES 2011-2012 data set, it was detected in approximately 3% of the NHANES population (range 0.11 – 9.2 µg/gm Cr).

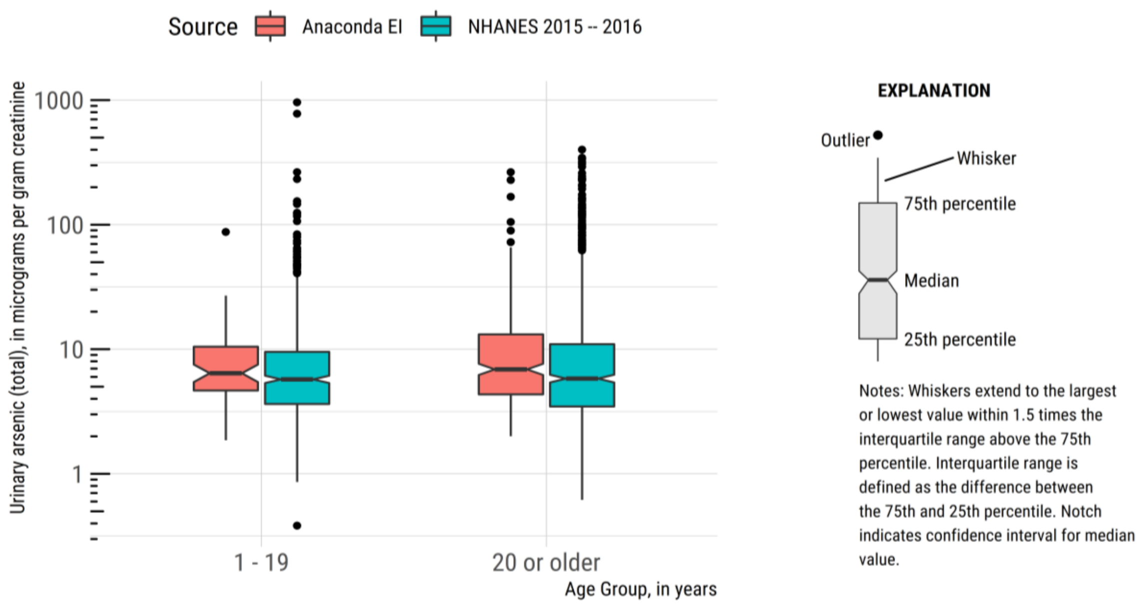
Figure 6: Anaconda Urinary Inorganic Arsenic Compared to NHANES Values*



*NHANES 2015-2016 data set

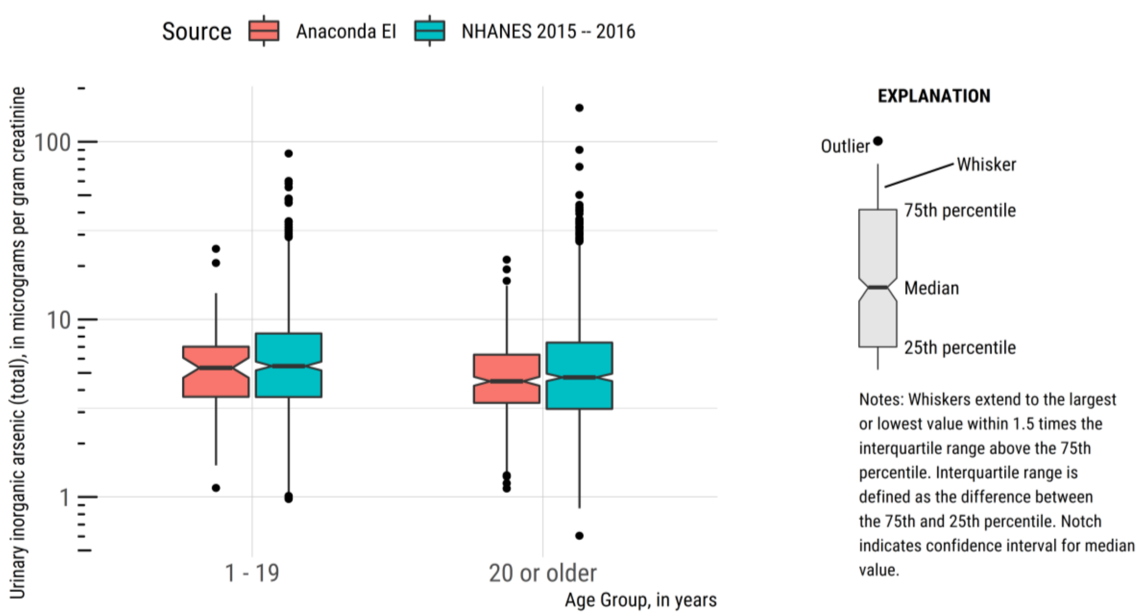
ATSDR compared the Anaconda EI urinary total and inorganic arsenic to NHANES values in (see Table 6 for NHANES values) at the 95th percentile, the median, as well as the 25th and 75th quantile values (Figures 7, 8, 9, and 10). For the Anaconda EI participants, the median urinary total arsenic of 6.7 of arsenic per gram of creatinine (µg/gm Cr) (95% CI 6.2 – 7.4 µg/gm Cr) was 0.9 µg/gm Cr higher than the age-adjusted NHANES median of 5.8 (µg/gm Cr (95% CI 5.5 – 6.1 µg/gm Cr). However, Anaconda EI participants had a median urinary total inorganic of 4.6 µg/gm Cr (95% CI 4.3 – 4.8 µg/gm Cr), which was lower than the age – adjusted NHANES median of 4.8 (95% CI 4.6 – 5.1 µg/gm Cr) (difference of 0.2 µg/gm Cr). This result indicates that the increase in total arsenic is associated with organic arsenic. The responses to the questionnaire, in which participants reported eating food potentially containing organic arsenic (e.g., seafood, chicken) in the week preceding the testing, are consistent with this finding. Organic arsenic is not harmful to humans at these levels [ATSDR 2007c].

Figure 7: Boxplots of Anaconda urinary total arsenic compared to NHANES*



*NHANES 2015-2016 data set

Figure 8: Boxplots of Anaconda urinary inorganic arsenic compared to NHANES*



*NHANES 2015-2016 data set

4.5 Correlation of Blood Lead and Urinary Arsenic Levels

ATSDR analyzed the correlation between BLL and urine arsenic levels. Pearson correlation coefficients between log transformed urine total arsenic, urine inorganic arsenic, and blood lead identified significant ($p < 0.01$) correlations exist between urine and blood measurements, but the strength of the relationship is weak between lead and total and inorganic arsenic (r = 0.22 and 0.26, respectively).

The weak correlation suggests that people with low BLL values may still be at risk for increased urine arsenic values and vice versa. Public health actions should not assume that risk reduction of exposure to one site contaminant ensures protective public health actions for the other contaminant.

5.0 Limitations of this Exposure Investigation

All investigations have some inherent limitations. This EI has the following limitations:

- The results of this EI are applicable only to the individuals tested and cannot be generalized to other populations.
- The results cannot be used to predict the future occurrence of disease in individuals.
- The sampling offers insight into current levels of exposure to lead and arsenic. The investigation methodology does not measure past exposures. Elevated blood lead indicates there was exposure to lead. However, results do not provide information to determine when the exposure occurred. As stated before, the results are a 'snapshot in time' of current levels in peoples' bodies.

6.0 EI Conclusions

- The overall conclusion of the EI is that levels of blood lead and urinary arsenic measured in residents of Anaconda that participated in the EI are comparable to the U.S. population, as reported in NHANES.
- All 18 children younger than 6 years old who participated in the testing events measured a BLL below the 5 µg/dL follow-up level.
- The median BLL for all EI participants was approximately 0.15 µg/dL higher than the U.S. median, but this difference is not clinically significant.
- For arsenic, Anaconda EI participants had a slight elevation in total urinary arsenic (approximately 0.9 µg/gm Cr higher) compared to NHANES participants. The elevation in total arsenic, however, appears to be attributable to organic arsenic given that the level of inorganic arsenic was slightly lower (0.2 µg/gm Cr) than comparable NHANES values. Organic arsenic enters the body through diet and is not toxic at these levels. The organic arsenic testing results correlated to participants who reported eating foods high in organic arsenic. ATSDR would not anticipate health effects associated with urine arsenic levels measured in the Anaconda participants.
- Evaluation of the questionnaire administered at the time of the testing suggests that people can take measures to further reduce their exposure to lead. The analysis of

questionnaire data in relation to BLL indicates that people who reported working in construction and maintenance jobs had higher BLLs.

- Many Anaconda attics are contaminated with lead and arsenic as a result of smelter activities in the past. Participants who reported entering their attics on a regular basis generally had higher BLL and total arsenic than other participants.
- ***The EI results do not mean that the risk of exposure to lead and arsenic in Anaconda has been eliminated; residents should continue to be proactive in preventing exposure.***

7.0 EI Recommendations

ATSDR identified specific actions, consistent with prudent public health practice that may further reduce the risk of lead and arsenic exposures in Anaconda residents. ATSDR recommends primary prevention efforts to avoid exposure to lead and arsenic in soil. ATSDR supports the following recommendations and public health actions.

- Anaconda citizens (including landlords) should participate in the Superfund Community Soils OU residential yard and attic clean-up programs as a primary mechanism for reducing potential exposure to lead and arsenic. Through the Superfund program (funded by ARCO with EPA oversight), residents may opt for soil and attic testing. Based on the results, residents can qualify for a contractor to clean contaminated attics. EPA and ADLC should make efforts to increase participation in these programs. In the meantime, ATSDR recommends that residents minimize time (or seal entryway) in untested or contaminated (but not yet remediated) attics.
- Anaconda citizens should take prudent actions to avoid contact with potentially contaminated soil. These actions include:
    - Avoid areas of known contamination (e.g., slag piles) and instruct children not to play or ride bikes there;
    - Supervise children closely to modify or eliminate risky hand-to-mouth behaviors or intentional eating of dirt (pica behavior);
    - Damp mop and damp dust surfaces;
    - Cover bare soils with vegetation (grass, mulch, etc.) and create safe play areas for children with clean ground cover;
    - Remove shoes before entering the home;
    - Bathe pets regularly to avoid them tracking contaminated soil into homes.

- Anaconda citizens should take precautions to prevent exposure to lead from lead paint during house renovations in homes build prior to 1978. Information is available at: https://www.epa.gov/lead/protect-your-family-lead-your-home.
- The EPA and ARCO should minimize risk of exposure to lead and arsenic from uncovered slag through improved signage (specifically uncapped slag piles) and Superfund remedial actions.

- The ALDC Health Department should conduct regular BLL screenings for children under age 6 based on risk identified from site contamination and the AAP recommendation [AAP, 2016] of regular BLL screenings for communities with a significant portion of homes built before 1960. Ensure venous draws and physician follow-up for capillary BLL at or above the CDC Reference value of 5 µg/dL.
- Primary healthcare providers should continue to improve understanding of lead screening and ways to reduce exposure to site contaminants and lead paint. ATSDR's Case Studies in Environmental Medicine (CSEM) provide a self-instructional primer. The lead and arsenic CSEMs are available at:
  https://www.atsdr.cdc.gov/csem/csem.asp?csem=34&po=0
  https://www.atsdr.cdc.gov/csem/csem.asp?csem=1&po=0
- People working in jobs where lead and arsenic are present should use appropriate personal protective equipment (PPE) while on the job to reduce exposure. Regular hand washing and removing outer garments before entering the home after work reduces exposures and protects family members.

