A Targeted Approach to Blood Lead Screening in Children, Washington State

2015 Expert Panel Recommendations

Washington State Department of Health

DOH 334-383
May 2016 (rev)

Contents

Executive Summary

A Targeted Approach to Blood Lead Screening in Children, Washington State
2015 Expert Panel Recommendations

This report was prepared by Washington State Department of Health, Division of Environmental Public Health, Office of Environmental Public Health Sciences, Environmental Epidemiology Section; Childhood Lead Poisoning Prevention Program.

The Centers for Disease Control and Prevention encourages each state to develop their own screening guidelines based on state-specific data. This document summarizes the justifications, clinical recommendations, and tools for a more targeted approach to childhood blood lead screening in children in Washington State.

An Expert Panel consisting of public health and clinical practitioners, academia, health plans, state agencies, and lead poisoning prevention advocates was convened and chaired by the Washington State Health Officer. The Expert Panel reviewed current practice, state specific data, current research on risk factors, and national best practices to identify strategies for targeting screening of children at increased risk of exposure to lead.

The Expert Panel acknowledges that primary prevention (i.e., reducing environmental lead exposures from soil, dust, paint and other sources *before* children become exposed to these hazards) is the only practical approach to preventing elevated blood lead levels. The recommendations put forth in this document are clinical guidelines to assist health care providers in targeting their blood lead testing for children at increased risk for lead exposure.

This document includes supporting evidence, a one-page clinical algorithm, and a list of risk factors to consider; the report also includes a link to an interactive mapping tool for identifying communities that are at higher risk of lead exposure. Additionally, this document includes reporting requirements, clinical guidance on the medical management of children with elevated blood lead levels, and recommendations and resources for public health management and response to children with elevated blood lead levels.

Identifying those at risk for lead exposure will help our children be the healthiest next generation.

For more information, please contact:

Elisabeth Long, MPH
Childhood Lead Poisoning Surveillance Epidemiologist
Washington State Department of Health
Elisabeth.Long@doh.wa.gov
(360) 236-3336

Introduction

In 1997, the Centers for Disease Control and Prevention (CDC) withdrew their former recommendation of universal childhood lead screening and encouraged each state to develop their own screening guidelines based on state-specific data. In response to this recommendation, the Department of Health (DOH) convened an Expert Panel in 1999 which concluded "healthcare providers should use clinical judgment to identify children who should be tested." The panel did not recommend universal screening or the use of a risk factor questionnaire. A second Expert Panel was convened in 2008 to review and revise the department's existing guidelines related to lead exposure in children. This panel recommended that the department "adopt and modify a risk factor questionnaire and make it available to physicians and other healthcare providers."

In March 2015, the Department of Health convened a third Expert Panel to develop targeted childhood lead screening recommendations for clinicians in Washington State. The Expert Panel was comprised of representatives from DOH, Department of Ecology, Health Care Authority, Department of Commerce, University of Washington-Pediatric Environmental Health Specialty Unit, health care providers, and local public health jurisdictions. The methods used to develop these targeted lead screening recommendations included reviewing the national literature to identify risk factors for lead poisoning, analyzing and interpreting lead testing data from the DOH Childhood Lead Program, reviewing strategies used in other states, and exploring the use of various tools including a Lead Exposure Risk Index model and risk factor questionnaires. The Expert Panel also developed public health recommendations for follow-up for children with elevated blood lead levels.

Effects of Lead on Child Health

Lead is a heavy metal that occurs naturally in the earth's crust and is also found throughout the manmade world. All people can be affected by lead, but young children and pregnant women are the most vulnerable. Lead has negative impacts on nearly every system of the human body, particularly the nervous (brain), renal (kidney), and hematologic (blood) systems. Neurodevelopmental effects occur at low levels. At levels below 10 μg/dL, there is a strong inverse relationship between blood lead level and IQ. Other observed effects include decreased learning ability and attention span, lower school test scores, and reduced fine motor skills. Increased dropout rates, aggressiveness, and delinquency have been associated with lead toxicity in some studies. At high levels, lead can cause problems like anemia, high blood pressure, seizures, and death. There is no known safe level of lead exposure for children.[1]

Lead's toxicity primarily stems from its ability to mimic calcium and zinc thus interfering in virtually every organ system in the body.[2] Our understanding of adverse effects of lead continues to evolve and is best reflected in the incremental lowering of CDC's reference value, the level requiring intervention. The latest CDC reference level of 5 µg/dL is based on the 97.5th percentile of the National Health and Nutrition Examination Survey's (NHANES) blood lead distribution in children. It represents a level based on the U.S. population of children 1-5 years of age who are in the highest 2.5% of children when tested for lead in their blood.[3] This level is not considered a safe threshold; instead it is meant to be a reference level to trigger public health action.

Health effects of lead range from sub-clinical effects at the lowest exposure levels to fatal lead encephalopathy after extreme exposure. Acute high dose exposure can lead to symptomatic poisoning often characterized by constipation, fatigue, anemia and neurological disorders. Even though acute high dose exposures still occur in the United States, these exposures are now rare.

For the low-level lead exposures now observed in the United States, the most important sub-clinical effect is on the central nervous system. This is widely studied using IQ tests. It is estimated that for preschoolers with blood lead levels between 10–20 µg/dL, each 1 µg/dL rise in blood lead level is associated with a lower IQ of up to 1 point. Recent evidence suggests that this relationship is steeper at blood lead levels below 10 µg/dL.[4,5] In an international pooled data analysis on 1,333 children from seven population based cohort studies, authors found that there was an inverse relationship and that lead associated IQ decline was significantly greater in populations with a maximum blood level of 7.5 µg/dL than that of children whose lead level was above 7.5 µg/dL. These neurological deficits are irreversible and persist in young adulthood, independent of later changes in blood lead levels. An 11-year follow-up study of children with elevated blood lead levels in childhood found that their impaired neurobehavioral function persisted in young adulthood. This manifested in the form of a higher risk of dropping out of school, lower test scores, and increased absenteeism.[6] Additionally, a study following children with elevated blood lead levels into adulthood showed that blood lead levels were associated with higher rates of total arrests and/ or arrests for offenses involving violence.[7]

The primary target organ of non-neurodevelopmental effects of lead in children is the kidney. Lead interferes with activation of vitamin D and increases the risk of children developing hypertension in adulthood.[8] In addition, lead also interferes with the heme biosynthetic pathway at blood lead levels higher than 18 µg/dL.[9]

Lead exposure in pregnancy

Maternal lead exposure is also a substantial source of *in utero* lead exposure for children. Evidence from several prospective cohort studies indicates that even at maternal blood lead

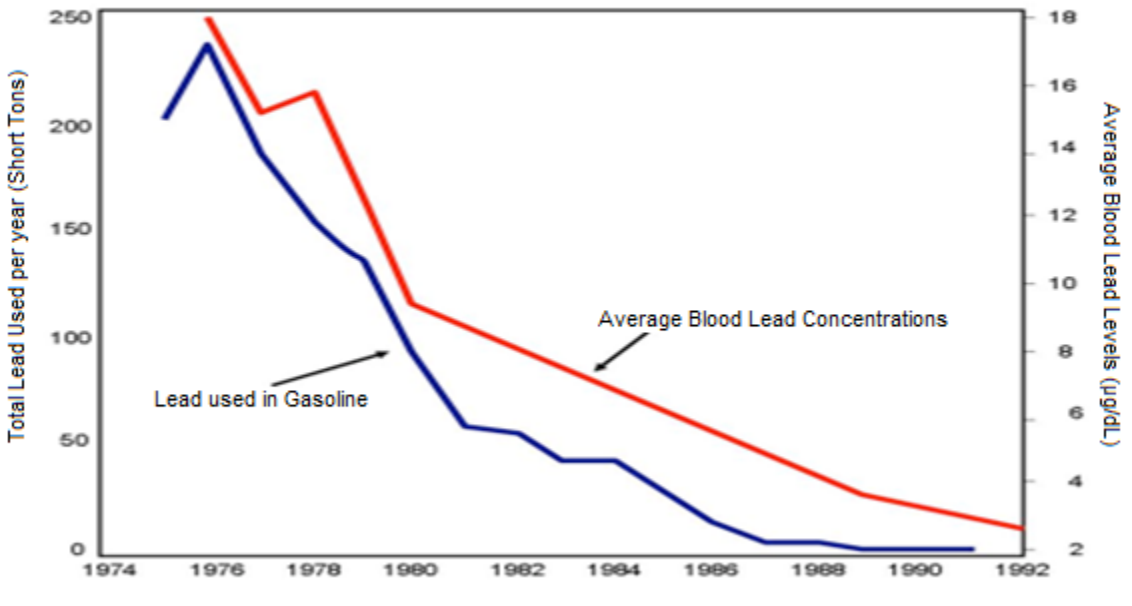
levels below 10 µg/dL, prenatal exposure is inversely related to fetal growth and neurodevelopment.[10] These adverse effects are most pronounced in the first trimester. Continuous monitoring of maternal and fetal blood lead levels in 146 pregnant women with blood lead levels lower than 10 µg/dL, revealed that an increase in maternal blood lead level by one standard deviation in the first trimester was associated with a 3.5 point reduction in the child's mental development index score at 24 months of age.[11]

In addition to environmental exposures during pregnancy, children are also susceptible to lead stored in the mother's body. Adults with chronic exposure to lead store 95% of their total lead body burden in the skeleton. After chronic exposure, elimination of lead from the body is very slow with a half-life of 25-30 years.[12] This skeletal reserve serves as an endogenous source of lead and is mobilized in events of physiological stress like pregnancy and lactation resulting in pre-and post-natal exposure for the infant even in the absence of environmental lead sources.[13]

Risk Factors for Lead Exposure

Phasing out of leaded gasoline and lead-based paint in the 1970s has led to a dramatic decline in blood lead levels.

Figure 1. Decline in average blood lead levels in U.S. children and in total lead used in gasoline for years 1974-1992. Image: Michigan Network for Children's Environmental Health.



Legacy lead paint and dust remain primary sources of lead exposure in the United States[14] Yet, more than 30% of elevated blood lead levels do not have a lead paint source. These non-paint

sources remain insufficiently characterized including but not limited to ethnic remedies and goods, consumer products (imported children's toys and jewelry), and imported ceramics. This section presents environmental and host risk factors for elevated childhood blood lead levels.

Environmental Risk Factors

Age of Housing

Even though lead-based paint was banned in 1978, as of 2000, 38 million households in the United States still had lead-based paint and 24 million households had significant lead-based paint hazards.[15] Children living in houses with lead-based paint can attain blood lead levels as high as 20 µg/dL even without frequently engaging in pica.[16] A 2002 study of 34,798 children found a dose-response relationship between the age of housing (by decade built) and elevated blood lead levels.[17] Notably, for a given housing age, lesser-valued houses were associated with higher blood lead levels suggesting that lesser valued houses had more likelihood of deteriorating paint. Lead dust from chipping paint and home renovations that settles into household soil present additional risk of childhood exposure. In fact, renovation of older houses is significantly associated with increased childhood blood lead levels in the household.[18] According to a DOH analysis performed in 2009, the proportion of children with blood lead levels at or above 5 µg/dL declined steadily as age of housing decreased.

At the present time, housing age, as an indication of potential residential lead hazards, is the most established risk factor for lead poisoning. Washington State ranks 17th in the nation in number of homes built prior to 1950 and in number of pre-1978 homes.[19] Residential lead hazards include chipping, peeling, and cracking paint, interior settled dust, contaminated soils, and the activities of remodeling and repainting buildings built prior to 1978.

Table 1. Estimated number of housing units with lead hazards by housing age. Source: Washington State Department of Ecology Lead Chemical Action Plan, 2009.

