Attachment 1

An official website of the United States government.

Close

We've made some changes to EPA.gov. If the information you are looking for is not here, you may be able to find it on the EPA Web Archive or the January 19, 2017 Web Snapshot.

Lead at Superfund Sites

On this page:

- What is the issue and why should people care?
- What is EPA doing about it?
- What are others doing about it?
- What can you (as a person or as an organization) do about it?
- Other resources to learn more
- Examples of Superfund Site cleanups

What is the issue and why should people care?

Lead contamination at Superfund sites presents a threat to human health and the environment. Lead, a naturally occurring element, can be harmful to humans (particularly children) when ingested or inhaled. Over time, lead has become a common environmental contaminant at Superfund sites across the country. To learn more about the effects of lead poisoning and EPA's role in reducing the presence of lead in the environment, visit EPA's Lead Web page.

- EPA's Lead Web page
- EPA's actions under Federal Lead Action Plan

What is EPA doing about it?

EPA response actions at Superfund sites address a release or threat of release of a hazardous substance such as lead into the environment. Childhood blood lead (PbB) concentrations at or above 10 micrograms of Pb per deciliter of blood (µg Pb/dL) present risks to children's health. Accordingly, EPA response actions seek to limit the risk that children will have lead concentrations above 10 µg Pb/dL. The Agency’s risk assessments reduce the likelihood that such exposures will occur.

To help in making this determination, the Integrated Exposure Uptake Biokinetic (IEUBK) model and the Adult Lead Methodology (ALM) estimate the concentration of lead in the blood of children, pregnant women and their developing fetuses who might be exposed to lead-contaminated soils. The level to which EPA remediates lead contamination at Superfund sites is guided by risk assessors' application of the IEUBK model and the ALM to estimate blood lead concentrations. These findings help EPA estimate possible adverse health effect exposures.

- Integrated Exposure Uptake Biokinetic (IEUBK) model
- Adult Lead Methodology (ALM)

EPA has convened two workgroups to assist in the use of the IEUBK model and the ALM:

- Technical Review Workgroup for Metals and Asbestos (TRW) Lead Committee
- Lead Sites Workgroup (LSW)

The workgroups address risk assessment and risk management issues.

Please refer to the Software and Users' Manuals page as well as the Guidance page for important documents related to the LSW, the TRW, the IEUBK model, the ALM and risk assessment.

- Software and Users' Manuals page
- Guidance page

What are others doing about it?

To learn more about the efforts of other federal agencies, states, counties and organizations to prevent lead exposure, visit EPA's Other Lead Links page.

- EPA’s Other Lead Links page

What can you (as a person or as an organization) do about it?

Education is the key. EPA's Lead Awareness Program designs outreach activities and education materials, awards grants, and manages a toll-free hotline. The hotline helps parents, homeowners and lead professionals learn what they can do to protect their families and themselves from the dangers of lead.

- EPA's Lead Awareness Program

Other resources to learn more

EPA's Related Links page provides other resources to learn more.

- Related Links page

Examples of Superfund Site Cleanups

Superfund cleans up contaminated media, such as soil, to protect human health and the environment. Lead can be toxic when ingested or inhaled and blood lead levels can be used as a measure of exposure. Blood lead levels measured before and after cleanup confirm that exposure to lead has been reduced. The process of cleanup and changes in blood lead levels can be better understood by examining site cleanup work.

Below are a few examples of Superfund cleanup actions that show blood lead level reductions among children. At each of these sites, blood lead testing took place before and during cleanup. The table below provides additional information on the cleanups.

Superfund cleanup actions at sites where lead testing was performed

Site Name	City	State	Sources of Contamination
Vasquez Boulevard and I-70	Denver	CO	Historic smelting operations
Bunker Hill Mining & Metallurgical Complex	Smelterville	ID	Historic mining and smelting operations (More information on blood lead levels)
Cherokee County	Galena	KS	Historic mining operations
Big River Mine Slag/St. Joe Minerals Corp.	Desloge	MO	Historic mining operations
Madison County Mines	Fredericktown	MO	Historic mining operations

Site Name	City	State	Sources of Contamination
Oronogo-Duenweg Mining Belt	Joplin	MO	Historic mining and smelting operations (More information on blood lead levels)
East Helena Site	East Helena	MT	Historic smelting operations
Omaha Lead	Omaha	NE	Historic smelting operations
National Zinc Corp.	Bartlesville	OK	Historic smelting operations
Midvale Slag	Midvale	UT	Historic smelting operations (More information on blood lead levels)
Tar Creek (Ottawa County)	Ottawa County	OK	Historic mining operations (More information on blood lead levels)
RSR Corporation	Dallas	TX	Historic smelting operations
Eureka Mills	Eureka	UT	Historic mining operations

LAST UPDATED ON APRIL 3, 2019

Attachment 2

APPENDIX A
Table 7
DEFAULT VALUES FOR CALCULATING MEDIUM-SPECIFIC CONCENTRATIONS FOR LEAD

[Input Values Used in UBK Model for Lead] [(for residential exposure scenario)]			
[Geometric Standard Deviation] [(GSD)]	[1.42] [(default)]	[Drinking water intake]	[Model default]
[Outdoor air lead concentration]	[0.2 μg/m^3] [(default)]	[Soil lead level]	[495 μg/g]
[Indoor air lead concentration] [(% of outdoor)]	[30]	[Indoor dust lead level]	[495 μg/g]
[Time spent outdoors]	[Model default]	[Soil/dust ingestion weighting factor] [(%)]	[45]
[Ventilation rate]	[Model default]	[Paint lead intake]	[Model default]
[Lung absorption]	[Model default]	[Maternal contribution method]	[Infant model]
[Dietary lead intake]	[Model default]	[Mother's blood lead at birth]	[7.5 μg/dL blood] [(model default)]
[GI method/bioavailability]	[Non-linear]	[Target blood lead level]	[10 μg/dL blood]
[Lead concentration in drinking water]	[4.00 μg/L] [(default)]		

[Input Values Used in SEGH Equation] [(for nonresidential exposure scenario)]	
[Concentration of lead in soil (S)]	[987 μg/g]
[Target blood lead level in adults (T)]	[20 μg/dL blood]
[Geometric standard deviation of blood lead distribution (G)]	[1.4]
[Baseline blood lead level in target population (B)]	[4 μg/dL blood]
[Number of standard deviations corresponding to degree of protection required for the target population (n)]	[1.645 (for 95% of population)]
[Slope of blood lead to soil lead relationship (δ)]	[7.5 μg/dL blood per μg/g soil]

[REFERENCE]

[WIXSON, B.G. (1991). The Society for Environmental Geochemistry and Health (SEGH) Task Force Approach to the Assessment of Lead in Soil. Trace Substances in Environmental Health . 11-20.]

Input Values Used in IEUBK Model for Lead (for residential exposure scenario)		
Parameter	**Value**	
Outdoor Air Pb Concentration (µg/m^3)	**Constant Value: 0.1**	
Dietary Lead Intake (µg/day)	**Age (Years)**	**Input**
	0-1	**2.26**
	1-2	**1.96**
	2-3	**2.13**
	3-4	**2.04**
	4-5	**1.95**
	5-6	**2.05**
	6-7	**2.22**
Water Consumption (L/day)	**Age (Years)**	**Input**
	0-1	**0.2**
	1-2	**0.5**
	2-3	**0.52**
	3-4	**0.53**
	4-5	**0.55**
	5-6	**0.58**
	6-7	**0.59**
Use Alternate Water Value?	**NO**	
Lead concentration in drinking water (µg/L)	**4**	
MEDIA	**ABSORPTION FRACTION PERCENT**	
Soil	**30**	
Dust	**30**	
Water	**50**	
Diet	**50**	
Alternate	**0**	
Calculate PRG		
Select Age Group for Graph	**0 to 84 months**	
Change Cutoff	**TBD**	
Change GSD	**1.6**	
Probability of Exceeding the Cutoff	**5**	

Input Values Used in the Adult Lead Model (ALM) (for non-residential exposure scenario)			
Variable	**Description of Variable**	**Units**	**Value**
$PbB_{fetal, 0.95}$	**Target PbB in fetus**	**µg/dL**	**TBD**
$R_{fetal/maternal}$	**Fetal/maternal PbB ratio**	**--**	**0.9**
BKSF	**Biokinetic Slope Factor**	**µg/dL per µg/day**	**0.4**
GSD_i	**Geometric standard deviation PbB**	**--**	**1.8**
PbB_0	**Baseline PbB**	**µg/dL**	**0.6**

IR_S	**Soil ingestion rate**	**g/day**	**0.050**
$AF_{S, D}$	**Absorption fraction**	**--**	**0.12**
$EF_{S, D}$	**Exposure frequency**	**days/yr**	**219**
$AT_{S, D}$	**Averaging time**	**days/yr**	**365**

Attachment 3

Cleanup Standards Scientific Advisory Board
Meeting Minutes
RCSOB Room 105
April 4, 2018

CSSAB Members Present:

Ronald Buchanan, Chairman
Joel Bolstein
Chuck Campbell
James Connor
Colleen Costello
Annette Guiseppi-Elie
Michael Meloy
Craig Robertson
Mark Smith
Mark Urbassik
Don Wagner

Department of Environmental Protection (DEP) Staff Present:

Abbey Cadden
Troy Conrad
Carolyn Fair
George Hartenstein
Mike Maddigan
Frank Nemec
Brie Sterling
Ali Tarquino Morris
Sharon Trostle

Others Present:

John Clarke – Penn DOT
Jenny DeBoer – Stantec
Will Hitchcock – Manko, Gold, Katcher, & Fox
J. Neil Ketchum – Groundwater Sciences
Kay Linnell - Langan
Ted Mosher – React Environmental

Call to Order

Chairman Ronald Buchanan called the Cleanup Standards Scientific Advisory Board (CSSAB) meeting to order at 9:10 a.m.

Administrative Items

The draft meeting minutes of the September 7, 2017, CSSAB conference call were approved unanimously without comment or revision.

Troy Conrad announced that Mr. Buchanan is retiring after many years of service. Mr. Conrad read a letter of appreciation from PA DEP Secretary McDonnell aloud. Mr. Buchanan subsequently requested nominations from the Board to elect a new Chairman. Craig Robertson nominated Chuck Campbell, which was seconded by Mike Meloy. Mr. Campbell accepted the nomination, and it was unanimously approved by the Board pending approval from Mr.

Campbell's employer. Mr. Meloy will remain Vice-Chairman. Upon acceptance, Mr. Campbell chaired the remainder of the meeting.

Mr. Conrad reminded the Board that recent revisions to the bylaws allow members with expired terms to remain active on the Board until reappointment. Michael Maddigan reviewed the list of Board members' terms and expiration dates. Currently, Mr. Campbell (term expired 7/2013) and Mark Urbassik (term expired 7/2016) will remain active while awaiting reappointment, and there are currently two vacant positions on the Board. Additionally, J. Neil Ketchum has been appointed by Secretary McDonnell as an alternate for Mr. Robertson on the Board.

Land Recycling Program (LRP) Update

George Hartenstein announced that Mr. Conrad has been named Acting Director of the Bureau of Environmental Cleanup & Brownfields. Mr. Hartenstein reported on the financial status of the Bureau. The Hazardous Sites Cleanup Fund (HSCF), which funds the operating budget of the Bureau, is expected to provide sufficient funds to fully maintain operation of the Bureau until the fiscal year ending June 30, 2019. At that point, HSCF is expected to provide only 40-50 percent of the funds required to maintain Bureau functions at full capacity. Solutions to the upcoming financial situation remain under consideration by DEP executive staff and the legislature. Joel Bolstein offered to discuss the financial shortfall with PENNVEST to determine if financing opportunities exist. Colleen Costello suggested the Brownfields Reauthorization Act as a possible funding source.

Mr. Conrad reported that the final-omit rulemaking was published on March 17, 2018, in the *Pennsylvania Bulletin*. This rulemaking was solely to correct specific errors in the MSCs and toxicity values. The errors were due to a transcription error for the groundwater medium-specific concentration (MSC) for Aldrin and transcription errors for the toxicity values used to calculate soil MSCs for beryllium and cadmium.

The Chapter 250 regulations contain a requirement to review and propose necessary revisions to the MSCs every 36 months. Therefore, in support of the next rulemaking cycle, the Bureau expects to share concepts for the upcoming rulemaking (36-month period expires September 2019) with the CSSAB during the next Board meeting on August 1, 2018.

Mr. Conrad provided an update on the Department's activity regarding emerging contaminants Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA). EPA issued drinking water Health Advisory Levels (HAL) in 2016 for the chemicals. By law, the HAL is adopted as the MSC for groundwater upon publication in EPA's most recent edition of the Drinking Water Standards and Health Advisories. The PFOS/PFOA MSC will be added to the next Chapter 250 rulemaking. Mr. Bolstein expressed concern with the use of the HAL outside of its intended use as a drinking water advisory level. He is concerned that the HAL has limitations that may prevent it from being used as a cleanup value for groundwater or surface water. Mr. Bolstein also suggested the Department evaluate the equations in Chapter 250 to determine if they can be used to calculate MSCs for PFAS chemicals. Brie Sterling of DEP is closely monitoring the U.S. Environmental Protection Agency's (EPA's) research and is a member of ITRC's PFOS/PFOA

research team. All newsworthy items regarding this issue will be posted on DEP's webpage devoted to this issue. Mr. Campbell states that this set of chemicals may be extremely challenging for remediators who are attempting to attain the Background cleanup standard. He also requested that the Board have ample time ahead of the next scheduled meeting if any input is required regarding the development of toxicity values for these chemicals. Audience member John Clarke requested that the cost of analytical testing be considered when the relevant parties develop methodologies.

Mr. Conrad reported that the public comment period for the draft publication of the LRP Technical Guidance Manual (TGM) ended on March 16, 2018. A total of nine commentators submitted nearly 100 total comments to the Bureau. LRP staff are presently consolidating comments and preparing a comment-response document. An overview of the comments will be discussed at the next Board meeting with the goal of finalizing the TGM in the 4th quarter of 2018. The Board suggested an ongoing review of portions of the TGM for future meetings rather than being asked to review the entire revised document all at one time.

Management of Fill Policy Presentation

Ali Tarquino Morris, Municipal and Residual Waste Program Manager from the Bureau of Waste Management, provided a PowerPoint presentation regarding proposed revisions to DEP's Management of Fill Policy (MoFP). Don Wagner indicated that some native materials in Pennsylvania may contain regulated substances at concentrations higher than what is designated as clean fill. He requested that the revised MoFP emphasize that a spill or release must occur for fill material to be considered regulated fill. Mr. Wagner also noted the term "background" is defined differently by the Bureau of Waste Management than the LRP. Ms. Tarquino Morris stated that the issue of naturally occurring substances with concentrations above clean fill thresholds is currently addressed on the MoFP FAQ webpage. It was suggested that a "Decision Tree" be included in the revised MoFP for those not familiar with the process. Mr. Meloy stated that it is important to differentiate the terms "background" versus "point source," especially at urban sites. Mr. Bolstein queried whether DEP performs investigation/enforcement regarding fill sources originating from other states. Ms. Tarquino Morris responded that regional Waste Management staff review information provided by out-of-state sources and follow up as needed. Mr. Bolstein asked the Department to ensure major changes to the clean fill values are highlighted in the revised policy. Mr. Robertson suggested removing the word "uncontaminated" from the policy, as the definition of that term may differ between DEP programs. Mr. Meloy suggested that remediators be able to use due diligence information to demonstrate inorganics concentrations are at background levels without the need to collect additional samples. Mark Smith suggested short lists be developed for sampling at specific sites such as gas stations, oil and gas sites, etc. Mr. Campbell inquired about timing aspects regarding sampling plans when moving fill from one site to another. Mr. Hartenstein reported that if soil is from an unknown source, a sampling plan may be warranted. DEP would have 10 days to review the submitted sampling plan, or the plan would be deemed approved.

Chapter 250 Technical Questions

DEP posed the following technical issues to the Board:

1. The recommended groundwater ingestion rate as issued by EPA's Office of Solid Waste and Emergency Response has increased from 2.0 to 2.5 L/day. By implementing this revision, PA's groundwater MSC values would become lower. Annette Guiseppi-Elie recommended usage of the Exposure Factors Handbook for further assistance on this matter. The Board will form a workgroup to evaluate other exposure factors to determine if any additional updates to the Chapter 250 MSC equations are needed.
2. EPA allows for rounding risk characterization results to one significant figure. The Land Recycling and Environmental Remediation Standards Act (Act 2) uses a hazard index of 1.0 which is at odds with EPA's risk assessment guidance. After some discussion, the Board advised the Department that rounding to one significant figure seemed reasonable.
3. § 250.305(g) states that a remediator conducting a remediation of soils contaminated with a substance having a secondary Maximum Contaminant Level (MCL) will not be required to comply with the soil-to-groundwater pathway requirements for those substances to protect groundwater in aquifers for drinking water. However, as an example, the substance fluoride has both a primary and secondary MCL. The Board suggested using the primary MCL in this case. Or, if a Health Advisory Level (HAL) exists for a substance, the HAL should be utilized to calculate an MSC.
4. EPA and Centers for Disease Control and Prevention (CDC) have determined that childhood blood lead concentrations at or above 10 micrograms of lead per deciliter (µg/dL) present risks to children's health. However, CDC has a blood lead action level of 5 µg/dL. Additionally, the input parameters used in calculating the residential ingestion numeric value for lead in soil are based on EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model from 1990. Guidance was requested regarding which level should be used and whether DEP should update the model used for the input parameters. Ms. Guiseppi-Elie stated that blood lead action levels are a top priority for EPA and it is possible that the action level could go as low as 3 µg/dL. She recommended the Department monitor the development of this issue, and she offered to research this issue further and report back to DEP. Ms. Guiseppi-Elie also recommended the Department update the input values on Table 7 in Chapter 250 and the model references.
5. The current definition of a volatile compound in § 250.1 is based solely on boiling point which results in the exclusion of naphthalene as well as several other semi-volatiles. It also is incongruent with the volatile description provided in the current DEP Vapor Intrusion Guidance (see Appendix A, Section 1, page 74). After some discussion, the Board recommended the Department revise the definition of a volatile in the Chapter 250 regulations so that it is consistent with the definition in the DEP Vapor Intrusion Guidance and the most widely accepted science for what is a volatile compound.
6. The recommendation was made by the Board to add the EPA Office of Pesticide Program's toxicity value database to the toxicity value source hierarchy in § 250.605.

Other Business

- Ms. Guiseppi-Elie agreed to further investigate toxicity values/updates for vanadium and report back at a future Board meeting. Provisionally peer-reviewed toxicity values (PPRTV) for vanadium (pentoxide) have a low level of confidence.
- Mr. Campbell requested that DEP examine the use of statistical analysis at sites being remediated to the Background standard. Mr. Campbell related that DEP staff may be too dependent on requiring statistical analysis of sampling data when it is not warranted. Mr. Conrad encouraged any Board member who may have similar experiences in the future to contact Central Office for additional assistance.
- Mr. Conrad and Mr. Maddigan agreed to provide clarification on the terms 'subcommittee' vs. 'workgroup' and their respective public notification requirements at the next Board meeting.
- Mr. Meloy reported that a meeting in which he participated between DEP's Oil & Gas Program and the Land Recycling Program was a good step forward towards the goal of site cleanup policy integration.

Meeting Adjourned at 2:10 p.m.

Attachment 4

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Bureau of Environmental Cleanup & Brownfields

Land Recycling Program
Concepts for Potential Regulatory Changes for the Chapter 250 Rulemaking

Cleanup Standards Scientific Advisory Board Meeting
August 1, 2018

presented by
Michael Maddigan
PADEP

Tom Wolf, Governor

Patrick McDonnell, Secretary

Concepts Overview

Today's Discussion

- Summary and discussion of potential minor changes.
- Discussion of potential substantive changes.
- Next steps in rulemaking process.

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Minor Changes Summary

- Updating document references and section references.
- Updating medium-specific concentration (MSC) tables by adding new chemicals, correcting footnotes, correcting Chemical Abstract Service (CAS) number errors, etc.
- Minor text clarifications and updates.

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Minor Changes

- Update US Environmental Protection Agency (EPA) Exposure Factors Handbook (EFH) reference.
- Add conversion factor to § 306 and § 307 equations so output units (µg/L) match units in tables.
- § 250.704(d) - Replace § 250.707(b)(2)(i) reference with § 250.707. § 250.707(b)(2)(i) relates only to the 75% 10x rule, not all statistical tests.
- Remove chemicals with both primary and secondary Maximum Contaminant Levels (MCLs) from secondary contaminants list at the end of Table 2 and update § 250.305(g) text.

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Minor Changes

- Reword text in § 250.402(d) to clarify that the Statewide health standard eco-screen process described in § 250.311(e) cannot be used to protect ecological receptors under the site specific standard.
- Correct the CAS number for dichloroacetic acid in Table 1 from “76-43-6” to “79-43-6.”
- Explain Act 2 does not provide liability protection for analytes reported by labs not accredited for those analytes for which accreditation is available.
- Correct misuse of the word “standards” when “MSCs” should be used.

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Minor Changes

- Update all table footnotes.
- Add Office of Pesticide Programs (OPP) to toxicity value source hierarchy in § 250.605.
- Add “24 hours/day” to numerator in § 250.307(g)(1) equation. Inadvertently omitted in last rulemaking.
- Update Constituents of Potential Ecological Concern (CPEC) list in Table 8.
- State in § 250.408 or § 250.409 that an approved remedial investigation report is needed to have an approvable risk assessment report.

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Minor Changes

- Change references to the Groundwater Monitoring Guidance in § 250.10 to reference Appendix A of revised Technical Guidance Manual (TGM).
- Explain in § 250.503(e) that when land use changes from non-residential to residential at Special Industrial Area (SIA) sites, a revised baseline environmental report needs to be submitted, not just a new remediation plan.
- Update aqueous solubility sources in § 250.304(f).

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Substantive Changes

Increase Groundwater Ingestion Rate

- Change groundwater ingestion rate for adults from 2.0 L/day to 3.0 L/day.
- EPA EFH recommends 3.0 L/day for ages ≥ 21 years old (adults). This value represents both per capita and consumer-only water ingestion rates.
- Change would cause ingestion-based numeric values to decrease.

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Substantive Changes

Lead in Soil Evaluations

- Use the Integrated Exposure Uptake Biokinetic (IEUBK) model and the Adult Lead Methodology (ALM) to calculate MSCs for residential and non-residential lead exposure, respectively.
- EPA – *"Recent scientific evidence has demonstrated adverse health effects at blood lead concentrations below 10 µg/dL down to 5 µg/dL, and possibly below. OSRTI is developing a new soil lead policy to address this new information."*
- Should DEP use 10 or 5 µg/dL?

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Substantive Changes

Change Volatile Definition

- Change the definition of a volatile in § 250.1. Current definition results in the exclusion of naphthalene as well as several other semi-volatiles that are included in the new vapor intrusion (VI) guidance. EPA has a better definition that DEP could adopt, and it is more appropriate given the recent changes in the VI guidance.
- New definition would lead to some numeric values changes.

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Substantive Changes

Add Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) to Tables

- Add PFOS/PFOA HAL to Table 1 as MSCs
- Add footnote that the HAL/MSC also applies when PFOS and PFOA are combined.
- Add PFOS/PFOA toxicity data to Table 5A.
- Calculate PFOS/PFOA soil MSCs for Tables 3A and 3B.

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Substantive Changes

Additional Changes

- Add language to § 250.707(b)(1)(iii) clarifying when/if a vapor intrusion analysis is needed.
- Add language to Subchapter A similar to § 245.314 making requirements for professional geologist (PG) and professional engineer (PE) seals on reports for Act 2 and storage tanks sites consistent.

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Next Steps for Rulemaking

- Draft proposed language for Annex, including draft tables, to be provide to CSSAB at December 6, 2018, meeting.
- EQB consideration of proposed rulemaking in Spring 2019.

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Bureau of Environmental Cleanup & Brownfields

Questions?

Mike Maddigan

mmaddigan@pa.gov

Attachment 5

Cleanup Standards Scientific Advisory Board
Meeting Minutes
RCSOB Room 105
August 1, 2018

CSSAB Members Present:

Chuck Campbell, Chairman
Joel Bolstein
Colleen Costello
Neil Ketchum (Alternate for Craig Robertson)
Michael Meloy
James Connor
Don Wagner

Department of Environmental Protection (DEP) Staff Present:

Abbey Cadden
Troy Conrad
Carolyn Fair
Mike Maddigan
Frank Nemec
Robert Schena
Brie Sterling

Others Present:

Jenny DeBoer Kachel - GHD
Ben Myers - GTA
Terence O'Reilly – TriState Environmental

Call to Order

Chairperson Chuck Campbell called the Cleanup Standards Scientific Advisory Board (CSSAB) meeting to order at 0923.

Administrative Items

The draft meeting minutes of the April 4, 2018, CSSAB meeting were approved unanimously without comment or revision.

Mr. Campbell reported that several CSSAB members are interested in developing workgroups to discuss relevant issues.

Two vacancies on the CSSAB remain. There are no new developments since the April 2018 meeting regarding filling these vacancies.

Mr. Campbell also requested that the Board receive a preview of the revised draft Technical Guidance Manual (TGM) prior to final publication. CSSAB would like a chance to review a red-

line version of the final document and provide input on any potential concerns with the final wording or other issues identified.

Land Recycling Program (LRP) Update

Troy Conrad gave an update on the health of the Hazardous Sites Cleanup Fund (HSCF), which funds the operating budget of the Bureau. The HSCF, along with funds received by the Environmental Protection Agency's (EPA) Section 128(a) Grant Program for State and Tribal Response Programs, is expected to provide sufficient funds to maintain 100% operation of Bureau of Environmental Cleanup & Brownfields (BECB) until the fiscal year ending June 30, 2019. Beyond this point, DEP will explore staff attrition and/or fewer response actions at Hazardous Sites Cleanup Act sites.

Personnel update – Mr. Conrad reported on the status of open managerial positions in the Bureau: The Environmental Program Manager (EPM) position in Central Office is expected to be filled later in 2018; the EPM position in the Southwest Regional Office (SWRO) will soon be vacant as Kevin Halloran, current EPM, is moving to the Assistant Regional Director position; two managerial positions in the Southeast Regional Office (SERO) remain unfilled. Colleen Costello inquired if DEP may implement a program such as New Jersey DEP's Licensed Remediation Site Professional due to staff attrition. There are no plans for PA DEP to transition to that type of program.

Per- and Polyfluoroalkyl Substances (PFAS) update – Mr. Conrad reported that he accompanied Lisa Daniels, Bureau Director of Safe Drinking Water, to the National PFAS Summit hosted by EPA in Washington, D.C. DEP and PA Department of Health will be exploring the feasibility of hiring a toxicologist to explore developing a maximum contaminant level for drinking water. Mr. Bolstein inquired as to whether Act 2 cleanups involving these substances can be undertaken utilizing the background cleanup standard. Mr. Conrad replied that yes, the background standard can be used, but most if not all Act 2 cleanups involving these substances have been undertaken using the site-specific standard with a pathway elimination remedy.

CSSAB subcommittee vs. workgroup public notification requirements – Mike Maddigan explained the difference between the entities and their respective notification requirements as requested by the CSSAB. A subcommittee is a subgroup of CSSAB members developed to address broad on-going topics and is comprised entirely of Board members. Subcommittee meetings are subject to the same notification requirements as full CSSAB meetings (meetings must be announced on the DEP website as well as comply with any other PA Sunshine Act requirements). Workgroups can be established to discuss a specific topic but can be comprised of CSSAB members, DEP staff, and other stakeholders and generally disband once a specific issue is resolved. There are no notification requirements for workgroup meetings. Also, conversations/emails between Board members on specific topics have no notification requirements.
(Editor's Note: According to DEP's draft Advisory Committee Guidelines (document # 012-1920-002), workgroups are established by DEP in concert with advisory committees and are

subject to the same notification requirements, when practicable, as subcommittees and advisory committees.)