8.0 Public Health Action Plan

The Public Health Action Plan for Anaconda contains a description of actions completed and proposed actions by ATSDR, EPA and ARCO. The purpose of the EI is to ensure that we identify exposures that may be of public health concern and to provide a plan of action designed to prevent or mitigate adverse human health effects from contaminant exposure. ATSDR will follow-up on this plan to ensure these actions are carried out.

8.1 Actions Completed

1. In December 2018 and February 2019, ATSDR sent each participant a letter informing them of their BLL and urinary arsenic results and the EI Medical Officer called participants that had levels above or approaching the follow-up level.

2. In September 2018, Grand Rounds were completed in Butte and Anaconda, MT. Educational materials containing information regarding impacts of lead and arsenic were provided to physicians in the area to assist with patient management.

8.2 On-going Actions

1. ARCO continues to test and remediate yard soil per their remediation plan under EPA oversight.
2. ARCO continues to test attics per their remediation plan. Some of these may be remediated.
3. The ADLC HD screens children in the Women, Infants, and Children (WIC) program for lead exposure.

8.3 Actions Proposed

1. ATSDR will provide the results, conclusions and recommendations to the community in a public meeting to be held in Anaconda the fall of 2019.

2. ATSDR will be available to community leaders and physicians in Anaconda to continue to provide information and recommendations regarding how to reduce exposure to metals in Anaconda.

3. ATSDR will partner with EPA, MT DPHHS and the ADLC HD to inform the Anaconda community about the health benefits that can be gained by participating in existing soil and attic remediation programs.

4. ATSDR will partner with MT DPPHS and ADLC to identify best practices in screening children for lead exposure.

5. ATSDR will partner with EPA, MT DPHHS and the ADLC HD to educate workers with potential occupational exposure to lead and arsenic about ways to reduce occupational exposure and minimize tracking contamination into the home.

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Acknowledgements

ATSDR is appreciative of the personnel who were involved in recruitment, sampling and data analysis for the EI, including ATSDR Personnel:

- Dr. Lourdes Rosales-Guevara
- Dr. Arthur Wendel
- Loretta Asbury
- Susan McBreairty

EPA Personnel:

- Charles Partridge
- Charles Coleman

Division of Laboratory Services (DLS) at the National Center for Environmental Health (NCEH):

- Sina De Leon Salazar
- Kathleen Caldwell
- Angela Hicks

Anaconda Deer Lodge County Health Department (ADLC HD)

- Kitty Basirico

Montana Department of Public Health and Human Services (MTDPHHS)

Laura Williamson
Todd Harwell
Connie Garrett
Heather Welch
Hallie Koeppen
Kristen Rogers
Lisa Schmidt
Jen Fladager
Matthew Ferguson
Jessica Miller
Dorota Carpenedo
Victoria Troeger
Carrie Oser
Robin Silverstein
Alex Long
Heather Zimmerman

Finally, ATSDR wants to thank the community, for its participation and collaboration on this EI, including members of the Anaconda city council and local government.

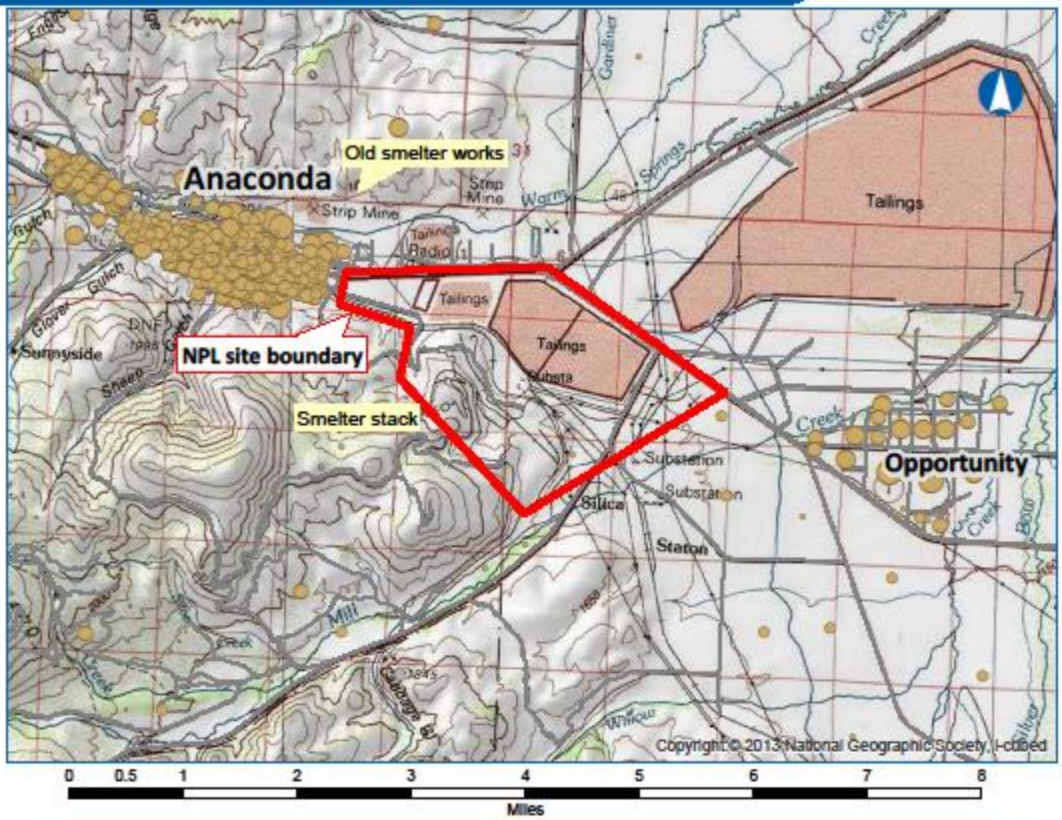
Appendix A: Anaconda Deer Lodge County Map and Demographics

Anaconda Co. Smelter

Anaconda, Deer Lodge County, MT

POPULATION PROFILE

EPA FACILITY ID MTD093291656



Demographic Statistics: Deer Lodge County, Montana

Data Source: American Community Survey, 2015 (US Census Bureau)

Measure	Estimate
Total Population	9,139
White Alone	8,487
Black Alone	45
Am. Indian & Alaska Native	333
Asian Alone	46
Native Hawaiian & Other Pacific Islander Alone	8
Some Other Race Alone	20
Two or More Races	220

Measure	Estimate
Hispanic or Latino Individuals identifying origin as Hispanic or Latino may be of any race.	275
Children Under Age 5	348
Adults Aged 65 and Older	1,002
Females Aged 15 to 44	1,318
Housing Units	5,179
Housing Units Pre 1980	4,143
Percent of population with income below poverty level	28%

Map legend

Population, 2010
(By census block)

- 1 - 5
- 6 - 10
- 11 - 25
- 26 - 50
- 51 - 131

PRJ 08226 LOY3 3/6/18

GRASP

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Human Health Sciences

ATSDR

Appendix B: Summary of Cancer Incidence in Anaconda Deer Lodge County

In 2018, residents of Anaconda expressed concern to local and state agencies that there may be too much cancer in the Anaconda community. Also, people were not sure what kinds of cancer among Deer Lodge County residents might be related to the heavy metal contamination. The Montana Cancer Control Program conducted analyses to determine if new cancer cases and cancer death rates among Deer Lodge County residents from 1985-2016 were statistically the same as the rest of Montana. The rate of new cancer cases remains the same among Deer Lodge County residents when compared to all Montana residents. Similar results were observed for rates of cancer deaths where no significant differences were observed.

Residents also wanted to know what cancers were associated with arsenic and lead exposures. Currently, there is no conclusive evidence that lead causes cancer in humans. However, arsenic is known to cause lung, urinary bladder, and skin cancers; and it is also associated with kidney, liver, and prostate cancers. The Montana Department of Public Health and Human Services (DPHHS) looked and compared data specific to these cancer types. Using data from 1985 to 2016, there were no significant differences between Deer Lodge County residents and the state's rates of observed new cancer cases for lung cancer, prostate cancer, kidney cancer, and bladder cancer (looking at a range of years from 1985-2016). Finally, Anaconda census tracks were identified and incidence rates within these areas were used to compare to the expected number of cases (Figure D.1). Since 2009 and with an average of 38 new cancer cases identified among Anaconda residents each year, the rates of new cancers cases are not occurring at rates higher than the rest of Montana.

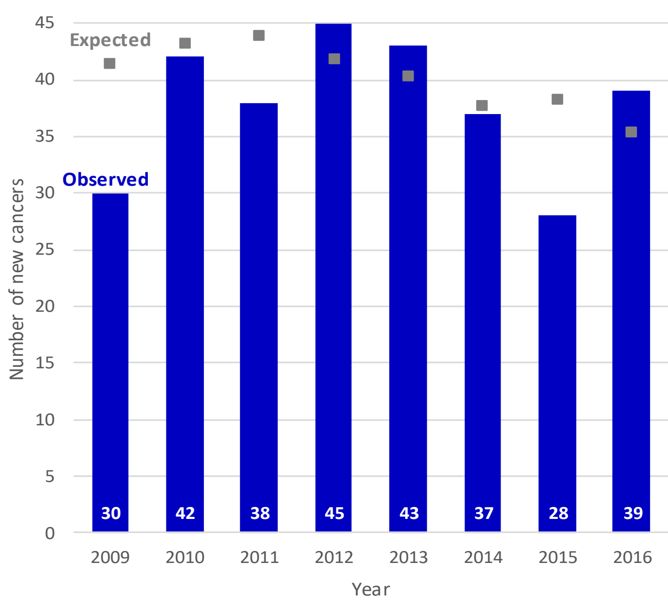


Figure D.1 Number of new cancer cases observed among Anaconda residents compared to how many were expected

Appendix C: Demographic and 2010 Census Information

Appendix C. Demographic Information				
	Testing Event			
	September	**November**	**Total**	**Info from 2010 Census***
Children Younger than 6 yrs				
	3/191 (1.6%)	15/177 (8.5%)	18/368 (4.9%)	348/9,139 (3.8%)
Gender				
Children (≤ 19yrs)				
Male	17/28 (61%)	28/44 (64%)	45/72 (63%)	NA
Female	11/28 (39%)	16/44 (36%)	27/72 (38%)	
Adult (≥ 20 yrs)				
Male	68/163 (42%)	60/133 (45%)	128/296 (43%)	
Female	95/163 (58%)	73/133 (55%)	168/296 (57%)	
Ethnicity				
Mexican Descent				
Children	4/28 (14%)	1/44 (2%)	5/72 (7%)	3%
Adults	3/163 (2%)	3/133 (2%)	6/296 (2%)	
Race†				
White				
Children	25/25 (100%)	42/44 (95%)	67/69 (97%)	93%
Adults	157/161 (98%)	127/132 (96%)	284/293 (97%)	
American Indian/Alaska Native				
Children	0/25 (0%)	2/44 (5%)	2/69 (3%)	3%
Adults	3/161 (2%)	4/132 (3%)	7/293 (2%)	
Home Information				
Lived in Anaconda more than 10 years‡				
Adults	126/163 (77%)	97/133 (73%)	223/296 (75%)	NA
Lives in a Single Family Home				
Residents	179/191 (94%)	164/177 (93%)	343/368 (93%)	NA
Lives in a home older than 1980				
Children	22/28 (79%)	39/44 (89%)	61/72 (85%)	80%

Adults	126/163 (77%)	101/133 (76%)	227/296 (77%)	
EPA has removed soil from resident's yard				
Residents	44/191(23%)	54/177 (31%)	98/368 (27%)	NA
Attic professionally clean				
Residents	18/191 (9%)	18/177 (10%)	36/368 (10%)	NA
Lifestyle				
Lives in a home where someone works at a job associated with lead exposure				
Residents	35/191 (18%)	53/177 (30%)	88/368 (24%)	NA
Takes off shoes before entering home (never or seldom)§				
Residents	105/190 (55%)	85/176 (48%)	190/366 (52%)	NA
Diet of Participants				
Seafood	55/191 (29%)	76/177 (43%)	131/368 (36%)	NA
Rice	84/191 (44%)	83/177 (47%)	167/368 (45%)	
Chicken	154/191 (81%)	153/177 (86%)	307 (368 (83%)	

* The demographic information from the 2010 census is provided in Appendix A.