Age of Housing	Lead-Based Paint	Lead Hazards[20]	Housing Units in Washington State	# Housing Units in Washington State with Lead Hazards
All Housing	40%	25%	2,451,075	472,035
Pre-1940	87%	68%	307,078	208,813
1940-1959	69%	43%	414,555	178,259
1960-1977	24%	8%	661,598	52,928

Parental Occupation

Children of workers in lead-related industries have a higher risk of lead absorption. This is primarily due to inadequate use of protective equipment and taking work clothes home resulting in elevated lead dust levels at the household that could be potentially inhaled and ingested by children.[21,22] According to the Occupational Safety and Health Administration (OSHA) approximately 1,642,000 workers in the United States are exposed to lead in several industries including construction, manufacturing, transportation, and remediation.[23] Jobs or hobbies that may involve working with lead or being exposed to dust or fumes from lead include: construction (particularly remodeling or renovating); painting, indoor target practice or bullet making; mining, smelting or battery recycling; soldering and welding work; stained glass work; and making fishing weights.

Use of Imported Goods Containing Lead

Some other sources of lead exposure include imported goods like ceramic pottery with lead glazing used for food consumption, foreign cosmetics and foods contaminated with lead and traditional folk medical remedies. For example, laboratory analysis of *kajal,* a traditional eye-cosmetic from Afghanistan, revealed a lead content of 54% and was association with elevated blood lead levels in refugee children residing in New Mexico.[24] Similarly, many traditional remedies can have high lead content. Greta and Azarcon (also known as alarcon, coral, luiga, maria luisa, or rueda) are Hispanic traditional medicines taken for an upset stomach (empacho), constipation, diarrhea, and vomiting. They are also used on teething babies. Greta and Azarcon are both fine orange powders with lead content as high as 90%. Ghasard, an Indian folk medicine, has also been found to contain lead. It is a brown powder used as a tonic. Ba-baw-san is a Chinese herbal remedy that can also contains lead. It is used to treat colic pain or to pacify young children. Some cosmetics such as Kohl, Kajal, Surma and Sindoor may also contain lead.

Lead has been found in some consumer candies imported from Mexico. Certain candy ingredients such as chili powder and tamarind may be a source of lead exposure. Lead sometimes gets into the candy when processes such as drying, storing, and grinding the ingredients are done improperly. Also, lead has been found in the wrappers of some imported candies. The ink of these plastic or paper wrappers may contain lead that leaches into the candy.

Host Risk Factors

In addition to the environmental risk factors presented above, several host risk factors have been shown to be associated with elevated blood lead levels. Since 1976, blood lead data from the National Health and Nutrition Examination Surveys (NHANES) have been used to

characterize children's blood lead levels. The most recent analysis performed by CDC concluded that despite progress in reducing overall blood lead levels in the 1-5 year age groups, differences between the geometric mean blood lead levels of different racial/ethnic and income groups still persist. The analysis concluded that children at highest risk live in housing built before 1950, are non-Hispanic Blacks, and are from poor families.[25, 26]

Age

Young children 6 – 36 months of age are especially susceptible to lead exposure because of their higher metabolism relative to body weight, ongoing neurological development, poor hygiene status, and lack of control over their environment.[27] Blood lead levels are known to peak around two years (24 months) of age. Children under 3 years (36 months) of age expose themselves to lead more readily by spending time on the floor and exhibiting hand to mouth behavior, which increases dust and soil intake.

Race and Ethnicity

Within the 1-5 years age group, blood lead levels are associated with race and ethnicity.[28] Even though the gap is narrowing over time, Black non-Hispanic children have disproportionately higher blood lead levels. Among children aged 1–2 years participating in the National Health and Nutrition Examination Study (NHANES)[29] in 2007–2010, 7.7% (CI 4.0–12.4) non-Hispanic Black children had blood lead levels 5 µg/dL or higher compared to 1.6% (CI 0.7–3.0) Mexican American and 3.2% (CI 1.2–6.0) non-Hispanic, White children.

Poverty

Low income children are at particular risk for lead exposure.[30] According to the analysis of recent NHANES data among children aged 1-2 years, differences in the prevalence of blood lead levels ≥5 µg/dL were observed by poverty levels; 6.0% of children living in a household with an income-to-poverty ratio of <1.3 (that would be 130% below the poverty level**) had blood lead levels ≥5 µg/dL, compared to 0.5% of children living in a household with an income-to-poverty ratio of ≥1.3.[31] Therefore, a child living in a household below 130% the poverty level is more at risk of having an elevated blood lead level.

Table 2. Number and percentage of children 1-2 years with blood lead levels ≥5 µg/dL, by income -to-poverty ratio. Source: National Health and Nutrition Examination Survey, US 1999-2010.

Income-to-poverty ratio*	Number	%	(95% CI)
<1.3	**430**	**6.0**	**(3.7-8.9)**
≥1.3	**309**	**0.5**	**(0.1-1.2)**

* Income-to-poverty ratios represent the ratio of family income to their appropriate poverty threshold. Source: US Census Bureau. Poverty Definitions. Washington, DC: US Census Bureau 2015 https://www.census.gov/hhes/www/poverty/methods/definitions.html

** The U.S. Census defines the ratio of income-to-poverty as "People and families are classified as being in poverty if their income is less than their poverty threshold. If their income is less than half their poverty threshold, they are below 50% of poverty; less than the threshold itself, they are in poverty (below 100% of poverty); less than 1.25 times the threshold, below 125% of poverty, and so on."

Immigrant and Refugee Status

In addition to the mentioned environmental factors, foreign birth is also a known risk factor for elevated blood lead levels in children.[32] A matched case-control study of 203 pairs of New York City children revealed that the blood lead levels were strongly associated both with foreign birthplace and recent immigration. Many migrant children are exposed to lead in their native countries and their blood lead levels may rise after coming to the United States due to lead contamination in their new environment or use of imported goods.

Refugee children originating in all regions of the world, especially those from resource-poor countries are at risk of having elevated blood lead levels upon arrival to the United States.[33] In areas of the world where many refugees originate, potential lead exposures include lead-containing gasoline combustion, industrial emissions, ammunition manufacturing and use, burning of fossil fuels and waste, and lead-containing traditional remedies, foods, ceramics, and utensils. Malnourished children may be at increased risk for lead poisoning, likely through increased intestinal lead absorption from micronutrient deficiencies. Poor nutritional status of children can also lead to higher lead uptake through increased absorption from the gastrointestinal tract.[34] The best-studied micronutrient deficiency related to lead levels is iron deficiency. Iron-deficient children are at increased risk for developing lead poisoning. Deficiencies in calcium and zinc may also increase a child's risk.[35]

Lead Testing Data from Washington State

The Department of Health has been conducting lead surveillance since 1993 and continues to receive, record, and analyze blood lead results reported as a requirement of the Washington State notifiable condition rule (WAC 246-101). While the number of blood lead tests has increased in Washington State over the past decade, the proportion of children screened in Washington State remained well below the national average (Table 3). Table 3 compares Washington State data to U.S. data using the CDC definition of a confirmed case; confirmed cases are defined as a venous test or two elevated capillary tests performed within 12 weeks of each other that are ≥5 µg/dL.

Table 3: Estimated proportion of children under 6 years old screened for lead and proportion of confirmed blood lead results ≥ 5µg /dL in Washington State and the United States. Source: CDC National Lead Poisoning Surveillance Data (1997-2013).

Year	Estimated % of WA children screened	Estimated % of U.S. children screened	Proportion of WA tests ≥10 µg/dL	Proportion of U.S. tests ≥10 µg/dL	Proportion of WA tests ≥5 µg/dL	Proportion of U.S. tests ≥5 µg/dL
2007	1.3%	15.9%	0.48%	0.94%	*	*
2008	2.4%	17.1%	0.31%	0.72%	*	*
2009	3.0%	17.2%	0.28%	0.61%	*	*
2010	3.5%	16.7%	0.23%	0.60%	3.02%	6.64%
2011	3.1%	15.2%	0.15%	0.56%	2.40%	5.81%
2012	3.4%	10.5%	0.10%	0.62%	2.60%	5.42%

*Prior to 2010 tests ≤10.0 µg/dL were not considered elevated

Screening rates vary by county - from 0% in Garfield to 25% in Adams County in 2012. Figure 2 shows that the variability in screening rates does not seem to correlate with risk from older housing and greater likelihood of lead risks in homes.

Figure 2. Proportion of pre-1950 housing and 2012 screening rates by county, Washington State vs. U.S. average. Sources: U.S. Census Bureau, American Community Survey (ACS), 2014 and DOH Lead Registry.

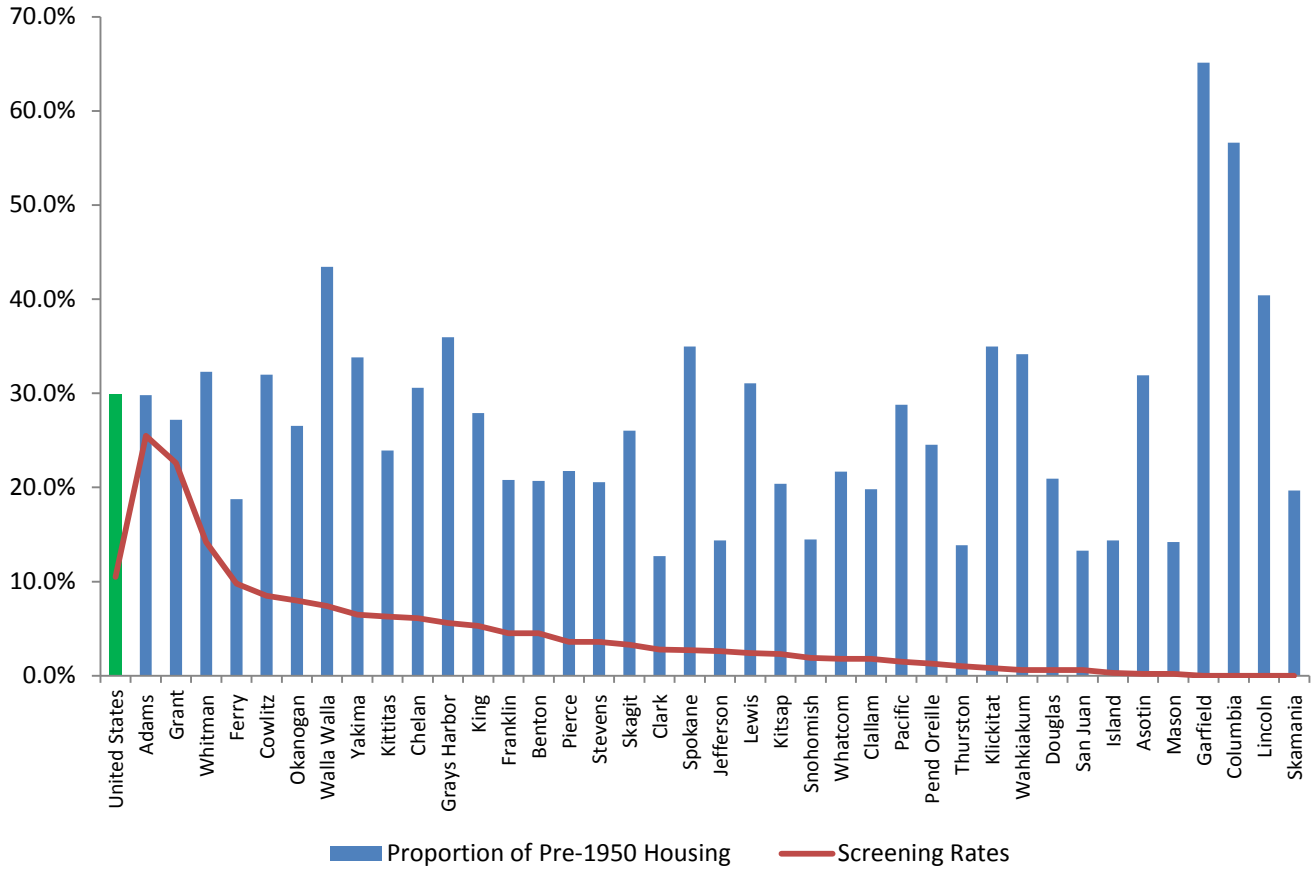


Figure 3. Among children under 6 years of age who have been tested in Washington State, percentage who have reported blood lead levels ≥5 µg/dL, 1993-2012. Source: DOH Lead Registry