TGM revision timeline – Mr. Conrad reported that the final TGM is anticipated to be published in December 2018. Going forward, DEP expects to update the TGM every 3 years. DEP is not planning on producing a comment/response document specifically addressing CSSAB comments regarding draft versions of the TGM as these comments have been addressed in CSSAB meetings over the past few years. DEP will consider providing the CSSAB with a redline version of the final document prior to publication to identify any minor grammatical changes. Michael Meloy inquired whether a redline version or user's guide will be available to the public to help readers understand the revisions to the TGM. DEP will consider publishing a summary of major revisions. DEP is also producing a Response to Comments document which will be published simultaneously with the final TGM.

New Rulemaking Timeline – Mr. Conrad reported that proposed revisions to the Chapter 250 regulations will be presented to the CSSAB during the December 2018 meeting. The entire new rulemaking process is anticipated to last 15-18 months in total.

Overview of TGM responses to public comments presentation

Mr. Maddigan presented an overview of public comments received regarding the draft TGM.

Mr. Meloy emphasized the importance of giving the CSSAB access to a redline version of the revised draft TGM prior to its final publication. DEP agreed to take Mr. Meloy's request under consideration. Mr. Campbell requested DEP to distribute a calendar indicating future milestones regarding TGM publication. The calendar would greatly benefit CSSAB with the knowledge of internal DEP deadlines, enabling CSSAB members to review and offer input on topics in a timely manner.

Mr. Bolstein inquired as to whether a Q&A database will continue after final TGM publication. Mr. Conrad replied yes.

Mr. Campbell inquired if separate phase liquid (SPL) guidance is forthcoming from DEP. Specific SPL requirements as detailed in Chapter 245 regulations (Storage Tank and Spill Prevention Program) that are applicable to Act 2 will be added to the revised TGM.

Mr. Meloy asked if Act 2 program interaction with Oil & Gas and with the Toxic Substances Control Act (specifically, the cleanup of polychlorinated biphenyls – PCBs) will be addressed as requested in the comments he submitted during the public comment period. Mr. Conrad reported that language regarding Act 2 interaction with those two programs will not be integrated into the final TGM.

Mr. Bolstein and Ms. Costello have reportedly been experiencing a recent surge in excess site characterization activities required by Act 2 project staff. Ms. Costello stated that characterization activities have been required on offsite downgradient properties, causing delays

and unnecessary expenditures that can be avoided with the acceptance of groundwater modeling. As such, Mr. Bolstein and Ms. Costello are requesting more robust language in the TGM suggesting that groundwater modeling be an acceptable instrument for demonstrating attainment of a cleanup standard. Mr. Conrad stated the DEP will take the request under consideration. In the meantime, any disputes that may arise regarding this topic can be taken to the project officer's supervisory chain-of-command and, without satisfactory conclusion, to Central Office BECB staff.

Summary of possible Chapter 250 rulemaking revisions

Mr. Maddigan presented an overview of possible Chapter 250 rulemaking revisions for the CSSAB to consider. The proposed revisions were divided into the categories "potential minor changes" and "potential substantive changes." The following present significant discussion points during the presentation:

- Minor change – Mr. Maddigan asked if Act 2 provides liability protection for analytes reported by labs not accredited for those analytes for which accreditation is available. It was determined that this is rare and should be handled on a case-by-case basis. The Board recommended against adding this language as part of the rulemaking.
- Minor change – Explain in § 250.503(e) that when land use changes from non-residential to residential at Special Industrial Area (SIA) sites, a revised baseline environmental report (BER) needs to be submitted, not just a new remediation plan. CSSAB objected to the wording of the proposed change, as they believe the Act 2 project officer may be inclined to interpret 'revised' to indicate an entirely new BER is required in this instance. DEP will consider revising the wording for this change from "revised" to "amend" to avoid confusion.
- Substantive change – Increase groundwater ingestion rate from 2.0 L/day to 3.0 L/day. This change would cause ingestion-based numeric values to decrease. CSSAB was not in agreement with the volumetric revision as typical for human consumption. The CSSAB stated that a value of 2.5 L/day would be more appropriate and asked if the PA Department of Health or the Safe Drinking Water Program have an accepted value that can be used. After further discussion it was decided to form a CSSAB workgroup to further discuss this change.
- Substantive change – DEP requesting guidance on whether 5 µg/dL or 10 µg/dL is the proper blood lead concentration that demonstrates adverse health effects. CSSAB recommended that 10 µg/dL be used in the equation to calculate medium-specific concentrations (MSCs) for residential and non-residential lead exposure.
- Substantive change – The definition of a "volatile" is to be revised in § 250.1 to include several semi-volatiles that are included in the definition of a "volatile" in the vapor intrusion guidance. It was determined that this issue would be assigned to a CSSAB workgroup to further evaluate the implications of the proposed change.
- Substantive change – Add Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) to tables. Since a Health Advisory Limit (HAL) has been issued, the groundwater MSCs for these substances will be added to the regulations. The soil MSCs

will require calculation. It was determined that the PFOS/PFOA MSC derivation will be forwarded to a workgroup for further discussion.

Presentation and discussion of potential Chapter 250 numeric value changes (tables)

Brie Sterling presented the summary of potential numeric changes to the Chapter 250 regulations and the procedures for rounding the MSCs. Following Ms. Sterling's presentation, the following topics were discussed:

- Mr. Meloy expressed his continuing concern with the reportedly unjustified decrease in MSC by several orders of magnitude for vanadium in soil because of the previous Chapter 250 rulemaking revisions.
- On Table 4A of the Chapter 250 regulations (MSCs for Inorganic Regulated Substances in Soil) Mr. Meloy requested chlorides to be added. He believes the MSC for chlorides in soil can be calculated in a similar manner as the MSC for aluminum, which is included on the table.

Other Business

Mr. Bolstein asked for an update on the general health of the LRP regarding the number of incoming Act 2 sites observed across the Commonwealth. Mr. Conrad reported that the number of incoming sites has remained consistent over the past year.

Mr. Campbell concluded proceedings by reviewing potential action items: DEP to add calendar of milestones to CSSAB members; CSSAB to form one or more workgroups to further discuss: lead blood level concentrations, groundwater ingestion rates, definition of a volatile, PFOS/PFOA issue, toxicity value of vanadium, and development of a soil MSC for chlorides. CSSAB may call upon DEP staff and the public for assistance as needed. Mr. Conrad suggested that all workgroup considerations for DEP be submitted by the end of September 2018.

Mr. Conrad reported that the PA Brownfields Conference is being held October 1-3, 2018, at the Sands Casino in Bethlehem, PA. Registration at the conference website is open.

Meeting Adjourned at 1520.

Attachment 6

Lead Model Comparison

Direct contact Soil Lead Numeric Value	Current Value mg/kg	New Modeled Value Target Pb_b = 10 µg/dL	New Modeled Value Target Pb_b = 5 µg/dL
Residential	500 (UBK)	420 (IEUBK)	153 (IEUBK)
Non-residential	1,000 (SEGH)	2,517 (ALM)	1,050 (ALM)

Pb_b = Blood lead level

Current Values

The current residential soil direct contact numeric value for lead was calculated using EPA's 1990 version of the Uptake Biokinetic (UBK) model with a target child blood lead level of 10 µg/dL. The default UBK model input parameters used to calculate this value are listed in Table 7 of Chapter 250.

The current non-residential soil direct contact numeric value for lead was calculated using the Society for Environmental Geochemistry and Health (SEGH) model from 1991 with a target adult blood lead level of 20 µg/dL. The default SEGH model input parameters used to calculate this value are listed in Table 7 of Chapter 250.

Proposed Values

EPA's lead guidance website states, *"Recent scientific evidence has demonstrated adverse health effects at blood lead concentrations below 10 µg/dL down to 5 µg/dL, and possibly below. OSRTI is developing a new soil lead policy to address this new information."* Thus, the Department has calculated residential and non-residential soil direct contact numeric values using the most up-to-date EPA models at both target blood lead levels to demonstrate the difference between the two.

EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model (2010) was used to calculate the residential soil direct contact numeric values. The IEUBK model is similar to the 1990 UBK model in that its purpose is to predict an acceptable soil concentration given a target child blood lead level. The IEUBK model was run using the most current default values set by EPA with target blood lead levels of 10 µg/dL and 5 µg/dL.

EPA's Adult Lead Methodology (ALM) (2003) was used to calculate the non-residential soil direct contact numeric value. The SEGH model's target receptor is an adult while the ALM's target receptor is the potential fetus of a female adult worker. The ALM was also run using the most current default values set by EPA and target blood lead levels of 10 µg/dL and 5 µg/dL.

EPA's guidance for the ALM cautions that the values calculated using this new model are high and may not be protective of all receptors, i.e. a school or playground that borders a non-residential property. This is not necessarily in-line with the purpose of the statewide health standard which should be protective across the entire state.

Attachment 7

Meeting Minutes
Cleanup Standards Scientific Advisory Board
Rachel Carson State Office Building – Room 105
February 13, 2019

CSSAB Members Present:

Chuck Campbell, Chairman
Joel Bolstein
James Connor
Colleen Costello
Annette Guiseppi-Elie (via telephone)
Michael Meloy
Craig Robertson
Mark Urbassik (via telephone)
Don Wagner

Department of Environmental Protection (DEP) Staff Present:

C. David Brown
Abbey Cadden
Troy Conrad
Laura Edinger
Mike Maddigan
Lee McDonnell
Frank Nemec
Robert Schena
Brie Sterling

Others Present:

Jenny Kachel - GHD
Neil Ketchum – Groundwater Sciences Corporation
Ed Layton – BAI Group
Kay Linnell - Langan

<u>Call to Order</u>

Mr. Chuck Campbell, Chairman of the Cleanup Standards Scientific Advisory Board (CSSAB), called the meeting to order at 0920. Around the room introductions proceeded.

The draft meeting minutes of the August 1, 2018 CSSAB meeting were approved unanimously without comment or revision.

Membership update: Mr. Troy Conrad confirmed that any CSSAB members whose term has expired may remain on the Board and actively participate until re-appointment or replacement. Mr. Conrad reported that obtaining member re-appointments and filling vacancies on a timely basis has been problematic for many DEP advisory boards.

Mr. Campbell proposed future CSSAB meetings to start at 0930 as Call to Order usually has occurred closer to 0930 than 0900. Mr. Campbell also suggested that future meetings be preceded by a CSSAB Workgroup telephone conference for meeting preparation.

Land Recycling Program (LRP) Update

Funding Update: Mr. Conrad gave an update on the status of the Hazardous Sites Cleanup Fund (HSCF), which funds the operating budget of the Bureau of Environmental Cleanup & Brownfields (BECB). As a result of reduced funding available, there is a growing number of vacancies across the Bureau. Going forward, central and regional office staff will be focused on providing customer service, and less focus will be given to state-funded hazardous site cleanups. The Agency will continue to explore possible funding sources for beyond the fiscal year ending June 2020. Mr. Joel Bolstein inquired about Industrial Sites Reuse Program funding administered by the Department of Community & Economic Development, and its availability to provide funding to the program. Mr. Bolstein stated that funding from this program for remediation work has been drastically reduced.

Personnel update: Mr. Conrad introduced Mr. Lee McDonnell to the CSSAB. Mr. McDonnell is the Bureau's new Environmental Program Manager for the Division of Cleanup Standards.

Per- and Polyfluoroalkyl Substances (PFAS) update: Mr. Conrad reported on continuing statewide efforts for this emerging contaminant. Presently, PA is in the process of attaining proper instrumentation and trained staff to conduct laboratory analysis. DEP staff is collecting samples from drinking water suppliers for laboratory analysis. DEP is working in coordination with PA Department of Transportation to identify sources of fire-fighting foam usage throughout the Commonwealth. DEP is also focusing on expansion of data collection in areas where continuing sources of PFAS persist. Additionally, DEP is investigating the possible promulgation of medium specific concentrations (MSC) for PFAS in soil and a PA state drinking water maximum contaminant level (MCL). Mr. Bolstein inquired who would take responsibility for any associated contamination resulting from a firefight using PFAS-laden foam. Mr. Conrad reported that no discussions regarding this issue have been undertaken. Ms. Colleen Costello inquired whether PFAS compounds can be remediated under the Act 2 background cleanup standard. Mr. Conrad stated that the background standard would be available for PFAS contaminated sites. Mr. Bolstein reminded the Board and DEP that Act 2 cleanups allow contaminants to remain in-place above their respective MSCs (e.g. 75%/10x rule for Statewide health standard cleanup attainment). Ms. Annette Guiseppi-Elie inquired if PA has representation in the Environmental Council of States (ECOS); Ms. Guiseppe-Elie offered to work with the DEP regarding this emerging contaminant's toxicological research.

New Rulemaking Timeline: Mr. Conrad reported that proposed revisions to the Chapter 250 regulations are expected to be promulgated within a 22-24-month timeframe. Mr. Michael Meloy stated that the Bureau of Waste Management's Management of Fill Policy (MOFP) and its interaction with the Chapter 250 regulations may continue to produce confusion to the consulting community due to the lack of consistency between the adopted MSCs, the proposed MSC revisions, and the regulated fill concentrations proposed for the MOFP.

Technical Guidance Manual (TGM): Mr. Conrad reported that final publication of the TGM occurred on 1/19/2019. DEP appreciated all the time and effort that CSSAB devoted to finalizing

this publication. Updates to the TGM are planned to occur on a 24-36-month basis going forward. Since the Question & Answer (Q&A) database has been removed from the LRP website, Mr. Bolstein questioned the protocol for general technical questions going forward. Mr. Conrad requested that all technical questions be forwarded to Mr. Michael Maddigan. Mr. Meloy suggested keeping the Q&A database on the LRP website. Ms. Costello suggested keeping the Q&A database on the LRP website but removing the answers and replacing them with section references indicating the location of the answers in the revised TGM. Ms. Costello and Mr. Craig Robertson volunteered to assist in this effort.

Discussion of proposed capping guidance addendum to TGM

Mr. Maddigan presented a proposed addendum to the TGM regarding guidance of the construction of caps as engineering controls. Following Mr. Maddigan's presentation regarding the origin and proposed text, he opened the proceedings for questions/comments from the Board.

Several members of the CSSAB commented that the cap construction guidance is overly prescriptive. There is concern that regional Act 2 project officers will consider this guidance as a 'requirement' with respect to engineering control cap construction. The consensus from the CSSAB is that this guidance is not needed and that implementing such guidance makes the Act 2 process more cumbersome which may discourage some from entering the Act 2 process. The CSSAB expressed particular concern with the Inspections and Maintenance section of the proposed capping guidance as being particularly prescriptive. It was suggested that this section be removed and replaced with a reference to the post-remediation care plan section of the TGM and focusing the guidance on the goals of the remedy. Mr. Conrad stated that DEP would consider the recommended revision.

Mr. C. David Brown, Professional Geologist Manager in the Southeast Regional Office (SERO) explained that SERO has been receiving inquiries from consultants and stakeholders seeking guidance for constructing engineering control caps. In addition, SERO has experienced instances of failure to document construction of caps after workplan approval has been issued. Additionally, Secretary McDonnell of DEP has requested that LRP develop guidance for this engineering remedy.

The CSSAB committed to developing a workgroup to review the proposed capping guidance developed by the DEP and will propose revisions/recommendations. The workgroup will be chaired by Ms. Jenny Kachel of GHD; Ms. Costello will assist and inform DEP of other CSSAB members who will participate in the workgroup. DEP informed CSSAB that any revisions/recommendations proposed to the guidance should be presented to DEP within six to ten weeks from the date of this meeting.

Summary of possible Chapter 250 rulemaking revisions presentation

Mr. Maddigan presented an overview of proposed Chapter 250 rulemaking revisions for the CSSAB to consider. The following present significant discussion points and CSSAB

recommendations during the presentation, and is based on distributed hard copy proposed language revisions:

- § 250.6 Public Participation: After discussion, it was suggested that in § 250.6(c)(4) the word "measures" should be substituted for the word "opportunities"; in § 250.6(d) revise language as follows: "If a public involvement plan has been requested, it shall be provided to the municipality and the Department prior to implementation of the plan/report", delete rest of the sentence, and delete subsections (1) and (2).
- § 250.306 Ingestion numeric values: The default groundwater ingestion rate is 2.0 L/day. The proposed revision has been increased to 2.5 L/day. However, since DEP's Clean Water Program has proposed to use 2.4 L/day as a default water ingestion rate, it was suggested the LRP also use 2.4 L/day to maintain consistency.
- § 250.409(1) Risk assessment report: CSSAB stated that the proposed new language, "A risk assessment report that uses **site characterization information from an approved Remedial Investigation Report to** describe[s] the potential adverse effects, …" reads as if a remediator can no longer submit a Remedial Investigation Report with a Risk Assessment Report simultaneously. This subsection will be revised further to prevent this misinterpretation.
- § 250.410(d) Cleanup plan: The proposed revision of this section follows: "A cleanup plan is not required and no **new** remedy is required to be proposed or completed if no current or future exposure pathways exist **in the absence of institutional or engineering controls.**" CSSAB noted that a cleanup plan is not necessary for groundwater prohibition ordinances. It was suggested that the phrase "already in-place" be added to the revised subsection.
- § 250.704(d) General attainment requirements for groundwater: the consensus among the CSSAB was no revision to this subsection is warranted.
- Subchapter G. Demonstration of Attainment: It was determined that the terms "Statewide health standard" and "medium-specific concentrations" are inconsistently used throughout this referenced section of Chapter 250. It was suggested that the entire section be reviewed and revised as necessary for consistency.

Discussion and recommendations from the Board

Due to time constraints, the discussion regarding the remaining proposed rulemaking revisions were postponed. It was confirmed by Mr. Conrad that the CSSAB will be able to review the Chapter 250 proposed revisions again prior to being presented to the Environmental Quality Board.

Mr. Meloy presented four topics for additional discussion/consideration prior to meeting adjournment:

- Polychlorinated Biphenyls (PCBs): Mr. Craig Robertson and Mr. Meloy expressed concern with the proposed revision of removing individual aroclor MSCs from the Chapter 250 regulations and replacing them with a Total PCBs MSC. Mr. Meloy stated that each individual aroclor has different specific chemical characteristics. Additionally,

revising this PCB MSC structure will cause conflict with the Bureau of Waste Management's proposed Management of Fill Policy.

- Vanadium: Mr. Meloy stated that the revised residential MSC (0-15 feet) for vanadium in soil (15 mg/kg) is unreasonably conservative and is below what is considered naturally occurring throughout Pennsylvania.
- Polycyclic Aromatic Hydrocarbons (PAHs): Mr. Meloy stated that some of the revised MSCs for PAHs are based on California toxicity values rather that EPA's Provisional Peer-Reviewed Toxicity Values (PPRTV). The California toxicity values are much more stringent that EPA's PPRTV. Additionally, some PAH MSCs have been revised based on their solubility limits as opposed to their risk-based values. The solubility limits values result in a more conservative MSC than the risk-based values would create.
- Chlorides: Mr. Meloy stated that methodology to generate an MSC for chlorides in soil is available. He emphasized that having an MSC would be extremely beneficial to the Agency and the regulated community.

Mr. Conrad stated that the Agency is willing to work with the CSSAB further on these issues.

Other Business/Closing Issues

Mr. Campbell confirmed that the next CSSAB meeting (scheduled for June 12, 2019) will begin at 9:30 AM. Mr. Campbell also confirmed that there are no PA Sunshine notification requirements for any workgroups that will be formed by the CSSAB as a result of today's proceedings. Lastly, the CSSAB will compile a summary of outstanding issues regarding the proposed Chapter 250 MSC revisions and present it to the DEP.

Meeting Adjourned at 1542.

Attachment 8

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Bureau of Environmental Cleanup & Brownfields

Land Recycling Program
Chapter 250 Rulemaking Overview

Cleanup Standards Scientific Advisory Board Meeting
February 13, 2019

presented by
Michael Maddigan
PADEP

Tom Wolf, Governor

Patrick McDonnell, Secretary

Concepts Overview

Today's Discussion

- Overview of rulemaking text changes.
- Overview of changes to medium-specific concentration (MSC) and other tables.
- Next steps in rulemaking process.

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Subchapter A – GENERAL PROVISIONS

- 250.1 – Changed the definition of a volatile compound.
- 250.4 – Updated practical quantitation limit (PQL) calculation language.
- 250.6(c) and (d) – Updated public involvement plan (PIP) language.
- 250.10 – Changed references to the Groundwater Monitoring Guidance to reference Appendix A of the Technical Guidance Manual (TGM).
- Addition of § 250.12 – Professional Seals

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Subchapter C. SATEWIDE HEALTH STANDARD

- 250.304(f) – Added five aqueous solubility sources.
- 250.305(g) – Clarified that this provision does not apply to compounds with a primary Maximum Contaminant Level (MCL) or Health Advisory Level (HAL) and a secondary MCL (SMCL). Removed fluoride and manganese from Table 2 Secondary Contaminants table.
- 250.306(d) – Changed groundwater ingestion rate from 2 L/day to 2.5 L/day. This resulted in changes to the groundwater ingestion related exposure factors in the table in § 250.306(d).

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Subchapter C. STATEWIDE HEALTH STANDARD

- 250.306(e) – Changed the references and text of this section to reflect new blood lead model use.
- 250.307(g)(1) – Added “x 24 hr/day” to the numerator in the equation in § 250.307(g)(1). This was inadvertently omitted from the equation in the previous rulemaking.
- 250.308(a)(2)(ii) – The word “standard” was replaced with “generic numeric value” to avoid the implication that the 1/10th value is always the soil MSC for saturated soil.

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Subchapter D. SITE-SPECIFIC STANDARD

- 250.402(d) – Clarified that 250.311(e) cannot be used to protect ecological receptors under the site-specific standard (SSS).
- 250.409(1) – Clarified that an approved remedial investigation report is needed prior to having an approvable risk assessment report.
- 250.410(d) – Clarified that a cleanup plan is required when institutional or engineering controls are used to attain the SSS.

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Subchapter E. SIA STANDARDS

- 250.503(e) – Added language to clarify that when land use changes from non-residential to residential at Special Industrial Area (SIA) sites, an amendment to the baseline environmental report may be needed, not just a new remediation plan.

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Subchapter F. EXPOSURE AND RISK DETERMINATIONS

- 250.603 – Changed citation of the EPA's 1992 *Final Guidelines for Exposure Assessment* to EPA's 2011 *Exposure Factors Handbook*.
- 250.605 – Added EPA's Office of Pesticide Program's Human Health Benchmarks for Pesticides to the toxicity value source hierarchy.

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Subchapter G. DEMONSTRATION OF ATTAINMENT

- 250.704(d) – Changed reference to § 250.707 because § 250.707(b)(2)(i) relates only to the 75% 10x rule, not all statistical tests.
- 250.707(b)(1)(ii) – Replaced “Statewide health standard” with “Medium-Specific Concentration.”
- 250.707(b)(1)(iii) – Add language clarifying when or if a vapor intrusion analysis is necessary at sites with localized petroleum releases.

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Tables 1 & 2

- Table 1 – Added perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutane sulfonate (PFBS).
- Table 1 – Added footnote that the PFOS and PFOA MSC also applies when combined.
- Tables 1 & 2 – Added TDS units of “mg/L” in the headers.
- Table 2 – Added footnote stating that the MSCs for copper and lead are PA State MCLs.

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Tables 3A & 3B

- Tables 3A & 3B – Calculated PFOS, PFOA, and PFBS soil numeric values.
- Tables 3A & 3B – Calculated total PCB soil numeric values and deleted individual Aroclors.
- Table 3B – Footnotes regarding trihalomethanes (THMs) and haloacetic acids (HAAs) removed.

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Tables 4A, 4B, & 5A

- Table 4A – Residential and non-residential direct contact values calculated for lead using updated models and target blood lead level of 10 µg/dL.
- Table 4B – No soil or groundwater numeric values for aluminum or iron so removed all “NA’s.”
- Table 4B – Calculated copper values and removed all “NA’s.”
- Table 5A – Added PFOS, PFOA, and PFBS toxicity data.

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Table 7 – Default Values for Calculating MSCs for Lead

- Updated the residential exposure input parameters for use in the IEUBK blood lead model.
- Updated the non-residential exposure input parameters for use in the Adult Lead Model used by EPA.

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PCBs

- Total PCB groundwater value based on MCL.
- Removed individual Aroclor PCB values from Tables 1, 3A, 3B, and 5A.
- Calculated total PCB numeric values for soil (Tables 3A and 3B).
- This approach is more consistent with EPA's evaluation of PCBs in soil.

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Next Steps for Rulemaking

- Finalize language for proposed annex, including proposed changes to tables.
- Environmental Quality Board consideration of proposed rulemaking in mid-2019.

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Bureau of Environmental Cleanup & Brownfields

Questions?