† Three children and two adults in the September testing and 1 adult in the November testing did not respond to the race question

ǂ The results represent the number of adults that have lived in Anaconda more than 10 years since the results for children vary by the child's age

§ One participant in each sampling event did not answer the question regarding shoe removal

Appendix D: PESHU Recommendations for Lead

PEHSU
Pediatric Environmental Health Specialty Units

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

Recommendations on Medical Management of Childhood Lead Exposure and Poisoning

No level of lead in the blood is safe. In 2012, the CDC established a new "reference value" for blood lead levels (5 mcg/dL), thereby lowering the level at which evaluation and intervention are recommended (CDC).

Lead level	**Recommendation**
< 5 mcg/dL	1. Review lab results with family. For reference, the geometric mean blood lead level for children 1-5 years old is less than 2 mcg/dL. 2. Repeat the blood lead level in 6-12 months if the child is at high risk or risk changes during the timeframe. Ensure levels are done at 1 and 2 years of age. 3. For children screened at age < 12 months, consider retesting in 3-6 months as lead exposure may increase as mobility increases. 4. Perform routine health maintenance including assessment of nutrition, physical and mental development, as well as iron deficiency risk factors. 5. Provide anticipatory guidance on common sources of environmental lead exposure: paint in homes built prior to 1978, soil near roadways or other sources of lead, take-home exposures related to adult occupations, imported spices, cosmetics, folk remedies, and cookware.
5-14 mcg/dL	1. Perform steps as described above for levels < 5 mcg/dL. 2. Re-test venous blood lead level within 1-3 months to ensure the lead level is not rising. If it is stable or decreasing, retest the blood lead level in 3 months. Refer patient to local health authorities if such resources are available. Most states require elevated blood lead levels be reported to the state health department. Contact the CDC at 800-CDC-INFO (800-232-4636) or the National Lead Information Center at 800-424-LEAD (5323) for resources regarding lead poisoning prevention and local childhood lead poisoning prevention programs. 3. Take a careful environmental history to identify potential sources of exposures (see #5 above) and provide preliminary advice about reducing/eliminating exposures. Take care to consider other children who may be exposed. 4. Provide nutritional counseling related to calcium and iron. In addition, recommend having a fruit at every meal as iron absorption quadruples when taken with Vitamin C-containing foods. Encourage the consumption of iron-enriched foods (e.g., cereals, meats). Some children may be eligible for Special Supplemental Nutrition Program for Women, Infants and Child (WIC) or other nutritional counseling. 5. Ensure iron sufficiency with adequate laboratory testing (CBC, Ferritin, CRP) and treatment per AAP guidelines. Consider starting a multivitamin with iron.

	6. Perform structured developmental screening evaluations at child health maintenance visits, as lead's effect on development may manifest over years.
15-44 mcg/dL	1. Perform steps as described above for levels 5-14 mcg/dL. 2. Confirm the blood lead level with repeat venous sample within 1 to 4 weeks. 3. Additional, specific evaluation of the child, such as abdominal x-ray should be considered based on the environmental investigation and history (e.g., pica for paint chips, mouthing behaviors). Gut decontamination may be considered if leaded foreign bodies are visualized on x-ray. Any treatment for blood lead levels in this range should be done in consultation with an expert. Contact local PEHSU or PCC for guidance; see resources on back for contact information.
>44 mcg/dL	1. Follow guidance for BLL 15-44 mcg/dL as listed above. 2. Confirm the blood lead level with repeat venous lead level within 48 hours. 3. Consider hospitalization and/or chelation therapy (managed with the assistance of an experienced provider). Safety of the home with respect to lead hazards, isolation of the lead source, family social situation, and chronicity of the exposure are factors that may influence management. Contact your regional PEHSU or PCC for assistance; see resources on back for contact information.

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Principles of Lead Exposure in Children
• A child's blood lead concentration depends on their environment, habits, and nutritional status. Each of these can influence lead absorption. Children with differing habits or nutritional status but who live in the same environment can vary on blood lead concentration. Further, as children age or change residences, habits or environments change creating or reducing lead exposure potential. • While clinically evident effects such as anemia, abdominal pain, nephropathy, and encephalopathy are seen at levels >40 µg/dL, even levels below 10 µg/dL are associated with subclinical effects such inattention and hyperactivity, and decreased cognitive function. Levels above 100 µg/dL may result in fatal cerebral edema. • Lead exposure can be viewed as a lifelong exposure, even after blood lead levels decline. Bone acts as a reservoir for lead over an individual's lifetime. Childhood lead exposure has potential consequences for adult health and is linked to hypertension, renal insufficiency, and increased cardiovascular-related mortality. • Since lead shares common absorptive mechanisms with iron, calcium, and zinc, nutritional deficiencies in these minerals promotes lead absorption. Acting synergistically with lead, deficiencies in these minerals can also worsen lead-related neurotoxicity.

Principles of Lead Screening
• Lead screening is typically performed with a capillary specimen obtained by a finger prick with blood blotted onto a testing paper. Testing in this manner requires that the skin surface be clean; false positives are common. Therefore, elevated capillary blood lead levels should be followed by venipuncture testing to confirm the blood lead level. In cases where the capillary specimen demonstrates an elevated lead level but the follow-up venipuncture does not, it is important to recognize that the child may live in a lead-contaminated environment that resulted in contamination of the finger tip. Efforts should be made to identify and eliminate the source of lead in these cases. Where feasible, lead screening should be performed by venipuncture.

Principles of Iron Deficiency Screening
• The iron deficiency state enhances absorption of ingested lead.
• Hemoglobin is a lagging indicator of iron deficiency and only 40% of children with anemia are iron deficient.
• Lead exposed children (≥ 5 mcg/dL) are at risk for iron deficiency and should be screened using CBC, Ferritin, and CRP. Alternatively, reticulocyte hemoglobin can be used, if available.
• Children with iron deficiency, with or without anemia, should be treated with iron supplementation.

Resources	
• Pediatric Environmental Health Specialty Unit (PEHSU) Network	• www.pehsu.net or 888-347-2632
• Poison Control Center (PCC)	• www.aapcc.org/ or 800-222-1222
• Centers for Disease Control and Prevention	• www.cdc.gov/nceh/lead/ or 800-232-4636
• U.S. Environmental Protection Agency	• www.epa.gov/lead/ or 800-424-5323

Suggested Reading and References:
Pediatric Environmental Health, 3rd edition. American Academy of Pediatrics, 2012.
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Levin R, et al. *Environmental Health Perspectives* 2008; 116(10):1285-1293.
Baker RD, Greer FR. *Pediatrics* 2010;126(5):1040-50.
Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women. CDC, 2010.
CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in "Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention" June 7, 2012

This document was supported by the Association of Occupational and Environmental Clinics (AOEC) and funded (in part) by the cooperative agreement award number 1U61TS000118-04 from the Agency for Toxic Substances and Disease Registry (ATSDR).

Acknowledgement: The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing funds to ATSDR under Inter-Agency Agreement number DW-7592301301-0. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications. (June 2013 update)

Appendix E: Analysis of Blood Lead and Total Urinary Arsenic Levels for Anaconda Participants

Methods

We matched participant questionnaire results with laboratory results for lead and arsenic by participant identification number. There was one participant who returned for retesting in November, so we averaged the results of blood lead and urinary arsenic for this participant. Geometric means were calculated for the questions and 95% confidence intervals were generated using t-statistics of the log-transformed values [Helsel 2012]. We combined categorical responses that had a low number of responses for the purposes of analysis. Since there were often multiple participants from a single address, linear mixed effects model (lmer) [Kuznetsova et al. 2017] was used to age adjust measures of association by demographic and questionnaire responses using a b-spline to account for the non-linear effects of age. We modeled each address as a random intercept in the lmer to account for random differences in lead levels at each address. Since the regression was performed on the log transformed variable, the measures of effect (Beta) are ratios of model predicted geometric means after controlling for the effect of age. We first performed analysis of each questionnaire individually (bi-variate analysis), controlling for the fixed effects of age, and the random effect of address. From the bivariate analysis, we considered any factor with a p-value less than 0.1 as a candidate factor in the multivariate analysis. After elimination of redundant and collinear variables (such as time in Anaconda, time at address), we used forward selection of variables using corrected Akaike Information Criterion to arrive at the best fitting lmer [Long 2012]. We modeled only blood lead and total urinary arsenic because they were slightly higher than the referent age adjusted NHANES 2015 – 2016 population. If the participant was a minor, ATSDR asked 3 specific questions related to potential for hand – mouth transfer of dust or direct ingestion of soil. We analyzed these questions individually for the 71 participants who were minors but did not develop a full multivariate model because of the small sample size.

Results

Blood lead

Results of the bivariate analysis are shown in Tables

Table E - 1 and E - 2. In addition to age and sex, we found the following to be potentially associated with higher blood lead levels after controlling for the effect of age:

- hours per day outside, (greater than 6 hours),
- entry into attic (respondent entering on daily or weekly basis),
- peeling paint in house (do not know),

- changing clothes (sometimes or always),
- occupation (self-reported job with contact with lead or slag, construction work, mechanical work),
- self-reported hobbies with contact with lead (firearms, hunting, or fishing), and
- consumption of 3 or more servings of rice in past week.

We found the following questionnaire responses to be potentially associated with lower blood lead levels after controlling for the effects of age:

- time at address (greater than 2 years),
- removing shoes (sometimes or always),
- never entering attic, and
- consumption of chicken in past week.

In the final fully adjusted model (Table E - 3), the lowest AICc was produced by a spline of age, with additive factors of sex, construction or maintenance, consumption of chicken, and entry into attic (daily or weekly). The marginal and conditional r – squared was 0.32 and 0.68, respectively, with an AICc of 493.85. To show the overall impact of these responses on blood lead in the lmer, predicted marginal geometric means were plotted for a 49.88 year old male (Figure E - 1) and showing all ages by sex (Figure E - 2) (Lüdecke 2018). In general, marginal effects were below 1 µg/dL, consistent with the comparison of the Anaconda EI participants to the NHANES 2015 – 2016. Children who responded as having behaviors that would increase soil or dust ingestion had slightly higher blood lead levels, but the effects on blood lead had relatively high p values, so we could not rule out the effects being a result of statistical chance alone (Table E - 2).