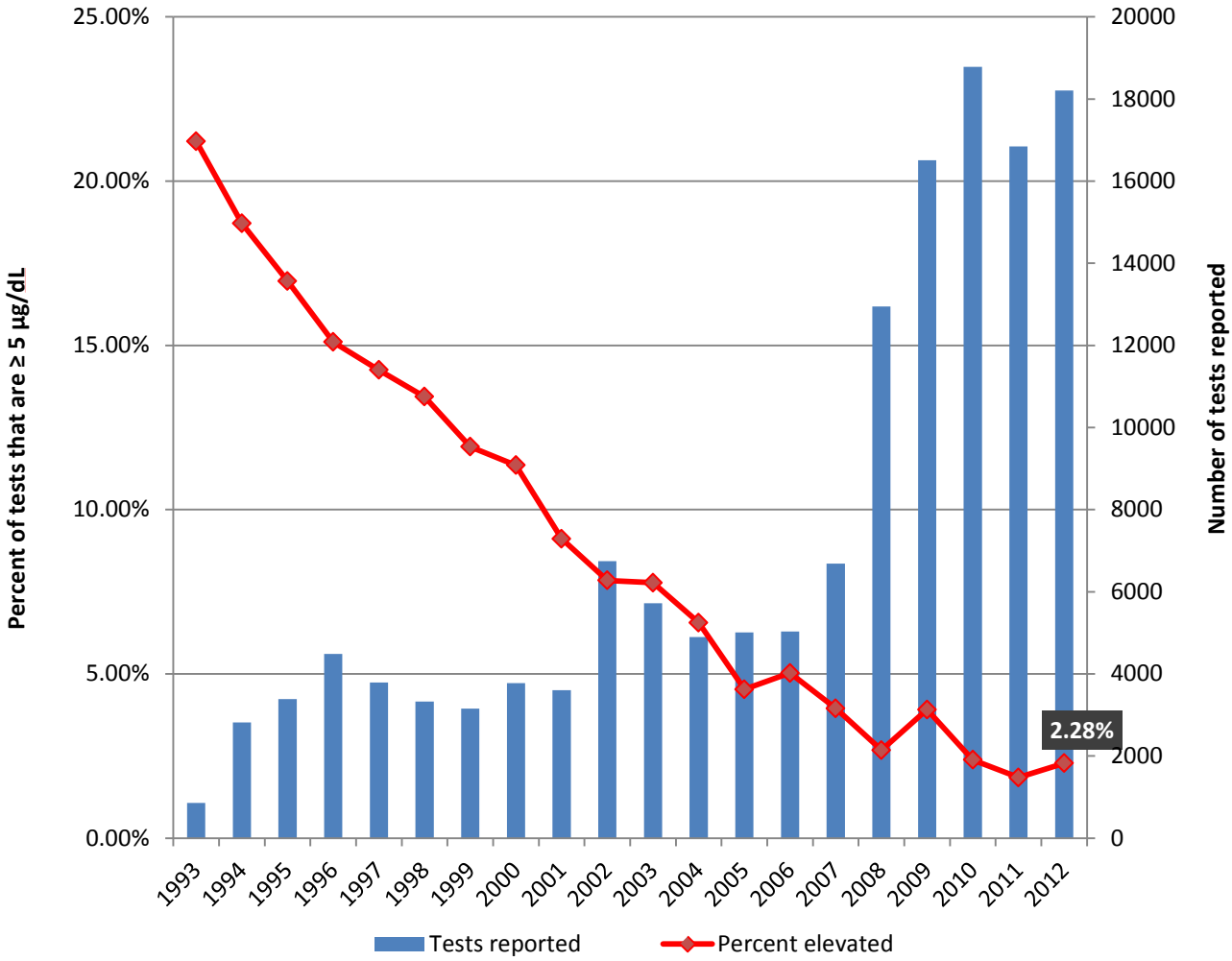
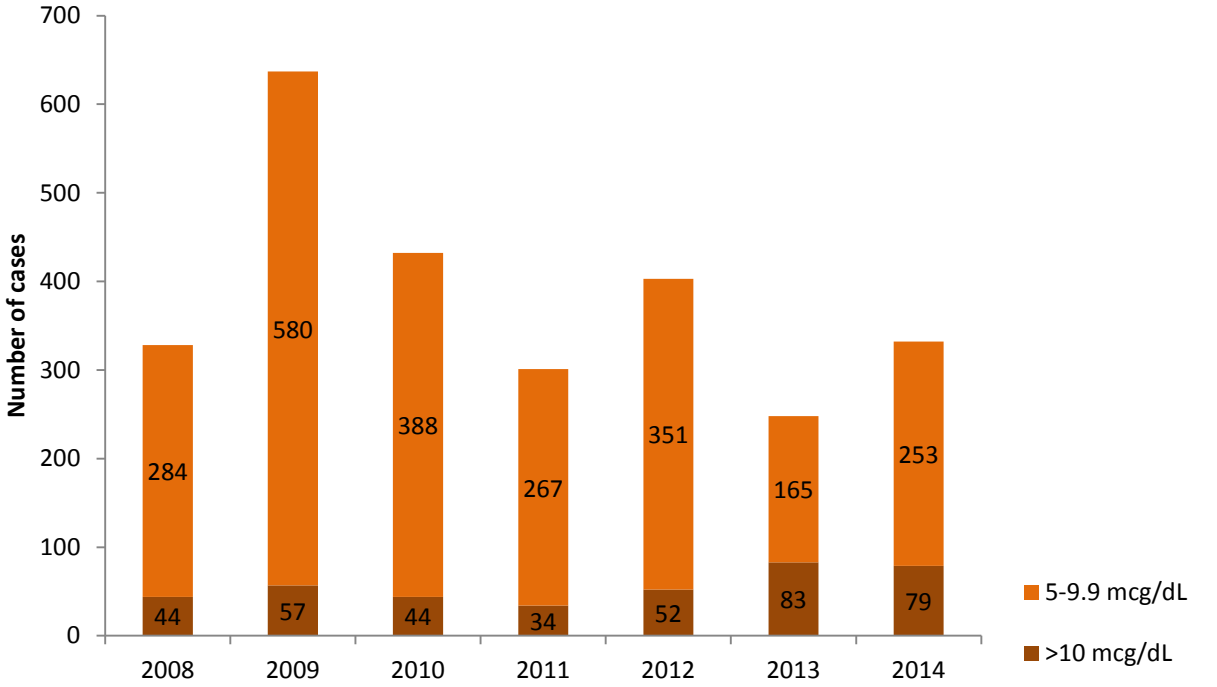


Figure 4. Childhood lead screening tests and elevated results in children <6 years old in Washington State, 2008-2014. Source: DOH Lead Registry.

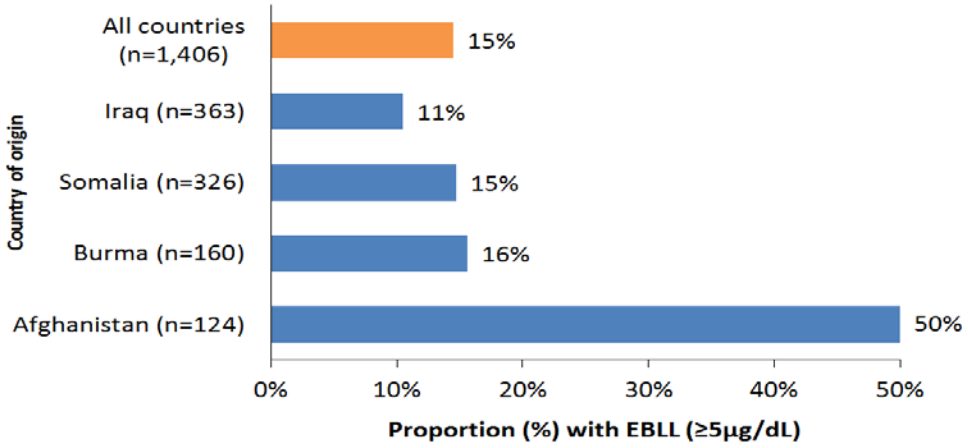


The childhood blood lead surveillance data collected by the Department of Health (DOH) have several limitations. First, healthcare providers in Washington State often do not either perform confirmatory testing or report confirmatory test results after identifying a child with an elevated capillary (probable) result. Therefore, DOH includes all elevated results in data summaries, which would include probable and false positive tests. The type of blood draw (venous versus capillary) is important for interpreting a blood lead test result; however, draw type data is missing for approximately 45% of tests. In addition, data collected by DOH represent a non-random sample of 3–4% of children in the state. Having the child's address is important for understanding likely exposure; however, addresses are only available for approximately 60% of the children screened. Other demographics such as insurance status and race/ethnicity are also rarely reported.

Approximately 2000-3000 new refugees arrive in Washington State annually. Starting in July 1 2013, DOH implemented universal screening among refugees entering Washington State. Many of the refugees that resettle to Washington State come from countries such as Afghanistan, Iraq, and Burma: all countries that still use leaded gasoline and may pose a risk to exposure. When comparing the crude rates of elevated blood lead levels (≥5 µg/dL) between refugees and non-refugees aged 0-16 years, for the time period July 1, 2012 – December 31,

2012, refugees had a rate of 16.7% compared to 3.4% for non-refugee children (DOH Lead Registry).

Figure 5. Proportion of elevated blood lead tests by country of origin for refugee children aged 6 months – 16 years, screened July 1, 2013 – December 31, 2014 in Washington State. Sources: DOH Lead Registry and DOH Refugee Health Program.



Risk of Elevated Blood Lead Levels in Washington State and the United States

The prevalence of elevated blood lead levels has decreased dramatically in the United States and Washington State since the 1970s. Some data suggest the risk of childhood lead exposure in Washington State may be lower than the risk of lead exposure in other states. In 1999, DOH conducted a statewide survey that estimated 0.9% (95% CI 0.3–2.7) of 1- to 2-year old children in Washington State had blood lead levels of 10 µg/dL or higher. During the same time period, the national prevalence estimate among 1- to 5-year olds participating in the National Health and Nutrition Examination Survey was 2.2%. Since 1999, the proportion of elevated blood lead levels in Washington State has remained lower than the proportion elevated in the United States as a whole. From 1999 to 2012, the proportion of blood lead levels ≥10 µg/dL decreased from 0.9% to 0.1% in Washington State compared to 5.0% to 0.6% in the United States.[36]

In addition, a study performed by the Department of Housing and Urban Development between 1998 and 2000 showed that the prevalence of lead hazards in housing in the Northeast and Midwest was approximately double the prevalence of lead hazards in homes in the South and West.[37] In contrast, a study performed in Multnomah County, Oregon in 2001 showed that 71%

of homes built prior to 1930 had lead dust levels above the federal standard, which was similar to the results found in Rochester, NY in 1996.[38]

Recommendations for Lead Screening in Children, Washington State

The Centers for Disease Control and Prevention (CDC) and the Department of Health concur with the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) that primary prevention (i.e., ensuring that all homes are lead-safe and do not contribute to childhood lead exposure) is the only practical approach to preventing elevated blood lead levels in children. Prevention requires reducing environmental exposures from soil, dust, paint, and water before children are exposed to these hazards. Efforts to increase awareness of lead hazards and nutritional interventions to increase iron and calcium, which can reduce lead absorption, are other key components of a successful prevention policy.[39] Additionally, healthcare providers should annually educate parents of children 6 months to 6 years of age by providing lead anticipatory guidance during routine check-ups, as detailed in Figure 5 below. Bright Futures, a national health promotion and prevention initiative and the American Academy of Pediatrics recommend healthcare providers assess a child's risk for lead exposure and provide anticipatory guidance around lead hazard identification when children are 6 months, 9 months, 12 months, 18 months, 24 months, 3 years, 4 years, 5 years and 6 years of age.[40]

Figure 6. Lead anticipatory guidance for parents of young children.