Mike Maddigan

mmaddigan@pa.gov

Attachment 9

Appendix A
Table 4 – Medium-Specific Concentrations (MSCs) for Inorganic Regulated Substances in Soil
A. Direct Contact Numeric Values

REGULATED SUBSTANCE	*CASRN*	*Residential MSC 0-15 feet*		*Nonresidential MSCs*			
				Surface Soil 0-2 feet		*Subsurface Soil 2-15 feet*	
ALUMINUM	7429-90-5	190,000	C	190,000	C	190,000	C
ANTIMONY	7440-36-0	88	G	1,300	G	190,000	C
ARSENIC	7440-38-2	12	G	61	G	190,000	C
BARIUM AND COMPOUNDS	7440-39-3	44,000	G	190,000	C	190,000	C
BERYLLIUM	7440-41-7	440	G	6,400	G	190,000	C
BORON AND COMPOUNDS	7440-42-8	44,000	G	190,000	C	190,000	C
CADMIUM	7440-43-9	110	G	1,600	G	190,000	C
CHROMIUM III	16065-83-1	190,000	C	190,000	C	190,000	C
CHROMIUM VI	18540-29-9	**[4] 37**	G	**[220] 180**	G	**[20,000] 140,000**	N
COBALT	7440-48-4	66	G	960	G	190,000	N
COPPER	7440-50-8	**[8,100] 7,200**	G	**[120,000] 100,000**	G	190,000	C
CYANIDE, FREE	57-12-5	130	G	1,900	G	190,000	C
FLUORIDE	16984-48-8	8,800	G	130,000	G	190,000	C
IRON	7439-89-6	150,000	G	190,000	C	190,000	C
LEAD	7439-92-1	**[500] 420**	U	**[1,000] 2,517**	**[S] A**	190,000	C
LITHIUM	7439-93-2	440	G	6,400	G	190,000	C
MANGANESE	7439-96-5	**[10,000] 31,000**	G	**[150,000] 190,000**	**[G] C**	190,000	C
MERCURY	7439-97-6	35	G	510	G	190,000	C
MOLYBDENUM	7439-98-7	1,100	G	16,000	G	190,000	C
NICKEL	7440-02-0	4,400	G	64,000	G	190,000	C
PERCHLORATE	7790-98-9	150	G	2,200	G	190,000	C
SELENIUM	7782-49-2	1,100	G	16,000	G	190,000	C
SILVER	7440-22-4	1,100	G	16,000	G	190,000	C
STRONTIUM	7440-24-6	130,000	G	190,000	C	190,000	C
THALLIUM	7440-28-0	**[2] 2.2**	G	32	G	190,000	C
TIN	7440-31-5	130,000	G	190,000	C	190,000	C
VANADIUM	7440-62-2	15	G	220	G	190,000	C
ZINC	7440-66-6	66,000	G	190,000	C	190,000	C

All concentrations in mg/kg
R – Residential
NR – Non-Residential
G – Ingestion
N – Inhalation
C- Cap
U – **[UBK Model] Integrated Exposure Uptake Biokinetic (IEUBK) Model**
[S – SEGH Model] A – Adult Lead Model
[NA – Not Applicable]

Attachment 10

Appendix A
Table 4 – Medium-Specific Concentrations (MSCs) for Inorganic Regulated Substances in Soil
A. Direct Contact Numeric Values

REGULATED SUBSTANCE	CASRN	Residential MSC 0-15 feet		Nonresidential MSCs			
				Surface Soil 0-2 feet		Subsurface Soil 2-15 feet	
ALUMINUM	7429-90-5	190,000	C	190,000	C	190,000	C
ANTIMONY	7440-36-0	88	G	1,300	G	190,000	C
ARSENIC	7440-38-2	12	G	61	G	190,000	C
BARIUM AND COMPOUNDS	7440-39-3	44,000	G	190,000	C	190,000	C
BERYLLIUM	7440-41-7	440	G	6,400	G	190,000	C
BORON AND COMPOUNDS	7440-42-8	44,000	G	190,000	C	190,000	C
CADMIUM	7440-43-9	110	G	1,600	G	190,000	C
CHROMIUM III	16065-83-1	190,000	C	190,000	C	190,000	C
CHROMIUM VI	18540-29-9	**[4] 37**	G	**[220] 180**	G	**[20,000] 140,000**	N
COBALT	7440-48-4	66	G	960	G	190,000	N
COPPER	7440-50-8	**[8,100] 7,200**	G	**[120,000] 100,000**	G	190,000	C
CYANIDE, FREE	57-12-5	130	G	1,900	G	190,000	C
FLUORIDE	16984-48-8	8,800	G	130,000	G	190,000	C
IRON	7439-89-6	150,000	G	190,000	C	190,000	C
LEAD	7439-92-1	**[500] 420**	U	**[1,000] 2,500**	**[S] A**	190,000	C
LITHIUM	7439-93-2	440	G	6,400	G	190,000	C
MANGANESE	7439-96-5	**[10,000] 31,000**	G	**[150,000] 190,000**	**[G] C**	190,000	C
MERCURY	7439-97-6	35	G	510	G	190,000	C
MOLYBDENUM	7439-98-7	1,100	G	16,000	G	190,000	C
NICKEL	7440-02-0	4,400	G	64,000	G	190,000	C
PERCHLORATE	7790-98-9	150	G	2,200	G	190,000	C
SELENIUM	7782-49-2	1,100	G	16,000	G	190,000	C
SILVER	7440-22-4	1,100	G	16,000	G	190,000	C
STRONTIUM	7440-24-6	130,000	G	190,000	C	190,000	C
THALLIUM	7440-28-0	**[2] 2.2**	G	32	G	190,000	C
TIN	7440-31-5	130,000	G	190,000	C	190,000	C
VANADIUM	7440-62-2	15	G	220	G	190,000	C
ZINC	7440-66-6	66,000	G	190,000	C	190,000	C

All concentrations in mg/kg
R – Residential
NR – Non-Residential
G – Ingestion
N – Inhalation
C- Cap
U – **[UBK Model] IEUBK Model**
[S – SEGH Model] A – Adult Lead Model
NA – Not Applicable

Attachment 11

Appendix A
Table 4 – Medium-Specific Concentrations (MSCs) for Inorganic Regulated Substances in Soil
A. Direct Contact Numeric Values

REGULATED SUBSTANCE	CASRN	Residential MSC 0-15 feet		Nonresidential MSCs			
				Surface Soil 0-2 feet		Subsurface Soil 2-15 feet	
ALUMINUM	7429-90-5	190,000	C	190,000	C	190,000	C
ANTIMONY	7440-36-0	88	G	1,300	G	190,000	C
ARSENIC	7440-38-2	12	G	61	G	190,000	C
BARIUM AND COMPOUNDS	7440-39-3	44,000	G	190,000	C	190,000	C
BERYLLIUM	7440-41-7	440	G	6,400	G	190,000	C
BORON AND COMPOUNDS	7440-42-8	44,000	G	190,000	C	190,000	C
CADMIUM	7440-43-9	110	G	1,600	G	190,000	C
CHROMIUM III	16065-83-1	190,000	C	190,000	C	190,000	C
CHROMIUM VI	18540-29-9	**[4] 37**	G	**[220] 180**	G	**[20,000] 140,000**	N
COBALT	7440-48-4	66	G	960	G	190,000	N
COPPER	7440-50-8	**[8,100] 7,200**	G	**[120,000] 100,000**	G	190,000	C
CYANIDE, FREE	57-12-5	130	G	1,900	G	190,000	C
FLUORIDE	16984-48-8	8,800	G	130,000	G	190,000	C
IRON	7439-89-6	150,000	G	190,000	C	190,000	C
LEAD	7439-92-1	**[500] 420**	U	**[1,000] 2,500**	**[S] A**	190,000	C
LITHIUM	7439-93-2	440	G	6,400	G	190,000	C
MANGANESE	7439-96-5	**[10,000] 31,000**	G	**[150,000] 190,000**	**[G] C**	190,000	C
MERCURY	7439-97-6	35	G	510	G	190,000	C
MOLYBDENUM	7439-98-7	1,100	G	16,000	G	190,000	C
NICKEL	7440-02-0	4,400	G	64,000	G	190,000	C
PERCHLORATE	7790-98-9	150	G	2,200	G	190,000	C
SELENIUM	7782-49-2	1,100	G	16,000	G	190,000	C
SILVER	7440-22-4	1,100	G	16,000	G	190,000	C
STRONTIUM	7440-24-6	130,000	G	190,000	C	190,000	C
THALLIUM	7440-28-0	**[2] 2.2**	G	32	G	190,000	C
TIN	7440-31-5	130,000	G	190,000	C	190,000	C
VANADIUM	7440-62-2	15	G	220	G	190,000	C
ZINC	7440-66-6	66,000	G	190,000	C	190,000	C

All concentrations in mg/kg
R – Residential
NR – Non-Residential
G – Ingestion
N – Inhalation
C- Cap
U – **[UBK Model] IEUBK Model**
[S – SEGH Model] A – Adult Lead Model
NA – Not Applicable

Attachment 12

APPENDIX A
Table 7
DEFAULT VALUES FOR CALCULATING MEDIUM-SPECIFIC CONCENTRATIONS FOR LEAD

[Input Values Used in UBK Model for Lead] [(for residential exposure scenario)]			
[Geometric Standard Deviation] [(GSD)]	[1.42] [(default)]	[Drinking water intake]	[Model default]
[Outdoor air lead concentration]	[0.2 μg/m^3] [(default)]	[Soil lead level]	[495 μg/g]
[Indoor air lead concentration] [(% of outdoor)]	[30]	[Indoor dust lead level]	[495 μg/g]
[Time spent outdoors]	[Model default]	[Soil/dust ingestion weighting factor] [(%)]	[45]
[Ventilation rate]	[Model default]	[Paint lead intake]	[Model default]
[Lung absorption]	[Model default]	[Maternal contribution method]	[Infant model]
[Dietary lead intake]	[Model default]	[Mother's blood lead at birth]	[7.5 μg/dL blood] [(model default)]
[GI method/bioavailability]	[Non-linear]	[Target blood lead level]	[10 μg/dL blood]
[Lead concentration in drinking water]	[4.00 μg/L] [(default)]		

[Input Values Used in SEGH Equation] [(for nonresidential exposure scenario)]	
[Concentration of lead in soil (S)]	[987 μg/g]
[Target blood lead level in adults (T)]	[20 μg/dL blood]
[Geometric standard deviation of blood lead distribution (G)]	[1.4]
[Baseline blood lead level in target population (B)]	[4 μg/dL blood]
[Number of standard deviations corresponding to degree of protection required for the target population (n)]	[1.645 (for 95% of population)]
[Slope of blood lead to soil lead relationship (δ)]	[7.5 μg/dL blood per μg/g soil]

[REFERENCE]

[WIXSON, B.G. (1991). The Society for Environmental Geochemistry and Health (SEGH) Task Force Approach to the Assessment of Lead in Soil. Trace Substances in Environmental Health . 11-20.]

Input Values Used in IEUBK Model for Lead (for residential exposure scenario)		
Parameter	**Value**	
Outdoor Air Pb Concentration (µg/m^3)	**Constant Value: 0.1**	
Dietary Lead Intake (µg/day)	**Age (Years)**	**Input**
	0-1	**2.26**
	1-2	**1.96**
	2-3	**2.13**
	3-4	**2.04**
	4-5	**1.95**
	5-6	**2.05**
	6-7	**2.22**
Water Consumption (L/day)	**Age (Years)**	**Input**
	0-1	**0.2**
	1-2	**0.5**
	2-3	**0.52**
	3-4	**0.53**
	4-5	**0.55**
	5-6	**0.58**
	6-7	**0.59**
Use Alternate Water Value?	**NO**	
Lead concentration in drinking water (µg/L)	**4**	
MEDIA	**ABSORPTION FRACTION PERCENT**	
Soil	**30**	
Dust	**30**	
Water	**50**	
Diet	**50**	
Alternate	**0**	
Calculate PRG		
Select Age Group for Graph	**0 to 84 months**	
Change Cutoff	**TBD**	
Change GSD	**1.6**	
Probability of Exceeding the Cutoff	**5**	

Input Values Used in the Adult Lead Model (ALM) (for non-residential exposure scenario)			
Variable	**Description of Variable**	**Units**	**Value**
$PbB_{fetal, 0.95}$	**Target PbB in fetus**	**µg/dL**	**TBD**
$R_{fetal/maternal}$	**Fetal/maternal PbB ratio**	**--**	**0.9**
BKSF	**Biokinetic Slope Factor**	**µg/dL per µg/day**	**0.4**
GSD_i	**Geometric standard deviation PbB**	**--**	**1.8**
PbB_0	**Baseline PbB**	**µg/dL**	**0.6**

IR_S	**Soil ingestion rate**	**g/day**	**0.050**
$AF_{S, D}$	**Absorption fraction**	**--**	**0.12**
$EF_{S, D}$	**Exposure frequency**	**days/yr**	**219**
$AT_{S, D}$	**Averaging time**	**days/yr**	**365**

Attachment 13

APPENDIX A
Table 7
DEFAULT VALUES FOR CALCULATING MEDIUM-SPECIFIC CONCENTRATIONS FOR LEAD

[Input Values Used in UBK Model for Lead] [(for residential exposure scenario)]			
[Geometric Standard Deviation] [(GSD)]	[1.42] [(default)]	[Drinking water intake]	[Model default]
[Outdoor air lead concentration]	[0.2 μg/m^3] [(default)]	[Soil lead level]	[495 μg/g]
[Indoor air lead concentration] [(% of outdoor)]	[30]	[Indoor dust lead level]	[495 μg/g]
[Time spent outdoors]	[Model default]	[Soil/dust ingestion weighting factor] [(%)]	[45]
[Ventilation rate]	[Model default]	[Paint lead intake]	[Model default]
[Lung absorption]	[Model default]	[Maternal contribution method]	[Infant model]
[Dietary lead intake]	[Model default]	[Mother's blood lead at birth]	[7.5 μg/dL blood] [(model default)]
[GI method/bioavailability]	[Non-linear]	[Target blood lead level]	[10 μg/dL blood]
[Lead concentration in drinking water]	[4.00 μg/L] [(default)]		

[Input Values Used in SEGH Equation] [(for nonresidential exposure scenario)]	
[Concentration of lead in soil (S)]	[987 μg/g]
[Target blood lead level in adults (T)]	[20 μg/dL blood]
[Geometric standard deviation of blood lead distribution (G)]	[1.4]
[Baseline blood lead level in target population (B)]	[4 μg/dL blood]
[Number of standard deviations corresponding to degree of protection required for the target population (n)]	[1.645 (for 95% of population)]
[Slope of blood lead to soil lead relationship (δ)]	[7.5 μg/dL blood per μg/g soil]

[REFERENCE]

[WIXSON, B.G. (1991). The Society for Environmental Geochemistry and Health (SEGH) Task Force Approach to the Assessment of Lead in Soil. Trace Substances in Environmental Health . 11-20.]

Input Values Used in IEUBK Model for Lead (for residential exposure scenario)		
Parameter	**Value**	
Outdoor Air Pb Concentration (µg/m^3)	**Constant Value: 0.1**	
Dietary Lead Intake (µg/day)	**Age (Years)**	**Input**
	0-1	**2.26**
	1-2	**1.96**
	2-3	**2.13**
	3-4	**2.04**
	4-5	**1.95**
	5-6	**2.05**
	6-7	**2.22**
Water Consumption (L/day)	**Age (Years)**	**Input**
	0-1	**0.2**
	1-2	**0.5**
	2-3	**0.52**
	3-4	**0.53**
	4-5	**0.55**
	5-6	**0.58**
	6-7	**0.59**
Use Alternate Water Value?	**NO**	
Lead concentration in drinking water (µg/L)	**4**	
MEDIA	**ABSORPTION FRACTION PERCENT**	
Soil	**30**	
Dust	**30**	
Water	**50**	
Diet	**50**	
Alternate	**0**	
Calculate PRG		
Select Age Group for Graph	**0 to 84 months**	
Change Cutoff	**TBD**	
Change GSD	**1.6**	
Probability of Exceeding the Cutoff	**5**	

Input Values Used in the Adult Lead Model (ALM) (for non-residential exposure scenario)			
Variable	**Description of Variable**	**Units**	**Value**
$PbB_{fetal, 0.95}$	**Target PbB in fetus**	**µg/dL**	**TBD**
$R_{fetal/maternal}$	**Fetal/maternal PbB ratio**	**--**	**0.9**
BKSF	**Biokinetic Slope Factor**	**µg/dL per µg/day**	**0.4**
GSD_i	**Geometric standard deviation PbB**	**--**	**1.8**
PbB_0	**Baseline PbB**	**µg/dL**	**0.6**

IR_S	**Soil ingestion rate**	**g/day**	**0.050**
$AF_{S, D}$	**Absorption fraction**	**--**	**0.12**
$EF_{S, D}$	**Exposure frequency**	**days/yr**	**219**
$AT_{S, D}$	**Averaging time**	**days/yr**	**365**

Attachment 14

An official website of the United States government.

Close

We've made some changes to EPA.gov. If the information you are looking for is not here, you may be able to find it on the EPA Web Archive or the January 19, 2017 Web Snapshot.

Lead at Superfund Sites: Frequent Questions from Risk Assessors on the Adult Lead Methodology

- Back to Lead: Frequent Questions

The following frequent questions on the Adult Lead Methodology (ALM) have been divided into three categories:

General Questions

Input Variables

Application

General Questions

- What is the receptor population for the Adult Lead Methodology?
- Does the Adult Lead Methodology calculate a value for a commercial worker or an industrial worker?
- What is a reasonable screening value for soil lead at commercial/industrial sites?
- What is a reasonable baseline blood lead level (PbB_0) to use for a future exposure scenario?
- How can I obtain the IEUBK model source code?
- References

What is the receptor population for the Adult Lead Methodology?

In the commercial/industrial setting, the most sensitive receptor is the fetus of a worker who develops a body burden as a result of non-residential exposure to lead. This body burden is available to transfer to the fetus for several years after

exposure ends (Gulson et al., 1998; Gulson et al., 1999). Based on the available scientific data, a fetus is more sensitive to the adverse effects of lead than an adult (National Academy of Sciences, 1993). We assume that cleanup goals (preliminary remediation goals, or PRGs) that are protective of a fetus will also afford protection for male or female adult workers. The model equations were developed to calculate cleanup goals such that there would be no more than a 5 percent probability that fetuses exposed to lead would exceed a blood lead (PbB) of 10 micrograms lead per deciliter of blood (µg/dL). This same approach also appears to be protective for lead's effect on blood pressure in adult males (see the *Adult Lead Methodology Review Report*, available on the Software and Users' Manuals page).

- Software and Users' Manuals page

Does the ALM calculate a value for a commercial worker or an industrial worker?

The ALM does not distinguish between commercial and industrial workers; rather, it is applicable to non-residential exposure scenarios. According to EPA's guidance on the ALM, a soil ingestion rate of 50 mg/day is recommended as a plausible central tendency value for non-contact-intensive activities (U.S. EPA, 1997). Either commercial or industrial workers may work primarily indoors, so that exposure to soil occurs primarily via indoor dust. Workers' limited and occasional contact with outdoor soils (e.g., picnicking, walking to parking lots, standing on a loading dock) should be adequately accounted for via the 50 mg/day incidental soil ingestion. If an individual is performing a contact-intensive activity with soil, then a soil ingestion rate greater than 50 mg/day would be expected. At sites where lead materials have historically been used, exposure scenarios would have to be evaluated individually to determine the indoor and outdoor activities that may result in greater exposure to soil and the corresponding soil ingestion rate.

What is a reasonable screening value for soil lead at commercial/industrial sites?

A screening goal is often more protective than a cleanup goal. A screening goal is intended to provide health protection without knowledge of the specific exposure conditions at a site. A cleanup goal can be derived using exposure assumptions based on site-specific data rather than default values (which are often more conservative). An updated screening level for soil lead at commercial/industrial (i.e., non-residential) sites of 800 part per million (ppm) is based on a recent analysis of the combined phases of the National Health and Nutrition Examination Survey (NHANES III) that choose a cleanup goal protective for all subpopulations.

What is a reasonable baseline blood lead level (PbB_0) to use for a future exposure scenario?

Although the best estimates for PbB_0 are based on site-specific data, such information may not be available for a future exposure scenario. Application of this value should consider the proportion of each population (present on site or anticipated in the future) as defined by the NHANES III study and as described in the TRW's recommendations for use of NHANES III data for adult lead risk assessment. For site applications of the adult lead methodology, estimates of the $PbB_{adult,0}$ and $GSD_{i,adult}$ parameters could be based on either race/ethnicity or geographic categories determined appropriate based on the specific demographic or geographic characteristics of the site. Because of the small sample sizes that result, the TRW recommends that users do not use data from the NHANES III survey that are stratified by both census region and race/ethnicity group to derive $PbB_{adult,0}$ and $GSD_{i,adult}$.

- Guidance page

How can I obtain the IEUBK model source code?

Source code for the IEUBK model software is EPA property and is not distributed. Because EPA's Superfund program uses the IEUBK model to implement hazardous waste regulations, the Agency controls the code and performs validation checks to ensure the model performs adequately.

The Parameters and Equations Dictionary in the System Requirements Document for the IEUBK model may be used to better understand the operation of the IEUBK model software. However, is not intended to be an exact, line-by-line documentation of the source code.

- System Requirements Document

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LAST UPDATED ON JUNE 4, 2018

Attachment 15

The American College of
Obstetricians and Gynecologists
WOMEN'S HEALTH CARE PHYSICIANS

COMMITTEE OPINION

Number 533 • August 2012 (Reaffirmed 2016)

Committee on Obstetric Practice

This document reflects emerging clinical and scientific advances as of the date issued and is subject to change. The information should not be construed as dictating an exclusive course of treatment or procedure to be followed.

Lead Screening During Pregnancy and Lactation

Abstract: Prenatal lead exposure has known adverse effects on maternal health and infant outcomes across a wide range of maternal blood lead levels. Adverse effects of lead exposure are being identified at lower levels of exposure than previously recognized in both children and adults. In 2010, the Centers for Disease Control and Prevention issued the first guidelines regarding the screening and management of pregnant and lactating women who have been exposed to lead.

Prenatal lead exposure has known adverse effects on maternal health and infant outcomes across a wide range of maternal blood lead levels (1). Adverse effects of lead exposure are being identified at lower levels of exposure than previously recognized in both children and adults (2–7). In 2010, the Centers for Disease Control and Prevention issued the first guidelines regarding the screening and management of pregnant and lactating women who have been exposed to lead (8).

Background

Environmental policies and public health education programs have led to significant reductions in cases of lead exposure in the United States (9). Despite these improvements, approximately 1% of women of childbearing age (15–49 years) have blood lead levels greater than or equal to 5 micrograms/dL (8).

Although no threshold has been found to trigger the adverse health effects of lead (8), in nonpregnant adults blood lead levels less than 5 micrograms/dL are considered normal, blood lead levels between 5 micrograms/dL and 10 micrograms/dL require follow-up, and blood lead levels greater than 10 micrograms/dL are managed with environmental assessment and abatement of exposures. Chelation therapy is considered at blood lead levels greater than 40 micrograms/dL for symptomatic individuals, and levels greater than 70 micrograms/dL are considered a medical emergency. In children, treatment is recommended at blood lead levels of 45 micrograms/dL or greater.

The main target for lead toxicity is the nervous system, both in adults and children (10). High levels of exposure can result in delirium, seizures, stupor, coma, or even death. Other overt signs and symptoms of lead toxicity may include hypertension, peripheral neuropathy, ataxia, tremor, headache, loss of appetite, weight loss, fatigue, muscle and joint aches, changes in behavior and concentration, gout, nephropathy, lead colic, and anemia. Health effects of chronic low-level exposure in adults include cognitive decline, hypertension and other cardiovascular effects, decrements in renal function, and adverse reproductive outcome. The developing nervous systems in children make them more susceptible to the neurologic effects of lead toxicity.

Adverse Health Effects of Prenatal Exposure

Lead readily crosses the placenta by passive diffusion and has been detected in the fetal brain as early as the end of the first trimester (8). Elevated lead levels in pregnancy have been associated with several adverse outcomes, including gestational hypertension, spontaneous abortion, low birth weight, and impaired neurodevelopment (11–14).

Lead exposure has been associated with an increased risk of gestational hypertension, but the magnitude of the effect, the exposure level at which risk begins to increase, and whether risk is most associated with acute or cumulative exposure remain uncertain. Also, it is unclear whether lead-induced increases in blood pressure during pregnancy lead to severe hypertension or preeclampsia (11, 15–18).

Evidence shows that maternal exposure to high levels of lead increases the risk of spontaneous abortion (19).

However, data for an association between low or moderate lead levels and spontaneous abortion are inconsistent. The strongest available evidence comes from a prospective study of 668 pregnant women in Mexico City that demonstrated a statistically significant dose–response relationship between low-to-moderate maternal blood lead levels and the risk of spontaneous abortion (12). Yet, another longitudinal study of 351 women in Japan showed no difference in blood lead levels between spontaneous abortion cases (n=15) and ongoing pregnancies (20). Larger prospective studies are needed to further clarify the effects of low and moderate levels of lead on spontaneous abortion risk.

More recent and well-designed studies suggest that maternal lead exposure during pregnancy is inversely related to fetal growth, as reflected by duration of pregnancy and infant size. One study that used a registry-based approach found that offspring of mothers occupationally exposed to lead had an increased risk of low birth weight (relative risk [RR], 1.34; confidence interval [CI], 1.12–1.6) compared with infants of women not exposed to lead (13). A case–control study in Mexico City found umbilical cord blood lead levels to be higher in preterm infants (mean value, 9.8 micrograms/dL) compared with term infants (mean value, 8.4 micrograms/dL) (21). A birth cohort study, also conducted in Mexico City, found maternal bone lead burden to be inversely related to offspring weight (22), length, and head circumference at birth (23).

A large number of studies provide evidence that prenatal lead exposure impairs children's neurodevelopment. Some prospective studies have included children with low levels of prenatal lead exposure and continue to detect inverse associations with neurodevelopment, although these data are less consistent than those related to the high levels of lead exposure. In one study, each 1 microgram/dL increase in umbilical cord blood lead was found to be associated with a reduction of 0.6 points in the mental development index scores of the Bayley Scales of Infant Development at age 3 months, with similar results at age 6 months (14, 24). However, another prospective cohort study found that the relationship between prenatal blood lead levels and early childhood IQ is not linear, with the strongest postnatal effects noted at low levels of prenatal exposure (25). The available data are inadequate to establish the presence or absence of an association between maternal lead exposure and major congenital anomalies in the fetus.

Lead Exposure During Breastfeeding

Although the benefits of breastfeeding generally outweigh the risks of environmental exposure, the effects of breastfeeding on infant lead levels have been studied. Lead has been detected in the breast milk of women in population-based studies; however, the availability of high-quality data to assess the risk for toxicity to the breastfeeding infant is limited (8). Although infant blood lead levels have been correlated with the duration of breastfeeding (26), the ratio of breast milk lead levels to blood lead levels has been found to be less than 3% (27). According to the American Academy of Pediatrics, because of the contribution of lead levels found in infant formula and other infant foods, breastfed infants of mothers with normal blood lead levels are actually exposed to slightly less lead than if they were not breastfed (28).

Screening and Management

Pregnancy

The Centers for Disease Control and Prevention (CDC) and the American College of Obstetricians and Gynecologists do not recommend blood lead testing of all pregnant women in the United States. Obstetric health care providers should consider the possibility of lead exposure in individual pregnant women by evaluating risk factors for exposure as part of a comprehensive health risk assessment and perform blood lead testing if a single risk factor is identified. Assessment of lead exposure should take place at the earliest contact with the pregnant patient.

Important risk factors for lead exposure in pregnant women are listed in Box 1. Lead-based paint is less likely to be an important exposure source for pregnant women than it is for children, except during renovation or remodeling in older homes. Women should take precautions when repainting surfaces with deteriorated paint or performing any remodeling or renovation work that disturbs painted surfaces, such as scraping off paint or tearing out walls (8).

For pregnant women with blood lead levels of 5 micrograms/dL or higher, sources of lead exposure should be identified and women should receive counseling regarding avoidance of further exposure. Confirmatory and follow-up blood lead testing should be performed in accordance with the CDC's recommended schedules (Table 1) and maternal or umbilical cord blood lead levels should be measured at delivery (8). Women with confirmed blood lead levels of 45 micrograms/dL or more should be treated in consultation with clinicians experienced in the management of lead toxicity and high-risk pregnancy. Once the source of lead exposure is identified and eliminated, the initial decrease in blood lead level occurs relatively rapidly because of lead's short (35-day) initial half-life in blood (29). This initial rapid decrease is followed by a slow, continuous decrease over several months to several years because of mobilization of lead from stores in the bone (8). Recommendations for the frequency of blood lead follow-up tests are included in Table 1.

Adequate dietary intake of calcium, iron, zinc, vitamin C, vitamin D, and vitamin E is known to decrease lead absorption (30, 31). Iron-deficiency anemia is associated with elevated blood lead levels and may increase lead absorption. During pregnancy and lactation, lead from prior exposures can be mobilized from bones because

Box 1. Risk Factors for Lead Exposure in Pregnant and Lactating Women ⇦

- Recent emigration from or residency in areas where ambient lead contamination is high—women from countries where leaded gasoline is still being used (or was recently phased out) or where industrial emissions are not well controlled.
- Living near a point source of lead—examples include lead mines, smelters, or battery recycling plants (even if the establishment is closed).
- Working with lead or living with someone who does—women who work in or who have family members who work in an industry that uses lead (eg, lead production, battery manufacturing, paint manufacturing, ship building, ammunition production, or plastic manufacturing).
- Using lead-glazed ceramic pottery—women who cook, store, or serve food in lead-glazed ceramic pottery made in a traditional process and usually imported by individuals outside the normal commercial channels.
- Eating nonfood substances (pica)—women who eat or mouth nonfood items that may be contaminated with lead, such as soil or lead-glazed ceramic pottery.
- Using alternative or complementary substances, herbs, or therapies—women who use imported home remedies or certain therapeutic herbs traditionally used by East Indian, Indian, Middle Eastern, West Asian, and Hispanic cultures that may be contaminated with lead.
- Using imported cosmetics or certain food products—women who use imported cosmetics, such as kohl or surma or certain imported foods or spices that may be contaminated with lead.
- Engaging in certain high-risk hobbies or recreational activities—women who engage in high-risk activities (eg, stained glass production or pottery making with certain leaded glazes and paints) or have family members who do.
- Renovating or remodeling older homes without lead hazard controls in place—women who have been disturbing lead paint, creating lead dust, or both or have been spending time in such a home environment.
- Consumption of lead-contaminated drinking water—women whose homes have leaded pipes or source lines with lead.
- Having a history of previous lead exposure or evidence of elevated body burden of lead—women who may have high body burdens of lead from past exposure, particularly those who have deficiencies in certain key nutrients (calcium or iron).
- Living with someone identified with an elevated lead level—women who may have exposure in common with a child, close friend, or other relative living in the same environment.