Urinary Total Arsenic

For urinary arsenic, we show results of the bivariate analysis in Table E - 4. After controlling for the effects of age, questionnaire responses that were potentially associated in the bivariate analysis with increased total urinary arsenic:

- sex (male),
- daily or weekly entry into attic,
- remove shoes (sometimes or always),
- use vacuum cleaner (several times a week or monthly),
- consume seafood

The following questionnaire responses were associated in the bivariate analysis with decreased total urinary arsenic:

- Enter attic (yearly), and,
- Change clothing when entering home (seldom do this, always do this).

As with the lead results, the child specific questions were not statistically associated with urinary total arsenic (**Error! Reference source not found.**). The model with the lowest AICc consisted of a spline of age and additive terms for sex, consumption of seafood, and entry into attic (Table E - 6).

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Helsel, DR. 2011. Statistics for Censored Environmental Data Using Minitab and R, Wiley.

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Tables

Table E - 1: Participant Questionnaire Results and Age-Adjusted Estimates of Association with Blood Lead, Anaconda EI (N=367, 9 missing blood lead results)

Abbreviations: CI: Confidence Interval, NA: Not Applicable, Ref: Reference Factor Level, SE: Standard Error

Risk Factor	*Value*	*Number of participants [missing blood lead]*	*Geometric mean blood lead [95% CI]*	*Estimate [SE]*	*Ratio of Geometric Means [CI]*	*p value (fixed effects)*
What is your or your child/ward's sex?	Female	194 [5]	1 [0.93--1.1]	Ref	Ref	Ref
	Male	**173 [4]**	**1.2 [1.1--1.4]**	**0.28 [0.046]**	**1.3 [1.2--1.4]**	**<0.001**
City	Anaconda	358 [8]	1.1 [1--1.2]	Ref	Ref	Ref
	Bozeman or Deer Lodge	9 [1]	1.1 [0.71--1.7]	-0.13 [0.25]	0.88 [0.54--1.4]	0.595
Are you or your child/ward Hispanic, Latino/a, or Spanish Origin? (one or more categories may be selected)	No	355 [8]	1.1 [1--1.2]	Ref	Ref	Ref
	Yes	11 [0]	0.97 [0.63--1.5]	0.16 [0.17]	1.2 [0.84--1.6]	0.360
	(Missing)	1 [1]	NA	NA	NA	NA
What is your or your child/ward's race? (one or more categories may be selected)	White	352 [8]	1.1 [1--1.2]	Ref	Ref	Ref
	Other	9 [0]	1.3 [0.81--2.2]	0.24 [0.19]	1.3 [0.88--1.8]	0.205
	(Missing)	6 [1]	0.7 [0.34--1.4]	NA	NA	NA
Do you or your child/ward spend time outside the home (e.g., work or daycare/school)?	No	43 [0]	1.5 [1.2--1.7]	Ref	Ref	Ref
	Yes	324 [9]	1.1 [1--1.2]	-0.043 [0.098]	0.96 [0.79--1.2]	0.658
If yes, how long are your or your child/ward out of the house during	0 hours	36 [0]	1.4 [1.2--1.7]	Ref	Ref	Ref
	1 to 4 hours	86 [2]	1.2 [1.1--1.4]	-0.06 [0.12]	0.94 [0.75--1.2]	0.605

Risk Factor	***Value***	***Number of participants [missing blood lead]***	***Geometric mean blood lead [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
the day?	5 to 8 hours	79 [1]	1.1 [1--1.3]	-0.012 [0.12]	0.99 [0.79--1.2]	0.921
	Over 8 hours	165 [6]	0.99 [0.89--1.1]	0.052 [0.12]	1.1 [0.84--1.3]	0.654
	(Missing)	1 [0]	NA	NA	NA	NA
If you or your child/ward are out of the house during the day, how many times per week?	0 days	36 [0]	1.4 [1.2--1.7]	Ref	Ref	Ref
	1-3 days per week	24 [0]	0.9 [0.64--1.3]	-0.2 [0.15]	0.82 [0.61--1.1]	0.175
	4 or more days per week	306 [9]	1.1 [1--1.2]	0.0071 [0.11]	1 [0.82--1.2]	0.946
	(Missing)	1 [0]	NA	NA	NA	NA
How many hours per day do you or your child/ward typically spend outdoors?	Do not spend time outdoors	7 [0]	1.3 [0.61--2.8]	Ref	Ref	Ref
	2 to 4 hours per day	150 [4]	1 [0.92--1.1]	0.15 [0.22]	1.2 [0.76--1.8]	0.491
	4 to 6 hours per day	59 [1]	1.1 [0.96--1.3]	0.21 [0.23]	1.2 [0.79--1.9]	0.351
	Less than 2 hours per day	104 [4]	1.1 [0.95--1.2]	0.14 [0.22]	1.1 [0.74--1.8]	0.535
	Over 6 hours per day	**46 [0]**	**1.5 [1.3--1.8]**	**0.52 [0.23]**	**1.7 [1.1--2.6]**	**0.024**
	(Missing)	1 [0]	2.9			
Approximately when was the building built?	pre1980	287 [4]	1.1 [1.1--1.2]	Ref	Ref	Ref
	post1980	62 [3]	1.1 [0.93--1.3]	-0.0085 [0.092]	0.99 [0.83--1.2]	0.926
	Don't know	17 [2]	0.84 [0.6--1.2]	-0.069 [0.16]	0.93 [0.68--1.3]	0.675
	(Missing)	1 [0]	NA	NA	NA	NA
How many hours per day do you or your child/ward typically spend in your attic?	Do not spend time in attic	343 [9]	1.1 [1--1.2]	Ref	Ref	Ref
	Spend time in attic	**16 [0]**	**1.7 [1.3--2.2]**	**0.32 [0.14]**	**1.4 [1.1--1.8]**	**0.021**
	(Missing)	8 [0]	1.2 [0.67--2]	NA	NA	NA
Does you or your child/ward wash hands before eating?	Always	231 [4]	1.2 [1.1--1.3]	Ref	Ref	Ref
	Never or Sometimes	136 [5]	1 [0.92--1.2]	0.19 [0.069]	1.2 [1.1--1.4]	0.007

Risk Factor	***Value***	***Number of participants [missing blood lead]***	***Geometric mean blood lead [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
How long have you lived at this address?	Less than 6 months	15 [1]	1.5 [1--2.2]	Ref	Ref	Ref
	6 months to less than 2 years	18 [0]	1.3 [0.93--1.8]	-0.28 [0.22]	0.76 [0.49--1.2]	0.205
	2 to 5 years	**81 [3]**	**0.98 [0.85--1.1]**	**-0.35 [0.18]**	**0.7 [0.5--1]**	**0.053**
	6 to 10 years	**52 [2]**	**0.95 [0.81--1.1]**	**-0.59 [0.18]**	**0.55 [0.39--0.79]**	**0.001**
	More than 10 years	**200 [3]**	**1.2 [1.1--1.3]**	**-0.54 [0.17]**	**0.58 [0.42--0.82]**	**0.002**
	(Missing)	1 [0]	NA	NA	NA	NA
Do you speak a language other than English at home? (5 years or older)	No	353 [9]	1.1 [1--1.2]	Ref	Ref	Ref
	Yes	11 [0]	1.6 [0.96--2.5]	0.045 [0.17]	1 [0.74--1.5]	0.797
	(Missing)	3 [0]	1.3 [0.088--20]	NA	NA	NA
Do you live in a(n):	Single Family Home	342 [8]	1.1 [1.1--1.2]	Ref	Ref	Ref
	Apartment, Townhouse, Condominium, or Other	18 [1]	0.88 [0.66--1.2]	-0.097 [0.17]	0.91 [0.65--1.3]	0.577
	Mobile Home	7 [0]	1.2 [0.62--2.3]	-0.13 [0.25]	0.88 [0.54--1.4]	0.594
Do the windows (e.g., sills) have peeling paint?	No	293 [7]	1.1 [1.1--1.2]	Ref	Ref	Ref
	Yes	74 [2]	0.99 [0.86--1.1]	-0.057 [0.083]	0.94 [0.8--1.1]	0.491
Is there peeling paint in other places such as cabinets, interior walls and/or exterior walls?	No	261 [7]	1.1 [1--1.2]	Ref	Ref	Ref
	Do not know	**3 [0]**	**2.4 [1.9--3.1]**	**0.92 [0.32]**	**2.5 [1.3--4.7]**	**0.004**
	Yes	96 [2]	1.1 [0.94--1.2]	0.12 [0.077]	1.1 [0.97--1.3]	0.115
	(Missing)	7 [0]	1.6 [1--2.7]	NA	NA	NA
Any peeling paint	No	228 [5]	1.1 [1.1--1.2]	Ref	Ref	Ref
	Yes	133 [4]	1.1 [0.94--1.2]	0.037 [0.07]	1 [0.9--1.2]	0.600
	(Missing)	6 [0]	1.7 [0.92--3]	NA	NA	NA
How often do you clean your home using a wet mop?	Daily to several times a week	46 [1]	1.2 [1—1.4]	Ref	Ref	Ref
	Weekly to Monthly	284[8]	1.1 [1.1--1.2]	-0.065 [0.099]	0.94 [0.77--1.1]	0.512

Risk Factor	***Value***	***Number of participants [missing blood lead]***	***Geometric mean blood lead [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
	Other	37 [0]	1.2 [0.98--1.5]	-0.55 [0.32]	0.57 [0.31--1.1]	0.688
How often do you clean your home using a vacuum cleaner?	Daily	67 [2]	1 [0.87--1.2]	Ref	Ref	Ref
	Several times a week	100 [3]	1.1 [0.96--1.2]	-0.048 [0.11]	0.95 [0.78--1.2]	0.649
	Weekly	150 [3]	1.1 [1--1.2]	-0.03 [0.098]	0.97 [0.8--1.2]	0.760
	Monthly	25 [1]	1.6 [1.3--1.9]	0.14 [0.15]	1.2 [0.86--1.5]	0.349
	no carpets	2 [0]	2.4 [0.046--130]	0.76 [0.48]	2.1 [0.85--5.4]	0.112
	Other	23 [0]	1 [0.77--1.4]	0.15 [0.17]	1.2 [0.84--1.6]	0.368
Do you have an attic in your home?	No	53 [3]	1.2 [1--1.4]	Ref	Ref	Ref
	Yes	314 [6]	1.1 [1--1.2]	-0.13 [0.097]	0.88 [0.73--1.1]	0.194
If you have an attic in your home, how often do you enter the attic?	Daily	6 [0]	2.1 [1.1--3.8]	Ref	Ref	Ref
	Weekly	9 [0]	1.5 [0.98--2.4]	-0.091 [0.28]	0.91 [0.53--1.6]	0.747
	Monthly	20 [0]	1.4 [1.1--1.7]	-0.28 [0.25]	0.76 [0.47--1.2]	0.273
	Yearly	56 [0]	1.1 [0.9--1.3]	-0.34 [0.23]	0.71 [0.45--1.1]	0.137
	Never	**224 [6]**	**1 [0.96--1.1]**	**-0.44 [0.22]**	**0.64 [0.42--0.99]**	**0.050**
	(Missing)	52 [3]	1.2 [1.1--1.5]	-0.24 [0.24]	0.79 [0.5--1.3]	0.322
If you have an attic in your home, how often do you enter the attic?	Monthly, Yearly, Never, or no attic	352 [9]	1.1 [1--1.2]	Ref	Ref	Ref
	Daily_or_Weekly	**15 [0]**	**1.7 [1.3--2.4]**	**0.32 [0.14]**	**1.4 [1--1.8]**	**0.026**
Have you had your attic cleaned, if yes, when was it cleaned?	Before 2017	9 [0]	1.6 [0.97--2.6]	Ref	Ref	Ref
	2017 and After	17 [1]	1.2 [0.84--1.7]	-0.17 [0.36]	0.84 [0.44--1.6]	0.643
	(Missing)	341 [8]	1.1 [1--1.2]	NA	NA	NA
Does your home have a yard with bare dirt?	No	183 [4]	1.2 [1.1--1.3]	Ref	Ref	Ref
	Yes	184 [5]	1.1 [0.97--1.2]	-0.014 [0.068]	0.99 [0.86--1.1]	0.831
Has soil in your yard been removed and replaced with clean soil?	No	264 [6]	1.1 [1--1.2]			
	don't know	5 [1]	1.2 [0.56--2.7]	0.44 [0.43]	1.6 [0.68--3.6]	0.302