Lead Anticipatory Guidance for Parents of Young Children
1. Keep your child away from peeling paint and home repairs that disturb lead paint.
2. Report peeling paint to your landlord. If your landlord does not make repairs, contact your local tenant's rights organization.
3. Frequently wash hands, toys, pacifiers, bottles, and other items your child places in his or her mouth.
4. Clean floors, windowsills, and dusty places often with wet mops and wet cloths.
5. Avoid using health remedies (such as azarcon, greta, paylooah) and eye cosmetics (such as kohl, kajal, surma) from other countries. Some of these products have been found to contain high levels of lead.
6. Use caution when using candies, spices, snack foods, and children's toys and jewelry made in other countries. These items may contain lead.
7. Use only cold water for making baby formula, drinking, and cooking. Let the water run for at least

Lead Anticipatory Guidance for Parents of Young Children

60 seconds before use.

8. Keep your child away from work clothes and tools of household members who do construction work or other work and hobbies that may expose them to lead.
9. Wash work clothes separately from other laundry. Remove shoes and work clothes before entering your home.
10. Use safe work methods when doing home repair that disturbs paint. For information on lead-safe work methods, see EPA's lead webpage at www.epa.gov/lead .

Screening Recommendations for Children 12 and 24 Months of Age

Healthcare providers should assess all children for risk of lead poisoning at 12 and 24 months of age. The Department of Health recommends performing a blood lead test based on the following guidance. If the parent or caregiver does not know if the child has one of the following risk factors, a blood lead test should be performed. See Appendix A for one-page clinical algorithm for targeted screening recommendations.

The Department of Health recommends testing children with any of the following risk factors:

- ☐ Lives in or regularly visits any house built before 1950.*
  - *The risk of lead exposure is highest to children living in low income housing built prior to 1950.*
- ☐ Lives in or regularly visits any house built before 1978 with recent or ongoing renovations or remodeling (i.e., within the past six months).
- ☐ From a low income family (defined as incomes <130% of the poverty level).**
- ☐ Known to have a sibling or frequent playmate with an elevated blood lead level.
- ☐ Is a recent immigrant, refugee, foreign adoptee, or child in foster care.
- ☐ Has a parent or principal caregiver who works professionally or recreationally with lead.
  - *Examples: remodeling & demolition; painting; works in or visits gun ranges; mining; battery recycling; makes lead fishing weights or shotgun pellets; hobbies involving stained glass, pottery, soldering, or welding.*
- ☐ Uses traditional, folk, or ethnic remedies or cosmetics.
  - *Examples include Greta, Azarcon, Ghasard, Ba-baw-san, Sindoor and Kohl*

*Screening may not be indicated if the home has previously undergone lead abatement or tested negative for lead after remodeling.

** Federal law mandates screening for all children covered by Medicaid. Apple Health in Washington State Medicaid covers children with family incomes up to 300% of the federal poverty level. If family income is unknown, testing should be offered.

Note: Healthcare providers are encouraged to use the Department of Health Lead Exposure Risk Index found at https://fortress.wa.gov/doh/wtn/WTNIBL/ to better understand which areas in their community are at higher risk for lead exposure. See Appendix B for further information.

Healthcare providers should consider testing additional children per clinical judgment, such as:

- ☐ Children whose parents have concerns or request testing (including older children that have risk of exposure).
- ☐ Children living within a kilometer of an airport or lead emitting industry, or on former orchard land.
  - Information about lead emitting industries in WA can be found on EPA's web site.
  - Information about former orchards is available on the Washington State Department of Ecology's website.
- ☐ Children with pica behavior.
- ☐ Children with neurodevelopmental disabilities or conditions such as autism, ADHD, and learning delays.

Note: Other consumer products that have been found to have lead risk are informally imported foods and spices. Some candies imported from Mexico have been found to contain lead. Certain ingredients used in the candies, such as chili powder and tamarindo, are found to be the most common source of exposure. Lead has also been found in the ink of some imported candy wrappers as well as in nonregulated imported spices such as turmeric.

Implementation of Screening Recommendations

This guidance is primarily based on published national research studies and may be challenging to implement in a clinical setting. Since every clinic serves a different community, healthcare providers are encouraged to develop implementation plans that work best for their patient population. These plans will likely vary from clinic to clinic. For example, clinics that serve very

low income children may decide to perform universal testing, rather than attempting to determine if children have any of the risk factors stated above.

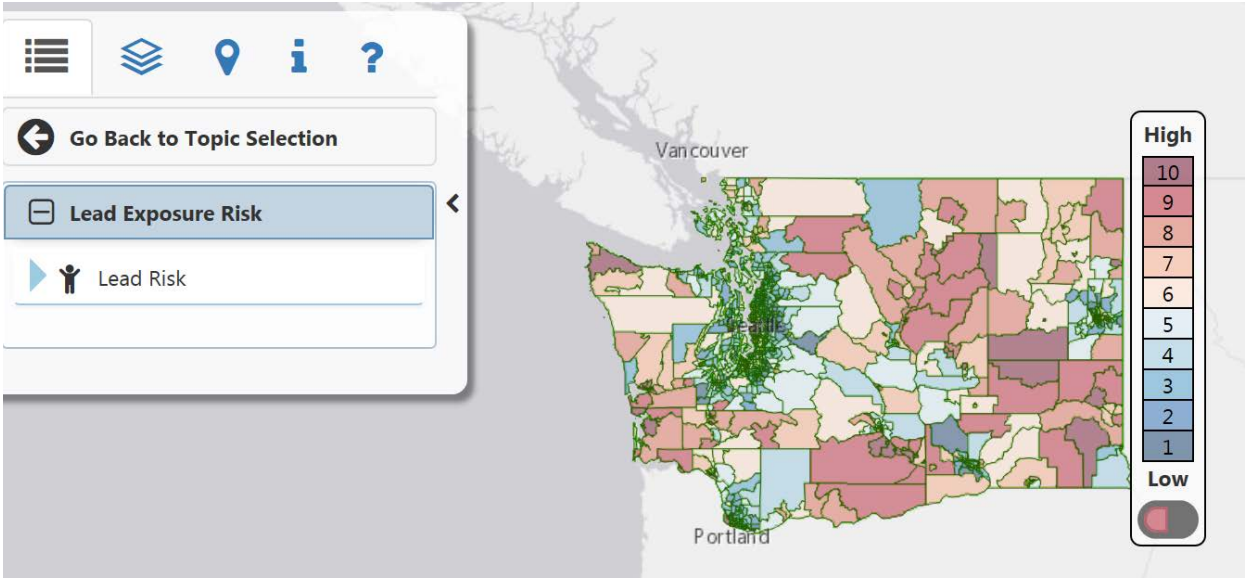
As mentioned above, children living in low income or deteriorating housing built prior to 1950 are among the highest risk groups. While it is ideal to try to determine the age of the patient's home, some healthcare providers may feel the only reasonable way to assess risk is to understand the lead risk in their community (see below) and ask the patient in which part of community they live.

Risk Geographically – Lead Exposure Risk Index Model

To assist providers with understanding lead risk in the communities they serve, the Department of Health created a Lead Exposure Risk Index model which can be accessed at: *https://fortress.wa.gov/doh/wtn/WTNIBL/*. The model combines lead risk from housing and poverty and displays it on a map in deciles from 1 to 10. Decile 1 is where there is lowest risk from these two factors and 10 is highest risk. (See Appendix B for Methods.)

There are many other factors that influence lead exposure that are not included in the map, such as take home occupational exposure and risk from lead emitting industries. If high quality data becomes available they may be added to the map in the future. Providers and clinics should use the risk map in addition to other information when deciding on their screening protocol.

Figure 7. Example of Lead Exposure Index Model information (for illustration purposes only.)
Source: Washington Tracking Network website



Screening Recommendations for Children 3 – 17 Years Old

Healthcare providers should also consider performing blood lead testing on older children at increased risk for lead poisoning, including those who have hobbies that potentially expose them to lead (e.g., shooting guns) and those who use traditional, folk or ethnic remedies or cosmetics imported from abroad.

The Centers for Disease Control and Prevention recommends performing blood lead level testing of all refugee children 6 months–16 years of age upon their arrival in the United States. Within 3–6 months post-resettlement, a follow-up blood lead test should be conducted on all refugee children aged 6 months–6 years of age, regardless of the initial screening blood lead level.[41]

Diagnostic Blood Lead Testing

Blood lead testing should also be considered as part of a diagnostic work-up of any child regardless of age with the following symptoms:

- **Behavioral problems:** aggression, hyperactivity, attention deficit, school problems, learning disabilities, excessive mouthing or pica behavior, and other behavior disorders.

- **Developmental problems**: growth, speech and language delays and/or hearing loss.

- **Symptoms or signs consistent with lead poisoning:** irritability, headaches, vomiting, seizures or other neurological symptoms, anemia, loss of appetite, abdominal pain or cramping or constipation.

- **Ingestion of foreign body.**

Testing Types

Blood lead testing is the only acceptable laboratory test for screening and confirming lead poisoning. Venipuncture is preferred for specimen collection, but finger stick (capillary) collection is acceptable if care is taken to properly clean and prepare the finger. Capillary samples are easier to contaminate because of the possibility of lead containing dust and dirt on the hand or under the fingernails. Children with capillary specimens testing 5 µg/dL or higher on a point of care test should undergo confirmatory testing, ideally with a venous specimen.

Reporting Requirements

WAC 246-101-201 requires laboratories performing blood lead testing to report all blood lead test results to the Washington State Department of Health. Healthcare providers using a capillary point of care machine (LeadCare®II) are also required to report all results. All elevated blood lead levels (5 µg/dL or higher in youths under age 15, and 10 µg/dL or higher in adults) must be reported to the Department of Health within two business days. All other test results must be reported within one month. Information reported must include: specimen type; name and telephone number of laboratory; date specimen collected; date specimen received; health care provider's name and telephone number or address; test result; name of patient; sex; date of birth of patient; and patient's address. Additional information on reporting is available on the DOH web site.

Clinical Management of Children with Elevated Blood Lead Levels

Medical Management of Children with Lead Exposure and Poisoning

Healthcare providers should manage children with blood lead levels ≥5 µg/dL per the recommendations from the Pediatric Environmental Health Specialty Unit (PEHSU):

Recommendations on Medical Management of Childhood Lead Exposure and Poisoning (See Appendix C.)

Interpreting and Managing Low Blood Leads Levels

Healthcare providers should also review supplemental information on interpreting and managing low blood lead levels produced by the NW PEHSU: Interpreting and Managing Low Blood Lead Levels: Supplemental Information for Clinicians. See Appendix D.

Public Health Management of Children with Elevated Blood Lead Levels

Responding to growing evidence that there is no safe level of lead exposure in young children, CDC has revised its case management recommendations.[42] Even the terminology has changed. "Level of concern" has been replaced by a "reference value" that is used to identify children with a blood lead level that warrants case management. That value is set as the top 2.5% of 1 – 5 year-olds that have been tested in the National Health and Nutrition Examination Survey. Currently the blood lead reference value is 5.0 µg/dL. The new CDC guidance also emphasizes the importance of prevention as a primary approach to deal with the threat of lead exposure.

Public Health System Response

Case investigation is performed to identify and mitigate any further lead exposure. The clinical management of the child is the responsibility of the health care provider and parent/guardian of the child. The following steps describe the ideal process the public health system could undertake when a child receives a blood lead result of ≥5 µg/dL. Local health jurisdictions with inadequate resources may not be able to perform all of the recommended follow up steps.