Modified from Centers for Disease Control and Prevention. Guidelines for the identification and management of lead exposure in pregnant and lactating women. Atlanta (GA): CDC; 2010. Available at: http://www.cdc.gov/nceh/lead/publications/leadandpregnancy2010.pdf. Retrieved March 7, 2012.

Table 1. Frequency of Maternal Blood Lead Follow-up Testing During Pregnancy ⇦

Venous Blood Lead Level* (micrograms/dL)	Perform Follow-up Test(s)†
Less than 5	• None (no follow-up testing is indicated)
5–14	• Within 1 month • Obtain a maternal blood lead level‡ or cord blood lead level at delivery
15–24	• Within 1 month and then every 2–3 months • Obtain a maternal blood lead level‡ or cord blood lead level at delivery • More frequent testing may be indicated based on risk factors
25–44	• Within 1–4 weeks and then every month • Obtain a maternal blood lead level‡ or cord blood lead level at delivery
45 or more	• Within 24 hours and then at frequent intervals depending on clinical interventions and trend in blood lead levels • Consultation with a clinician experienced in the management of pregnant women with blood lead levels in this range is strongly advised • Obtain a maternal blood lead level or cord blood lead level at delivery

*Venous blood sample is recommended for maternal blood lead testing.

†The higher the blood lead level on the screening test, the more urgent the need for confirmatory testing.

‡If possible, obtain a maternal blood lead level before delivery because blood lead levels tend to increase over the course of pregnancy.

Modified from Centers for Disease Control and Prevention. Guidelines for the identification and management of lead exposure in pregnant and lactating women. Atlanta (GA): CDC; 2010. Available at: http://www.cdc.gov/nceh/lead/publications/leadandpregnancy2010.pdf. Retrieved March 7, 2012.

of the increased bone turnover. Pregnant and lactating women with a current or past blood lead level of 5 micrograms/dL or higher should receive specific nutritional recommendations regarding calcium and iron supplementation. A balanced diet that contains 2,000 mg of calcium and 60–120 mg of iron daily is recommended (8). This can be achieved through either food intake or supplementation. Supplements should be divided into doses of 500 mg of calcium and 60 mg of iron to improve absorption.

Lactation

Women with risk factors for elevated lead levels (Box 1) who have not been screened during pregnancy should be screened postpartum if they plan to breastfeed. Initiation of breastfeeding should be encouraged postpartum in a woman with a blood lead level less than 40 micrograms/dL.

A woman with a confirmed blood lead level of 40 micrograms/dL or higher should not initiate breastfeeding and should be advised to pump and discard her breast milk until her blood lead level has decreased to less than 40 micrograms/dL. Blood lead measurements should be repeated every 1–2 weeks after the source of exposure has been identified and removed. At maternal blood lead levels of 5–39 micrograms/dL, breastfeeding should be initiated and accompanied by sequential testing of infant blood lead levels to monitor trends. If the infant's blood lead level is greater than 5 micrograms/dL, breastfeeding should be discontinued until the maternal blood lead level decreases. If no external source is identified, and the maternal blood lead level is greater than 20 micrograms/dL and the infant blood lead level is 5 micrograms/dL or more, breast milk should be suspected as the source and temporary interruption of breastfeeding until the maternal blood lead level decreases should be considered.

In addition to removing the source of lead exposure for the mother and infant, several nutritional interventions have been studied. Calcium supplementation (1,200 mg daily) has been associated with a 5–10% decrease in breast milk lead levels among women over the course of lactation (31–34), suggesting that calcium supplementation also may be an intervention strategy to reduce lead in breast milk from both current and previously accumulated sources. Among women in the postpartum period, increased intakes of vitamin C also have been associated with decreased levels of lead in breast milk.

Conclusions and Recommendations

- Routine blood lead testing of all pregnant women is not recommended.
- Risk assessment of lead exposure should take place at the earliest contact with pregnant or lactating women, and blood lead testing should be performed if a single risk factor is identified (Box 1).
- Elevated lead levels in pregnancy have been associated with gestational hypertension, spontaneous abortion, low birth weight, and impaired neurodevelopment.
- Prenatal lead exposure has known adverse effects on maternal health and infant outcomes across a wide range of maternal blood lead levels.
- Pregnant women with blood lead levels of 5 micrograms/dL or higher should be treated as follows:
  - — Sources of lead exposure should be identified.
  - — Women should receive counseling regarding avoidance of further exposure and receive specific nutritional recommendations regarding calcium and iron supplementation because these strategies can decrease their lead levels.
  - — Confirmatory and follow-up blood lead testing should be performed in accordance with the CDC's recommended schedules (Table 1).
- Women with confirmed blood lead levels of 45 micrograms/dL or more should be treated in consultation with clinicians experienced in the management of lead toxicity and high-risk pregnancy.
- Initiation of breastfeeding should be encouraged postpartum in a woman with a blood lead level less than 40 micrograms/dL.
- A breastfeeding woman with a confirmed blood lead level of 40 micrograms/dL or higher should be advised to pump and discard her breast milk until her blood lead level has decreased to less than 40 micrograms/dL.
- If no external source is identified, and the maternal blood lead level is greater than 20 micrograms/dL and the infant blood lead level is 5 micrograms/dL or more, breast milk should be suspected as the source and temporary interruption of breastfeeding until the maternal blood lead level decreases should be considered.

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Lead screening during pregnancy and lactation. Committee Opinion No. 533. American College of Obstetricians and Gynecologists. Obstet Gynecol 2012;120:416–20.

Attachment 16

World Health Organization

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Lead poisoning and health

23 August 2019

Key facts

- **Lead is a cumulative toxicant that affects multiple body systems and is particularly harmful to young children.**
- **Lead in the body is distributed to the brain, liver, kidney and bones. It is stored in the teeth and bones, where it accumulates over time. Human exposure is usually assessed through the measurement of lead in blood.**
- **Lead in bone is released into blood during pregnancy and becomes a source of exposure to the developing fetus.**
- **There is no level of exposure to lead that is known to be without harmful effects.**
- **Lead exposure is preventable.**

Lead is a naturally occurring toxic metal found in the Earth's crust. Its widespread use has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world.

Important sources of environmental contamination include mining, smelting, manufacturing and recycling activities, and, in some countries, the continued use of leaded paint, leaded gasoline, and leaded aviation fuel. More than three quarters of global lead consumption is for the manufacture of lead-acid batteries for motor vehicles. Lead is, however, also used in many other products, for example pigments, paints, solder, stained glass, lead crystal glassware, ammunition, ceramic glazes, jewellery, toys and in some cosmetics and traditional medicines. Drinking water delivered through lead pipes or pipes joined with lead solder may contain lead. Much of the lead in global commerce is now obtained from recycling.

Young children are particularly vulnerable to the toxic effects of lead and can suffer profound and permanent adverse health effects, particularly affecting the development of the brain and nervous system. Lead also causes long-term harm in adults, including increased risk of high blood pressure and kidney damage. Exposure of pregnant women to high levels of lead can cause miscarriage, stillbirth, premature birth and low birth weight.

Sources and routes of exposure

People can become exposed to lead through occupational and environmental sources. This mainly results from:

- **inhalation of lead particles generated by burning materials containing lead, for example, during smelting, recycling, stripping leaded paint, and using leaded gasoline or leaded aviation fuel; and**
- **ingestion of lead-contaminated dust, water (from leaded pipes), and food (from lead-glazed or lead-soldered containers).**

An additional source of exposure is the use of certain types of unregulated cosmetics and medicines. High levels of lead have, for example, been reported in certain types of kohl, as well as in some traditional medicines used in countries such as India, Mexico and Viet Nam. Consumers should therefore take care only to buy and use regulated products.

Young children are particularly vulnerable to lead poisoning because they absorb 4–5 times as much ingested lead as adults from a given source. Moreover, children's innate curiosity and their age-appropriate hand-to-mouth behaviour result in their mouthing and swallowing lead-containing or lead-coated objects, such as contaminated soil or dust and flakes from decaying lead-containing paint. This route of exposure is magnified in children with a psychological disorder called pica (persistent and compulsive cravings to eat non-food items), who may, for example pick away at, and eat, leaded paint from walls, door frames and furniture. Exposure to lead-contaminated soil and dust resulting from battery recycling and mining has caused mass lead poisoning and multiple deaths in young children in Nigeria, Senegal and other countries.

Once lead enters the body, it is distributed to organs such as the brain, kidneys, liver and bones. The body stores lead in the teeth and bones where it accumulates over time. Lead stored in bone may be remobilized into the blood during pregnancy, thus exposing the fetus. Undernourished children are more susceptible to lead because their bodies absorb more lead if other nutrients, such as calcium or iron, are lacking. Children at highest risk are the very young (including the developing fetus) and the economically disadvantaged.

Health effects of lead poisoning on children

Lead exposure can have serious consequences for the health of children. At high levels of exposure, lead attacks the brain and central nervous system to cause coma, convulsions and even death. Children who survive severe lead poisoning may be left with mental retardation and behavioural disorders. At lower levels of exposure that cause no obvious symptoms lead is now known to produce a spectrum of injury across multiple body systems. In particular lead can affect children's brain development resulting in reduced intelligence quotient (IQ), behavioural changes such as reduced attention span and increased antisocial behavior, and reduced educational attainment. Lead exposure also causes anaemia, hypertension, renal impairment, immunotoxicity and toxicity to the reproductive organs. The neurological and behavioural effects of lead are believed to be irreversible.

There is no known 'safe' blood lead concentration; even blood lead concentrations as low as 5 µg/dL, may be associated with decreased intelligence in children, behavioral difficulties and learning problems. As lead exposure increases, the range and severity of symptoms and effects also increases.

Encouragingly, the successful phasing out of leaded gasoline in most countries, together with other lead control measures, has resulted in a significant decline in population-level blood lead concentrations. There is now only one country that continues to use leaded fuel *(1)*. More, however, needs to be done regarding the phasing out of lead paint: so far only 37% of countries have introduced legally binding controls on lead paint *(2)*

Burden of disease from lead exposure

The Institute for Health Metrics and Evaluation (IHME) estimated that in 2017, lead exposure accounted for 1.06 million deaths and 24.4 million years of healthy life lost (disability-adjusted life years (DALYs)) worldwide due to long-term effects on health. The highest burden was in low- and middle-income countries. IHME also estimated that in 2016, lead exposure accounted for 63.2% of the global burden of idiopathic developmental intellectual disability, 10.3% of the global burden of hypertensive heart disease, 5.6% of the global burden of the ischaemic heart disease and 6.2% of the global burden of stroke *(3)*.

WHO response

WHO has identified lead as 1 of 10 chemicals of major public health concern, needing action by Member States to protect the health of workers, children and women of reproductive age.

WHO has made available through its website a range of information on lead, including information for policy-makers, technical guidance and advocacy materials.

WHO is currently developing guidelines on the prevention and management of lead poisoning, which will provide policy-makers, public health authorities and health professionals with evidence-based guidance on the measures that they can take to protect the health of children and adults from lead exposure.

Since leaded paint is a continuing source of exposure in many countries, WHO has joined with the United Nations Environment Programme to form the Global Alliance to Eliminate Lead Paint. This is a cooperative initiative to focus and catalyse efforts to achieve international goals to prevent children's exposure to lead from leaded paints and to minimize occupational exposures to such paint. Its broad objective is to promote a phase-out of the manufacture and sale of paints containing lead and eventually eliminate the risks that such paints pose.

The Global Alliance to Eliminate Lead Paint is an important means of contributing to the implementation of paragraph 57 of the *"Plan of Implementation"* of the World Summit on Sustainable Development and to resolution II/4B of the Strategic Approach to International Chemicals Management (SAICM), which both concern the phasing out of lead paint.

WHO is also a partner in a project funded by the Global Environment Facility that aims to support at least 40 countries in enacting legally binding controls on lead paint. *(4)*

The phasing out of lead paint by 2020 is one of the priority actions for governments included in the WHO *Road map to enhance health sector engagement in the Strategic Approach to International Chemicals Management towards the 2020 goal and beyond*. This road map was approved by the Seventieth World Health Assembly in decision WHA70(23).

The elimination of lead paint will contribute to the achievement of the following Sustainable Development Goal targets:

- **3.9: By 2030 substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination; and**
- **12.4: By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.**

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(1) Leaded Petrol Phase-out globally (2019)
Nairobi: United Nations Environment Programme; 2019.
(2) Global Health Observatory: Regulations and controls on lead paint.
Geneva: World Health Organization; 2019
(3) Institute for Health Metrics and Evaluation (IHME). GBD Compare.
Seattle, WA: IHME, University of Washington; 2017.
(4) SAICM GEF Project - Lead in Paint Component

Attachment 17

Lead

Protecting children from exposure to lead is important for lifelong good health. No safe blood lead level has been identified. Even low levels of lead in blood have been shown to affect IQ, ability to pay attention, and academic achievement. The effects of lead exposure cannot be corrected.

How Might Lead Affect Breastfeeding Mothers and Infants?

Women who have been or are currently exposed to lead can expose their fetus or infant to lead during pregnancy and lactation through blood and breast milk, which can have long-term effects on the neurodevelopment of their child. During pregnancy and lactation, mothers can have lead in their blood or breast milk for two reasons:

1. They have been directly exposed to lead during pregnancy or lactation.
2. Lead that is stored in a woman's bones and teeth from a prior exposure to lead can be released during pregnancy or lactation.

Can Mothers Breastfeed Their Children If They Have Elevated Blood Lead Levels (BLLs)?

If a pregnant or lactating woman has blood lead levels (BLLs) ≥5 µg/dL, the health care provider should attempt to determine the source(s) of lead exposure, working with the local health department and occupational medicine specialists as needed for environmental assessment and case management.

It is recommended that mothers with BLLs <40 µg/dL should breastfeed, but it is important to note:

- Infant BLLs should be monitored if his or her mother's BLLs are between 5 and 39 µg/dL. Breastfeeding should continue for all infants with BLLs below 5 µg/dL.
- If infant BLLs are rising or failing to decline by 5 µg/dL or more, the healthcare provider should contact the local health department for environmental sampling. If no external source is identified, and maternal BLLs are ≥20 µg/dL and infant BLLs are ≥5 µg/dL, then breast milk may be the source of lead exposure. Mothers should consider temporarily pumping and discarding their breast milk until maternal BLLs are lower.

Mothers with BLLs ≥40 µg/dL are encouraged to pump and discard their milk until their BLLs drop below 40 µg/dL.

- Testing breast milk for lead is not recommended.

Top of Page

What Are Some Kinds of Lead Hazards Breastfeeding Women Might Be Exposed To? How Can They Protect Themselves and Their Infants?

Breastfeeding women should be aware of or avoid the following:

- **Lead-based paint** (typically found in homes built before 1978). Stay away from repair, repainting, renovation, and remodeling work. Test paint before starting home improvements that disturb paint. If hiring someone else to perform work, make sure they follow lead paint repair rules from the Environmental Protection Agency (EPA).
- **Pica.** Never eat or mouth clay, soil, pottery, or paint chips because they may be contaminated with lead.
- **Tainted food.** Use caution when eating candies, spices, food additives, and other foods from abroad, especially if they appear to be noncommercial products of unknown safety. Limit eating game meat—such as deer—that have been hunted with lead ammunition.
- **Tainted foodware.** Avoid using imported lead-glazed ceramic pottery and pewter or brass containers or utensils to cook, serve, or store food. Avoid using leaded crystal to serve or store beverages. Do not use dishes that are chipped or cracked.
- **Tainted medicine or personal care products.** Avoid imported medicines and herbal remedies (azarcon, Ayurvedics); cosmetics and ceremonial powders (tiro, kohl, kajal, surma); and personal care products (litargirio) that may contain lead.
- **Water with lead levels exceeding 15 parts per billion (ppb).** If water lead levels exceed EPA's action level of 15 ppb, use bottled water or water from a filtration system certified by an independent testing organization to reduce or eliminate lead for cooking and drinking.
- **Some occupations or hobbies** that may involve lead exposure. These include construction or home renovation/repair in pre-1978 homes; firing ranges and military or police work; battery or electronics manufacturing or recycling; soldering or casting metal; oil field work; mining; and aviation gas used in small planes. If a household member works with lead, take precautions to avoid taking home lead dust in cars or on clothing, skin, hair, and shoes.
- **Prior exposure.** Prior significant exposure such as childhood environmental exposure or previous occupational exposure could lead to large stores of lead in bone which can become mobilized during pregnancy.
- **Recent immigration.** Recent immigration to the United States from countries where relatively high lead exposure is endemic, such as countries where leaded gasoline is still used or where use of consumer products containing lead is widespread.

Top of Page

Learn More

- Angelon-Gaetz KA, Klaus C, Chaudhry EA, et al. (2018) Lead in Spices, Herbal Remedies, and Ceremonial Powders Sampled from Home Investigations for Children with Elevated Blood Lead Levels — North Carolina, 2011–2018. *MMWR*, 67(46):1290–1294. [PDF-131KB]
- Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women [PDF-3.67MB]

- Resources for Workers with Lead Exposure
- Prevention Tips for Pregnant Women
- What Do Parents Need to Know to Protect Their Children?

External Resources

- Lead Screening During Pregnancy and Lactation – American College of Obstetricians and Gynecologists
- Prevention of Childhood Lead Toxicity – American Academy of Pediatrics

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Page last reviewed: December 22, 2019

Attachment 18

Lead and Pregnancy
Know the Risks

The Bottom Line

Pregnant women with high blood lead levels can have high blood pressure, spontaneous abortion, small babies, and brain damage in the infant. All pregnant women with even one risk factor for lead poisoning should have a blood lead level done. Pregnant women with lead levels at or above 5 micrograms/deciliter must have further assessment and treatment.

The Full Story

For thousands of years, we've known that lead is harmful. It is especially dangerous for young children. Lead damages the brain and nervous system, especially when children are still growing. They can have a lower IQ, behavior problems, damaged hearing, abdominal pains, and trouble learning.

Pregnant women with high lead levels can pass lead to their unborn children. (Lead also can be passed to children in breast milk.) Now, there are guidelines for when pregnant women should be tested for high lead levels.

The Centers for Disease Control and Prevention (CDC) and the American College of Obstetricians and Gynecologists recommend that all pregnant women be asked about their risk factors for lead poisoning.

Pregnant women should be tested for lead if they have any one of these risk factors:

- Recent arrival to the U.S. from a country with a lot of environmental lead.
- Living near a source of lead, for example lead mines or battery recycling plants.
- Working in a lead industry or living with someone who does.
- Having a lead-based hobby, for example stained glass.
- Using lead-based pottery for food or drinks.

- Using lead-based cosmetics, such as imported kohl or sarma.
- Using spices, herbs, or medicines that could be contaminated with lead. These are usually imported from other countries.
- Repairing or renovating a home with lead paint.
- Living in a home with lead in the water pipes.
- Having a history of lead poisoning; lead is stored in bone for decades and is released into the blood during pregnancy.
- Living with someone with a high lead level.

If a pregnant woman's level is less than 5 micrograms per deciliter (mcg/dL), nothing more needs to be done.

If the level is 5 or above, repeat testing is needed. How often a woman is re-tested depends on her blood lead level. Pregnant women with lead levels of 5 mcg/dL or above also need extra calcium and iron in their diets. These supplements help prevent higher blood lead levels.

Every pregnant woman should discuss possible lead risks with her health provider. For questions about lead and lead poisoning, call Poison Control at 1-800-222-1222.

Take Home Messages:

High blood lead levels are dangerous for a pregnant woman and her fetus. Possible problems include high blood pressure, spontaneous abortion, small babies, and brain damage in the infant. Now, there are specific guidelines for pregnant women:

- All pregnant women should talk to their doctors (or other health care providers) about risk factors for lead poisoning.
- All pregnant women with even one risk factor should have a blood lead level done.
- All pregnant women with lead levels at or above 5 micrograms/deciliter (mcg/dL) must have further assessment and treatment.

Rose Ann Gould Soloway, RN, BSN, MSEd, DABAT *emerita*
Clinical Toxicologist

For More Information

Prevent lead poisoning before getting pregnant (https://www.cdc.gov/nceh/lead/tips/pregnant.htm) (CDC).

Background information and recommendations about lead screening in pregnancy (https://www.acog.org/~/media/Committee%20Opinions/Committee%20on%20Obstetric%20Practice/co533.pdf?dmc=1&ts=20131016T1426013489)(American College of Obstetricians and Gynecologists).

For questions about lead and lead poisoning, call Poison Control at 1-800-222-1222.

References

American College of Obstetricians and Gynecologists. Lead screening during pregnancy and lactation. Committee Opinion N. 533. American College of Obstetrics and Gynecologists. Obstet Gynecol 2012;120:416-20.

Centers for Disease Control and Prevention. Blood lead levels in children aged 1-5 years - United States, 1999-2010. MMWR 2013;62:245-248. (https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6213a3.htm?s_cid=mm6213a3_w)

Poisoned?

CALL
1-800-222-1222

Prevention Tips

If you are pregnant, talk to your health care provider about lead. If you have risk factors for lead poisoning, have a blood test for lead.

This Really Happened

A 38-year-old woman who was 25 weeks pregnant came into the emergency room complaining of chronic abdominal pain, fatigue, constipation and body aches. Blood work obtained prior to her pregnancy revealed anemia and an abnormally high whole-blood lead level (67.5 mcg/dL; a normal level is less than 5). At that time, the woman did not seek treatment.

When she went to the emergency room during her pregnancy, her whole-blood lead level was again high (62.8 mcg/dL), her anemia had worsened, and her blood showed characteristics of lead poisoning when viewed under the microscope. The ultrasound of the fetus appeared normal at that time.

Four weeks after her diagnosis of lead poisoning, the patient was treated with oral chelators. These are medicines that help the body excrete some of the lead. The goal was to prevent some of the severe effects of lead poisoning in both the woman and her fetus.

At birth, the baby had a very high lead level (74.7 mcg/dL). Although the child was born 3 weeks early, she appeared normal and healthy at that time. The child was treated in the hospital with intravenous chelators for 3 days. Then, she was given an oral chelator for another 19 days. At 6 weeks old, the child's whole-blood lead level was still high (30.7 mcg/dL); she was treated with another 19 days of chelation therapy.

After 6 months of monitoring, the child's lead level was still elevated (30.5 mcg/dL). At that time, her pediatrician felt that she appeared normal. She did not have any apparent developmental delay. It is unknown if the child showed any problems with learning, behavior, or health as she continued to grow and develop.

Summarized from: Horowitz BZ, Mirkin, DB. Lead poisoning and chelation in a mother-neonate pair. Clinical Toxicology. 2001; 39(7):727-731.

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Attachment 19

healthychildren.org
Powered by pediatricians. Trusted by parents.
from the American Academy of Pediatrics
CELEBRATING 10 YEARS

Blood Lead Levels in Pregnant & Breastfeeding Moms

Lead is toxic and particularly harmful for developing nervous systems. Lead can be passed through a pregnant woman's placenta to the fetus, or through breast milk to a baby.

To minimize the risk to you and your baby from lead, take a moment to educate yourself about making your environment more lead safe.

Is there anything I can do to lower my exposure to lead during pregnancy?

Yes, you can avoid exposure to any known sources of lead before and during pregnancy.

- If you are working with lead in your job or have a hobby such as making jewelry or stained glass, have your health care provider check your blood lead level.
- If you are fixing up an older home containing lead-based paint, be sure that the people working it are following safe procedures (http://www.health.state.mn.us/divs/eh/lead/homes/interior.html) to protect you and your family from lead exposure. About 75% of homes built before 1978 contain some lead-based paint. The older the home the more likely it is to contain lead-based paint.
- Water from public sources is regularly tested for lead. You can get information about your drinking water from your local board of health. Houses that use well water should have the water tested regularly for lead and other possible contaminants. *See Lead in Tap Water & Household Plumbing: Parent FAQs* (/English/safety-prevention/at-home/Pages/Lead-in-Tap-Water-Household-Plumbing.aspx).
- Eat frequent and regular meals. Environmental lead is more easily absorbed into your bloodstream and retained in your body if you have an empty stomach.
- A diet poor in calcium, iron, zinc, vitamin C, vitamin D and vitamin E *can* be associated with increased amount of lead absorbed into your bloodstream. Therefore, it is important for pregnant woman to eat a well-balanced diet and take prenatal vitamins.

Is there a test to tell how much lead I have been exposed to?

Yes, a blood lead test (/English/safety-prevention/all-around/Pages/Where-We-Stand-Lead-Screening.aspx) can be done to see how much lead is present. Although most people will have some lead in their blood, levels greater than 5 micrograms per deciliter (μg/dL) indicate that there is some exposure that needs to be addressed. While there is no clear safe level of lead in the body, the goal is to have the lowest level possible. Women who had exposure to lead in the past should have levels checked.

The Centers for Disease Control and Prevention (CDC) recommends blood lead testing for pregnant and lactating women with one or more important risk factors for lead exposure and increased blood lead levels:

- Recent immigration (from an area where lead contamination is high)
- Living near point source of lead (e.g., lead mines, smelters, battery recycling plants, home remodeling)
- Pica (i.e., compulsive eating of non-food items)
- Occupational exposures (e.g., painters, those exposed to batteries or radiators, living with someone who works in lead industry)

- Environmental exposures (e.g., lead-contaminated soil, water, or food)
- Use of lead-containing cosmetics
- Cooking/storing in lead-glazed pottery
- Use of some herbal/alternative medicines

Back to Top

What effects could lead have on my baby?

The most serious effect of high levels of lead during pregnancy can cause miscarriage and stillbirth. Other pregnancy problems such as low birth weight and premature delivery can also occur. Additionally, high maternal lead levels can cause learning and behavior problems in exposed babies. It is unlikely that exposure to lead during pregnancy would significantly increase the chance for major physical birth defects.

Is there concern about lead if I am breastfeeding?

Generally speaking, breastfeeding is safe for women with elevated blood lead levels; however, babies of breastfeeding mothers with very high blood lead levels should be closely monitored.

A blood test should be performed within two weeks of baseline measurement and then at least on a monthly basis:

- **For babies with a blood lead level of 5 µg/dL or greater or rising:** An environmental assessment is recommended.
- **For babies with a blood lead level that stays below 10 µg/dL:** Breastfeeding should continue.

Additional Information:

- Lead Exposure: Steps to Protect Your Family (/English/safety-prevention/all-around/Pages/Lead-Screening-for-Children.aspx)
- Lead in Tap Water & Household Plumbing: Parent FAQs (/English/safety-prevention/at-home/Pages/Lead-in-Tap-Water-Household-Plumbing.aspx)
- Lead Screening during Pregnancy and Lactation (http://www.acog.org/Resources-And-Publications/Committee-Opinions/Committee-on-Obstetric-Practice/Lead-Screening-During-Pregnancy-and-Lactation) (American College of Obstetricians and Gynecologists)
- Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women (http://www.cdc.gov/nceh/lead/publications/LeadandPregnancy2010.pdf) (Centers for Disease Control and Prevention)

Last Updated 11/19/2019
Source Section on Hematology/Oncology & Council on Environmental Health (Copyright © 2016 American Academy of Pediatrics)

The information contained on this Web site should not be used as a substitute for the medical care and advice of your pediatrician. There may be variations in treatment that your pediatrician may recommend based on individual facts and circumstances.