Risk Factor	***Value***	***Number of participants [missing blood lead]***	***Geometric mean blood lead [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
	Yes	97 [2]	1.2 [1.1--1.4]	0.055 [0.077]	1.1 [0.91--1.2]	0.477
	(Missing)	1 [0]	NA	NA	NA	NA
If yes, when was it done?	No soil replaced	264 [6]	1.1 [1--1.2]	Ref	Ref	Ref
	After 2016	67 [2]	1.2 [1--1.3]	0.046 [0.091]	1 [0.88--1.2]	0.614
	Before and during 2016	26 [0]	1.4 [1.1--1.6]	0.068 [0.13]	1.1 [0.83--1.4]	0.599
	Other	2 [0]	1.3 [0.0024--710]	0.31 [0.47]	1.4 [0.55--3.4]	0.509
	(Missing)	8 [1]	1 [0.58--1.8]	NA	NA	NA
How often do you or your child/ward remove shoes before entering your home?	Never or Seldom Remove Shoes	189 [7]	1.2 [1.1--1.3]	Ref	Ref	Ref
	Sometimes or Always Remove Shoes	**176 [2]**	**1 [0.95--1.1]**	**-0.11 [0.062]**	**0.9 [0.79--1]**	**0.080**
	(Missing)	2 [0]	1.8 [0.29--12]	NA	NA	NA
Does anyone in the home work primarily outdoors in a job with frequent soil or slag contact? (slag reprocessor, construction worker, landscaping, etc.)	No	274 [7]	1.1 [1--1.2]	Ref	Ref	Ref
	Yes	**88 [2]**	**1.2 [1--1.3]**	**0.2 [0.077]**	**1.2 [1.1--1.4]**	**0.009**
	(Missing)	5 [0]	1.9 [1.2--3.1]	NA	NA	NA
How often do they change clothing when entering the home after work outdoors?	Never do this	58 [3]	1 [0.86--1.2]	Ref	Ref	Ref
	Seldom do this	29 [2]	1.1 [0.89--1.4]	0.11 [0.14]	1.1 [0.85--1.5]	0.434
	Sometimes do this	**36 [0]**	**1.4 [1.1--1.7]**	**0.27 [0.13]**	**1.3 [1--1.7]**	**0.038**
	Always do this	**51 [1]**	**1.2 [1.1--1.5]**	**0.3 [0.12]**	**1.4 [1.1--1.7]**	**0.011**
	(Missing)	193 [3]	1.1 [0.98--1.2]	NA	NA	NA
Do you have a job that may bring you into contact with lead?	No	281 [7]	1.1 [1--1.2]	Ref	Ref	Ref
	Yes	**62 [1]**	**1.3 [1.1--1.5]**	**0.22 [0.075]**	**1.3 [1.1--1.4]**	**0.003**
	(Missing)	24 [1]	1.3 [0.95--1.7]	NA	NA	NA

Risk Factor	***Value***	***Number of participants [missing blood lead]***	***Geometric mean blood lead [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
Do you have a job that may bring you into contact with lead?	No	276 [7]	1.1 [0.99--1.1]			
	Construction or Maintenance	**29 [1]**	**1.4 [1.2--1.8]**	**0.44 [0.1]**	**1.6 [1.3--1.9]**	**<0.001**
	Mechanic	**4 [0]**	**1.8 [0.54--5.9]**	**0.46 [0.26]**	**1.6 [0.96--2.6]**	**0.077**
	Other	24 [0]	1 [0.74--1.3]	-0.067 [0.11]	0.94 [0.75--1.2]	0.547
	Mining	3 [0]	0.75 [0.45--1.3]	-0.024 [0.29]	0.98 [0.55--1.7]	0.934
	Historic	5 [0]	1.8 [0.89--3.6]	0.14 [0.23]	1.1 [0.74--1.8]	0.550
	Nonoccupation	2 [0]	1.7 [0.59--5.2]	0.26 [0.36]	1.3 [0.65--2.6]	0.464
	(Missing)	24 [1]	1.3 [0.95--1.7]			
Have you or your child/ward used any Mexican pottery in the past month?	Don't know	1 [0]	1.5 [NaN--NaN]			
	No	363 [9]	1.1 [1--1.2]	0.085 [0.56]	1.1 [0.37--3.2]	0.879
	Yes	2 [0]	1.8 [0.16--21]	0.4 [0.68]	1.5 [0.4--5.6]	0.558
	(Missing)	1 [0]	1.1 [NaN--NaN]			
Have you or your child/ward used any home (folk) remedies (used in Indian, Asian and Hispanic cultures) in the past month for any illnesses?	Don't know	3 [0]	1.2 [0.15--9.8]	Ref	Ref	Ref
	No	345 [8]	1.1 [1--1.2]	0.11 [0.3]	1.1 [0.62--2]	0.718
	Yes	14 [0]	1.2 [0.92--1.6]	0.1 [0.33]	1.1 [0.58--2.1]	0.757
	(Missing)	5 [1]	1.2 [0.56--2.7]	NA	NA	NA
Have you or your child/ward eaten any Mexican candy (containing chili powder or tamarind) in the past month?	No	363 [9]	1.1 [1--1.2]	Ref	Ref	Ref
	Don't know	2 [0]	1.6 [0.019--130]	-0.034 [0.48]	0.97 [0.38--2.4]	0.942
	Yes	2 [0]	1.1 [0.94--1.3]	-0.18 [0.37]	0.83 [0.4--1.7]	0.627
Do you or your child/ward own any imported toy or costume jewelry	No	294 [7]	1.1 [1.1--1.2]			
	Don't know	5 [0]	0.74 [0.32--1.7]	-0.34 [0.25]	0.71 [0.43--1.2]	0.182

Risk Factor	***Value***	***Number of participants [missing blood lead]***	***Geometric mean blood lead [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
that are over 10 years old?	Yes	68 [2]	1.1 [0.91--1.3]	-0.1 [0.08]	0.9 [0.77--1.1]	0.210
Do you or your child/ward have any hobbies that may involve exposure to lead?	No	264 [7]	1.1 [1--1.2]	Ref	Ref	Ref
	Yes	**92 [1]**	**1.2 [1.1--1.4]**	**0.17 [0.067]**	**1.2 [1--1.4]**	**0.010**
	(Missing)	11 [1]	0.81 [0.59--1.1]	NA	NA	NA
Do you or your child/ward have any hobbies that may involve exposure to lead?	No	264 [7]	1.1 [1--1.2]		Ref	Ref
	firearms, fishing, hunting	**73 [1]**	**1.2 [0.99--1.3]**	**0.16 [0.074]**	**1.2 [1--1.4]**	**0.033**
	gardening	6 [0]	1.8 [0.93--3.5]	0.27 [0.23]	1.3 [0.84--2]	0.235
	Other	13 [0]	1.5 [0.96--2.5]	0.23 [0.16]	1.3 [0.93--1.7]	0.146
	(Missing)	11 [1]	0.81 [0.59--1.1]	NA	NA	NA
How many portions of fish and other seafood (including shrimp) did you or your child/ward eat in the past week?	None	237 [7]	1 [0.95--1.1]	Ref	Ref	Ref
	1-2	120 [2]	1.3 [1.1--1.4]	0.1 [0.066]	1.1 [0.97--1.3]	0.129
	3-4	10 [0]	1.5 [0.87--2.7]	0.21 [0.19]	1.2 [0.86--1.8]	0.262
How many portions of rice (white or brown) did you or your child/ward eat in the past week?	None	200 [5]	1.1 [1--1.2]	Ref	Ref	Ref
	1-2	146 [4]	1.1 [0.98--1.2]	0.022 [0.065]	1 [0.9--1.2]	0.734
	3 or more	**21 [0]**	**1.6 [1.2--2]**	**0.3 [0.13]**	**1.4 [1--1.8]**	**0.025**
How many portions of chicken did you or your child/ward eat in the past week?	None	60 [1]	1.4 [1.2--1.7]	Ref	Ref	Ref
	1-2	**194 [6]**	**1.1 [1--1.2]**	**-0.29 [0.079]**	**0.75 [0.64--0.87]**	**<0.001**
	3-4	**98 [2]**	**1 [0.89--1.1]**	**-0.28 [0.093]**	**0.76 [0.63--0.91]**	**0.003**
	5 or more	**15 [0]**	**1 [0.7--1.4]**	**-0.37 [0.17]**	**0.69 [0.5--0.95]**	**0.026**

Table E - 2: Participant Child Specific Questionnaire Results and Age-Adjusted Estimates of Association with Blood Lead, Anaconda EI (N=71, 7 missing blood lead results)

Abbreviations: CI: Confidence Interval, NA: Not Applicable, Ref: Reference Factor Level, SE: Standard Error

Risk Factor	*Value*	*Number of participants [missing blood lead]*	*Geometric mean blood lead [95% CI]*	*Estimate [SE]*	*Ratio of Geometric Means [CI]*	*p value (fixed effects)*
Does the child put their hands or toys in their mouth?	No	33 [3]	0.67 [0.56--0.8]	Ref	Ref	Ref
	Yes	37 [4]	0.89 [0.73--1.1]	0.16 [0.15]	1.2 [0.88--1.6]	0.286
	(Missing)	1 [0]	0.45	NA	NA	NA
Have you noticed the child eating dirt while playing outside?	No	64 [5]	0.75 [0.66--0.86]	Ref	Ref	Ref
	Yes	5 [1]	1.3 [0.64--2.6]	0.1 [0.24]	1.1 [0.68--1.8]	0.670
	(Missing)	2 [1]	0.45 [NA]	NA	NA	NA
Has your child ever had their blood tested for lead?	No	42 [5]	0.68 [0.59--0.78]	Ref	Ref	Ref
	Yes	28 [2]	0.94 [0.73--1.2]	0.25 [0.15]	1.3 [0.96--1.7]	0.110
	(Missing)	1 [0]	0.45	NA	NA	NA

Table E - 3: Adjusted Model Fixed Effects – Blood Lead

Abbreviations: NA: Not Applicable

Parameter	*Estimate*	*Standard Error*	*Ratio of Geometric Means*	*Degrees of Freedom*	*t value*	*p value*
Intercept	-0.10	0.11	NA	237.5753	-0.97	0.33
Basis Spline of age (1)	-1.49	0.33	NA	243.0301	-4.54	<0.01
Basis Spline of age (3)	1.01	0.25	NA	326.7575	4.00	<0.01
Basis Spline of age (3)	0.30	0.25	NA	322.457	1.20	0.23
Sex: Male	0.21	0.05	1.2	205.8827	4.49	<0.01
Construction or Maintenance	0.34	0.10	1.4	308.1739	3.38	<0.01
Enter Attic: Daily or Weekly	0.41	0.13	1.5	326.6467	3.02	<0.01
Do not eat Chicken	0.30	0.07	1.4	321.637	4.10	<0.01