1. Laboratory or health care provider report elevated blood lead level result directly to DOH within two business days (48 hours).
    a. Patient information is required to be reported to DOH per WAC 246-101-201**.**

2. DOH staff contacts the laboratory or health care provider to collect complete case information.
    a. DOH staff contacts labs and providers to obtain the minimum information required to begin case investigation if the report is incomplete.
        i. Additional missing information should be obtained by the case investigator by contacting the lab or Health Care Provider.

3. DOH enters the case into the Childhood Lead Registry and also enters case information into the web-based reporting system for notifiable conditions that facilitates communication between DOH and local health jurisdictions.
    a. DOH contacts the local health jurisdiction to notify them that a new case or blood lead level has been entered into the reporting system.
    b. Case investigation for the local health jurisdiction begins.
        i. Case classification:
            1. ***Probable***: (1) a single capillary draw with a blood lead result of ≥5 µg/dL; OR (2) a capillary blood draw performed greater than 12 weeks after an initial capillary blood draw.
            2. ***Confirmed:*** (1) A second capillary blood draw with a blood lead result of ≥5 µg/dL within 12 weeks of the first blood lead draw; OR (2) <u>any</u> venous blood draw with a blood lead result of ≥5 µg/dL.

4. The local health jurisdiction responds to elevated blood lead cases based upon capacity. Ideally, the following steps should be taken.
    a. <u>In all cases, the Health Care Provider of record is notified</u>.
        i. Follow-up testing is crucial for case management. False positive results can cause undue alarm for families.
            1. Please note: Elevated capillary blood lead levels provide valuable information about the child's environment. An elevated capillary can mean that lead was present in the child's environment, or on the child's skin, at the time of the blood draw. Alternately, it can mean that there is a flaw in the medical practice of the blood draw. Some materials should not be used when drawing blood for a blood lead test. If using a Lead Care II machine to perform blood lead testing please review Magellan's website (link) to learn how to reduce unintentional contamination of a blood lead draw.
        ii. Health Care Providers have a relationship with, and history of, the family.
            1. Health Care Providers can provide:
                a. Details on why a blood lead test was performed.
                    i. Did the Provider believe the child was at high risk?
                    ii. Is the child part of a demographic that is known to be at high-risk for exposure to lead? (i.e. refugees).
                    iii. Did the parent request the test? If so, why?
                b. Information regarding the plan for follow-up testing.
                    i. DOH recommends using the PEHSU guidelines for guidance on scheduling follow-up tests for children with a higher than normal blood lead level.

c. Information on whether the case has already been referred to a case manager for follow-up.
    i. Some providers have an established relationship with nursing associations and others, to follow up with families in the event of an elevated blood lead level.
d. Additional family information.
    i. Presence of siblings who may also need to be tested.
    ii. Information about the home or parent's occupation that may lead to an increased risk of lead exposure.
    iii. Family language.
    iv. Medical history that may be connected to the elevated blood lead level, either as an increased risk or as a result of sustained lead exposure (ex: anemia, cognitive disability, etc.).

b. Connection between the case investigator and the Health Care Provider allows the Provider to ask questions of the investigator.
    i. Due to the infrequent nature of elevated blood lead results Providers often have questions for the case investigators.
    ii. Health care providers unclear about the public health actions being taken for their patients are encouraged to consult with their local public health department about specifics. Links to contact information for local health departments can be found on the DOH website, http://www.doh.wa.gov

Blood Lead Level Range	Recommended Public Health Response
5.0 – 7.5 µg/dL	Contact provider. A letter (see Appendix E) and educational brochures are sent to the family.
7.5 – 10.0 µg/dL	Contact provider. The family is contacted by phone, interviewed to identify sources of the lead exposure (see Appendix F) and educated to minimize exposure to lead and its health impacts. An action plan letter and educational brochures are sent to the family and health care provider.
Above 10.0 µg/dL	Contact provider. Depending on local health resources, the family may be contacted to schedule an in-home investigation. During the investigation analytical sampling with X-ray fluorescence (XRF) is used to identify the source of the lead exposure. The investigator works with the family to develop an action plan to eliminate the exposure. Interpreters may be provided if needed.

Resources available to case investigators are specific to the child's residential county. Circumstances involving a child with a confirmed blood lead level of 40 µg/dL or higher may

merit assistance from additional partners if local health jurisdiction resources are limited. Please contact DOH staff for assistance.

Following the phone or in-home consultation, it is recommended that a letter be sent to the client along with a copy to the client's primary care provider. This letter provides notification of lead case management completion, a program summary, and a visit summary to include:

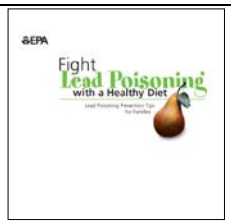
- Documentation of lead testing results to date.
- Information on when to have a follow-up provider visit and re-test.
- A current problem list of lead exposure sources and steps/actions used to address those exposures (include environmental sample results, if collected).
- Resources given.
- Referrals made.

Education Materials and Forms

Lead education and outreach materials have been developed and fine-tuned over a number of years. Below is a listing of frequently used materials, some of which have been translated into additional languages, related to increasing awareness of lead and its health impacts; clinical reporting; investigations; and understanding the blood lead testing results from the Department of Health and the U.S. Environmental Protection Agency.

To increase parent awareness of the new targeted policy for lead screening, the Health Care Authority will partner with the Washington State Department of Early Learning (DEL) to develop communication and educational tools for parents of children enrolled in preschool programs under DEL's leadership, including Early Childhood Education and Assistance Program and Head Start.

This listing is not topically comprehensive (i.e., working lead safe, Ayurveda, environmental sampling) nor does it reflect local variations.

Type	Agency	Title/Languages	Doc ID	Photo
General	DOH	*LEAD WARNING! Lead Can Poison Your Child* Chinese English Korean Russian Somali Spanish Tagalog Vietnamese	DOH 334-141 View or Download	
	EPA	*Protect Your Family For Lead In Your Home* Arabic English Somali Spanish Vietnamese	EPA747-K-99-001 View or Download	
	EPA	*Fight Lead Poisoning With A Healthy Diet* English Spanish	EPA-747-F-01-004 View or Download	
Reporting	WA DOH	*Blood Lead Level Reporting* English	DOH 334-153 View or Download	

Investigation	WA DOH	*Childhood Lead Investigation Form* English	DOH-334-169 View or Download	
Results	WA DOH	What Does Your Child's Lead Test Result Mean? English Arabic Burmese Farsi Nepali Russian Somali Spanish Swahili Tigrinya	DOH 334-339 View or Download	

Appendix A: Clinical Algorithm for Recommended Blood Lead Testing of Children in Washington State

See next page

RECOMMENDATIONS FOR BLOOD LEAD TESTING OF CHILDREN IN WASHINGTON STATE

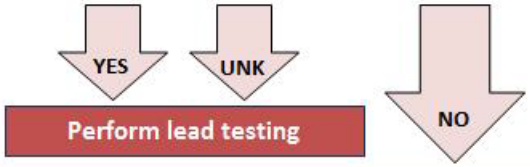
The Department of Health recommends screening children using the below algorithm at 12 and 24 months of age.

Does the child have any of the following risk factors:

- Lives in or regularly visits any house built before 1950.*
- Lives in or regularly visits any house built before 1978 that has recent or ongoing renovations or remodeling.
- From a low income family; (defined as incomes <130% of the poverty level)**
- Known to have a sibling or frequent playmate with elevated blood lead level.
- Is a recent immigrant, refugee, foreign adoptee, or child in foster care.
- Has a parent or principal caregiver who works professionally or recreationally with lead. (See sidebar for examples.)
- Uses traditional, folk, or ethnic remedies or cosmetics (such as Greta, Azarcon, Ghasard, Ba-baw-san, Sindoor or Kohl.)

* Screening may not be indicated if the home has previously undergone lead abatement or tested negative for lead after remodeling.

** Federal law mandates screening for all children covered by Medicaid.



Healthcare providers should consider testing additional children per clinical judgment, such as:

- Child whose parents have concerns or request testing (including older children that have risk of exposure).
- Child living within a kilometer of an airport or lead emitting industry, or on former orchard land.
- Child with pica behavior.
- Child with neurodevelopmental disabilities or conditions such as autism, ADHD, and learning delays.

LEAD RISK EXPOSURE EXAMPLES:

Occupations and Hobbies:

- *Remodeling and demolition*
- *Painting*
- *Work or visit gun range*
- *Mining, smelting, battery recycling*
- *Making lead fishing weights or ammunition*
- *Stained glass*
- *Soldering and welding*

Consumer Products:

- *Pottery or porcelain with lead glaze*
- *Informally imported foods, candies and spices*
- *Antique furniture and inexpensive jewelry*

Healthcare providers are encouraged to use the Department of Health's Lead Risk Index Map to better understand which areas in their community are at higher risk for lead exposure. See https://fortress.wa.gov/doh/wtn/WTNIBL/

Interpretation and Medical Management of Blood Lead Levels:
If blood lead level is ≥5 mcg/dL: See PEHSU Recommendations on Medical Management of Childhood Lead Poisoning

Washington State Department of Health

DOH 334-382
May 2016 (rev)

Appendix B: Lead Exposure Risk Index Methods

Methods

The Washington Tracking Network (WTN) is a public website where users can find data and information about environmental health hazards, population characteristics, and health outcomes. Relative lead exposure risk is provided on the WTN's Information by Location (IBL) feature. IBL allows users to view a map of multiple indicators, with rankings, at the community level. After reviewing a large number of possible geospatial risk factors for estimating geographic lead exposure risk only two were appropriate for use in Washington State: Lead risk from age of housing and poverty.

These two risk factors were identified by the Washington State Department of Health and were reviewed by a multi-stakeholder expert panel. Although there are other risk factors for lead exposure such as having a sibling or playmate with an elevated blood lead level or parents who work in an industry where lead is used, we did not have sufficiently high quality data to account for these variables in the tool.

Data and sources:

Age of housing – data on housing age comes from the U.S. Census's American Community Survey's 5-year rollup. This dataset provides the total number of houses and proportion of houses by year of construction. We used this data in conjunction with national estimates of the proportion of housing from each era with lead risks.[43] Here is an example of how lead risk from age of housing was calculated for a fictitious census tract:

Example calculation of lead risk from age of housing using a fictitious census tract:

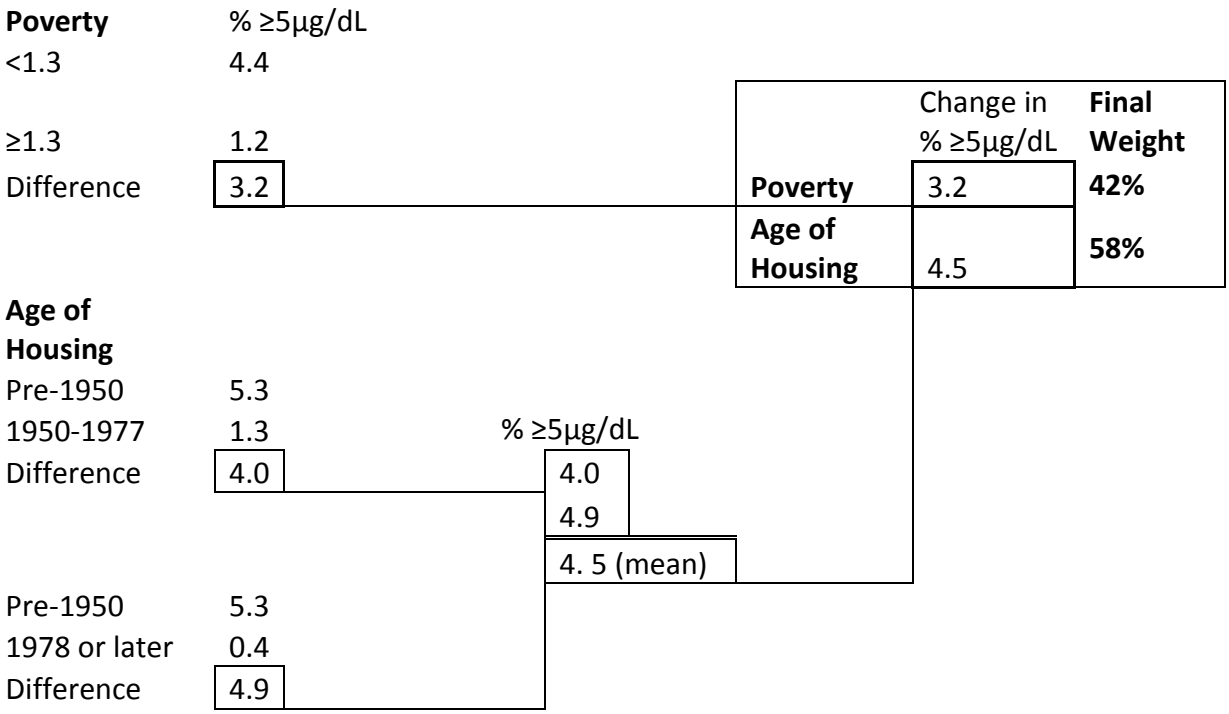
	Construction Year	Number of Houses	Percent with Lead Hazards	Estimate of homes with a lead risk
	After 1980	100	0	0
	1960-1979	100	8%	8
	1940-1959	100	43%	43
	Before 1940	100	68%	68
Total		400		119
	Proportion of homes with a lead risk:		119/400	**29.8%**