Attachment 20

NTP | National Toxicology Program
U.S. Department of Health and Human Services

NTP Monograph

Health Effects of Low-Level Lead

EXCERPTED BY
CLEAN AIR COUNCIL

June 2012

NTP
National Toxicology Program
U.S. Department of Health and Human Services

NTP MONOGRAPH ON HEALTH EFFECTS OF LOW-LEVEL LEAD

June 13, 2012

Office of Health Assessment and Translation

Division of the National Toxicology Program

National Institute of Environmental Health Sciences

National Institutes of Health

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

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PEER REVIEW OF THE DRAFT NTP MONOGRAPH

Peer review of the Draft NTP Monograph was conducted by an *ad hoc* expert panel at a public meeting held November 17-18, 2011, at the National Institute of Environmental Health Sciences, Research Triangle Park, NC (see *http://ntp.niehs.nih.gov/go/37090* for materials, minutes, and panel recommendations from the peer review meeting). The selection of panel members and conduct of the peer review were performed in accordance with the Federal Advisory Committee Act and Federal policies and regulations. The panel members served as independent scientists, not as representatives of any institution, company, or governmental agency. In this capacity, panel members had two major responsibilities in reviewing the draft NTP Monograph: (1) to determine whether the scientific information cited in the draft monograph is technically correct, clearly stated, and objectively presented and (2) to determine whether the scientific evidence presented in the draft monograph supports the NTP's conclusions regarding health effects of low-level lead (Pb).

The panel agreed with the draft NTP overall conclusions on cardiovascular, renal, and immune health effects associated with blood Pb levels <10 µg/dL. The panel recommended changing the draft summary conclusion for neurological effects in children and for reproductive effects in adult women from *sufficient* evidence of an association at blood Pb levels <10 ug/dL to *sufficient* evidence of an association at blood Pb levels <5 ug/dL. Comments from the peer reviewers and written public comments received on the draft monograph were considered during finalization of the document. The NTP concurred with the expert panel on all of its recommendations on the conclusions regarding health effects of Pb in this final document.

Peer-Review Panel

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ABSTRACT

Although reductions in lead (Pb) exposure for the U.S. population have resulted in lower blood Pb levels over time, epidemiological studies continue to provide evidence of health effects at lower and lower blood Pb levels. Low-level Pb was selected for evaluation by the National Toxicology Program (NTP) because of (1) the availability of a large number of epidemiological studies of Pb, (2) a nomination by the National Institute for Occupational Safety and Health for an assessment of Pb at lower levels of exposure, and (3) public concern for effects of Pb in children and adults. This evaluation summarizes the evidence in humans and presents conclusions on health effects in children and adults associated with low-level Pb exposure as indicated by less than 10 micrograms of Pb per deciliter of blood (<10 µg/dL). The assessment focuses on epidemiological evidence at blood Pb levels <10 µg/dL and <5 µg/dL because health effects at higher blood Pb levels are well established. The NTP evaluation was conducted through the Office of Health Assessment and Translation (OHAT, formerly the Center for the Evaluation of Risks to Human Reproduction) and completed in April of 2012.

The results of this evaluation are published in the NTP Monograph on Health Effects of Low-Level Lead. The document and appendices are available at *http://ntp.niehs.nih.gov/go/evals.* This document provides background on Pb exposure and includes a review of the primary epidemiological literature for evidence that low-level Pb is associated with neurological, immunological, cardiovascular, renal, and/or reproductive and developmental effects. The NTP Monograph presents specific conclusions for each health effect area. Overall, the NTP concludes that there is *sufficient* evidence that blood Pb levels <10 µg/dL and <5 µg/dL are associated with adverse health effects in children and adults.

This conclusion was based on a review of the primary epidemiological literature, scientific input from technical advisors that reviewed pre-public release drafts of each chapter summarizing the evidence for specific health effects associated with low-level Pb, public comments received during the course of the evaluation, and comments from an expert panel of *ad hoc* reviewers during a public meeting to review the Draft NTP Monograph on November 17-18, 2011 *(http://ntp.niehs.nih.gov/go/37090).*

1.0 EXECUTIVE SUMMARY

1.1 Introduction

Lead (Pb) exposure remains a significant health concern despite policies and practices that have resulted in continued progress in reducing exposure and lowering blood Pb levels in the U.S. population. Pb is one of the most extensively studied environmental toxicants, with more than 28,900 publications on health effects and exposure in the peer-reviewed literature[1]. While the toxicity associated with exposure to high levels of Pb was recognized by the ancient Greeks and Romans, the adverse health effects associated with low-level Pb exposure became widely recognized only in the second half of the 20th century. Over the past 40 years, epidemiological studies, particularly in children, continue to provide evidence of health effects at lower and lower blood Pb levels. In response, the Centers for Disease Control and Prevention (CDC) has repeatedly lowered the concentration of Pb in blood that is considered "elevated" in children (from 30 µg/dL to 25 µg/dL in 1985 and to the current level of 10 µg/dL in 1991).

The purpose of this evaluation is to summarize the evidence in humans and to reach conclusions about whether health effects are associated with low-level Pb exposure as indicated by less than 10 micrograms of Pb per deciliter of blood (<10 µg/dL), with specific focus on the life stage (childhood, adulthood) associated with these health effects. This evaluation focuses on epidemiological evidence at blood Pb levels <10 µg/dL because health effects at higher blood Pb levels are well established such that the definition of an elevated blood Pb level is ≥10 µg/dL for both children and adults (ABLES 2009, CDC 2010a). Pb was nominated by the National Institute for Occupational Safety and Health for a National Toxicology Program (NTP) evaluation to assess the reproductive and developmental effects of Pb (see *http://ntp.niehs.nih.gov/mtg?date=20100510&meeting=BSC*). The scope of the evaluation has been expanded from the original nomination to include an evaluation of health effects other than reproduction and development (e.g., cardiovascular effects in adults) in order to maximize the utility of the evaluation.

[1] Based on an April 2012 PubMed search for keyword (MeSH) "lead" or "lead poisoning."

1.2 Methods

The key questions and general approach for developing the conclusions on the health effects of low-level Pb are outlined below. **Section 2.0** of this document contains additional details on the authoritative sources considered, the literature search strategy, and the peer-review process.

1.2.1 Key Questions

What is the evidence that adverse health effects are associated with blood Pb <10 µg/dL?

- What reproductive, developmental, neurological, immune, cardiovascular, and renal health effects are associated with blood Pb levels <10 µg/dL?
- What is the blood Pb level associated with a given health effect (i.e., <10 µg/dL or <5 µg/dL)?
- At which life stages (childhood or adulthood) is the effect identified?
- Are there data to evaluate the association between bone Pb and the health effect, and how does the association to this biomarker of Pb exposure compare to the association with blood Pb?

1.2.2 Approach to Develop Health Effects Conclusions

Conclusions in the NTP evaluation of Pb-related health effects in humans associated with low-level Pb were derived by evaluating the data from epidemiological studies with a focus on blood Pb levels <10 µg/dL. The evaluation includes a review of the primary epidemiological literature for evidence that low-level Pb is associated with neurological, immunological, cardiovascular, renal, and/or reproductive and developmental effects. These health effect areas were selected because there is a relatively large database of human studies in each area. The NTP considered four possible conclusions for specific health effects within each area:

Sufficient Evidence of an Association:
An association is observed between the exposure and health outcome in studies in which chance, bias, and confounding could be ruled out with reasonable confidence.

Limited Evidence of an Association:
An association is observed between the exposure and health outcome in studies in which chance, bias, and confounding could not be ruled out with reasonable confidence.

Inadequate Evidence of an Association:
The available studies are insufficient in quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of an association between exposure and health outcome, or no data in humans are available.

Evidence of No Association:
Several adequate studies covering the full range of levels of exposure that humans are known to encounter (in this case limited to blood Pb levels <10 µg/dL) are mutually consistent in not showing an association between exposure to the agent and any studied endpoint.

The discussion of each health effect begins with a statement of the NTP's conclusion regarding whether the specific effect is associated with a blood Pb level <10 µg/dL or <5 µg/dL and the age group (childhood or adulthood) in which it is or is not identified, as well as the timing of exposure associated with the effect (prenatal, childhood, concurrent) if available. Then key data and principal studies considered in developing the NTP's conclusions are discussed in detail. General strengths and limitations of study designs were considered when developing conclusions, with prospective studies providing stronger evidence than cross-sectional or case-control studies. Each section concludes with a summary discussing each health effect, describing experimental animal data that relate to the human data, and stating the basis for the NTP conclusions.

For the purposes of this evaluation, "children" refers to individuals <18 years of age unless otherwise specified. In addition to the blood Pb level of <10 µg/dL, a lower effect level of <5 µg/dL was also selected because it is commonly used in epidemiological studies to categorize health effects data by exposure levels; therefore, data are often available to evaluate health effects for groups above and below this value as well.

1.2.3 Appendices of Studies Considered

The information to support the NTP's conclusions for individual health effects is presented in each chapter. In addition, human studies of groups with low-level Pb exposure that were considered in developing the conclusions are also abstracted for further reference and included in separate appendices for neurological effects, immune effects, cardiovascular effects, renal effects, and reproductive and developmental effects.

1.2.4 Authoritative Sources and Peer Review

In this evaluation, the NTP made extensive use of recent government assessments of the health effects of Pb, especially the U.S. Environmental Protection Agency (EPA) 2006 Air Quality Criteria Document (AQCD) for Lead (U.S. EPA 2006 and a draft updated version, 2012), which has undergone extensive external public peer review. In addition to the EPA's 2006 AQCD for Lead, sources include the Agency for Toxic Substances and Disease Registry's (ATSDR) 2007 Toxicological Profile for Lead (ATSDR 2007) and the CDC's Advisory Committee on Childhood Lead Poisoning Prevention reports, such as the 2010 Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women (CDC 2010b).

The NTP used independent subject matter experts as technical advisers to provide scientific input and to review pre-public release drafts of each chapter summarizing the evidence that health effects are associated with low-level Pb, the appendices, and **Section 3.0** that provides background on Pb exposure (see **Contributors** for a list of technical advisers). Peer review of the draft document was conducted by an expert panel of *ad hoc* reviewers at a public meeting held November 17-18, 2011, in Research Triangle Park, NC (see **Peer-Review of the Draft NTP Monograph** for details). Comments from peer reviewers and written public comments received on the draft monograph were considered during finalization of the document. The NTP concurred with the expert panel on all of the conclusions regarding health effects of Pb in this final document.

1.3 What Does It Mean to Refer to Blood Pb Levels <10 µg/dL?

The overwhelming majority of human epidemiological studies with Pb exposure data measured Pb in whole blood, and this measure of exposure serves as the basis for the evaluation of Pb levels <10 µg/dL. An individual's blood Pb level reflects an equilibrium between current environmental Pb exposure and the preexisting amount of Pb in the body, stored primarily in bone (Factor-Litvak *et al.* 1999, Brown *et al.* 2000, Chuang *et al.* 2001). In adults, bone and teeth store 90-95% of the total body burden of Pb, while in young children, bone Pb represents a smaller fraction (down to 70%) (Barry 1981, for review, see Barbosa *et al.* 2005, Hu *et al.* 2007). The body eliminates half of

the Pb in circulating blood (half-life) in approximately one month, while bone is a more stable repository for Pb and, therefore, bone Pb levels reflect cumulative exposure to Pb integrated over years or even decades (reviewed in Hu *et al.* 1998, Hu *et al.* 2007). The half-life of Pb in bone ranges from 10 to 30 years, depending on the rate of bone turnover, which in turn varies by type of bone and life stage (Rabinowitz 1991). In young children, continuous growth results in constant bone remodeling, and bone Pb is exchanged with blood Pb much more frequently than in adults (reviewed in Barbosa *et al.* 2005, Hu *et al.* 2007).

This evaluation focuses on the relationship between health effects and blood Pb levels because blood Pb is the most widely available measure of exposure, blood Pb reflects the equilibrium between current and past exposure, as described above, and numerous studies have reported an association between blood Pb levels and health outcomes. However, measuring Pb in one tissue at one point in time does not present a complete picture of either current or cumulative Pb exposure, and bone Pb reflects long-term stores of Pb in the body better than does blood Pb (reviewed in Barbosa *et al.* 2005, Hu *et al.* 2007); therefore, bone Pb data were also considered when available. Note that measuring bone Pb is expensive, requires specialized equipment that is not generally accessible, and requires study subjects to travel to the location of the measurement apparatus (K-x-ray fluorescence); thus, fewer Pb data are available for bone than for blood.

Before bans on Pb in paint, solder, and gasoline, environmental Pb levels in the United States were higher, so older adults accumulated more Pb as children than children do today. Average blood Pb levels in children 1-5 years of age have decreased 10-fold over the last 30 years, from 15.1 µg/dL in 1976-1980 to 1.51 µg/dL in 2007-2008 (geometric means; CDC 2007, 2011). This is clearly good news for current populations of children and represents a significant public health accomplishment. However, most U.S. adults who were born before 1980 had blood Pb levels >10 µg/dL during early childhood, so health effects in adults today may have been influenced by blood Pb levels >10 µg/dL that many individuals experienced earlier in life.

Keeping childhood blood Pb levels in mind, there are data on multiple health effects in adults for which studies report a significant relationship between concurrent blood Pb levels as adults and the health effect (e.g., elevated blood pressure, reduced kidney function, or decreases in specific measures of cognitive function). There is a considerable body of evidence that these health effects are associated with Pb exposure, and multiple studies report a significant association with concurrent blood Pb levels <10 µg/dL. Furthermore, the association with blood Pb is supported by the consistency of effects among epidemiological studies and biological coherence with animal data. It is well recognized that the role of early-life Pb exposure cannot be discriminated from the role of concurrent blood Pb without additional long-term studies. To eliminate the potential role of early-life blood Pb levels >10 µg/dL on health effects observed in adults with blood Pb levels <10 µg/dL, prospective studies (following a group over time) would be required in a group with blood Pb levels consistently <10 µg/dL from birth until measurement of the outcome of interest.

As described in **Section 1.2.2**, the NTP's conclusions were derived by evaluating data from epidemiological studies with a focus on blood Pb levels <10 µg/dL. The evidence discussed for specific health outcomes within each chapter varies by study design and type of analyses used to examine the relationship of the health outcome with blood Pb across the hundreds of studies evaluated. In some cases, studies examined only groups with blood Pb levels <10 µg/dL, <5 µg/dL, or even lower, and the association of the health effect with the blood Pb level is clear. For example, Lanphear *et al.* (2000) reported that higher blood Pb levels were associated with lower academic performance in a cross-sectional study (examining one point in time) of 4,853 children 6-16 years of age from the NHANES III data set. When they analyzed only children with blood Pb <10 µg/dL (n=4,681) or <5 µg/dL (n=4,043), the association with blood Pb was still significant ($p<0.001$ for <10 µg/dL and <5 µg/dL). In other cases, studies reported a significant association between blood Pb and an effect in a group whose mean blood Pb level was <10 µg/dL (e.g., higher blood Pb levels were associated with higher blood pressure in 964 adults in the Baltimore Memory Study (Martin *et al.* 2006)). These analyses support an effect of a blood Pb level <10 µg/dL, but they do not exclude the possibility that individuals significantly above or below the mean blood Pb level are driving the effect, or that past exposure levels are

driving the effect. Finally, some studies compared effects between two groups with higher and lower blood Pb levels. For example, Naicker *et al.* (2010) compared the effect of a blood Pb level ≥5 µg/dL with a blood Pb level <5 µg/dL on developmental markers of puberty in 13-year-old girls in South Africa (n=682) and found that a blood Pb level ≥5 µg/dL was significantly associated with delayed breast development, pubic hair development, and age of menarche.

1.4 Health Effects Evidence

1.4.1 NTP Conclusions

The NTP concludes that there is *sufficient* evidence for adverse health effects in children and adults at blood Pb levels <10 µg/dL, and <5 µg/dL as well (see **Table 1.1** for summary of effect by life stage at which the effect is identified). A major strength of the evidence supporting effects of low-level Pb comes from the consistency demonstrated by adverse effects associated with blood Pb <10 µg/dL across a wide range of health outcomes, across major physiological systems from reproductive to renal, among multiple groups, from studies using substantially different methods and techniques, and for health effects in both children and adults.

In children, there is *sufficient* evidence that blood Pb levels <5 µg/dL are associated with increased diagnosis of attention-related behavioral problems, greater incidence of problem behaviors, and decreased cognitive performance as indicated by (1) lower academic achievement, (2) decreased intelligence quotient (IQ), and (3) reductions in specific cognitive measures. There is also *limited* evidence that blood Pb <5 µg/dL is associated with delayed puberty and decreased kidney function in children ≥12 years of age. There is *sufficient* evidence that blood Pb levels <10 µg/dL in children are associated with delayed puberty and reduced postnatal growth. There is *limited* evidence that blood Pb levels <10 µg/dL are associated with elevated serum immunoglobulin E (IgE), which is a principal mediator of hypersensitivity; consistent with this effect, there is *limited* evidence that blood Pb levels <10 µg/dL are associated with changes to an IgE-related health effect, allergy diagnosed by skin prick test to common allergens. There is *inadequate* evidence of an association between blood Pb <10 µg/dL in children and other allergic diseases, such as eczema or asthma. There is also *inadequate* evidence of an association between blood Pb <10 µg/dL and cardiovascular effects in children of any age, or renal function in children <12 years of age.

In adults, there is *sufficient* evidence that blood Pb levels <5 µg/dL are associated with decreased renal function and that blood Pb levels <10 µg/dL are associated with increased blood pressure and hypertension. There is *sufficient* evidence that maternal blood Pb levels <5 µg/dL are associated with reduced fetal growth and *limited* evidence that maternal blood Pb levels <10 µg/dL are associated with increased spontaneous abortion and preterm birth. There is *sufficient* evidence that blood Pb levels <10 µg/dL, and *limited* evidence that blood Pb levels <5 µg/dL, are associated with essential tremor in adults. There is also *limited* evidence for an association between blood Pb <10 µg/dL and increased cardiovascular-related mortality, decreased auditory function, the neurodegenerative disease amyotrophic lateral sclerosis (ALS), and decreases in specific measures of cognitive function in older adults. The NTP conclusions of associations between blood Pb levels <10 µg/dL in adults and health effects cannot completely eliminate the potential contributing effects of early-life blood Pb levels, as discussed in **Section 1.3**.

Although the relationship between many health effects and bone Pb as a measure of exposure has not been examined, the data support the importance of cumulative Pb exposure on cardiovascular effects of Pb in adults, as well as neurocognitive decline in adults, because the association between Pb and these endpoints is more consistent for bone Pb than for blood Pb.

1.4.2 Neurological Effects

The NTP concludes that there is *sufficient* evidence that blood Pb levels <5 µg/dL are associated with adverse neurological effects in children and *limited* evidence that blood Pb levels <10 µg/dL are associated with adverse neurological effects in adults (see **Table 1.2** for summary of effects).

Unlike the data set for most other health effect areas, there are a number of prospective studies of neurological effects that include measures of prenatal exposure (either maternal blood or umbilical cord blood Pb levels). These prospective studies provide *limited* evidence that prenatal exposure to blood Pb levels <5 µg/dL is associated with decreases in measures of general and specific cognitive function

Table 1.1: NTP conclusions on health effects of low-level Pb by life stage

Life Stage	Blood Pb Level	NTP Conclusion	Principal Health Effects	Bone Pb Evidence
Children	<5 µg/dL	*Sufficient*	Decreased academic achievement, IQ, and specific cognitive measures; increased incidence of attention-related behaviors and problem behaviors	Tibia and dentin Pb are associated with attention-related behaviors, problem behaviors, and cognition.
		Limited	Delayed puberty and decreased kidney function in children ≥12 years of age	The one available study of bone Pb in children does not support an association with postnatal growth.
	<10 µg/dL	*Sufficient*	Delayed puberty, reduced postnatal growth, decreased IQ, and decreased hearing	No data
		Limited	Increased hypersensitivity/allergy by skin prick test to allergens and increased IgE* (not a health outcome)	No data
		Inadequate	*Any age* – asthma, eczema, nonallergy immune function, cardiovascular effects; *<12 years of age* – renal function	No data
Adults	<5 µg/dL	*Sufficient*	Decreased glomerular filtration rate; maternal blood Pb associated with reduced fetal growth	The one available study of bone Pb in the general population supports an association between bone Pb and decreased kidney function. Maternal bone Pb is associated with reduced fetal growth.
		Limited	Increased incidence of essential tremor	No data
	<10 µg/dL	*Sufficient*	Increased blood pressure, increased risk of hypertension, and increased incidence of essential tremor	The association between bone Pb and cardiovascular effects is more consistent than for blood Pb.
		Limited	Psychological effects, decreased cognitive function, decreased hearing, increased incidence of ALS, and increased cardiovascular-related mortality; maternal blood Pb associated with increased incidence of spontaneous abortion and preterm birth	The association between bone Pb and cognitive decline is more consistent than for blood Pb.
		Inadequate	Immune function, stillbirth, endocrine effects, birth defects, fertility or time to pregnancy**, sperm parameters**	No data

Abbreviations: ALS, amyotrophic lateral sclerosis; IgE, immunoglobulin E; IQ, intelligence quotient

*Increased serum IgE is associated with hypersensitivity; however, as described in **Section 1.4.3**, increased IgE does not equate to disease.

The NTP concludes that there is *inadequate* evidence that blood Pb levels <10 µg/dL are associated with fertility, time to pregnancy, and sperm parameters; however, given the basis of the original nomination, the NTP evaluated the evidence that higher blood Pb levels (i.e., >10 µg/dL) are associated with reproductive and developmental effects, and those conclusions are discussed in **Section 1.4.6 and presented in **Table 1.2**.

Table 1.2: NTP conclusions on health effects of low-level Pb by major health effect areas

Health Area	Population or Exposure Window		NTP Conclusion	Principal Health Effects	Blood Pb Evidence	Bone Pb Evidence
Neurological	Prenatal		*Limited*	Decrease in measures of cognitive function	Yes, <5 µg/dL	No data
			Limited	Decreased IQ, increased incidence of attention-related and problem behaviors, decreased hearing	Yes, <10 µg/dL	No data
	Children		*Sufficient*	Decreased academic achievement, IQ, and specific cognitive measures; increased incidence of attention-related and problem behaviors	Yes, <5 µg/dL	Tibia and dentin Pb are associated with attention, behavior, and cognition.
			Sufficient	Decreased hearing	Yes, <10 µg/dL	No data
	Adults		*Sufficient*	Increased incidence of essential tremor	Yes, <10 µg/dL	No data
			Limited	Psychiatric effects, decreased hearing, decreased cognitive function, increased incidence of ALS	Yes, <10 µg/dL	The association between bone Pb and cognitive decline is more consistent than blood.
			Limited	Increased incidence of essential tremor	Yes, <5 µg/dL	
Immune	Children		*Limited*	Increased hypersensitivity/allergy by skin prick test to common allergens and IgE* (not a health outcome)	Yes, <10 µg/dL	No data
			Inadequate	Asthma, eczema	Unclear	No data
	Adults		*Inadequate*	–	Unclear	No data
Cardiovascular	Children		*Inadequate*	–	Unclear	No data
	Adults		*Sufficient*	Increased blood pressure and increased risk of hypertension	Yes, <10 µg/dL	The association between bone Pb and cardiovascular effects is more consistent than blood.
			Limited	Increased cardiovascular-related mortality and ECG abnormalities	Yes, <10 µg/dL	
Renal	Children <12 years old		*Inadequate*	–	Unclear	No data
	Children ≥12 years old		*Limited*	Decreased glomerular filtration rate	Yes, <5 µg/dL	No data
	Adults		*Sufficient*	Decreased glomerular filtration rate	Yes, <5 µg/dL	Yes, one study
Reproductive and Developmental	Prenatal		*Limited*	Reduced postnatal growth	Yes, <10 µg/dL	No data
	Children		*Sufficient*	Delayed puberty, reduced postnatal growth	Yes, <10 µg/dL	One study does not support effects of bone Pb on growth.
			Limited	Delayed puberty	Yes, <5 µg/dL	
	Adults	Women	*Sufficient*	Reduced fetal growth	Yes, <5 µg/dL	Maternal tibia Pb is associated
			Limited	Increase in spontaneous abortion and preterm birth	Yes, <10 µg/dL	No data
		Men	*Sufficient*	Adverse changes in sperm parameters and increased time to pregnancy	Yes, ≥15-20 µg/dL	No data
			Limited	Decreased fertility	Yes, ≥10 µg/dL	No data
			Limited	Increased spontaneous abortion	Yes, >31 µg/dL	No data
		Adults	*Inadequate*	Stillbirth, endocrine effects, birth defects	Unclear	No data

Abbreviations: ALS, amyotrophic lateral sclerosis; ECG, electrocardiography; IgE, immunoglobulin E; IQ, intelligence quotient.
*Increased serum IgE is associated with hypersensitivity; however, as described in **Section 1.4.3**, increased IgE does not equate to disease.

evaluated in children. There is also *limited* evidence that prenatal exposure to blood Pb levels <10 µg/dL is associated with decreased IQ, increased incidence of attention-related behaviors and antisocial behavior problems, and decreased hearing measured in children. However, conclusions about effects of prenatal Pb exposure for outcomes evaluated as children are complicated by the high degree of correlation between prenatal and childhood blood Pb levels and as described below, blood Pb levels during childhood are also associated with these effects.

In children, there is *sufficient* evidence that blood Pb levels <5 µg/dL are associated with decreases in broad based and specific indices of cognitive function and an increase in attention-related behavioral problems and antisocial behavioral problems. The association between blood Pb and decreased IQ has been demonstrated in multiple prospective studies of children with blood Pb levels <10 µg/dL, pooled analyses that reported effects with peak blood Pb levels <7.5 µg/dL (Lanphear *et al.* 2005), and multiple cross-sectional studies that reported effects with mean blood Pb levels <5 µg/dL. Lower levels of academic achievement, as determined by class rank and achievement tests, have been reported in multiple prospective and cross-sectional studies of children with blood Pb <5 µg/dL. An association between blood Pb <5 µg/dL and decreases in specific measures of cognitive function has been demonstrated in prospective and cross-sectional studies using a wide range of tests to assess cognitive function. Increases in attention-related and problem behaviors are consistently reported in studies with mean blood Pb levels <5 µg/dL. The NTP concludes that blood Pb is associated with attention-related behaviors rather than attention deficit hyperactivity disorder (ADHD) alone because (1) this broad term more accurately reflects the range of Pb-associated behavioral effects in the area of attention, of which ADHD is one example on the more severe end of the spectrum, and (2) determination of ADHD in children from available studies are not as precise as an ADHD diagnosis by trained clinicians using specific *DSM-IV-TR* criteria. There is *sufficient* evidence that blood Pb levels <10 µg/dL in children are associated with decreased auditory acuity. Multiple cross-sectional studies reported hearing loss, as indicated by higher hearing thresholds and increased latency of brainstem auditory evoked potentials (BAEPs), in children with blood Pb levels <10 µg/dL.

In adults, there is *limited* evidence that blood Pb levels <10 µg/dL are associated with psychiatric outcomes (including anxiety and depression), decreased auditory function, ALS, and decreases in specific measures of cognitive function in older adults. There is *sufficient* evidence that blood Pb levels <10 µg/dL are associated with essential tremor in adults, and *limited* evidence for blood Pb levels <5 µg/dL. Associations with decreases in cognitive function in adults are more consistent for bone Pb than for blood Pb, suggesting a role for cumulative Pb exposure.

1.4.3 Immune Effects

The NTP concludes that there is *limited* evidence that blood Pb levels <10 µg/dL are associated with adverse immune effects in children and that there is *inadequate* evidence in adults (see **Table 1.2**).

In children, there is *limited* evidence that blood Pb levels <10 µg/dL are associated with changes to an immune-related health outcome such as allergy or increased hypersensitivity. There is also *limited* evidence that blood Pb levels <10 µg/dL are associated with elevated serum IgE levels. Five studies of groups with mean blood Pb levels of 10 µg/dL and below support the relationship between blood Pb and increased serum IgE. Two of these studies reported an association at blood Pb levels of ≥10 µg/dL rather than <10 µg/dL, and only one of the remaining studies adjusted for age, a particularly important confounder in analyses of IgE in children. Although increases in serum levels of total IgE are not definitive indicators of allergic disease, elevated levels of IgE are primary mediators of hypersensitivity associated with sensitization and allergic disease. Therefore, the studies demonstrating Pb-related increases in IgE suggest a link to hypersensitivity and support more definitive data such as a prospective study that found blood Pb levels <10 µg/dL were associated with increased hypersensitivity (or allergy by skin prick testing) in children. These data support the conclusion of *limited* evidence that increased hypersensitivity responses or allergy are associated with blood Pb levels <10 µg/dL in children; however, there is *inadequate* evidence of an association between blood Pb and other allergic diseases such as eczema or asthma.