Table E - 4: Participant Questionnaire Results and Age-Adjusted Estimates of Association with Total Urinary Arsenic, Anaconda EI (N=367, 13 missing urine results)

Risk Factor	*Value*	*Number of urinary arsenic participants [missing urinary arsenic]*	*Geometric mean urinary arsenic [95% CI]*	*Estimate [SE]*	*Ratio of Geometric Means [CI]*	*p value (fixed effects)*
What is your or your child/ward's sex?	Female	194 [5]	8.8 [7.8--10]	Ref	Ref	Ref
	Male	***173 [8]***	***7.4 [6.5--8.4]***	***-0.23 [0.076]***	***0.79 [0.68--0.92]***	***0.002***
City	Anaconda	358 [13]	8.1 [7.4--8.9]	Ref	Ref	Ref
	Bozeman or Deer Lodge	9 [0]	6.8 [4.5--10]	-0.3 [0.39]	0.74 [0.35--1.6]	0.443
Are you or your child/ward Hispanic, Latino/a, or Spanish Origin? (one or more categories may be selected)	No	355 [13]	8.2 [7.5--9]	Ref	Ref	Ref
	Yes	11 [0]	6.1 [3.6--10]	-0.11 [0.26]	0.89 [0.53--1.5]	0.667
	(Missing)	1 [0]	4.7			
What is your or your child/ward's race? (one or more categories may be selected)	White	352 [13]	8.2 [7.5--9]	Ref	Ref	Ref
	Other	9 [0]	6.6 [4.3--10]	-0.23 [0.3]	0.8 [0.45--1.4]	0.442
	(Missing)	6 [0]	4 [1.9--8.5]	NA	NA	NA
Do you or your child/ward spend time outside the home (e.g., work or daycare/school)?	No	43 [2]	10 [7.3--14]	Ref	Ref	Ref
	Yes	324 [11]	7.9 [7.2--8.6]	-0.11 [0.16]	0.89 [0.66--1.2]	0.471
If yes, how long are your or your child/ward out of the house during the day?	0 hours	36 [2]	9.4 [6.7--13]	Ref	Ref	Ref

Risk Factor	Value	Number of urinary arsenic participants [missing urinary arsenic]	Geometric mean urinary arsenic [95% CI]	Estimate [SE]	Ratio of Geometric Means [CI]	p value (fixed effects)
	1 to 4 hours	86 [5]	8.6 [7.1--10]	-0.014 [0.19]	0.99 [0.68--1.4]	0.939
	5 to 8 hours	79 [2]	8.5 [6.9--11]	-0.019 [0.19]	0.98 [0.67--1.4]	0.919
	Over 8 hours	165 [4]	7.4 [6.6--8.4]	-0.08 [0.19]	0.92 [0.63--1.3]	0.668
	(Missing)	1 [0]	7	NA	NA	NA
If you or your child/ward are out of the house during the day, how many times per week?	0 days	36 [2]	9.4 [6.7--13]	Ref	Ref	Ref
	1-3 days per week	24 [2]	10 [6.4--16]	0.15 [0.24]	1.2 [0.72--1.9]	0.537
	4 or more days per week	306 [9]	7.8 [7.1--8.6]	-0.044 [0.17]	0.96 [0.68--1.3]	0.798
	(Missing)	1 [0]	7	NA	NA	NA
How many hours per day do you or your child/ward typically spend outdoors?	Do not spend time outdoors	7 [0]	15 [7.8--28]	Ref	Ref	Ref
	2 to 4 hours per day	150 [5]	7.8 [6.8--8.9]	-0.27 [0.35]	0.77 [0.39--1.5]	0.448
	4 to 6 hours per day	59 [1]	7.2 [5.7--9]	-0.45 [0.37]	0.64 [0.31--1.3]	0.221
	Less than 2 hours per day	104 [7]	8.5 [7.1--10]	-0.2 [0.36]	0.82 [0.41--1.6]	0.583
	Over 6 hours per day	46 [0]	8.4 [6.6--11]	-0.2 [0.37]	0.82 [0.4--1.7]	0.589
	(Missing)	1 [0]	61	NA	NA	NA

Risk Factor	*Value*	*Number of urinary arsenic participants [missing urinary arsenic]*	*Geometric mean urinary arsenic [95% CI]*	*Estimate [SE]*	*Ratio of Geometric Means [CI]*	*p value (fixed effects)*
Approximately when was the building built?	pre1980	287 [9]	8.1 [7.3--8.9]	Ref	Ref	Ref
	post1980	62 [2]	8.6 [6.7--11]	0.2 [0.14]	1.2 [0.92--1.6]	0.175
	Don't know	17 [2]	7.2 [4.6--11]	0.12 [0.25]	1.1 [0.69--1.9]	0.623
	(Missing)	1 [0]	2.9	NA	NA	NA
How many hours per day do you or your child/ward typically spend in your attic?	Do not spend time in attic	343 [12]	8.1 [7.4--8.9]	Ref	Ref	Ref
	Spend time in attic	16 [0]	10 [6.4--17]	0.18 [0.22]	1.2 [0.78--1.8]	0.413
	(Missing)	8 [1]	4.7 [3.2--7]	NA	NA	NA
Does you or your child/ward wash hands before eating?	Always	231 [3]	8.7 [7.8--9.8]	Ref	Ref	Ref
	Never or Sometimes	136 [10]	7.1 [6.1--8.2]	-0.11 [0.11]	0.9 [0.73--1.1]	0.325
How long have you lived at this address?	Less than 6 months	15 [2]	8.4 [4.9--15]	Ref	Ref	Ref
	6 months to less than 2 years	18 [1]	8.9 [5--16]	-0.16 [0.36]	0.85 [0.43--1.7]	0.650
	2 to 5 years	81 [1]	8.1 [6.7--9.7]	-0.12 [0.29]	0.89 [0.5--1.6]	0.678
	6 to 10 years	52 [2]	7.6 [6.1--9.4]	-0.27 [0.3]	0.77 [0.43--1.4]	0.369
	More than 10 years	200 [7]	8.2 [7.2--9.2]	-0.31 [0.28]	0.73 [0.43--1.3]	0.273
	(Missing)	1 [0]	10	NA	NA	NA

Risk Factor	*Value*	*Number of urinary arsenic participants [missing urinary arsenic]*	*Geometric mean urinary arsenic [95% CI]*	*Estimate [SE]*	*Ratio of Geometric Means [CI]*	*p value (fixed effects)*
Do you speak a language other than English at home? (5 years or older)	No	353 [13]	8 [7.3--8.7]	Ref	Ref	Ref
	Yes	11 [0]	11 [6.5--17]	0.14 [0.27]	1.2 [0.68--2]	0.600
	(Missing)	3 [0]	21 [0.82--560]	NA	NA	NA
Do you live in a(n):	Single Family Home	342 [12]	8.1 [7.4--8.9]	Ref	Ref	Ref
	Apartment, Townhouse, Condominium, or Other	18 [1]	7 [4.2--11]	0.047 [0.28]	1 [0.61--1.8]	0.865
	Mobile Home	7 [0]	8.9 [3.2--25]	0.045 [0.39]	1 [0.49--2.3]	0.909
Do the windows (e.g., sills) have peeling paint?	No	293 [5]	8.5 [7.7--9.4]			
	Yes	74 [8]	6.6 [5.7--7.6]	-0.21 [0.13]	0.81 [0.63--1.1]	0.128
Is there peeling paint in other places such as cabinets, interior walls and/or exterior walls?	No	261 [6]	8.4 [7.5--9.3]			
	Do not know	3 [0]	6.2 [2.3--16]	-0.16 [0.51]	0.85 [0.31--2.3]	0.753
	Yes	96 [6]	7.2 [6--8.6]	-0.021 [0.12]	0.98 [0.77--1.2]	0.865
	(Missing)	7 [1]	13 [6.4--27]	NA	NA	NA
Any peeling paint	No	228 [3]	8.6 [7.7--9.7]	Ref	Ref	Ref
	Yes	133 [9]	7.1 [6.2--8.2]	-0.12 [0.11]	0.89 [0.71--1.1]	0.306

Risk Factor	***Value***	***Number of urinary arsenic participants [missing urinary arsenic]***	***Geometric mean urinary arsenic [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
	(Missing)	6 [1]	15 [6.3--35]	NA	NA	NA
How often do you clean your home using a wet mop?	Daily	4 [0]	6.4 [3.2--13]	Ref	Ref	Ref
	Monthly	61 [1]	9 [7.3--11]	0.23 [0.49]	1.3 [0.49--3.3]	0.636
	Other	37 [4]	10 [7.8--14]	0.34 [0.5]	1.4 [0.53--3.7]	0.502
	Several times a week	42 [0]	8.6 [6.2--12]	0.24 [0.5]	1.3 [0.48--3.3]	0.629
	Weekly	223 [8]	7.5 [6.7--8.4]	0.066 [0.48]	1.1 [0.42--2.7]	0.890
How often do you clean your home using a vacuum cleaner?	Daily	67 [1]	7.1 [6.1--8.1]			
	Several times a week	***100 [3]***	***9.1 [7.5--11]***	***0.33 [0.17]***	***1.4 [1--1.9]***	***0.052***
	Weekly	150 [4]	7.4 [6.5--8.5]	0.031 [0.16]	1 [0.76--1.4]	0.844
	Monthly	***25 [1]***	***12 [7.9--19]***	***0.4 [0.24]***	***1.5 [0.94--2.4]***	***0.092***
	no carpets	2 [0]	5.4 [0.6--48]	-0.24 [0.76]	0.78 [0.18--3.4]	0.749
	Other	23 [4]	8.7 [5.7--13]	0.065 [0.29]	1.1 [0.62--1.9]	0.821
Do you have an attic in your home?	No	53 [2]	8.1 [6.3--10]	Ref	Ref	Ref
	Yes	314 [11]	8.1 [7.4--8.9]	-0.028 [0.15]	0.97 [0.72--1.3]	0.855
If you have an attic in your home, how often do you enter the attic?	Monthly, Yearly, Never, No attic	352 [13]	7.9 [7.2--8.6]	Ref	Ref	Ref

Risk Factor	***Value***	***Number of urinary arsenic participants [missing urinary arsenic]***	***Geometric mean urinary arsenic [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
	Daily or Weekly	***15 [0]***	***14 [8.1--25]***	***0.54 [0.22]***	***1.7 [1.1--2.7]***	***0.015***
If yes, when was it cleaned?	Before 2017	9 [1]	9.5 [4.2--22]	Ref	Ref	
	2017 and After	17 [3]	6.6 [4.9--8.9]	-0.66 [0.41]	0.52 [0.25--1.1]	0.148
	(Missing)	341 [9]	8.1 [7.4--8.9]	NA	NA	NA
Does your home have a yard with bare dirt?	No	183 [6]	8.1 [7.2--9.2]	Ref	Ref	Ref
	Yes	184 [7]	8.1 [7.1--9.2]	0.012 [0.11]	1 [0.82--1.2]	0.909
Has soil in your yard been removed and replaced with clean soil?	No	264 [9]	7.8 [7--8.6]	Ref	Ref	Ref
	don't know	5 [0]	8.1 [3.7--18]	0.11 [0.67]	1.1 [0.3--4.1]	0.874
	Yes	97 [4]	9.1 [7.5--11]	0.11 [0.12]	1.1 [0.88--1.4]	0.383
	(Missing)	1 [0]	3.6	NA	NA	NA
If yes, when was it done?	No soil replaced	264 [9]	7.8 [7--8.6]	Ref	Ref	Ref
	After 2016	67 [4]	9.4 [7.5--12]	0.16 [0.14]	1.2 [0.88--1.6]	0.276
	Before and during 2016	26 [0]	8.9 [5.9--13]	0.066 [0.2]	1.1 [0.72--1.6]	0.747
	Other	2 [0]	3.5 [0.73--16]	-0.79 [0.75]	0.46 [0.11--2]	0.299
	(Missing)	8 [0]	7.6 [4.4--13]	NA	NA	NA
How often do you or your child/ward remove shoes before entering your home?	Never or Seldom Remove Shoes	189 [9]	7.2 [6.4--8]	Ref	Ref	Ref