Poverty – There is a significant association between poverty and elevated blood lead levels.[44] Children who live below the poverty line and live in pre-1950 housing are at the greatest risk for lead exposure because the home is more likely to have aging lead paint that is in poor condition.[45]

Weighting:

IBL combines age of housing and poverty into a single geographic risk layer and classifies census tracts into deciles. A decile is a group that represents one tenth of the whole. IBL allows us to weight risk factors to best approximate the amount of risk attributable to the indicator. The weights were calculated using data from the National Health and Nutrition Examination Survey reported in CDC's 2013 MMWR "Blood Lead Levels in Children Aged 1-5 Years – United States 1990-2010".

Weighting Risk Factors in the Lead Risk Map:



Appendix C: Pediatric Environmental Specialty Units Recommendation on Medical Management of Childhood Lead Exposure and Poisoning

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.

Recommendations on Medical Management of Childhood Lead Exposure and Poisoning

PEHSU Pediatric Environmental Health Specialty Units

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.
Woolf A, Goldman R, Bellinger D. *Pediatric Clinics of North America* 2007;54(2):271-294.
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-75-92301301-0. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.

(April 2013 version)

Appendix D: Interpreting and Managing Low Blood Lead Levels

INTERPRETING AND MANAGING LOW BLOOD LEAD LEVELS:
Supplemental Information for Clinicians

PEHSU Pediatric Environmental Health Specialty Units

Note that federal, state, and local strategies for preventing and screening pediatric lead poisoning vary. Primary prevention of lead exposure is essential, but secondary prevention (screening and early detection) also has an important role. This guidance is intended to help clinicians respond to lower BLL results once a blood sample has been collected.

The National PEHSU has released a factsheet for clinicians addressing "*Recommendations on Medical Management of Childhood Lead Exposure and Poisoning*" (April 2013, located at http://www.aoec.org/pehsu/documents/medical-mgmnt-childhood-lead-exposure-June-2013.pdf). This intent of this local NW PEHSU factsheet is to supplement the national factsheet, providing additional detail and discussion.

Blood lead level (BLL) and children's health

In order to identify children with excessive lead exposure, the CDC recommends using a national reference value based on the 97.5th percentile of BLL distribution in children 1-5 years old. As of 2012, this equates to a BLL of 5 µg/dL. Children with BLLs of 5 µg/dL and above are in the top 2.5% of lead exposure. This reference value will be recalculated by the CDC every 4 years.

Unfortunately, there is no safe level of lead exposure for children, and even lower ranges of BLLs (below 5-10 µg/dL) are known to be a risk factor for impaired cognitive and behavioral outcomes in children[i]. Current and consistent evidence suggests that the reduction in children's IQ scores (per unit increase in BLL) is greater in the range of BLLs that are 0 to 10 µg/dL than it is for BLLs > 10 µg/dL[ii]. New findings also suggest that the adverse health effects of low BLLs extend beyond cognitive function to include cardiovascular, immunological, and endocrine effects.

However, a single blood lead level in this range for any individual child is not predictive of effects for that child. It is one of multiple risk factors. Cognitive effects related to lead may be mitigated by a healthy home psychosocial environment and genetic inheritance[iii].

Blood lead interpretation considerations

- Initial BLLs can be measured from venous or capillary blood samples. Providers should have children wash hands with soap and water prior to obtaining a capillary sample to minimize fingerstick contamination issues.
- It is generally recommended that an initial capillary BLL > 4 µg/dL be confirmed with a venous sample within 1-4 weeks, because laboratory and sample collection methods can influence the results. Formal reporting and confirmation requirements may vary by state[iv].
- Limits of lead detection vary by analytical method and laboratory. Most laboratories performing BLL testing can achieve an error range within +/- 2 µg/dL. However, the current allowable error range for a lab to be in compliance with proficiency testing is +/- 4 mcg/dL or +/- 10%, whichever is greater[v]. There is ongoing discussion that this error range should be reduced to better reflect modern lead reference ranges and lab capabilities.
    - When the most sophisticated machines (inductively coupled plasma method - ICP MS) are used the limit of detection is typically 1 µg/dL or less (e.g. 0.1 µg/dL)[vi].
    - Many sites do not have these and instead use graphite furnace atomic absorption spectrophotometry (GFAAS) or flame atomic absorption spectrometry (FAAS), which have limits of detection of < 1-2 µg/dL or ~10 µg/dL, respectively[vii].
    - The error range for the handheld LeadCheck II instruments (a CLIA-waived instrument using a capillary sample) is +/- 3 mcg/dL.

- Ingested lead distributes first into the red blood cells, and then re-distributes into soft tissues (25%) and bone (70%). For children with baseline lower levels of lead exposure, after an acute exposure, the blood level will fall rapidly (weeks). A large decrease from the first to second lead level may reflect an acute exposure followed by body equilibration, or may result from laboratory or fingerstick contamination issues.

Identifying sources of lead exposure

The first priority is to identify sources and prevent ongoing exposure. Lead paint and contaminated dust/soil are sources responsible for the majority of BLLs above the reference value in U.S. children, but there is increasing evidence of exposure through other sources. It is important to question families about the child's home environment as well as other potential exposure sources. Talk to parents about exposure pathways (floor to hand to mouth) and important sites of exposure (windowsills). Some pertinent questions include:

- Does the child live in a home or regularly visit 1) a building (*e.g. school, daycare*) built before 1950, or 2) a building built before 1978 with recent or ongoing painting, repair, and/or remodeling?
- Could the soil where the child lives or plays be contaminated with lead (*e.g. neighborhood with older housing, current or historical mining, smelting, or agriculture)*?
    - Could the child's drinking water be contaminated (*e.g. from indoor plumbing*)?
        - Consider testing water sources, such as kitchen tap water, for lead contamination. Most NSF certified faucet mounted water filters remove lead - see PEHSU factsheet on lead removal from drinking water.
- Does the family have older or antique furniture with lead-based paint? Older children's toys? Newer imported toys?
- Does the child spend time with anyone who has a job or hobby where they may work with lead in the home or bring lead dust home on shoes and clothing (*e.g. painting, remodeling, auto radiators, ship repair, soldering, making sinkers or bullets, going to shooting ranges, welding, mining, stained glass, pottery, jewelry, antiques, or imported toys*)?
- Does the family use pottery or ceramics made in other countries (especially Mexico and China), lead crystal or pewter, or vintage dishes for cooking, storing, or serving food or drink?
        - Restrictions on lead in dishes were implemented in late 1980s and strengthened in early 1990s—since then US made dishes are without lead.
- Are imported spices used or home spices brought from other countries?
- Has the child ever used imported cosmetics or taken any traditional home remedies (*e.g. Azarcon, Alarcon, Greta, Rueda, Pay-loo-ah, Kohl*)?
- Has the child been adopted from, lived in, or visited another country?
- For children < 12 months, consider mother as the source for transmission prenatally and through human milk. Are there maternal risks for lead exposure (see CDC Guidelines for Pregnant and Lactating Mothers)?

Although a specific source may not be identified, the medical provider can still provide information and counseling to the family on common sources of exposure and how to avoid them (*e.g. use a doormat and take off shoes when entering the home, wash children's and adults' hands often, do not allow children to chew on painted wooden toys or furniture or windowsills).*

If a lead paint hazard is identified (e.g. paint prior to 1978), some practical lower cost approaches include simply keeping it in good condition, cleaning up dust often (wet wiping and using vacuums with HEPA filters), painting over suspect paint, or placing a barrier over the area to keep it out of reach from children.

A home inspection and risk assessment may be the best approach to identify and characterize lead hazards in the home. Such inspections typically cost $400 - $1000 and individual dust wipe samples cost about $35 each. Trained lead professionals can use EPA approved test kits (http://epa.gov/lead/pubs/testkit.htm); these test kits are not generally recommended for consumer use. Proper and safe remediation is important to avoid actually increasing the risk for a child's exposure. Information on proper remediation and repair is available from the EPA at http://epa.gov/lead/pubs/leadinfo.htm#remodeling.

Also, note that federal law requires that home sellers and landlords must disclose a lead hazard at the time of sale or before a rental lease takes effect[vii].

Additional considerations

- For infants with initial BLLs > 4 mcg/dL, recheck earlier than the standard 1-3 months and include iron status testing. Their increasing mobility increases their risk of exposure.
- Consider testing other members of the household/family, as this may aid identification of lead sources.
- Chelation therapy is *not* recommended for BLL's < 45 µg/dL except in special circumstances. Consult the PEHSU for chelation questions. The FDA recently released a statement warning of the dangers of off-label use of chelation therapies: http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm229358.htm

Resources for advice on identifying and reducing potential exposure sources

Call the local health department for assistance in evaluating the home environment for lead and check with your state or local housing agencies for resources to remediate lead-based pain hazards.

Region X State-specific lead programs

- Alaska Lead Surveillance Program: http://www.epi.hss.state.ak.us/eh/lead/default.htm
- Idaho Department of Health and Welfare lead education:http://healthandwelfare.idaho.gov/Health/EnvironmentalHealth/IndoorEnvironment/Lead/tabid/941/Default.aspx
- Oregon lead poisoning prevention: http://www.oregon.gov/DHS/ph/lead/index.shtml
- Washington State Childhood Lead Poisoning Prevention program: http://www.doh.wa.gov/ehp/lead/default.htm

National programs

- CDC factsheet on new reference level: http://www.cdc.gov/nceh/lead/ACCLPP/Lead_Levels_in_Children_Fact_Sheet.pdf
- CDC tips for reducing lead exposure: http://www.cdc.gov/nceh/lead/tips.htm
- EPA information on childhood lead exposure and lead in general: http://www.epa.gov/lead/index.html and http://www.epa.gov/iaq/lead.html
- National Center for Healthy Housing (NCHH) consumer factsheet: http://www.nchh.org/Portals/0/Contents/Consumer BLL Fact Sheet 8-7-12.pdf

For additional questions or guidance, contact the NW PEHSU. The University of Washington based Pediatric Environmental Health Specialty Unit (PEHSU) serves medical and public health professionals in Alaska, Washington, Idaho, and Oregon. For more information contact us at 206-221-8671 or pehsu@uw.edu or visit our website http://www.depts.washington.edu/pehsu.

Acknowledgment: A. Otter, DNP, ARNP; M. Martyn, MD; C. Karr, MD, PhD; K. Ivicek, MN, RN; N. Beaudet, MS, CIH; S. Sathyanarayana, MD, MPH. **Last updated June 2013.**

This material was supported by the Association of Occupational and Environmental Clinics (AOEC) and funded under the cooperative agreement award number 1U61TS000118-02 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-75-92301301-02. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.