There is *inadequate* evidence in adults to address the potential association between blood Pb <10 µg/dL and IgE, allergy, eczema, or asthma. Few studies have investigated the relationship between

immune function and Pb in humans, and most studies reported general observational markers of immunity rather than function. There is *inadequate* evidence that blood Pb levels <10 µg/dL are associated with observational immune effects such as altered lymphocyte counts or serum levels of IgG, IgM, or IgA in the blood of children or adults, because few studies have examined the lower exposure level and the available data are inconsistent. There is also *inadequate* evidence that blood Pb levels <10 µg/dL are associated with changes in immune function other than hypersensitivity, because few studies have examined immune function at lower blood Pb levels.

Bone Pb levels may be particularly relevant for cells of the immune system and immune function. All of the white blood cells or leukocytes that develop after birth are derived from progenitor cells in the bone marrow. Unfortunately, very few studies of immune effects have measured exposure other than blood Pb; therefore, the relative importance of blood or bone Pb levels for immune effects of Pb is unknown.

1.4.4 Cardiovascular Effects

The NTP concludes that there is *sufficient* evidence that blood Pb levels <10 µg/dL in adults are associated with adverse effects on cardiovascular function and that there is *inadequate* evidence to evaluate cardiovascular effects in children (see **Table 1.2** for summary of effects).

There is *sufficient* evidence of a bone Pb-related increase in the risk of hypertension and increases in blood pressure in adults. Two prospective studies and five cross-sectional studies support a significant association between bone Pb and blood pressure or hypertension in groups with blood Pb levels <10 µg/dL. Studies show less consistent associations between blood Pb and blood pressure or hypertension than for bone Pb; however, most of the recent studies with mean blood Pb levels <5 µg/dL found significant associations between concurrent blood Pb levels and increased blood pressure. There is *sufficient* evidence that blood Pb levels <10 µg/dL increase the risk of hypertension during pregnancy, supported by one prospective study and five cross-sectional studies with blood Pb levels during pregnancy <10 µg/dL. There is *limited* evidence of increased risk of cardiovascular mortality associated with blood Pb levels <10 µg/dL. An association between increased cardiovascular mortality and blood Pb is supported by three prospective studies (two of which used the same NHANES III sample) but is not supported by two other prospective studies. One of the studies that did not find an association with blood Pb (at a mean blood Pb level of 5.6 µg/dL) reported a significant association between bone Pb levels and increased cardiovascular mortality. There is *limited* evidence for Pb effects on other cardiovascular outcomes, including electrocardiography (ECG) abnormalities and clinical cardiovascular disease primarily due to lack of replication studies. Chronic Pb exposure appears to be more critical than current Pb exposure, as shown by more consistent associations between chronic cardiovascular effects and bone Pb than for blood Pb. Studies support an association with concurrent blood Pb levels; however, the potential effect of early-life blood Pb levels on cardiovascular outcomes in adults cannot be discriminated from the effect of concurrent blood Pb levels without additional prospective studies in a population for which blood Pb levels remain consistently below 10 µg/dL from birth until evaluation of the various cardiovascular outcomes as described in **Section 1.3**. There is *inadequate* evidence for Pb effects on heart rate variability, due to a lack of replicated studies.

There is *inadequate* evidence to assess whether children or menopausal women present a sensitive life stage for cardiovascular effects of Pb. No prospective studies have followed children with early-life Pb measures and evaluated cardiovascular health in adulthood. During periods of bone demineralization such as menopause and with osteoporosis, Pb stored in bone may enter the blood stream at a higher rate, increasing circulating Pb levels; for example, increased blood Pb levels have been demonstrated in women after menopause in several studies (e.g., Silbergeld *et al.* 1988, Symanski and Hertz-Picciotto 1995, Webber *et al.* 1995, Korrick *et al.* 2002). Too few studies have examined Pb-related cardiovascular health risks in postmenopausal women to enable conclusions.

Although hypertension can contribute to adverse renal effects, and kidney dysfunction can contribute to increased blood pressure, effects are considered separately in this evaluation because most studies examined one outcome or the other, rather than testing both systems comprehensively.

1.4.5 Renal Effects

The NTP concludes that there is *sufficient* evidence that blood Pb levels <5 µg/dL are associated with

adverse renal effects in adults (see **Table 1.2** for summary of effects). There is *limited* evidence that blood Pb levels <5 µg/dL are associated with adverse renal effects in children ≥12 years of age, and the current evidence is inadequate to conclude that blood Pb <10 µg/dL is associated with renal effects in children <12 years of age.

There is *sufficient* evidence that blood Pb levels <5 µg/dL are associated with adverse effects on kidney function in adults. Most of the 13 epidemiological studies of the general population reported blood Pb levels <10 µg/dL are associated with (1) increased risk of chronic kidney disease (CKD), and (2) decreases in the estimated glomerular filtration rate (eGFR) and creatinine clearance, markers of kidney function. The associations are typically stronger in studies of groups with hypertension or diabetes. Few studies have examined other markers of Pb exposure, such as bone Pb; therefore, it is unknown whether blood or bone Pb levels would be a better measure of exposure for kidney effects related to Pb. Epidemiological data from the general population support an association with concurrent blood Pb levels in adults; however, the potential effect of early-life blood Pb levels on kidney function in adults cannot be discriminated from the effect of concurrent blood Pb levels without additional prospective studies in a group for which blood Pb levels remain consistently below 10 µg/dL from birth until evaluation of kidney function as described in **Section 1.3**.

There is *inadequate* evidence to address the potential association between blood Pb levels <10 µg/dL in children <12 years of age and impaired kidney function, because results are inconsistent and available studies of kidney function in young children are less reliable in general because tests of kidney function lack clear predictive value in this age group. There is *limited* evidence that blood Pb levels <5 µg/dL are associated with adverse effects on kidney function in children ≥12 years of age. This conclusion is based on one study of NHANES data, which reported effects in children ≥12 years of age that are consistent with reduced eGFR reported in adults in several NHANES studies.

1.4.6 Reproduction and Developmental Effects

The NTP concludes that there is *sufficient* evidence that blood Pb levels <10 µg/dL are associated with adverse health effects on development in children and that blood Pb levels <5 µg/dL are associated with adverse health effects on reproduction in adult women (see **Table 1.2** for summary of effects).

Because most data on reproductive effects come from studies of occupational exposure, many of the available studies are for blood Pb levels >10 µg/dL. For this reason, and because the original nomination focused on reproductive and developmental effects, the evaluation of health effects in this area includes higher blood Pb levels, unlike other sections of this document. Consideration of these higher blood Pb levels resulted in several conclusions for Pb-related reproductive effects in men but did not affect the conclusions for women or children.

Unlike the data for most other health effect areas, a number of prospective studies of developmental effects have included prenatal measures of exposure (either maternal blood or umbilical cord blood). These prospective studies provide *limited* evidence that prenatal exposure to blood Pb levels <10 µg/dL is associated with reduced postnatal growth in children. Conclusions about effects of prenatal Pb exposure in children are complicated because blood Pb levels <10 µg/dL during childhood are also associated with reduced postnatal growth, and prenatal Pb levels are highly correlated with childhood Pb levels.

In children, there is *sufficient* evidence that blood Pb levels <10 µg/dL are associated with delayed puberty and *limited* evidence for this effect at blood Pb levels <5 µg/dL. Nine studies reported that concurrent blood Pb levels <10 µg/dL in children are associated with delayed puberty. There is *sufficient* evidence that blood Pb levels <10 µg/dL are associated with decreased postnatal growth. Numerous cross-sectional studies, including studies with large sample sizes such as the NHANES data sets, reported that concurrent blood Pb <10 µg/dL in children is associated with reduced head circumference, height, or other indicators of growth.

In adults, there is *sufficient* evidence that maternal blood Pb levels <5 µg/dL are associated with reduced fetal growth or lower birth weight. Three prospective studies with maternal blood Pb data during pregnancy, a large retrospective study (examining medical history) of >43,000 mother-infant pairs with a mean maternal blood Pb level of 2.1 µg/dL, and several cross-sectional studies of Pb levels in maternal or cord blood at delivery support an association

between higher blood Pb and reduced fetal growth at mean blood Pb levels from 1 to 10 µg/dL. Although maternal or paternal bone Pb data are not available in most studies of reproductive health outcomes, a set of studies of a single group reported that higher maternal bone Pb is related to lower fetal growth. There is also *limited* evidence that maternal blood Pb levels <10 µg/dL are associated with preterm birth and spontaneous abortion. Although several prospective studies reported an association between maternal blood Pb and preterm birth, the conclusion of *limited* evidence is due to inconsistent results and a retrospective study with a large cohort of >43,000 mother-infant pairs not finding an association between maternal blood Pb levels and preterm birth. The conclusion of *limited* evidence for an association with spontaneous abortion is based primarily on the strength of a single prospective nested case-control study in women, with additional support provided by occupational studies that reported an association with Pb exposure but lacked blood Pb measurements. In men, there is *inadequate* evidence that blood Pb levels <10 µg/dL are associated with effects on reproduction.

In men there is *sufficient* evidence that blood Pb levels ≥15 µg/dL are associated with adverse effects on sperm or semen and that blood Pb levels ≥20 µg/dL are associated with delayed conception time. Decreases in sperm count, density, and concentration have been reported in multiple retrospective and cross-sectional occupational studies of men with mean blood Pb levels from 15 to 68 µg/dL. Four studies reported increased time to pregnancy in women whose male partners had blood Pb levels of 20-40 µg/dL. A single retrospective occupational study reported increased risk of infertility among men with blood Pb levels ≥10 µg/dL, and the consistency of this observation with other studies reporting effects on time to pregnancy at higher blood Pb levels supports a conclusion of *limited* evidence that blood Pb levels ≥10 µg/dL in men are associated with other measures of reduced fertility. There is also *limited* evidence that paternal blood Pb levels >31 µg/dL are associated with spontaneous abortion, based primarily on the strength of a single retrospective nested case-control study in men, with additional support provided by occupational studies that reported an association with Pb exposure but lacked blood Pb measurements.

1.5 Future Research

There are robust data and *sufficient* evidence that blood Pb levels <10 µg/dL in children and adults are associated with adverse health effects across a wide range of health outcomes, as described above. Over time, epidemiological studies have provided data to support health effects at lower and lower blood Pb levels, particularly in children. Prospective studies in children better address the lower limits of Pb exposure associated with health effects because they focus on children whose blood Pb levels remain <10 µg/dL or <5 µg/dL with certainty throughout their lifetime. Studies of health effects in adults cannot eliminate the potential effects of early-life blood Pb levels on health effects observed as adults. This is particularly important in an evaluation of the health effects of blood Pb levels <10 µg/dL because older adults were likely to have had blood Pb levels >10 µg/dL as children (see discussion in **Section 1.3**), compared with only 0.8% of children with confirmed blood Pb levels >10 µg/dL in 2008.

Clarification of the effects of early-life blood Pb levels relative to the effects of concurrent blood Pb levels remains a significant issue for evaluating Pb-related health effects in adults. Epidemiological data from adults support an association between concurrent blood Pb levels <5 µg/dL and decreased renal function and between concurrent blood Pb levels <10 µg/dL and increased blood pressure and hypertension. Future research should be directed at clarifying the extent to which early life exposure (e.g., blood Pb levels >10 µg/dL) contribute to health effects observed in adults. Long-term prospective studies in a group for which blood Pb levels remain consistently <10 µg/dL from birth until the outcome of interest is measured would take one step in this direction by eliminating the potential role of early-life blood Pb levels >10 µg/dL on health effects observed in adults with concurrent blood Pb levels <10 µg/dL.

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Attachment 21

Centers for Disease Control and Prevention

Childhood Lead Poisoning Prevention

Lead Poisoning Prevention

The goal is to **prevent** childhood lead exposure before any harm occurs.

- *Primary prevention* – the removal of lead hazards from the environment before a child is exposed – is the most effective way to ensure that children do not experience harmful long-term effects of lead exposure.
- *Secondary prevention* – including blood lead testing and follow-up – remains an essential safety net for children who may already be exposed to lead.

View Larger Text Equivalent

A blood test is the best readily available way to measure exposure to lead. The amount of lead in blood is referred to as blood lead level which is measured in micrograms of lead per deciliter of blood (µg/dL).

No safe blood lead level in children has been identified. Even low levels of lead in blood have been shown to affect IQ, the ability to pay attention, and academic achievement. The good news is that childhood lead poisoning is 100% preventable.

Preventing childhood lead exposure is cost-effective.

According to a 2017 report from the Health Impact Project, a federal investment of $80 billion would prevent all U.S. children born in 2018 from having any detectable levels of lead in their blood. This investment has an estimated $83.9 billion in societal benefits, which represents a 5% return on investment. If it cost less than $80 billion to remove lead from the environment, then the cost-benefit ratio would be greater. Additionally, permanently removing lead hazards from the environment would benefit future birth cohorts, and savings would continue to grow over time.

CDC is committed to help address this threat and improve health outcomes for our nation's most vulnerable citizens – our children.

Sources of Lead

At Risk Populations

Blood Lead Levels in Children

Health Effects

Lead FAQs

Page last reviewed: July 30, 2019

Attachment 22

Centers for Disease Control and Prevention

Childhood Lead Poisoning Prevention

Blood Lead Levels in Children

Protecting children from exposure to lead is important to lifelong good health. No safe blood lead level in children has been identified. Even low levels of lead in blood have been shown to affect IQ, ability to pay attention, and academic achievement. And effects of lead exposure cannot be corrected.

The most important step parents, doctors, and others can take is to prevent lead exposure before it occurs.

Highlights

- In 2012, CDC updated its recommendations on children's blood lead levels.
- By shifting our focus to primary prevention of lead exposure, we can reduce or eliminate dangerous lead sources in children's environments BEFORE they are exposed.
- What has not changed is the recommendation for when to use medical treatment for children. Experts recommend chelation therapy when a child is found with a test result of greater than or equal to 45 micrograms per deciliter of lead in blood.
- Though lead can be found in many sources, lead exposure is entirely preventable. The key is stopping children from coming into contact with lead and treating children who have been poisoned by lead. Parents can take simple steps to make their homes more lead-safe.
- Children can be given a blood test to measure the level of lead in their blood. Talk to your child's doctor if you are concerned about lead exposure.

CDC Blood Lead Reference Value (BLRV)

- CDC now uses a blood lead reference value of 5 micrograms per deciliter to identify children with blood lead levels that are much higher than most children's levels. This new level is based on the U.S. population of children ages 1-5 years who are in the highest 2.5% of children when tested for lead in their blood.
- This reference value is based on the 97.5th percentile of the National Health and Nutrition Examination Survey (NHANES)'s blood lead distribution in children. The current reference value is based on NHANES data from 2007-2008 and 2009-2010.
- Every four years, CDC will review the most recent two sets of NHANES data to find the 97.5th percentile of blood lead distribution in children.
- NHANES is a population-based survey to assess the health and nutritional status of adults and children in the United States and determine the prevalence of major diseases and risk factors for diseases.

Previous Terminology

- Until 2012, children were identified as having a blood lead "level of concern" if the test result is 10 or more micrograms per deciliter of lead in blood. CDC is no longer using the term "level of concern" and is instead using the reference value to identify children who have been exposed to lead and who require case management.
- In the past, blood lead level tests below 10 micrograms per deciliter of lead in blood may, or may not, have been reported to parents. The new lower value means that more children will likely be identified as having lead exposure allowing parents, doctors, public health officials, and communities to take action earlier to reduce the child's future exposure to lead.

What Has Not Changed

- What has not changed is the recommendation for when medical treatment is advised for children with high blood lead levels. The new recommendation does not change the guidance that chelation therapy be considered when a child has a blood lead test result greater than or equal to 45 micrograms per deciliter.

- Children can be given a blood test to measure the level of lead in their blood. These tests are covered by Medicaid and most private health insurance.

Additional Resources

- CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in "Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention" [PDF – 165 KB]
- Recommendations of the Advisory Committee for Childhood Lead Poisoning Prevention [PDF – 890 KB]
- Summary of Recommendations for Follow-up and Case Management of Children Based on Confirmed Blood Lead Levels

Page last reviewed: July 30, 2019

Attachment 23

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

EXCERPTED BY
CLEAN AIR COUNCIL

January 4, 2012

Disclaimer

This document was solely produced by the Advisory Committee for Childhood Lead Poisoning Prevention. The posting of this document to our website in no way authorizes approval or adoption of the recommendations by CDC. Following the committee vote on January 4, 2012 to approve these recommendations, HHS and CDC will begin an internal review process to determine whether to accept all or some of the recommendations and how to implement any accepted recommendations.

TABLE OF CONTENTS

Abbreviations iii
ACCLPP and Blood Lead Level Work Group Rosters iv
Executive Summary ix
Introduction 1
I. Scientific Rationale for Eliminating the CDC's 10 μg/dL Blood Lead Level of Concern 3
II. Putting Primary Prevention First 16
III. Health Management for Primary Prevention of Lead Exposure 18
IV. Achieving Lead-Safe Housing 32
V. Environmental Interventions 39
VI. Research Needs 44
VII. References 49

Executive Summary

Based on a growing body of studies concluding that blood lead levels (BLLs) <10 µg/dL harm children, the Centers for Disease Control and Prevention (CDC) Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommends elimination of the use of the term "blood lead level of concern". This recommendation is based on the weight of evidence that includes studies with a large number and diverse group of children with low BLLs and associated IQ deficits. Effects at BLLs < 10 µg/dL are also reported for other behavioral domains, particularly attention-related behaviors and academic achievement. New findings suggest that the adverse health effects of BLLs less than 10 µg/dL in children extend beyond cognitive function to include cardiovascular, immunological, and endocrine effects. Additionally, such effects do not appear to be confined to lower socioeconomic status populations. Therefore, the absence of an identified BLL without deleterious effects combined with the evidence that these effects, in the absence of other interventions, appear to be irreversible, underscores the critical importance of primary prevention.

Primary prevention is a strategy that emphasizes the prevention of lead exposure, rather than a response to exposure after it has taken place. Primary prevention is necessary because the effects of lead appear to be irreversible. In the U.S., this strategy will largely require that children not live in older housing with lead-based paint hazards. Screening children for elevated BLLs and dealing with their housing only when their BLL is already elevated should no longer be acceptable practice.

The purpose of this report is to recommend to the CDC how to shift priorities to implement primary prevention strategies and how to best provide guidance to respond to children with BLLs <10 µg/dL. This report also makes recommendations to other local, state and federal agencies, and the

ACCLPP recommends that CDC work cooperatively with these other stakeholders to provide advice and guidance on the suggested actions.

This report recommends that a reference value based on the 97.5th percentile of the NHANES-generated BLL distribution in children 1-5 years old (currently 5 µg/dL) be used to identify children with elevated BLL. There are approximately 450,000 U.S. children with BLLs above this cut-off value that should trigger lead education, environmental investigations, and additional medical monitoring.

In the pediatric primary care office, primary prevention must start with counseling – even prenatally when possible. This includes recommending environmental assessments for children PRIOR to screening BLLs in children at risk for lead exposure. After confirmatory testing, children at or above the reference value of 5 µg/dL must undergo ongoing monitoring of BLLs. These children should also be assessed for iron deficiency and general nutrition (*e.g.* calcium and vitamin C levels), consistent with American Academy of Pediatrics (AAP) guidelines. Iron-deficient children should be provided with iron supplements. All BLL test results should be communicated to families in a timely and appropriate manner. Children with elevated BLLs will need to be followed over time until the environmental investigations and subsequent responses are complete.

Despite significant progress in reducing geometric mean BLLs in recent decades, racial and income disparities persist. These observed differences can be traced to differences in housing quality, environmental conditions, nutrition, and other factors. The goal of primary prevention is to ensure that all homes become lead-safe and do not contribute to childhood lead exposure. Prevention requires that we reduce environmental exposures from soil, dust, paint and water, before children are exposed to these hazards. Efforts to increase awareness of lead hazards and ameliorative nutritional interventions are also key components of a successful prevention policy.

Historical information on where children with elevated BLLs reside, and other housing data can be used to direct resources for environmental testing and evaluation to homes where lead hazards are more likely to be found. Because lead-based paint hazards are the primary source of childhood exposure to lead in the U.S, and because lead-paint is present in one-third of the nation's dwellings, additional investment is needed to reduce lead hazards in older homes. Housing policies to protect children against lead exposure must target the highest risk properties for priority action, ensure that lead-safe practices are followed during renovation, repair and painting of pre-1978 homes, and to prohibit lead-based paint hazards, including deteriorated paint, in pre-1978 homes.

Local and state government must facilitate data-sharing between health and housing agencies, enact and enforce preventive lead-safe housing standards for rental and owner-occupied housing, help identify financing for lead hazard remediation, and provide families with the information needed to protect their children from hazards in the home.

Additional research is needed to develop and evaluate interventions that effectively maintain BLLs below the reference value in children who reside in pre-1978 housing. Other research priorities should include efforts to improve the use of data from screening programs, develop next-generation point-of-care lead analyzers, and improve the understanding of epigenetic mechanisms of lead action.

Introduction

The Lead Contamination Control Act of 1988 authorized the Centers for Disease Control and Prevention (CDC) to initiate efforts to eliminate childhood lead poisoning in the U.S. As a result, the CDC Childhood Lead Poisoning Prevention Program was created, with primary responsibility to: 1) develop programs and policies to prevent childhood lead poisoning; 2) educate the public and health-care providers about childhood lead poisoning; 3) provide funding to state and local health departments to determine the extent of childhood lead poisoning by screening children for elevated blood lead levels (BLLs), helping to ensure that lead-poisoned infants and children receive medical and environmental follow-up and developing neighborhood-based efforts to prevent childhood lead poisoning; and 4) support research to determine the effectiveness of prevention efforts at federal, state, and local levels.

Furthermore, CDCs Healthy People 2010 initiative set forth as one of its 10-year goals the elimination of childhood lead poisoning. Therefore, CDC, the Department of Housing and Urban Development, the Environmental Protection Agency, and other agencies have developed a federal interagency strategy to achieve this goal by 2010. The key elements of this interagency strategy include: identification and control of lead paint hazards, identification and care for children with elevated blood lead levels, surveillance of elevated BLLs in children to monitor progress; and research to further improve childhood lead poisoning prevention methods.

Advisory Committee On Childhood Lead Poisoning Prevention (ACCLPP)

The Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) was established by the CDC to advise and guide the CDC regarding new scientific knowledge and technical advances and their practical implications for childhood lead poisoning prevention efforts. The overall goal of the ACCLPP is to provide advice that will assist the nation in reducing the incidence and prevalence of

childhood lead poisoning. ACCLPP is charged with evaluating information about the health effects of lead exposure in children, the epidemiology of childhood lead poisoning, implementation issues, and other factors. Furthermore, according to its charter, ACCLPP:

- reviews and reports regularly on childhood lead poisoning prevention practices;
- recommends improvement in national childhood lead poisoning prevention efforts;
- develops written recommendations for the prevention and control of childhood lead poisoning.

Blood Lead Level of Concern Work Group Charge

In keeping with this assignment, ACCLPP established the Blood Lead Level Work Group in November 2010 to recommend a new approach, terminology, and strategy for responding to and preventing elevated BLLs in children. The charge of this working group was to:

- Recommend how to best replace the 'level of concern' in relation to accumulating scientific evidence of adverse effects of BLLs <10 µg/dL in children.
- Consider laboratory capability for measuring BLLs in establishing new guidance on childhood BLLs.
- Advise CDC on how to communicate advisories to groups impacted by policy changes concerning: 1) interpretation of childhood BLLs and trends in childhood BLLs over time; 2) screening and re-screening intervals; 3) requirements and procedures for notifying relevant family members concerning BLL test results; and 4) interventions known to reduce lead exposure.
- Make recommendations for future research on lead-exposure prevention and intervention strategies.

I. Scientific Rationale for Eliminating the CDCs 10 μg/dL Blood Lead Level of Concern

KEY POINTS/RECOMMENDATIONS

- ***Based on the scientific evidence, the ACCLPP recommends that the term "level of concern" be eliminated from all future agency policies, guidance documents, and other CDC publications, and that current recommendations based on the "level of concern" be updated according to the recommendations contained in this report.***

- ***CDC should use a childhood BLL reference value based on the 97.5th percentile of the population BLL in children ages 1-5 (currently 5 μg/dL) to identify children and environments associated with lead-exposure hazards. The reference value should be updated by CDC every four years based on the most recent population based blood lead surveys among children.***

Prior ACCLPP Guidance

The adverse health effects associated with elevated BLLs have been widely studied and documented (http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=158823#Download). In the past, the CDC responded to the accumulated evidence of adverse effects of elevated BLLs by lowering the level requiring intervention or what is now deemed the "blood lead level of concern." Over the period from 1960 to 1990, the designated BLL of concern was lowered incrementally from 60 to 25 μg/dL. In 1991, the CDC recommended lowering the BLL for individual intervention to 15 μg/dL, and implementing community-wide primary lead-poisoning prevention activities in areas where many children had BLLs > 10 μg/dL ([1] (http://www.cdc.gov/nceh/lead/publications/>).

In 2005, the ACCLPP again considered the BLL of concern and evaluated new studies that had been published through 2003 relating toxic effects, especially cognitive impairment in children, to BLLs < 10 μg/dL. Based on that evaluation, the CDC issued a statement in 2005[2] (http://www.cdc.gov/nceh/lead/publications/PrevLeadPoisoning.pdf) citing several reasons not to lower the BLL level of concern. These reasons included: 1) the absence of effective clinical or public health interventions identified that could reliably and consistently lower BLLs that were already <10

μg/dL, 2) the assessment that data on IQ in association with BLLs <10 μg/dL relied on fewer than 200 children, 3) the fact that because poor housing, poverty, lead exposure, and cognitive impairment often occurred together especially in the U.S., the role of any specific component in influencing IQ, was difficult to isolate with certainty, and, 4) uncertainties of BLL classification related to laboratory testing precision. The 2005 document also strongly endorsed primary prevention and incorporated these strategies into CDC-funded programs, as well as recommended to other agencies that they act accordingly to carry out primary prevention. In addition, the 2010 Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women [3] (http://www.cdc.gov/nceh/lead/publications/leadandpregnancy2010.pdf) gave the level of 5 μg/dL as the level at which to take action by healthcare and public health providers.

New Evidence and Updating Guidance

However, for multiple reasons, the reliance on both the 10 μg/dL BLL, as well as the concept of a "level of concern" has been increasingly questioned. Since 2003, additional reports of associations between BLLs <10 μg/dL in children with adverse cognitive, and increasingly with other physiological consequences, have been published. Additionally, data from earlier cross-sectional studies of IQ in older children, not considered central to the argument in 2003, have since been re-interpreted as highly relevant, based on reanalysis of prospective data focusing specifically on the time course of associations between blood lead and IQ. The process for setting a "level of concern" for lead has always failed to include consideration of uncertainty or the inclusion of a margin of safety. Although initially intended as a designation of a population-based action level, the level of concern has been widely treated as an individual toxicity threshold. At this time, other countries and even individual U.S. states, have abandoned both 10 μg/dL and the "level of concern."

Consequently, ACCLPP convened a Work Group in 2010 to reconsider the approach, terminology and strategy for elevated BLLs in children. After careful consideration of the current scientific literature, the ACCLPP recommends discontinuation of a designated 'level of concern' for elevated BLL in children. Because no measureable level of blood lead is known to be without deleterious effects, and because once engendered, the effects appear to be irreversible in the absence of any other interventions, public health, environmental and housing policies should encourage prevention of all exposures to lead. Correspondingly, this document emphasizes prevention of exposure rather than responses to specific BLLs, a strategy deemed 'primary prevention.' Public health goals must target the reduction of the disparities in children's BLLs that occur as a result of housing conditions, environmental contamination, race/ethnicity, and socioeconomic status.