Risk Factor	***Value***	***Number of urinary arsenic participants [missing urinary arsenic]***	***Geometric mean urinary arsenic [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
	Sometimes or Always Remove Shoes	***176 [4]***	***9.3 [8.1--11]***	***0.3 [0.097]***	***1.3 [1.1--1.6]***	***0.002***
	(Missing)	2 [0]	2.8 [0.066--120]	NA	NA	NA
Does anyone in the home work primarily outdoors in a job with frequent soil or slag contact? (slag reprocessor, construction worker, landscaping, etc.) (if NO, skip to question 49)	No	274 [10]	8.2 [7.4--9.2]	Ref	Ref	Ref
	Yes	88 [3]	7.2 [6.2--8.4]	-0.07 [0.12]	0.93 [0.74--1.2]	0.562
	(Missing)	5 [0]	27 [10--73]	NA	NA	NA
How often do they change clothing when entering the home after work outdoors?	Never do this	58 [1]	9 [6.9--12]	Ref	Ref	Ref
	Seldom do this	***29 [0]***	***6.3 [4.8--8.2]***	***-0.41 [0.21]***	***0.66 [0.44--1]***	***0.054***
	Sometimes do this	36 [3]	7.8 [6--10]	-0.19 [0.2]	0.83 [0.56--1.2]	0.339
	Always do this	***51 [2]***	***6.7 [5.6--8]***	***-0.31 [0.18]***	***0.74 [0.52--1]***	***0.086***
	(Missing)	193 [7]	8.6 [7.6--9.8]	NA	NA	NA
Do you have a job that may bring you into contact with arsenic?	No	291 [11]	8.4 [7.6--9.4]	Ref	Ref	Ref
	Yes	53 [1]	6.7 [5.6--7.9]	-0.15 [0.13]	0.86 [0.67--1.1]	0.261
	(Missing)	23 [1]	7.5 [5.5--10]	NA	NA	NA
Do you have a job that may bring you into contact with arsenic?	No	288 [11]	8.5 [7.6--9.5]	Ref	Ref	Ref

Risk Factor	***Value***	***Number of urinary arsenic participants [missing urinary arsenic]***	***Geometric mean urinary arsenic [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
	Mechanic	2 [0]	5.1 [0.0096--2800]	-0.34 [0.63]	0.71 [0.21--2.4]	0.591
	Construction or Maintenance	14 [0]	5.9 [4.5--7.7]	-0.16 [0.23]	0.85 [0.54--1.3]	0.476
	Other	25 [0]	6.5 [5.1--8.1]	-0.24 [0.18]	0.78 [0.55--1.1]	0.187
	Mining	2 [0]	5.4 [4.1e-05--7e+05]	-0.11 [0.63]	0.89 [0.26--3]	0.856
	Nonoccupational	9 [0]	7.7 [4.4--13]	-0.059 [0.29]	0.94 [0.54--1.6]	0.837
	Historic	4 [1]	11 [1.7--65]	-0.098 [0.47]	0.91 [0.36--2.3]	0.835
	(Missing)	23 [1]	7.5 [5.5--10]			
Have you or your child/ward used any Mexican pottery in the past month?	Don't know	1 [0]	7.4	Ref	Ref	Ref
	No	363 [13]	8.1 [7.4--8.9]	0.39 [0.88]	1.5 [0.27--8.1]	0.660
	Yes	2 [0]	7.4 [7.3--7.4]	0.19 [1.1]	1.2 [0.15--9.8]	0.858
	(Missing)	1 [0]	4	NA	NA	NA
Have you or your child/ward used any home (folk) remedies (used in Indian, Asian and Hispanic cultures) in the past month for any illnesses?	Don't know	3 [0]	10 [0.41--250]	Ref	Ref	Ref
	No	345 [11]	8 [7.3--8.8]	-0.064 [0.47]	0.94 [0.37--2.3]	0.891

Risk Factor	***Value***	***Number of urinary arsenic participants [missing urinary arsenic]***	***Geometric mean urinary arsenic [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
	Yes	14 [2]	9.5 [6.4--14]	-0.04 [0.54]	0.96 [0.33--2.8]	0.941
	(Missing)	5 [0]	8.1 [3.7--18]	NA	NA	NA
Have you or your child/ward eaten any Mexican candy (containing chili powder or tamarind) in the past month?	No	363 [13]	8.1 [7.4--8.8]	NA	NA	NA
	Don't know	2 [0]	11 [4.5--25]	0.014 [0.75]	1 [0.23--4.4]	0.985
	Yes	2 [0]	16 [0.065--3800]	0.61 [0.58]	1.8 [0.59--5.7]	0.297
Do you or your child/ward own any imported toy or costume jewelry that are over 10 years old?	No	294 [8]	8 [7.2--8.8]	Ref	Ref	Ref
	Don't know	5 [1]	4 [2.4--6.8]	-0.37 [0.41]	0.69 [0.31--1.5]	0.366
	Yes	68 [4]	9.1 [7.4--11]	0.17 [0.12]	1.2 [0.92--1.5]	0.184
Do you or your child/ward have any hobbies that may involve exposure to lead?	No	264 [8]	8.3 [7.4--9.2]	Ref	Ref	Ref
	Yes	92 [4]	7.6 [6.4--9.1]	-0.15 [0.11]	0.86 [0.7--1.1]	0.166
	(Missing)	11 [1]	7.8 [3.9--16]	NA	NA	NA
Do you or your child/ward have any hobbies that may involve exposure to lead?	No	264 [8]	8.3 [7.4--9.2]	Ref	Ref	Ref
	firearms, fishing, hunting	73 [3]	7.4 [6--9.1]	-0.16 [0.12]	0.85 [0.68--1.1]	0.172
	gardening	6 [0]	11 [3.5--33]	-0.0079 [0.36]	0.99 [0.5--2]	0.982

Risk Factor	***Value***	***Number of urinary arsenic participants [missing urinary arsenic]***	***Geometric mean urinary arsenic [95% CI]***	***Estimate [SE]***	***Ratio of Geometric Means [CI]***	***p value (fixed effects)***
	other	13 [1]	7.8 [5.4--11]	-0.16 [0.26]	0.86 [0.51--1.4]	0.554
	(Missing)	11 [1]	7.8 [3.9--16]	NA	NA	NA
How many portions of fish and other seafood (including shrimp) did you or your child/ward eat in the past week?	None	237 [12]	6.1 [5.6--6.6]	Ref	Ref	Ref
	1-2	***120 [1]***	***13 [11--16]***	***0.77 [0.094]***	***2.2 [1.8--2.6]***	***<0.001***
	3-4	***10 [0]***	***14 [5.5--34]***	***0.84 [0.26]***	***2.3 [1.4--3.9]***	***0.002***
How many portions of rice (white or brown) did you or your child/ward eat in the past week?	None	200 [5]	7.6 [6.7--8.5]			
	1-2	146 [7]	8.8 [7.6--10]	0.17 [0.1]	1.2 [0.96--1.4]	0.113
	3 or more	21 [1]	9.1 [7.1--12]	0.14 [0.21]	1.1 [0.76--1.7]	0.521
How many portions of chicken did you or your child/ward eat in the past week?	None	60 [1]	9.1 [7.2--11]	Ref	Ref	Ref
	1-2	194 [6]	8.4 [7.3--9.5]	-0.022 [0.13]	0.98 [0.76--1.3]	0.867
	3-4	98 [4]	7.3 [6.2--8.5]	-0.2 [0.15]	0.82 [0.61--1.1]	0.184
	5 or more	15 [2]	6.7 [4.5--10]	-0.17 [0.28]	0.84 [0.49--1.5]	0.551

Table E - 5: Participant Child Specific Questionnaire Results and Age-Adjusted Estimates of Association with Total Urinary Arsenic, Anaconda EI (N=71, 7 missing blood lead results)

Abbreviations: CI: Confidence Interval, NA: Not Applicable, Ref: Reference Level, SE: Standard Error

Risk Factor	*Value*	*Number of participants [missing urinary arsenic]*	*Geometric mean urinary arsenic [95% CI]*	*Estimate [SE]*	*Ratio of Geometric Means [CI]*	*p value (fixed effects)*
Does the child put their hands or toys in their mouth?	No	33 [3]	5.4 [4.6--6.4]	Ref	Ref	Ref
	Yes	37 [5]	9.4 [7.3--12]	0.27 [0.16]	1.3 [0.98--1.8]	0.083
	(Missing)	1 [0]	7.3	NA	NA	NA
Have you noticed the child eating dirt while playing outside?	No	64 [6]	7.1 [5.9--8.4]	Ref	Ref	Ref
	Yes	5 [2]	11 [4.9--24]	0.29 [0.33]	1.3 [0.71--2.5]	0.387
	(Missing)	2 [0]	5.8 [0.34--99]	NA	NA	NA
Has your child ever had their blood tested for lead?	No	42 [5]	5.9 [4.9--7.1]	Ref	Ref	Ref
	Yes	28 [3]	9.7 [7.3--13]	0.26 [0.16]	1.3 [0.95--1.8]	0.113
	(Missing)	1 [0]	7.3	NA	NA	NA

Abbreviations: NA: Not Applicable

Table E - 6: Adjusted Model Fixed Effects – Total Urinary Arsenic

Parameter	*Estimate*	*Standard Error*	*Ratio of Geometric Means*	*Degrees of Freedom*	*t value*	*p value*
Intercept	2.46	0.17	NA	246.173676	14.75	<0.01
Basis Spline of age (1)	-2.05	0.51	NA	248.1026229	-4.06	<0.01
Basis Spline of age (2)	0.12	0.38	NA	336.9649163	0.33	0.75
Basis Spline of age (3)	-0.40	0.38	NA	341.3293665	-1.06	0.29
Sex: Male	-0.24	0.07	0.79	199.6944344	-3.33	<0.01
Eat Seafood: 1 - 2 times/week	0.76	0.09	2.15	320.823082	8.26	<0.01
Eat Seafood: 3 - 4 times/week	0.89	0.26	2.43	257.1397725	3.40	<0.01
Enter Attic: Daily or Weekly	0.40	0.20	1.49	337.4456251	1.97	0.05

Figures

Figure E - 1: Linear Mixed Effect Model Predicted Marginal Geometric Mean Blood Lead (Chicken, Attic, Construction/Maintenance, Sex)