---

[i] ACCLPP. Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention. Report of the Advisory Committee on Childhood Lead Poisoning Prevention of the Centers for Disease Control and Prevention. January 4, 2012

[ii] ACCLPP 2012; Lanphear BP, Dietrich K, Auinger P, Cox C. Cognitive deficits associated with blood lead concentrations <10 mg/dL in US children and adolescents. *Public Health Report*. 2000; 115:521–529; Lanphear BP, Hornung R, Khoury J, et al. Low-level environmental lead exposure and children's intellectual function: an international pooled analysis. *Environmental Health Perspectives*. 2005; 113(7):894–899.

[iii] Moodie S, Ialongo N, Lopez P, et al. The conjoint influence of home enriched environment and lead exposure on children's cognition and behaviour in a Mexican lead smelter community. *Neurotoxicology*. 2012. Advance of print. http://dx.doi.org/10.1016/j.neuro.2012.10.004; Guilarte TR, Toscano CD, McGlothan JL, Weaver SA. Environmental enrichment reverses cognitive and molecular deficits induced by developmental lead exposure. *Annals of Neurology*. 2003; 53(1): 50-56

[iv] In Washington state, WAC 246-101 requires laboratories to report all blood lead test results to the Washington State Department of Health. All "elevated" blood lead levels, currently defined by the state as ≥10µg/dL in youths <15 years old and as ≥25µg/dL in people ≥15 years old, must be reported within 2 days. All other test results must be reported within 1 month.
(http://www.doh.wa.gov/PublicHealthandHealthcareProviders/HealthcareProfessionsandFacilities/ProfessionalResources/BloodLeadTestingandReporting/BloodLeadTestReporting, 9/19/12)

[v] Per current regulation, *Clinical Laboratory Improvement Amendments (CLIA) of 1988*. A useful discussion of lab limits can be found in: Advisory Committee on Childhood Lead Poisoning Prevention. Meeting Minutes, November 16-18, 2010. Atlanta, Georgia. Pages 19-25.

[vi] WHO. Brief guide to analytical methods for measuring lead in blood. 2011. Page 3.
(http://www.who.int/ipcs/assessment/public_health/lead_blood.pdf, 9/19/12)

[vii] EPA. Residential Lead-Based Paint Disclosure Program, Section 1018 of Title X (http://epa.gov/lead/pubs/leadbase.htm, 9/19/12)

Appendix E. Letter to Parents of Child with Elevated Blood Lead Level

[Date]

Parents of [Child's Name]
[Address]
[Address]

RE: Blood Lead Level Consultation

Dear Parents:

On [Date] [Child's Name] received a blood lead test showing a blood lead level of [Test Result] µg/dL. Blood lead levels at or above 5 µg/dl are considered elevated per the Centers for Disease Control and Prevention.

Public Health would like to provide you with some information that can help you identify potential sources of lead in your home that may be contributing to your child's lead level. There is also information on methods that can decrease your child's lead exposure and minimize the effects on your child's health.

We provide this information because lead damages the brain and nervous systems of children at a critical time in their development. Children who are exposed to lead often have behavioral and developmental problems, and difficulty in school.

If you have any questions about lead please contact me at (xxx) xxx-xxxx.

Sincerely,

[Name & Contact Information]

Enclosures
CC

Appendix F. Lead Exposure Investigation Form

Washington State Department of Health

Mail or fax completed form to:
WA State Dept of Health
Childhood Lead Poisoning
Prevention Program
PO Box 47846
Olympia, WA 95604-7846
Fax (360)236-3059

LHJ Use ID _____
☐ Reported to DOH Date ___/___/___

Classification
☐ Confirmed
☐ Probable

☐ Outbreak-related
*LHJ Cluster#*_____
LHJ Cluster Name:
_____
*DOH Outbreak #*_____

Child Blood Lead

County

REPORT SOURCE

LHJ notification date ___/___/___ Investigation start date: ___/___/___

Reporter (check all that apply)
☐ Lab ☐ Hospital ☐ HCP
☐ Public health agency ☐ Other

OK to talk to case? ☐ Yes ☐ No ☐ Don't know
Reporter name _____
Reporter phone _____
Primary HCP name _____
Primary HCP phone _____

PATIENT INFORMATION

Name (last, first) _____
Address _____ ☐ Homeless
City/State/Zip _____
Phone(s)/Email _____
Alt. contact ☐ Parent/guardian ☐ Spouse ☐ Other Name: _____
Zip code (school): _____ Phone: _____ Grade _____
School/child care name _____

Birth date ___/___/___ Age _____
Gender ☐ F ☐ M ☐ Other ☐ Unk
Ethnicity ☐ Hispanic or Latino ☐ Not Hispanic or Latino
English speaking? ☐ Y ☐ N ☐ Unk
Native language _____
Race (check all that apply)
☐ Amer Ind/AK Native ☐ Asian
☐ Native HI/other PI ☐ Black/Afr Amer
☐ White ☐ Other

CLINICAL INFORMATION

Clinical Findings

Y N DK NA
☐ ☐ ☐ ☐ Any consistent symptom for elevated lead level
- ☐ Abdominal pain
- ☐ Lethargy/decreased activity
- ☐ Nausea, vomiting, constipation or diarrhea
- ☐ Loss of appetite ☐ Muscle weakness
- ☐ Hyperactivity ☐ Irritability or behavior change
- Other: _____

☐ ☐ ☐ ☐ Ever referred for neurological, developmental or educational assessment
Specify: _____

Reason for lead test
☐ Routine screen ☐ Special screening project
☐ Symptoms of lead poisoning ☐ Known exposure to lead
☐ Anemia/iron deficiency ☐ Parental request
☐ Risk factors for lead exposure
☐ Other reason: _____

Y N DK NA
☐ ☐ ☐ ☐ History of blood lead tests, either before or after the elevated lead level was found
Collect date: __/__/__ Result: _____(µg/dL)
Sample type: ☐ capillary ☐ venous ☐ unknown
Collect date: __/__/__ Result: _____(µg/dL)
Sample type: ☐ capillary ☐ venous ☐ unknown

Y N DK NA
☐ ☐ ☐ ☐ Follow-up or confirmatory lead tests scheduled
☐ ☐ ☐ ☐ History of a hematocrit or hemoglobin test for iron status
Collect date: __/__/__ Result: _____

Laboratory

Elevated lead level
Collect date: __/__/__ Date results received: __/__/__
Result: _____(µg/dL)
Sample type: ☐ capillary ☐ venous ☐ unknown

NOTES

Case defining variables are in **bold**. Answers are: Yes, No, Unknown to case, Not asked /Not answered DOH 334-169 (8/08)

Washington State Department of Health **Case Name:** _____

EXPOSURE (over child's lifetime)

Current home type
☐ Single family ☐ Multiple unit ☐ Mobile home
Home ownership ☐ Owned ☐ Rented ☐ Public housing
If not owned by family, give owner's name and phone number:
_____
Years lived in home _____
If less than a year list previous address:_____
_____
Addresses of other places the child regularly spends time, such as day care or homes of friends or relatives:_____
_____

Year home constructed ☐ Exact year, if known_____
☐ 1980+ ☐ 1960-79 ☐ 1950-59
☐ 1940-49 ☐ 1920-39 ☐ Before 1920

Source of water for home
☐ Public water supply ☐ Small water system
☐ Private well ☐ Other_____

Y	N	DK	NA	
☐	☐	☐	☐	Recent repairs/renovations done in the home Describe: _____
☐	☐	☐	☐	Peeling or flaking paint inside or outside home Describe: _____ ☐ Spends time in areas with flaking or peeling paint ☐ Exposed to soil outside home with peeling exterior paint ☐ Seen putting paint chips in mouth ☐ Seen chewing on painted surfaces in home
☐	☐	☐	☐	Lives or plays in former orchard site (orchards on property before 1950)
☐	☐	☐	☐	Exposed to soil contaminated by Tacoma smelter plume
☐	☐	☐	☐	Handmade or imported ceramics (especially Mexican pots) used for cooking or storing food
☐	☐	☐	☐	Chili or tamarind candy imported from Mexico
☐	☐	☐	☐	Played with toys recalled due to lead content
☐	☐	☐	☐	Put metal or painted jewelry in mouth
☐	☐	☐	☐	Household member in occupation involving lead (e.g., radiator repair shops, battery manufacturer or dismantler, lead or brass foundry or smelter) Specify: _____
☐	☐	☐	☐	Child or household member with hobbies involving lead (e.g., soldering, stained glass, ceramics, lead shot, casting bullets, fishing sinkers, shooting at a rifle range or gun club) Specify: _____
☐	☐	☐	☐	Received alternative medications ☐ Azarcon ☐ Rueda ☐ Maria Luisa ☐ Greta ☐ Liga ☐ Coral ☐ Alarcon ☐ Pay-loo-ah ☐ Bali Goli ☐ Ghasard ☐ Kandu ☐ Estomaquil ☐ Alkohl (kohl) ☐ Other, specify _____
☐	☐	☐	☐	Recently traveled to foreign country Dates/locations: _____
☐	☐	☐	☐	Recently immigrated or adopted from foreign country Specify country: _____
☐	☐	☐	☐	Covered by Medicaid
☐	☐	☐	☐	Receives WIC Nutrition benefits
☐	☐	☐	☐	Attends Head Start or Early Head Start

How was this person likely exposed to lead:
☐ Paint ☐ Drinking Water ☐ Other country ☐ Job
☐ Hobby ☐ Candy, toy ☐ Alternative medication
☐ Soil ☐ Other specify _____ ☐ Unknown

Where did exposure probably occur?
☐ U.S. but not WA (State: _____)
☐ In WA (County: _____)
☐ Not in U.S. (Country/Region: _____)
☐ Unknown

Exposure details (e.g., exposure date, specific site, purchase or use-by date, product name/description): _____
_____

☐ **No risk factors or exposures could be identified**
☐ **Patient could not be interviewed**

PATIENT PROPHYLAXIS/TREATMENT

Y	N	DK	NA	
☐	☐	☐	☐	Chelated Date complete: _____
☐	☐	☐	☐	Others in the household (provide information below for each household members and attach to case investigation form)

Name	Relation	Age	Tested?	Collection date	Result (µg/dL)

PUBLIC HEALTH ISSUES

Y	N	DK	NA	
☐	☐	☐	☐	Need for environmental risk assessment ☐ If yes, OK to release patient's name and information to contractor
☐	☐	☐	☐	Environmental samples were collected
☐	☐	☐	☐	Other environmental risks in home ☐ Asthma trigger ☐ Fall hazards ☐ Mold ☐ Other, specify: _____

PUBLIC HEALTH ACTIONS

☐ Counseling on measures to avoid exposure
☐ Follow up/confirmatory blood lead tests recommended
☐ Referral to CTED's Lead Hazard Control Program
☐ Referral to developmental/educational assessment
☐ Referral to master home environmentalist
☐ Other, specify: _____

NOTES

Investigator _____ **Phone/email:** _____ **Investigation complete date** ___/___/___

Local health jurisdiction _____ **Record complete date** ___/___/___

Case defining variables are in **bold**. Answers are: Yes, No, Unknown to case, Not asked /Not answered DOH 334-169 (8/08)

Acknowledgements

Expert Panel Participants	Affiliation
Kathy Lofy, MD (Chair)	State Health Officer, Department of Health
Holly Davies, PhD	Senior Scientist, Department of Ecology
Charissa Fotinos, MD	Deputy Chief Medical Officer, Health Care Authority
Rhonda Kaetzel, PhD, DABT	Toxicologist, Public Health—Seattle & King County
Catherine Karr, MD, PhD	Pediatric Environmental Health Specialty Unit Director and Associate Professor of Pediatrics, University of Washington
Gail Kreiger, BSN	Medical Benefits/Clinical Review Manager, Health Care Authority
Anne Reese, MD	Pediatrician, Richmond Pediatrics
Cynthia Sanderson	Lead-based Paint Program Manager, Department of Commerce
Chris Spitters MD	Health Officer, Yakima Health District , Klickitat County Health Department
Nicole Thomsen, REHS	Environmental Public Health Planner, Public Health – Seattle & King County
Laura Wishik, JD	Attorney, City of Seattle
Technical Staff	
Rad Cunningham, MPH, MPA	Environmental Health Epidemiologist, Department of Health
Amanda Jones	Health Promotion Specialist, Department of Health
Elisabeth Long, MPH	Lead Epidemiologist, Department of Health
Jasmine Matheson, MPH	Refugee Health Program, Department of Health
Glen Patrick, MPH	Environmental Epidemiology Manager, Department of Health
Contributor	
Meenakshi Kushwaha, MPH	University of Washington School of Public Health MPH student
Heather McCauley	Office of Public Health Sciences, Department of Health

References

[1] Lanphear, B. P., Hornung, R., Khoury, J., Yolton, K., Baghurst, P., Bellinger, D. C., Roberts, R. (2005). Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis. *Environmental Health Perspectives*, *113*(7), 894–899. http://doi.org/10.1289/ehp.7688

[2] Godwin, H.A. (2001) The biological chemistry of lead. *Current Opinion in Chemical Biology,* 5.2 223-227.