As stated in reports from the State of California [5] and Healey et al [4] and, ***a biological "threshold" or "effect level" BLL is not synonymous with a BLL at which intervention is required or effective. Correspondingly, the ACCLPP recognizes that the selection of any BLL as a trigger for action or inaction at an individual or community level will be primarily dependent upon the availability of effective remediation approaches and financial means to accomplish them and, to some degree, related analytical considerations.*** Given those facts, recommendations in the later sections of the document refer to the use of reference values.

A statistically derived reference value characterizes the upper margin of the distribution of the laboratory measurement of a given analyte in a given population. A reference value is useful to characterize individual results as "elevated" or "not elevated" in comparison to the population average or mean value. These values have also been used to set health policy goals and to interpret results from measures of chemical exposure by CDC, the World Health Organization and other

government bodies. The German Federal Environmental Agency has recently applied the use of reference values to define "precautionary action values" for exposures to lead among children and adults [6].

A reference value* is derived from the distribution of concentrations of a specific compound or element in a body fluid of a reference population (often the 97.5th percentile). Therefore, these levels only apply to a specific population at a specific time. In the context of childhood BLLs in the U.S., NHANES data provides an appropriate source for characterizing a reference value for BLLs in children 1-5 years old. We propose that the 97.5th percentile derived from the combination of the two most recent cycles of NHANES data be used to identify individuals with increased exposure and set public health goals. The current reference value (approximately 5 µg/dL) for children's BLLs should be re-considered by the CDC every four years to ensure that changes in this population are adequately assessed.

* The term "reference value" used in this document should be distinguished from the term "reference dose" used by U.S. EPA, which refers to "An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime", or to U.S. EPA's definition of "Reference value (RfV) as "An estimate of an exposure for a given duration to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime" [cf: http://www.epa.gov/iris/help_gloss.htm#r] [accessed 11/09/2011].

Focus on the Weight of Evidence

Section I of this document describes the scientific rationale for the recommendation to eliminate the term "blood lead level of concern." This document is not intended as a risk assessment for lead, nor as a comprehensive review of the current scientific literature. Indeed, the scientific rationale presented here builds upon risk assessments carried out by other regulatory and policy bodies, including the German Human Biomonitoring Commission [6], the State of California [5], and

the literature reviewed in the 2005 CDC statement [2]. Advice on clinical, public health, housing and environmental interventions in relation to BLLs will be described in later sections.

Recognizing that any individual study may have shortcomings, the BLL Work Group based its conclusions on the overall weight-of-the-evidence from epidemiological studies of BLLs <10 μg/dL and the consistency of outcomes. In addition, it considered supporting biological plausibility evidence from animal studies.

Additional Evidence Relating Increasing BLLs with Reductions in IQ

The recommendation of the ACCLPP arises from several considerations. In 2003, Canfield et al. reported decrements in school age IQ among 213 children whose peak BLLs had never exceeded 10 μg/dL [7]. Similarly, Bellinger and Needleman, in a re-analysis of data from 48 children from the Boston cohort study whose BLLs never exceeded 10 μg/dL, reported a similar association [8]. ACCLPP reviewed these and other data, and stated in 2005 that these associations, more likely than not, were causal. There are now additional compelling studies in the scientific literature, reporting associations between BLLs <10 μg/dL and adverse effects in children, forming a more substantive body of evidence than was available at the time of the 2005 CDC statement. Collectively, these new studies and re-interpretation of past studies have demonstrated that it is not possible to determine a threshold below which BLL is not inversely related to IQ.

Healey et al. [4], citing Lanphear et al. [9] as the critical study in its toxicological assessment, asserted that that there is a negative slope relating BLL and IQ down to concurrent BLLs of 1 μg/dL. An increase in concurrent BLL from 1.0 to 4.0 μg/dL is associated with a change in mean IQ of approximately -2.3 to -5.2 IQ points, with a best estimate of -3.7 IQ points. The German Human

Biomonitoring Commission [6] concluded that it is not possible to identify a threshold BLL below which there are no cognitive deficits.

Evidence for Reductions in Academic Achievement and Specific Areas of Cognitive Dysfunction

Studies have also now extended the effects of low BLLs, and suggest the involvement of specific areas of cognitive dysfunction. These include measures of academic achievement such as reading and writing, as well as attention deficits, specifically impulsivity. For example, Chandramouli et al. [10] reported that BLLs in the range 5-10 μg/dL in 30 month-old children were associated with reductions in reading and writing scores in 7-8 year old children from the Avon Longitudinal Study. In a case-control study of children 6-17 years old [11], where the mean BLL was 0.73 and maximum BLL was 2.2 μg/dL, higher BLLs was associated with parent-reported combined-type attention deficit hyperactivity disorder and hyperactivity-impulsivity after controlling for IQ and prenatal smoking.

Significance of the Impact of BLLs on Intelligence

Although only 1 – 4% of the variance in cognitive ability in prospective cohort studies is attributable to lead, the public health impact of low level lead-exposure on the distribution of intelligence in society is considerable. Because exposure to lead is still widespread, it may be responsible for a general reduction in the mean IQ of children. A small change in mean IQ of even 3-5 points associated with BLLs between 1 and 10 μg/dL can shift the entire population IQ distribution, thereby reducing the number of high achieving individuals with IQs above 130, and increasing the number of children with IQ scores below 70, many of whom would need substantial remedial education services [12].

Critical Role of Concurrent BLLs and Intelligence

Studies published since 2005 have also established the importance of concurrent BLLs to IQ reductions. In the U.S., BLLs peak at approximately 2 years of age, after which they decline to lower levels in the absence of specific intervention. Bellinger et al. [13] reported that BLLs measured at 24 months of age, but not at 6, 12, 18 or 57 months of age, were associated with decrements in IQ when measured at 10 years of age in children from the Boston cohort [14]. These findings had cast doubt on any study that did not include data on early childhood BLLs, suggesting that any relationship between BLLs and IQ reductions in large surveys of school age children, such as NHANES, were not causal associations, but rather residual effects of higher BLLs that went unmeasured in early childhood. However, other studies noted that the findings from the Boston cohort appeared to be an exception, as most prospective studies showed stronger associations between concurrent BLLs and IQ reductions at school age, *even though the average BLL at that age was much lower* [15, 16]. In 2005, Chen et al. studied 780 children who qualified for a clinical trial by virtue of having BLLs in the range 20-44 µg/dL when they were "toddlers," and found that lower IQ at age 7 was strongly associated with concurrent BLL, but not associated with peak BLL at 2 years of age [17]. Similar findings were reported in a pooled analysis of major prospective cohort studies of IQ and BLLs, which involved children with and without such high BLLs [9]. Thus, since 2003, data from a much larger number and more diverse group of children with low BLLs and associated IQ deficits have informed consideration of the effect levels. The associations of concurrent BLLs with reduced IQ in this age group suggests a window of developmental vulnerability extending to older children, or perhaps the consequences of protracted exposure during childhood.

Low BLL Effects in Children Extend to Other Organs/Systems

Some recent studies have suggested that the adverse health effects of childhood BLLs <10 μg/dL extend beyond cognitive function to include cardiovascular, immunological, endocrine, and behavioral effects [18-22]. While the data on these outcomes are less extensive than the data characterizing the impact of lead on neurocognitive development, and therefore merit further investigation, they nevertheless raise the possibility that BLLs <10 μg/dL might be associated with broader public health consequences.

Elevated BLL Effects in Children are not Restricted to Low Socioeconomic Status Communities

The conclusions of the 2005 Working Group included concerns for residual confounding by socioeconomic status. It is noteworthy that several studies report associations in populations of relatively "advantaged" socioeconomic status. For example, the analyses from the Boston cohort study, including assessment of children whose BLLs never exceeded 10 μg/dL, was carried out in a "socioeconomically-advantaged population" [8, 13]. Moreover, the BLL-associated reductions in IQ in the Yugoslavian prospective study were seen in Mitrovica, where BLLs were elevated by the local smelter, even though the town also had higher HOME scores and higher maternal IQ scores than the comparison town, Pristina [23]. As pointed out in Healey et al.'s review of 12 longitudinal studies of BLLs and IQ ([4] p. xix), "The pattern of results does not appear to be dependent on cohort demographics, such as SES [socioeconomic status], nor do they appear to be dependent on exposure range – significant associations have been reported among both relatively low and relatively high socioeconomic strata…."

Expectations of Lower BLLs and Changes in IQ and Achievement

It has been argued that even though BLLs have declined, measures on standardized indices such as reading and IQ scores have not correspondingly increased in the U.S., which contradicts the proposed negative association between these measures. As far as the ACCLPP is aware, there are no published data that support this conclusion. Numerous studies have actually reported significant increases in IQ scores over the past century, a phenomenon dubbed the Flynn effect, which has been attributed both to characteristics of the IQ tests themselves and to cultural biases [24, 25]. While this does not demonstrate that lowering BLL is accompanied by higher IQ, it is not incompatible with that possibility. U.S reading scores have increased (http://nces.ed.gov/nationsreportcard/pdf/main2011/2012457.pdf), although to a lesser extent; changes over time are difficult to evaluate given changes in assessment format during this period (National Assessment of Education Progress (NAEP): http://nationsreportcard.gov/ltt_2008/ltt0003.asp and http://nationsreportcard.gov/ltt_2008/ltt0002.asp). (Note however the recent analysis suggesting that the reduction in childhood BLLs in Massachusetts underlies a modest but statistically significant improvement in scores on standardized English and mathematics tests (http://www.bos.frb.org/econoomic/wp/index.htm). Over the same time period, many other significant changes have occurred that could reduce any gains in these cognitive measures, as such functions clearly have multifactorial determinants. For example, the poverty rate has continued to increase (http://www.census.gov/hhes/www/poverty/data/incpovhlth/2010/tables.html), the rates of childhood obesity (http://www.cdc.gov/obesity/data/trends.html#State) and diabetes (http://www.diabetesandenvironment.org/home/incidence/historical) have increased dramatically, and have been associated with cognitive dysfunction [26, 27], and nutritional status has also changed. It is also clear that the U.S. has lost ground in terms of prenatal mortality

(http://www.cdc.gov/omhd/amh/factsheets/infant.htm#1). Moreover, as noted by Healey et al. ([4]p. xxxix): "While the magnitude of the slope of the recommended relationship between mean population IQ and concurrent blood lead in children is undoubtedly influenced to some unknown degree by confounding, it is also likely attenuated by over-control." Other outcomes, such as high school graduation, delinquency, violent crime, or incarceration have a less clear relationship with BLL and perhaps a variable latency. A comprehensive examination of such outcomes might be of interest; however, for reasons of multifactorial determination noted above, it seems unlikely that such effort would yield a consistent interpretation, nor that it would inform judgment about the toxicity of lead at a given BLL.

Shape of the BLL Curve and Outcomes

Other arguments also weigh in this decision. Recognizing the potential for residual confounding, the CDC's 2005 statement ([28]; http://www.cdc.gov/nceh/lead/publications/PrevLeadPoisoning.pdf) explored the question of the steeper dose response at lower BLLs, and evaluated how the interactions among lower dust lead, hand to mouth activity, IQ and BLL might artifactually produce the steeper curve. The document concluded that "Though this hypothetical example cannot demonstrate that residual confounding underlies the steep blood lead-IQ slopes observed at low levels, it does support the need for caution in interpreting the absolute value of the estimated effect sizes." However, it also did not state that the existence of a steeper slope in some data was evidence against any role for lead in cognitive impairment. As such, the specific shape of the curve above vs. below 10 µg/dL is not actually relevant to the question of an association of BLLs with effects below 10 µg/dL. Additionally, for other outcome

measures, effects below 10 µg/dL are found without reports of these effects being of greater magnitude than those above 10 µg/dL.

Uncertainties Regarding the Ability to Reverse Lead Effects in Children

While trials involving chelating agents did not result in improved IQ or behavioral outcomes relative to placebo [29], both human and animal studies have suggested that developmental effects arising from lead exposure could be at least partially ameliorated by opportunities for environmental 'enrichment' [30-33]. The extent to which the developmental impacts of lead-exposure in children can be fully reversed by such strategies as yet remains uncertain. The fact that significant stores of lead are present in bone with a half-life of decades, coupled with the fact that lead can be mobilized from bone back into the bloodstream to maintain equilibrium, if external lead exposure is reduced, makes it difficult to directly test this possibility. Moreover, the prospect that some environmental conditions or host factors (nutritional status, psychosocial stress, etc.) may aggravate the impact of developmental lead exposure has yet to be considered. In general, non-specific interventions that work in Head Start and other enrichment programs might be expected to produce similar results in children with and without a history of elevated BLLs. Tactics aimed solely at lowering BLLs with the expectation of reversing effects, however are unlikely to produce a benefit.

Biological Plausibility Support from Experimental Animal and In Vitro Studies

Finally, the effects reported in children are supported by biological plausibility, i.e., experimental animal studies. Rodent studies have revealed adverse consequences of BLLs of 7-11 µg/dL on cognitive domains comparable to those associated with elevated BLLs in children; these studies have not yet systematically attempted to define clear BLL threshold effects [34, 35].

Moreover, the alterations in the stress response of children in relation to low BLLs [19], particularly the delay in glucocorticoid negative feedback, actually replicates findings in animal models [34, 36].

Animal and *in vitro* studies have identified mechanisms of lead toxicity that could explain the observed greater magnitude of adverse outcomes at lower BLLs for some outcome measures. Reports of non-linear dose effect relationships between BLLs and multiple outcomes, both in human and experimental animal studies, are well established as first detailed by Davis and Svenndsgaard in 1990 [37]. A recent study found a greater delay in post-stress challenge reduction in corticosterone (the rodent version of cortisol) in rats with lower BLLs (maternal exposure yielding peak BLLs of 15-20 μg/dL) than at higher BLLs (30-35 μg/dL) [36].

Furthermore, with respect to the mechanisms of lead effects and possible differential effects at lower rather than higher BLLs, the work of Audesirk and colleagues [38, 39] is highly instructive. Based on a general belief that many effects of lead exposure arise from its ability to substitute for calcium, a metal which is essential to a substantive number of biochemical reactions and physiological processes, this group examined the effects of lead alone or lead plus calcium on the activity of Ca^{2+}/calmodulin-dependent calcineurin. This study demonstrated that lead had the potential, depending upon free concentration of Pb^{2+}, to either stimulate or inhibit Ca^{2+}/calmodulin-dependent calcineurin, with lower lead concentrations increasing and higher lead concentrations decreasing activation of calcineurin.

Summary of Scientific Rationale

In summary, many of the uncertainties associated with effects of BLLs <10 μg/dL cited by the CDC in 2005 [2] have been minimized by more recently published studies. As a result, a BLL without deleterious effects can not be identified at present, and thus the term 'level of concern', or any

suggestion of the existence of a BLL threshold, should be discarded from CDC guidance policies and replaced by new policies and terminology that offer scientifically-based and practical guidance for application in the clinical, laboratory, and public health contexts. Consequently, public health and environmental policies should encourage actions to reduce **all** lead exposure, to the extent feasible [40], and, should specifically focus on minimizing disparities in childhood BLLs as demonstrated by NHANES-documented disparities in housing conditions, environmental contamination, race/ethnicity, and socioeconomic status. Even though the most recent NHANES survey (2007 - 2008) demonstrates considerable progress in lowering BLLs in the U.S., it also confirms that higher BLLs persist in non-Hispanic black children. Similar disparities were noted when BLLs were stratified by poverty-income ratio [41].

A Renewed Call for Primary Prevention

The above arguments as well as those that follow all underscore the critical importance of primary prevention. Using a strategy of identifying lead poisoning or elevated BLL relies on detection in the child, relegating the child to the function of a sensing device for poor/contaminated housing, contaminated water and/or tainted consumer products. Thus, the child can be considered the proverbial 'canary in the coal mine.' The current strategy, which relies on the identifying extant elevated BLLs), while still warranted to some extent, does not prevent the damage already incurred. Moreover, while agents such as chelators can be used to treat overt lead poisoning and possibly reduce the case fatality rate, these agents have been demonstrated not to improve IQ or behavioral consequences of lead exposure. Therefore, primary prevention is the most important and significant strategy.

Attachment 24

CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in "*Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention*"

BACKGROUND

In late 2010, the Centers for Disease Control and Prevention's (CDC) Advisory Committee for Childhood Lead Poisoning Prevention (ACCLPP) formed a workgroup to evaluate new approaches, terminology, and strategies for defining elevated blood-lead levels (BLLs) among children. ACCLPP established the ad hoc Blood Lead Level workgroup on November 10, 2010. The charge of this workgroup was to:

1. Recommend how to best replace the term, 'level of concern,' regarding accumulating scientific evidence of adverse effects of BLLs at < 10 μg/dL in children.
2. Consider laboratory capability for measuring BLLs in establishing new guidance on childhood BLLs.
3. Advise ACCLPP on how CDC should communicate advisories to groups affected by policy changes concerning:
    a. Interpretation of childhood BLLs and trends in childhood BLLs over time;
    b. Screening and follow-up screening intervals;
    c. Requirements and procedures for notifying parents or guardians concerning BLL test results; and,
    d. Interventions known to control or eliminate lead exposure.

June 7, 2012 NOTE: This version of the CDC response has been slightly modified from one released on May 13, 2012. This version reflects the verbatim recommendations made by the ACCLPP on January 04, 2012 and has been formatted to link each recommendation to its response. No other changes were made.

On November 16–17, 2011, the ACCLPP met and deliberated on the ad hoc workgroup draft report. On January 4, 2012, the ACCLPP met and a majority approved the report, including the recommendations.

In brief, the ACCLPP recommendations include:

- Elimination of the use of the term "blood lead level of concern" based on the compelling evidence that low BLLs are associated with IQ deficits, attention-related behaviors, and poor academic achievement. The absence of an identified BLL without deleterious effects, combined with the evidence that these effects appear to be irreversible, underscores the critical importance of primary prevention. This strategy emphasizes preventing lead exposure rather than responding after the exposure has taken place. ACCLPP recommends specific actions that CDC and other local, state, and federal agencies should take to shift priorities to primary prevention and provides guidance to respond to BLLs < 10 μg/dL in children. The ACCLPP recommends that CDC collaborate with these and other stakeholders, and provide advice and guidance. ACCLPP also recommends using a reference value based on the 97.5th percentile of the BLL distribution among children 1–5 years old in the United States (currently 5 μg/dL) to identify children with elevated BLLs using data generated by the National Health and Nutrition Examination Survey (NHANES). Approximately 450,000 children in the United States have BLLs higher than this reference value.
- Additional research is needed to develop and evaluate interventions that effectively maintain BLLs below the reference value in children. Other research priorities should include efforts that better use data from screening programs; develop next-generation,

point-of-care lead analyzers; and improve the understanding of epigenetic mechanisms of lead action.

Herein we describe CDC's response to each of the ACCLPP recommendations. The proposed methods to address recommendations are contingent on the availability of resources. In FY 2012, funding for CDC's Childhood Lead Poisoning Prevention activities was reduced significantly from FY 2011. As a result, funding is not available for state and local Childhood Lead Poisoning Prevention Programs (CLPPPs). In many instances, these reductions limit CDC's ability to fully implement many of these recommendations in the short term. This draft response was prepared by CDC's National Center for Environmental Health (NCEH).

For the purpose of these responses:

Concur – We agree, and we have the funding, staff, and control over the means to implement the recommendation. The response provides potential strategies which are achievable within current FY 2012 or proposed FY 2013 resources.

Concur in principle – We agree, but we do not have the funding, staff, or control over the means to implement the recommendation. The response highlights strategies that have been shown to be effective, however a commitment to implement actions cannot be made due to our lack of control over available resources.

Nonconcur – We disagree with the recommendations and provide the reasons for the disagreement.

CDC concurred or concurred in principle with all of the recommendations approved by the ACCLPP.

RECOMMENDATIONS

I. Recommendation: ***Based on the scientific evidence, the ACCLPP recommends that the term, "level of concern", be eliminated from all future agency policies, guidance documents, and other CDC publications, and that current recommendations based on the "level of concern" be updated according to the recommendations contained in this report.***

Concur

Specific Means to Address or Implement

a. CDC will emphasize that the best way to end childhood lead poisoning is to prevent, control or eliminate lead exposures. Since no safe blood lead level in children has been identified, a blood lead "level of concern" cannot be used to define individuals in need of intervention.

b. In FY2012, CDC will discontinue using the term 'level of concern' in future publications and replace it with the reference value and the date of the NHANES that was used to calculate the reference value. CDC also will make this standard language available to operating divisions across CDC and use the cross-clearance procedure to ensure that authors adopt this language.

c. Publications on the Web site (www.cdc.gov/nceh/lead) will use the terminology in place at the time of their publication. The CDC Lead statement 1975–1991 includes

an asterisked note that "these documents are being kept on this website for historical purposes and are no longer in print." In FY2012, CDC will add the asterisk to the 2005 statement and the footnote will be edited to include the words "These documents refer to various blood-lead thresholds and levels of concern for adverse health outcomes in children. This terminology is outdated and readers are referred to the ACCLPP recommendations of 2012." A similar note will be applied to the document, "Managing Elevated Blood Lead Levels Among Children" (CDC, 2002) that states: "This document refers to a blood-lead level of 10 µg/dL as the CDC level of concern for adverse health outcomes in children. This terminology is outdated and readers are referred to the ACCLPP recommendations of 2012. However, the 2012 document does not recommend changes to the guidelines for the evaluation and treatment of children requiring chelation (BLLs ≥ 45 µg/dL) published here."

Status: The statement will be placed on www.cdc.gov/nceh/lead no later than two weeks following agency clearance. A joint publication summarizing the ACCLPP recommendations and CDC's response will be submitted jointly to the *Morbidity Mortality Weekly Review* and the journal, *Pediatrics*, no later than May 2012.

II. Recommendation: ***CDC should use a childhood BLL reference value based on the 97.5th percentile of the population BLL in children ages 1-5 (currently 5 µg/dL) to identify children and environments associated with lead-exposure hazards. The reference value should be updated by CDC every four years based on the most recent population based blood lead surveys among children.***

Concur in principle

Specific Means to Address or Implement

In FY12, CDC will:

a. Use the reference value in recommendations that involve follow-up evaluation of children after BLL testing.

b. Use the reference value as defined to identify high-risk childhood populations and geographic areas most in need of primary prevention.

c. Provide this information, including specific high-risk areas, to a wide variety of federal, state, and local government agencies and nongovernment organizations interested in lead-poisoning prevention.

In addition, CDC will update the value every 4 years using the two most recent NHANES surveys. The updated reference value will be posted at www.cdc.gov/nceh/lead and widely distributed through various Web-based LISTSERV sites, pediatric associations, and partners at the federal, state, and local level. Updated reference values will be reported in the National Report on Human Exposures to Environmental Chemicals and other relevant journals.

Status: CDC's National Center for Health Statistics (NCHS) will continue to monitor BLLs in the United States and make data tapes available on its Web site for public use at 2-year intervals.

CDC publications will use the reference value to provide guidance to clinical health care providers and others as these publications are prepared. Broader dissemination through Web sites, notices to clinical pediatric care providers, and the MMWR will be considered by CDC in the future.

III. Recommendation: ***CDC should develop and help implement a nationwide primary prevention policy to ensure that no children in the U.S. live or spend significant time in homes, buildings or other environments with lead-exposure hazards.***

Concur in Principle

Specific Means to Address or Implement

CDC recognizes the value of primary prevention. As feasible, CDC will develop strategies and guidelines for primary prevention. Implementation of primary-prevention programs is not currently practicable.

Status: CDC may examine the possibilities of working with the U.S. Department of Housing and Urban Development (HUD), the Health Resources and Services Administration (HRSA), state and local governments, and philanthropic organizations to identify opportunities for collaboration on primary prevention in the future.

IV. Recommendation: ***Clinicians should be a reliable source of information on lead hazards and take the primary role in educating families about preventing lead exposures. This includes***

recommending environmental assessments PRIOR to blood lead screening of children at risk for lead exposure.

Concur in Principle

Specific Means to Address or Implement

Although this recommendation is directed to clinicians, CDC may play a supportive role in enhancing the recommendation by working with providers to provide educational material. Some currently available resources can be used to update CDC/ATSDR documents to reflect the primacy of clinical health care providers in educating families about preventing lead exposure. For example, revisions to the ATSDR Lead Toxicity Case Study (available at http://www.atsdr.cdc.gov/csem/csem.html) are scheduled for 2012, and these changes can be incorporated.

Status: Full implementation contingent on funding

V. Recommendation: ***Clinicians should monitor the health status of all children with a confirmed BLL ≥5 µg/dL for subsequent increase or decrease in BLL until all recommended environmental investigations and mitigation strategies are complete, and should notify the family of all affected children of BLL test results in a timely and appropriate manner.***

Concur in Principle

Specific Means to Address or Implement

Although this recommendation is directed to clinicians, CDC may play a supportive role in enhancing the recommendation by working with clinical care providers and professional organizations to achieve this goal. Ensuring that children with BLLs > 5 µg/dL can be retested is feasible within the current resources because these tests are covered by Medicaid and many private health care insurance providers. As discussed earlier, some provider training will be conducted.

Status: Full implementation contingent on funding

VI. Recommendation: ***Clinicians should ensure that BLL values at or above the reference value are reported to local and state health and/or housing departments if no mandatory reporting exists and collaborate with these agencies in providing the appropriate services and resources to children and their families.***

Concur in Principle

Specific Means to Address or Implement

Although this recommendation is directed to clinicians, CDC may play a supportive role in enhancing the recommendation through CDC's continued work with testing laboratories, point-of-care instrument manufacturers, and clinical health care providers to ensure the availability of high-caliber laboratory services. In addition, most of the state CLPPPs funded by CDC have mandatory reporting laws in place, and those that do not are required to implement such laws during this year of funding.

Status: Full implementation contingent on funding

VII. Recommendation: ***Educate families, service providers, advocates, and public officials on primary prevention of lead exposure in homes and other child-occupied facilities, so that lead hazards are eliminated before children are exposed.***

Concur in Principle

Specific Means to Address or Implement

In FY12, CDC will provide available educational materials through its Web site, and seek the assistance of partner agencies and organizations to implement this recommendation. In FY 2012, funding is not available for state and local CLPPPs.

Status: Implementation contingent on funding

VIII. Recommendation: ***CDC should encourage local, state, and other federal agencies to: (a) facilitate data-sharing between health and housing agencies, (b) develop and enforce preventive lead-safe housing standards for rental and owner-occupied housing, (c) identify financing for lead hazard remediation, and (d) provide families with the information needed to protect their children from hazards in the home.***

Concur in Principle (a.-c.)

Specific Means to Address or Implement

a. In FY12, CDC will continue to recommend that health and housing agencies share data that can be used to identify geographic areas where lead-exposure risk is high. In the future, CDC can explore strategies to facilitate data sharing between health and housing agencies. If funds for CLPPPs become available, CDC will require data sharing between CLPPPs and housing agencies in all CLPPP grant programs.

b. CDC has developed guidelines for lead-safe housing and in FY2012 will encourage local, state, and federal agencies to enforce these standards.

c. HUD Lead Hazard Control Program provides approximately $100 million annually and is the most easily identifiable and largest source of federal funding for lead-hazard remediation. Many CLPPPs help property owners complete the HUD application process, help to identify alternative funding sources, and negotiate with local banks. In FY 2012, however, funding is not available for state and local CLPPPs.

Concur (d.)

Specific Means to Address or Implement

d. These materials currently exist and are distributed through a wide variety of networks. Future development of new materials could be considered by CDC in the future.

Status: Implementation contingent on funding

IX. Recommendation: ***Elected officials and the leaders of health, housing, and code enforcement agencies can help protect the children in their jurisdictions from lead exposure in their homes through many activities. CDC should work with officials to ensure adoption of a suite of preventive policies.***

Concur in Principle

Specific Means to Address or Implement

In the future, CDC could consider educating state and local elected officials about the importance of primary prevention and evidenced-based strategies at a national level. In FY 2012, funding is not available for state and local CLPPPs.