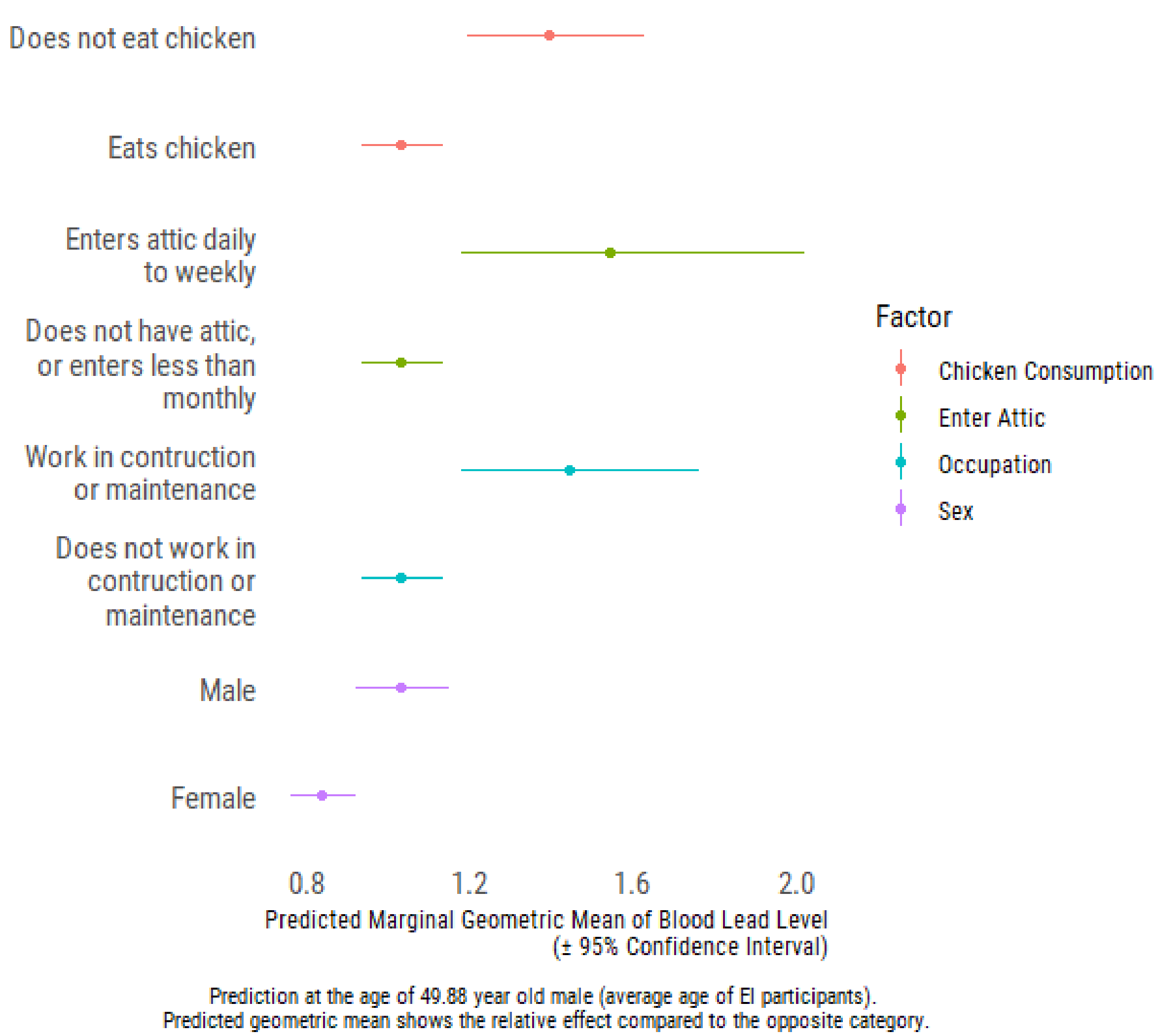

Figure E - 2: Linear Mixed Effect Model Predicted Marginal Geometric Mean Blood Lead (Age + Sex)

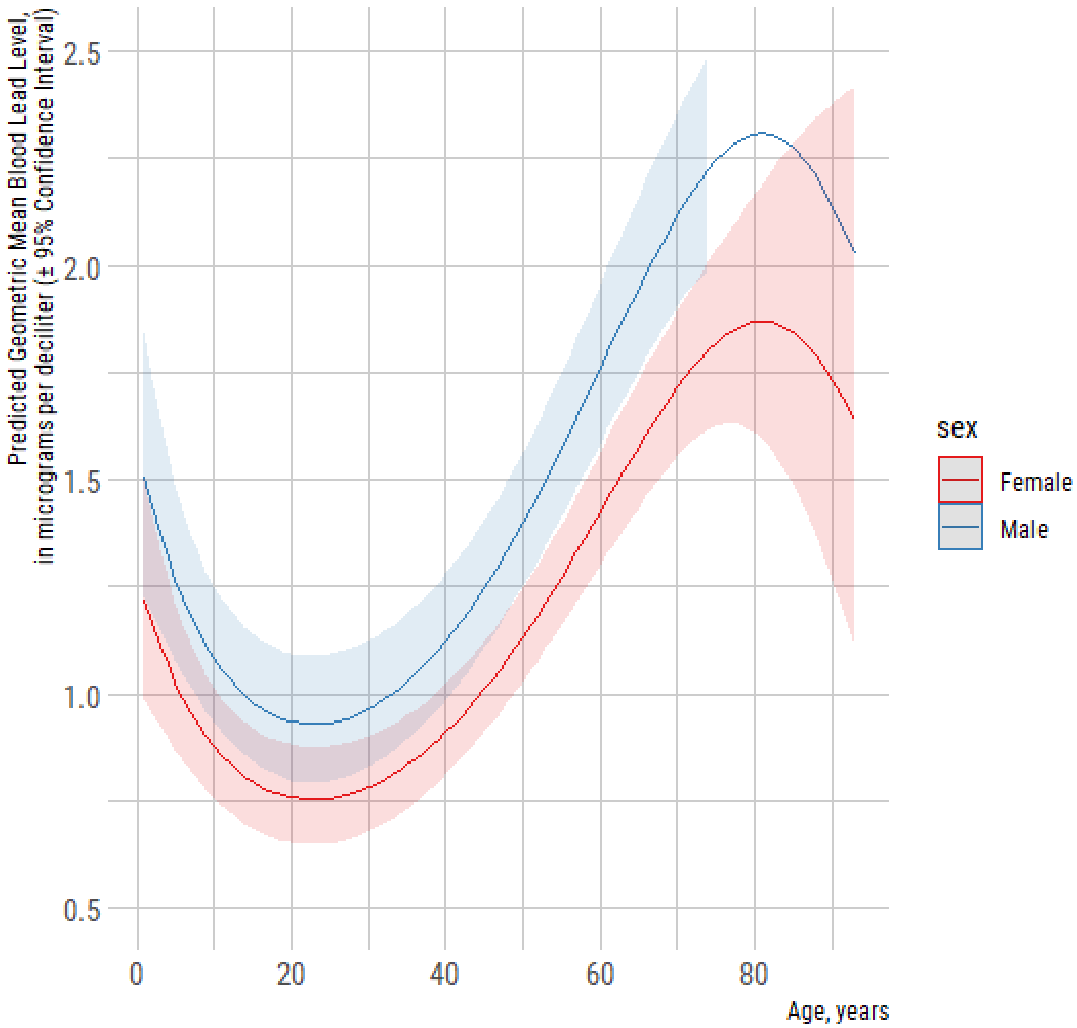

Figure E - 3: Linear Mixed Effect Model Predicted Marginal Geometric Mean Urinary Total Arsenic (Attic, Eat Seafood, Sex)

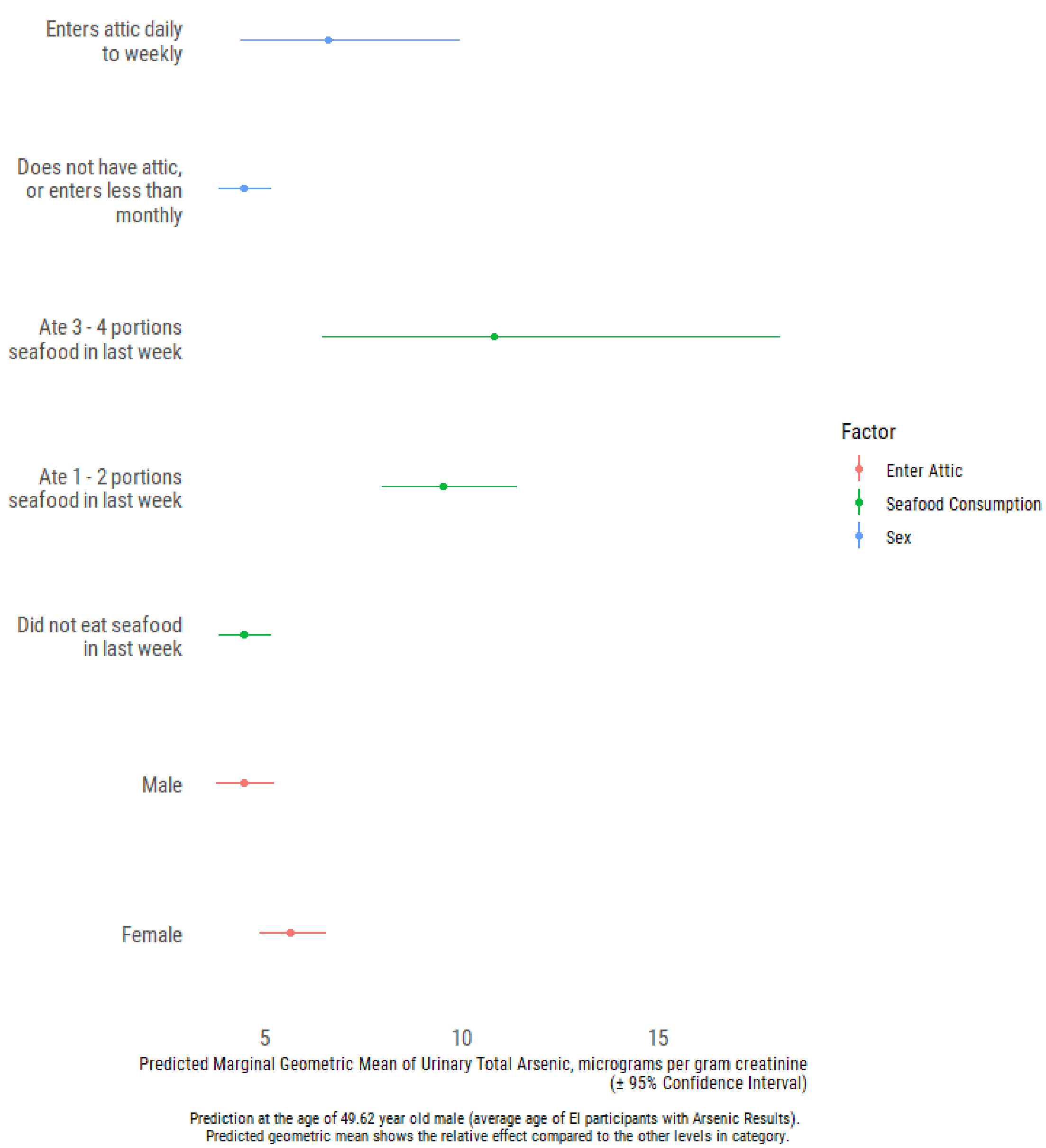

Figure E-4: Linear Mixed Effect Model Predicted Marginal Geometric Mean Urinary Total Arsenic (Age + Sex)