[3] *Centers for Disease Control and Prevention* (CDC). (2015, June) "Blood Lead Levels in Children: What Do Parents Need to Know to Protect Their Children?". Available at: http://www.cdc.gov/nceh/lead/ACCLPP/Lead_Levels_in_Children_Fact_Sheet.pdf

[4] Canfield, R. L., Henderson, C. R., Cory-Slechta, D. A., Cox, C., Jusko, T. A., & Lanphear, B. P. (2003). Intellectual Impairment in Children with Blood Lead Concentrations below 10 µg per Deciliter. *The New England Journal of Medicine*, *348*(16), 1517–1526. http://doi.org/10.1056/NEJMoa022848.

[5] Lanphear, B. P., Hornung, R., Khoury, J., Yolton, K., Baghurst, P., Bellinger, D. C., Roberts, R. (2005). Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis. *Environmental Health Perspectives*, *113*(7), 894–899. http://doi.org/10.1289/ehp.7688

[6] Needleman, H.L., Schell A, Bellinger, D., Leviton, A., Alfred, EN. (1991). The Long Term Effects of Exposure to Low Doses of Lead in Childhood. An 11 Year Follow-up Report. *New England Journal of Medicine,* 322.2: 83-88.

[7] Wright JP, Dietrich KN, Ris MD, Hornung RW, Wessel SD, et al. (2008) Association of Prenatal and Childhood Blood Lead Concentrations with Criminal Arrests in Early Adulthood. PLoS Med 5(5): e101. doi: 10.1371/journal.pmed.0050101

[8] AAP Council on Environmental Health, Etzel, R.A., Balk, S.J. Pediatric Environmental Health, 3rd Edition (2011).

[9] Piomelli, S., Seaman, C., Zullow, D. Curran, A. Davidow, B. (1982). *Proceedings of the National Academy of Sciences of the United States of America.*79:10, 3335-3339.

[10] Portier, C., & Brown, M. J. (2010). *Guidelines for the identification and management of lead exposure in pregnant and lactating women*. A. S. Ettinger (Ed.). US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Environmental Health/Agency for Toxic Substances and Disease Registry.

[11] Hu, H. Tellez-Rojo, M.M., Bellinger, D., Smith, D., Ettinger, A.S., Lamadrid-Figueroa, H., Schwart, J., Schnaas, L., Mercado-Garcia, A., Hernandez-Avila, M. (2006). Fetal lead exposure at each stage of pregnancy as a predictor of infant mental development. *Environmental Health Perspectives,* 1730-1735.

[12] US Department of Health and Human Services. (2007). *Toxicological Profile for L*ead. Agency for Toxic Substances and Disease Registry. 582.

[13] Gulson, B.L., Mizon, K.J., Korsch, M.J., Palmer, J.M., Donnelly, J.B. (2003). Mobilization of lead from human bone tissue during pregnancy and lactation: A summary of long-term research. *Science of the Total Environment,* 303 (1-2): 79-104.

[14] Levin, R., Brown, M. J., Kashtock, M. E., Jacobs, D. E., Whelan, E. A., Rodman, J.,Sinks, T. (2008). Lead exposures in US children, 2008: Implications for prevention. *Environ Health Perspect*, *116*(10), 1285-1293.

[15] Jacobs, D. E., Clickner, R. P., Zhou, J. Y., Viet, S. M., Marker, D. A., Rogers, J. W., Friedman, W. (2002). The prevalence of lead-based paint hazards in US housing. *Environmental health perspectives*, *110*(10), A599.

[16] Charney, E., Sayre, J., & Coulter, M. (1980). Increased lead absorption in inner city children: where does the lead come from? *Pediatrics*, *65*(2), 226-231.

[17] Kim, D. Y., Staley, F., Curtis, G., & Buchanan, S. (2002). Relation between housing age, housing value, and childhood blood lead levels in children in Jefferson County, Ky. *American Journal of Public Health*, *92*(5), 769.

[18] Spanier, A. J., Wilson, S., Ho, M., Hornung, R., & Lanphear, B. P. (2013). The contribution of housing renovation to children's blood lead levels: a cohort study. *Environ. Health Glob. Access Sci. Source*, *12*.

[19]Washington State Department of Ecology. (2009) Washington State Lead Chemical Action Plan. Olympia, WA. http://wdfw.wa.gov/conservation/loons/science/doe_wa_lead_chem_action_plan.pdf

[20] Jacobs, D. E., Clickner, R. P., Zhou, J. Y., Viet, S. M., Marker, D. A., Rogers, J. W., … Friedman, W. (2002). The prevalence of lead-based paint hazards in U.S. housing. *Environmental Health Perspectives*, *110*(10), A599–A606.

[21] Chan, J., Sim, M., Golec, R., & Forbes, A. (2000). Predictors of lead absorption in children of lead workers. *Occupational Medicine*, *50*(6), 398-405.

[22] Roscoe, R. J., Gittleman, J. L., Deddens, J. A., Petersen, M. R., & Halperin, W. E. (1999). Blood lead levels among children of lead-exposed workers: a meta-analysis. *American Journal of Industrial Medicine*, *36*(4), 475-481.

[23] U.S. Department of Labor. Occupational Health Safety and Health Administration (2015 June). *Safety and Health Topics | Lead*. https://www.osha.gov/SLTC/lead/

[24] Centers for Disease Control and Prevention (CDC. (2013). Childhood lead exposure associated with the use of kajal, an eye cosmetic from Afghanistan-Albuquerque, New Mexico, 2013. *MMWR. Morbidity and mortality weekly report*, *62*(46), 917.

[25] Pirkle, J. L., Kaufmann, R. B., Brody, D. J., Hickman, T., Gunter, E. W., & Paschal, D. C. (1998). Exposure of the US population to lead, 1991-1994.*Environmental health perspectives*, *106*(11), 745.

[26] Centers for Disease Control and Prevention (CDC. (2013). Blood lead levels in children aged 1-5 years-United States, 1999-2010. *MMWR. Morbidity and mortality weekly report*, *62*(13), 245.

[27] Lanphear, B. P., Hornung, R., Ho, M., Howard, C. R., Eberly, S., & Knauf, K. (2002). Environmental lead exposure during early childhood. *The Journal of pediatrics*, *140*(1), 40-47.

[28] Centers for Disease Control and Prevention (CDC. (2013). Blood lead levels in children aged 1-5 years-United States, 1999-2010. *MMWR. Morbidity and mortality weekly report*, *62*(13), 245.

[29] Raymond, J., Wheeler, W., & Brown, M. J. (1999). Lead Screening and prevalence of blood lead levels in children aged 1–2 years—Child Blood Lead Surveillance System, United States, 2002–2010 and National Health and Nutrition Examination Survey, United States, 1999–2010. *Use of selected clinical preventive services to improve the health of infants, children, and adolescents—United States*, *2011*.

[30] National Center for Healthy Housing. (2015 June). *Issue Brief: Childhood Lead Exposure and Educational Outcomes*.
http://www.nchh.org/Portals/0/Contents/Childhood_Lead_Exposure.pdf

[31] Raymond, J., Wheeler, W., & Brown, M. J. (1999). Lead Screening and prevalence of blood lead levels in children aged 1–2 years—Child Blood Lead Surveillance System, United States, 2002–2010 and National Health and Nutrition Examination Survey, United States, 1999–2010. *Use of selected clinical preventive services to improve the health of infants, children, and adolescents—United States*, *2011*.

[32] Tehranifar, P., Leighton, J., Auchincloss, A. H., Faciano, A., Alper, H., Paykin, A., & Wu, S. (2008). Immigration and Risk of Childhood Lead Poisoning: Findings From a Case–Control Study of New York City Children. *American Journal of Public Health*, *98*(1), 92.

[33] Centers for Disease Control and Prevention (CDC. (2005). Elevated blood lead levels in refugee children--New Hampshire, 2003-2004. *MMWR. Morbidity and mortality weekly report*, *54*(2), 42.

[34] Mahaffey, K. R. (1995). Nutrition and lead: strategies for public health. *Environmental Health Perspectives*, *103* (Suppl 6), 191.

[35] Wright, R. O., Shannon, M. W., Wright, R. J., & Hu, H. (1999). Association between iron deficiency and low-level lead poisoning in an urban primary care clinic. *American Journal of Public Health*, *89*(7), 1049-1053.

[36] Ossiander, E. M., Mueller, M. M., & VanEnwyk, J. (2005). Childhood lead poisoning in Washington state: A statewide survey. Archives of environmental & occupational health, 60(1), 25-30.

[37] Galke, W., Clark, S., Wilson, J., Jacobs, D., Succop, P., Dixon, S., Chen, M. (2001). Evaluation of the HUD lead hazard control grant program: early overall findings. *Environmental Research*, *86*(2), 149-156.

[38] Dougherty, J. (2001, February). Prevalence of Lead Dust Hazards Study: A report for the Community. Retrieved October 2, 2015, from https://multco.us/file/30130/download

[39] Betts, K. S. (2012). CDC updates guidelines for children's lead exposure. *Environmental Health Perspectives*, *120*(7), A268.

[40] American Academy of Pediatrics. Bright Futures. (2015). Recommendation s for Preventive Pediatric Care. https://www.aap.org/en-us/Documents/periodicity_schedule_oral_health.pdf

[41] *Centers for Disease Control and Prevention* (CDC). (2015, June) CDC Lead Poisoning Prevention in Newly Arrived Refugee Children: Tool Kit. Available at: http://www.cdc.gov/nceh/lead/publications/refugeetoolkit/refugee_tool_kit.htm

[42] U.S. Centers for Disease Control and Prevention. (2012). CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in *Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention.* Atlanta, GA. http://www.cdc.gov/nceh/lead/acclpp/cdc_response_lead_exposure_recs.pdf

[43] Jacobs, D. E., Clickner, R. P., Zhou, J. Y., Viet, S. M., Marker, D. A., Rogers, J. W., Friedman, W. (2002). The prevalence of lead-based paint hazards in US housing. *Environmental Health Perspectives*, *110*(10), A599.

[44] Centers for Disease Control and Prevention (CDC. (2013). Blood lead levels in children aged 1-5 years-United States, 1999-2010. *MMWR. Morbidity and mortality weekly report*, *62*(13), 245.

[45] Pirkle, J. L., Kaufmann, R. B., Brody, D. J., Hickman, T., Gunter, E. W., & Paschal, D. C. (1998). Exposure of the US population to lead, 1991-1994.*Environmental health perspectives*, *106*(11), 745.