Status: Full implementation contingent on funding

X. Recommendation: ***CDC should (a) emphasize the importance of environmental assessments to identify and mitigate lead hazards before children demonstrate BLLs at or higher than the reference value and (b) adopt prevention strategies to reduce environmental lead exposures in soil, dust, paint, and water before children are exposed.***

Concur (a.)

Specific Means to Address or Implement

a. For more than 20 years CDC has emphasized the importance of environmental assessment and mitigation of lead hazards before children are exposed (before their BLLs are at or higher than the reference value) through policies, cooperative agreements, interagency agreements, and publications. CDC will continue these efforts.

Status: Ongoing

Concur in Principle (b.)

Specific Means to Address or Implement

b. In FY12 and FY13, CDC will work with federal agencies that may also be affected by these recommendations including, but not limited to, HUD and the Environmental Protection Agency (EPA). The goal of the summit will be to develop primary prevention strategies. In FY 2012, funding is not available for state and local CLPPPs.

Status: Full implementation contingent on funding

XI. Recommendation:

If lead hazards trigger a response in any unit in a multi-family housing complex, the same response action should be applied to all similar untested units in the housing complex, unless a risk assessment demonstrates that no lead hazards are present in the other units.

(Note*:* During editing of this document, the wording of this recommendation was changed in the CDC response to the ACCLPP recommendations. On May 23, 2012 this error was corrected and the wording is now the same as that in the original ACCLPP recommendations.)

Concur in Principle

Specific Means to Address or Implement

CDC concurs with the evidence that a building that houses one child with lead poisoning is an indication that other children in that building are likely at risk. In the future, CDC may explore implementing recommendations for increased inspections.

Status: Implementation contingent on funding

***XII. Recommendation:* CDC should encourage additional research directed towards developing interventions capable of maintaining children's BLLs lower than the reference value.**

Concur in Principle

Specific Means to Address or Implement

CDC will work with the National Institute of Environmental Health Sciences (NIEHS) and academic partners to encourage research. This research will be designed to develop and evaluate effective, broadly useful interventions that are effective in the complex lead-exposure situations

that are commonly encountered. In the future, CDC may explore strategies to support additional research.

Status: NIEHS is working with other partners to foster collaboration on developing a research agenda that will address the spirit of the recommendation. In the future, CDC may explore strategies to support additional research.

XIII. Recommendation: ***Additional research priorities should include improve the use of data from screening programs, develop next generation point-of-care lead analyzers, and improve the understanding of epigenetic mechanisms of lead action.***

Concur

Specific Means to Address or Implement

As funding permits, CDC will work with NIEHS, academic partners, and laboratory instrument manufacturers to encourage research in these important areas.

Status: There is ongoing interaction with NIEHS and others to foster collaboration on developing a research agenda.

Attachment 25

Centers for Disease Control and Prevention

Childhood Lead Poisoning Prevention

Recommended Actions Based on Blood Lead Level

Summary of Recommendations for Follow-up and Case Management of Children Based on Confirmed* Blood Lead Levels

Blood Lead Level (BLL)					
<5 µg/dL	5–9 µg/dL	10–19 µg/dL	20–44 µg/dL	45–69 µg/dL	≥70 µg/dL
Routine assessment of nutritional and developmental milestones	Routine assessment of nutritional and developmental milestones	Routine assessment of nutritional and developmental milestones	Complete history and physical exam with neurodevelopmental assessment	Complete history and physical exam with neurodevelopmental assessment and complete neurological exam	Hospitalize and commence chelation therapy in conjunction with consultation with a medical toxicologist or a pediatric environmental health specialty unit
Anticipatory guidance about common sources of lead exposure	Environmental exposure history to identify potential sources of lead -and- environmental investigation of the home to identify potential sources of lead, as required**	Environmental exposure history to identify potential sources of lead-and- environmental investigation of the home to identify potential sources of lead	Environmental investigation of the home and lead hazard reduction	Environmental investigation of the home and lead hazard reduction	Environmental investigation of the home and lead hazard reduction; child receiving chelation therapy should not return to home until lead hazard remediation is completed
Follow-up blood lead testing at recommended intervals based on child's age according to schedule below	Follow-up blood lead monitoring at recommended intervals according to schedule below	Follow-up blood lead monitoring at recommended intervals according to schedule below	Follow-up blood lead monitoring at recommended intervals according to schedule below	Follow-up blood lead monitoring at recommended intervals according to schedule below	Follow-up blood lead monitoring at recommended intervals according to schedule below

Blood Lead Level (BLL)					
	Nutritional counseling related to calcium and iron intake	Nutritional counseling related to calcium and iron intake; consider lab work to assess iron status	Lab work: – Iron status – Hemoglobin or hematocrit	Lab work: – Iron status – Hemoglobin or hematocrit	Lab work: – Iron status – Hemoglobin or hematocrit
			Abdominal X-ray (with bowel decontamination if indicated)	Abdominal X-ray (with bowel decontamination if indicated)	Abdominal X-ray (with bowel decontamination if indicated)
				Oral chelation therapy may be considered in consultation with a medical toxicologist or a pediatric environmental health specialty unit; consider hospitalization, if lead-safe home environment cannot be assured	

µg/dL: micrograms per deciliter

***Confirmed BLL**: elevated capillary screening results should be confirmed with blood drawn by venipuncture (see Recommended Schedule for Obtaining a Confirmatory Venous Sample below).

References:

1. Binns HJ, Campbell C, Brown MJ, for the Advisory Committee on Childhood Lead Poisoning Prevention. Interpreting and Managing Blood Lead Levels of Less Than 10 µg/dL in Children and Reducing Childhood Exposure to Lead: Recommendations of the Centers for Disease Control and Prevention Advisory Committee on Childhood Lead Poisoning Prevention. Pediatrics 2007 Nov;120(5): e1285. www.pediatrics.org/cgi/doi/10.1542/peds.2005-1770
2. Caldwell KL, Cheng PY, Jarrett JM, Makhmudov A, Vance K, Ward CD, Jones RL, Mortensen ME. Measurement Challenges at Low Blood Lead Levels. Pediatrics 2017 Aug;140(2): e0272. www.pediatrics.org/cgi/doi/10.1542/peds.2017-0272
3. The Clinical & Laboratory Standards Institute (CLSI) Guidelines #C40: Measurement Procedures for the Determination of Lead Concentrations in Blood and Urine, 2nd Edition (October 2013). https://clsi.org/standards/products/clinical-chemistry-and-toxicology/documents/c40/

**** Environmental investigations** at BLLs 5–19 µg/dL vary according to local conditions based on jurisdictional requirements and available resources

Recommended Schedule for Obtaining a Confirmatory Venous Sample

Blood Lead Level (µg/dL)	Time to Confirmation Testing
≥5–9	1–3 months
10–44	1 week–1 month*

Blood Lead Level (µg/dL)	Time to Confirmation Testing
45–59	48 hours
60–69	24 hours
≥70	Urgently as emergency test

*The higher the BLL on the screening test, the more urgent the need for confirmatory testing.

Schedule for Follow-Up Blood Lead Testing[a]

Venous Blood lead Levels (µg/dL)	Early follow up testing (2-4 tests after identification)	Later follow up testing after BLL declining
≥5–9	3 months*	6–9 months
10–19	1–3 months*	3–6 months
20–24	1–3 months*	1–3 months
25–44	2 weeks–1 month	1–months
≥45	As soon as possible	As soon as possible

[a]Seasonal variation of BLLs exists and may be more apparent in colder climate areas. Greater exposure in the summer months may necessitate more frequent follow ups.
*Some case managers or healthcare providers may choose to repeat blood lead tests on all new patients within a month to ensure that their BLL level is not rising more quickly than anticipated.

References:

- Centers for Disease Control and Prevention, 2002. Managing Elevated Blood Lead Levels Among Young Children
- Advisory Committee for Childhood Lead Poisoning Prevention, 2012. Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention
- American Academy of Pediatrics, 2016. Prevention of Childhood Lead Toxicity [PDF – 1 MB]

The following actions are NOT recommended at any BLL:

- Searching for gingival lead lines
- Testing of neurophysiologic function
- Evaluation of renal function (except during chelation with EDTA)
- Testing of hair, teeth, or fingernails for lead
- Radiographic imaging of long bones
- X-ray fluorescence of long bones

Page last reviewed: November 25, 2019

Attachment 26

2018 Childhood Lead Surveillance Annual Report

Childhood Lead Poisoning Prevention Program

January 2020

pennsylvania
DEPARTMENT OF HEALTH

Table of Contents 1

Executive Summary 3

Data Methods and Case Definition 6

Limitations 10

Discussion 11

Definitions 12

Findings 14

Table 1: Summary of Blood Lead Tests Performed in 2018 by Age Category 14

Table 2: Characteristics of Children Tested for Lead by Age Category, 2018 15

Table 3: Elevated Blood Lead Confirmation Status per 2016 CDC Case Definition by Age Category, 2018 16

Table 4: Details of Elevated Blood Lead Confirmation Status by Age Category, 2018 17

Table 5: Confirmation After an Elevated Capillary Blood Lead Test by Capillary Test Level, 2018 18

Table 6: Blood Lead Reporting by Method of Report and Type of Reporting Organization, 2013–2018 19

Table 7: Number of Children Aged 0–23 Months by Race/Ethnicity and Elevated Blood Lead Confirmation Status,* 2018 20

Table 8: Number of Children Aged 0–71 Months by Race/Ethnicity, and Elevated Blood Lead Confirmation Status,* 2018 21

Table 9: Number of Children Aged 0–23 Months, by Major Municipality and Elevated Blood Lead Confirmation Status,* 2018 23

Table 10: Number of Children Aged 0–71 Months by Major Municipality and Elevated Blood Lead Confirmation Status,* 2018 24

Table 11: Number of Children with Confirmed EBLL*** by County of Residence and Race, Aged 0–23 Months, 2018 25

Table 12: Number of Children with Confirmed EBLL*** by County of Residence and Race, Children Aged 0–71 Months, 2018 28

Table 13: Number of Children Tested for Lead by Maximum Blood Lead Level and County of Residence, Children Aged 0–23 Months, 2018 31

Table 14: Number of Children Aged 0–23 Months by County of Residence and Elevated Blood Lead Confirmation Status, 2018 34

Figure 2: Number and Percentage of Children Aged 0–23 Months Tested for Blood Lead Level by County, 2018 37

Figure 3: Number and Percentage of Children Aged 0–23 Months with Confirmed Elevated Blood Lead Level by County, 2018 38

Table 15: Number of Children Tested for Lead by Maximum Blood Lead Level and County of Residence, Children Aged 0–71 Months, 2018 39

Table 16: Number of Children Aged 0–71 Months by County of Residence and Elevated Blood Lead Confirmation Status, 2018 42

Figure 4: Number and Percentage of Children Aged 0–71 Months Tested for Blood Lead Level by County, 2018 45

Figure 5: Number and Percentage of Children Aged 0–71 Months with Confirmed Elevated Blood Lead Level by County, 2018 46

Table 17: Number of Children Aged 0–71 Months by Urban/Rural Status of County of Residence and Elevated Blood Lead Confirmation Status, 2018 47

References 48

Contact Information 49

Executive Summary

This is the Pennsylvania Department of Health's (Department) 13th childhood lead surveillance annual report, covering data for children tested in Pennsylvania during calendar year 2018. Data were extracted from the Department's electronic reportable disease surveillance system, Pennsylvania National Electronic Disease Surveillance System (PA-NEDSS). This report is provided as a source of information for the public: federal, state and local agencies; health care providers; and other organizations and individuals interested in lead poisoning prevention in Pennsylvania. The report is an overview of lead testing in Pennsylvania and provides information about testing for children under the age of 2, as well as under the age of 6 by: confirmation status; method of testing; method of reporting; county of residence; municipality; race and ethnicity; and residence in a rural county or an urban county.

Exposure to lead, even at low levels, can cause intellectual, behavioral and academic deficits.[1,2] For this reason, in 2012, the Centers for Disease Control and Prevention (CDC) defined an elevated blood lead level (EBLL) as a blood lead level (BLL) ≥ 5 micrograms per deciliter (µg/dL).[3] This value is also used to identify children who require case management because, even at low levels, lead has been known to affect IQ, the ability to pay attention and educational achievement.

This report will be used by the Department to 1) identify areas that may be at high risk for lead exposure; 2) locate areas of potential under-testing; and 3) make data available for state and local needs assessments. This report may also be used by federal agencies, hospitals, universities, providers and county/municipal health departments.

The Department received 194,945 blood lead test reports for 184,310 blood lead tests for children ages 0-15 in 2018. Of the 5,491 children aged 0-15 with an initial capillary test > 5 µg/dL, 3,158 (57.51%) were retested appropriately. There were 84,475 children (30.88% of the population) under age 2 tested and 160,986 (19.01% of the population) children under age 6 tested in 2018. There were 2,562 children under the age of 2 (3.03% of those tested and 0.94% of the population) with a confirmed EBLL ≥ 5 µg/dL. There were 6,585 children under the age of 6 (4.09% of those tested and 0.78% of the population) with a confirmed EBLL > 5 µg/dL.

Nearly 60% of children did not have race or ethnicity information provided in their blood lead testing results data. This is the first year Pennsylvania was able to more fully explore race and ethnicity data by matching children's blood lead testing data to birth certificate data to determine race. Among those children 0-23 months of age, testing rates for non-Hispanic black or African American children and for Hispanic children, were higher statewide than for non-Hispanic white children (36.94% and 28.32 % versus 25.39%, respectively). Non-Hispanic black or African American and Hispanic children had higher percentages of EBLLs of 5-9.9 µg/dL than non-Hispanic white children (3.83% and 2.63% versus 1.61%, respectively) among those tested. Percentages of test results ≥ 10 µg/dL were also higher among non-Hispanic black or African American and among Hispanic children than for non-Hispanic white children (1.42% and 1.15% versus 0.62%, respectively), among those tested Non-Hispanic black or African American and Hispanic children also had higher percentages

of unconfirmed elevated results among those tested than did non-Hispanic white children. These same relationships were seen for children ages 0-71 months.

The 2018 annual report also provides more detailed data for the largest counties and for the largest municipalities/cities. Testing rates and percentages of children with EBLLs among major municipalities/cities were generally higher than for their respective county for both children under the age of 2 and under the age of 6. This finding likely highlights the historical burden of older housing stock and other urban sources of lead in Pennsylvania municipalities/cities. For children 0-23 months, testing rates were highest in Pittsburgh (43.37% of children tested) and lowest in Harrisburg (24.18% of children tested). Pittsburgh's testing rates may be that much higher due to the fact that, in 2018, Allegheny County started mandatory blood lead testing for children between 9 and 12 months and at 24 months. The percentage of EBLL ≥ 5 µg/dL as a percentage of those tested were highest in the cities of York (12.94% EBLL) and Reading (8.43% EBLL).

Nationally, among states with older housing stock, lead-based paint is a significant source of lead exposure in young children. According to the 2018 American Community Survey estimate, Pennsylvania ranks fifth in the nation for the percentage of housing units identified as having been built before 1950, when lead was most prevalent.[4] Other sources of lead exposure include toys, ceramics and other consumer products.[3] Drinking water can also be a source of lead exposure when it flows through older lead plumbing or pipes where lead solder has been used (which can occur in newer plumbing as well).

Lead poisoning is a preventable environmental health hazard and, if not addressed, affects families regardless of race, ethnicity or socioeconomic status. In recent years, there has been a national reduction in children's BLLs. The Department continues to provide resources to families to prevent and address elevated blood lead through multiple strategies. Through the federally funded Childhood Lead Poisoning Prevention Program (CLPPP), the Department is working collabortatively with six local county and municipal health departments in Allegheny, Chester, Montgomery, Luzerne, Lehigh and York counties to reduce lead exposure and promote childhood lead poisoning prevention. Specifically, local partners are utilizing CLPPP funding to implement strategies and activities to increase blood lead testing; strengthen population-based interventions; and strengthen processes to identify lead-exposed children and link them to services. Additionally, the Department maintains a toll free lead information hotline to provide information about lead poisoning prevention, testing, follow-up and local resources for assistance.

In 2018, lead abatement efforts were continued through the federally funded Lead Hazard Control Program (LHCP), which provided funding to local partners to contract with certified lead professionals. The department worked with partners in targeted high risk areas across the commonwealth to identify and remove lead hazards in housing units occupied by low income families with children 6 years of age and under. The goal of the LHCP is to protect Pennsylvania's children from the long-term effects of lead poisoning as well as evaluate the overall living conditions within the home to obtain healthier outcomes for Pennsylvania families.

The Department's community health nurses (CHNs) continue to monitor elevated lead levels (≥ 5 µg/dL) in children aged 6 and under living in Pennsylvania. The Department's community health nurses cover the counties and areas of the state not covered by the 10 county and municipal health departments (CMHDs). The CMHDs include six county (Allegheny, Bucks, Chester, Erie, Montgomery, and Philadelphia) and four municipal (Allentown, Bethlehem, Wilkes-Barre, and York city) health departments and have their own specific case management protocols. The Department's CHNs contact families to provide education on laboratory results, potential sources of lead exposure, and actions to take to prevent/decrease the risk of exposure and help facilitate follow-up testing between clients and their pediatricians. The CHNs encourage every family of children with levels of 5 and above to discuss the potential need for an environmental investigation with their provider; CHNs work with the pediatrician and facilitate referrals to obtain home inspections, which could identify the source of exposure as well as provide hands-on education to parents. CHNs also work to provide referrals to the Pennsylvania Special Supplemental Nutrition Program for Women, Infants and Children and to early intervention programs where appropriate.

In 2018, the Department also continued an ongoing collaboration with the Department of Human Services on a data match project to share data between the Medicaid claims database and the lead surveillance database. The data match will lead to improved quality lead data and better service provision for Medicaid-enrolled children.

The Wolf administration, through the Lead-Free PA Initiative, and the Department are committed to preventing lead exposure and, by coordinating with state agencies, will work toward improving the outcomes of children throughout the commonwealth. In August 2019, Governor Wolf launched the Lead-Free PA Initiative, which seeks to increase access to blood lead level testing for children, increase local response efforts and plan for training of more certified lead abatement professionals. The Department and other state agencies participate in an interagency workgroup to achieve the goals of the Lead-Free PA Initiative. This report is intended to provide information that is succinct, comprehensible and accessible to the public. Although lead surveillance should be considered an ongoing process, the goal of the report is to provide meaningful, useful and easy-to-access data to the commonwealth and its citizens, so that the data can be better utilized for decision-making, targeting of resources and implementing initiatives aimed at preventing exposure to lead.

Data Methods and Case Definitions

Reporting of Test Results and Case Investigations

In Pennsylvania, clinical laboratories are required to report all BLL results from both venous and capillary specimens for persons under 16 years of age to the Pennsylvania Department of Health (28 Pa. Code § 27.34). In addition, clinicians are required to report cases of lead poisoning for children under 16 and for pregnant women (28 Pa. Code § 27.34). Reports are submitted electronically (either through electronic laboratory reporting or online key entry) to the Department through NEDSS. In 2018, reports with a BLL ≥ 5 µg/dL were assigned to public health investigators for follow-up based on the location of the patients' residence. Investigators reviewed, verified and corrected, when necessary, critical pieces of information such as date of birth, address and specimen source.

It is quite common for different entities to report the same BLL test result. For example, the ordering provider and the lab performing the analysis may both report a test. The Department does not discourage reporting from multiple sources, as it maximizes the likelihood that reporting will occur. In addition, different reporters often have different information about the patient – for instance, one may know more details about the specimen source (capillary or venous) and another may have better address information. PA-NEDSS is designed to handle duplicate reports from different sources. Several strategies are used in PA-NEDSS to ensure that all reports pertaining to a single patient are assigned to a single patient identifier. For the purposes of this annual report, tests with identical specimen collection dates and identical BLL results from the same patient were considered as a single test. The total number of BLL tests was defined as the total number of deduplicated BLL tests obtained from children who were within the specified age categories during 2018. All BLL tests were included, including those collected for screening, confirmation or follow-up purposes. Since many children had more than one BLL test during the year, the total number of children tested is less than the total number of BLL tests performed. Per-child summary BLL measures were calculated using all BLL results obtained while the child was in the given age category.

Case Definition

In May 2012, the CDC accepted the recommendation from the Advisory Committee on Lead Poisoning Prevention to eliminate the term "level of concern" (associated with the level of 10 µg/dL) and to begin using a reference value of 5 µg/dL based on the 97.5 percentile of the blood lead distribution among U.S. children.[3,5] A new case definition was officially implemented by CDC in 2016, and is used in this report to identify children with confirmed EBLL. A confirmed EBLL is defined as a venous blood lead test ≥ 5 µg/dL, or two capillary blood lead tests ≥ 5 µg/dL drawn within 84 days (12 weeks) of each other. An unconfirmed EBLL is defined as a capillary blood lead test ≥ 5 µg/dL with no other blood lead test done in the next 84 days.[6,7]

To apply the CDC case definition, a number of different data elements need to be evaluated. These data elements were handled as follows in our analyses:

- If the specimen collection date was missing or illogical, the laboratory received date or result date was used instead. If all three were missing, the reported date was used.
- Specimens with unknown specimen source or characterized as simply “blood” (as opposed to venous or capillary) were treated as if they were capillary specimens.
- Tests with undetectable BLLs were either reported as below a numeric detection limit or with a qualitative result of “negative,” “not detected” or “normal.” For statistical purposes, these results were given a numeric BLL value of 0.1 µg/dL.
- If an elevated capillary test was obtained on a child near the end of 2018 or as the child neared the limit of a particular age category, and if another elevated test result was obtained within the next 84 days, the initial elevated test was considered to be confirmed, even if the confirmatory test occurred in 2019 or outside of the age category. For example, if a child had an elevated capillary test at 23 months of age in November 2018 and received a confirmatory follow-up test within 12 weeks (in 2019), this was considered an EBLL result in 2018 for a child “aged 0−23 months.”

For children who had multiple BLL tests performed, it was possible for them to qualify for more than one case definition category (for example, they may have had an unconfirmed elevated test and then, six months later, had another elevated test that was confirmed). In these situations, a child was assigned to the highest BLL case definition category for which they qualified.

Statistical Methods

All BLL test data obtained on children less than 16 years of age in 2018 was extracted from the PA-NEDSS database. Analyses were performed on a per-test or per-child basis as indicated in the tables below.

Most of the analyses in this report are limited to children in two overlapping age categories, under 2 years of age (0–23 months) and under 6 years of age (0–71 months). Age was defined as age at the time of the specimen collection date.

Information on race and ethnicity is not routinely collected or stored by most laboratories. No usable race information was reported in PA-NEDSS for almost 60% of children. Since obtaining more complete race and ethnicity data is critical to the evaluation of disparities in screening and lead exposures, data in PA-NEDSS was supplemented with data from the Pa. Birth registry, supplied by the Bureau of Health Statistics. Children with lead test results in PA-NEDSS were matched to 2012-2018 birth certificate data using a deterministic matching method. Deterministic matching is a rules-based process to determine an “exact match” between two records, followed by iterative loosening of criteria. We matched 85% (137,120 out of 160,986) of children under the age of 6 who had BLL test results reported in PA-NEDSS to children in the birth registry. If a PA-NEDSS record matched to a birth registry record by name and a combination of date of birth, sex, and residential zip code, race and ethnicity information from the birth registry was added to the PA-NEDSS data if ethnicity was missing or unknown and if race was listed as “Unknown” or “Other.” After the matching process was completed, race information was available for nearly 90% of the children under 6 years of age reported to PA-NEDSS with BLL test results. The race and ethnicity

categories aligned with those used in the U.S. census. Because of small numbers, multiracial children, American Indians, Alaskan Natives, and Pacific Islanders were combined into an “Other” category. For race and ethnicity analyses by county, categories were combined and collapsed into non-Hispanic black or African American, non-Hispanic white, and Hispanic. Children in the Asian, Pacific Islander, American Indian, Alaska Native, “Other” and unknown categories were not included in the county analyses due to small numbers.

For the per-child analyses, two measures were used to indicate their BLL status:

- The maximum BLL was defined as the highest venous BLL obtained from a child in 2018 while they were in the specified age category. If a child had no venous BLL test performed during that time period, maximum BLL was defined as the highest BLL from a capillary or unknown specimen source. Venous results were ranked over capillary results because capillary test results may be skewed by the presence of lead dust on the skin .
- EBLL confirmation status was determined as described in the case definition section above.

County-specific Analysis

For county-specific analyses, the residential address accompanying the report that contained the BLL result of interest was used to determine the county. For the maximum BLL measure, the county was determined from the report containing the maximum test result. For the EBLL confirmation status measure, county was determined from the address accompanying the initial EBLL. PA-NEDSS attempts to geocode all residential addresses. For addresses that were successfully verified, county was based on the actual home address. If an address was not able to be verified, the county was based on the centroid of the residential zip code. A small proportion of children did not have a residential address reported; the county was set by the location of the provider who ordered the test.

Intercensal population estimates for 2018 by county, age, race and ethnicity were obtained from the National Center for Health Statistics (NCHS) website (Vintage 2018 bridged-race postcensal population estimates, https://www.cdc.gov/nchs/nvss/bridged_race.htm).[8] These figures were used to calculate the proportion of children tested for BLL and the proportion of children with EBLLs in the county-specific analysis.

The 17 counties in Pennsylvania with the largest number of children under 6 years of age were selected for county-specific race/ethnicity analyses.

Municipality-specific Analysis

For the municipality-level analyses, the residential address accompanying the report that contained the EBLL confirmation status measure was used to determine the specific municipality. PA-NEDSS attempts to geocode all residential addresses. For addresses that were successfully verified, municipality was based on the actual home address. If an address was not able to be verified automatically, it was verified by the application of manual geocoding. If a child’s residential address in the lead report was missing, his/her mother’s residential address reported in matched birth certificate data was geocoded to determine the municipality and census tract. If an address was not able to be verified, municipality was

based on the centroid of the residential zip code. A small proportion of children (8 children under 2 years of age and 103 children under 6 years of age) whose municipality could not be determined were excluded for sub-county analyses.

For municipality-level analyses, the population estimate of children was obtained by the 2017 American Community Survey, the most recent and available population data source at municipal level.

The 10 municipalities in Pennsylvania with the highest number of children under 6 years of age, as well as two other cities with an Act 315 municipal health department were selected for municipality-specific analyses. These included Philadelphia, Pittsburgh, Allentown, Reading, Erie (city), Upper Darby township, Harrisburg, Scranton, Lancaster, York City, Bethlehem and Wilkes-Barre.

Limitations

The 2018 Childhood Lead Surveillance Annual Report presents an analysis of surveillance data displayed in graphic and tabular form, in keeping with CDC guidance for analysis of childhood lead data.

Users of the report should be aware that public health surveillance data for childhood lead has inherent limitations that influences interpretation of the data. Data such as specimen source, residence of child, race and ethnicity, and other important information may be missing on laboratory test results. As described in the Methods section, efforts were made to fill these gaps. Supplementing race and ethnicity data with information from the birth registry was done for the first time for the 2018 report.

In addition, Allegheny County is the only county in Pennsylvania with mandatory testing for children between 9 and 12 months and at 24 months. Pennsylvania does not mandate universal and complete screening of all children. Therefore, testing of children for BLL is targeted rather than random, which makes interpretation of rates of EBLLs by geographic area or demographic factors difficult.

An emerging issue is the increasing use of point-of-care testing devices for blood lead screening. A growing number of clinical practices are able to do their own capillary screening tests on children on-site. These providers are often unaccustomed to reporting results for the Department and are unaware of reporting requirements. This could adversely affect the number of screening test results counted and skew the proportion of children screened downwards. The Department is working with many clinics using this equipment to ensure that BLLs are reported. Furthermore, some point-of-care analyzers have been found to give falsely low BLL results when used to analyze venous blood. These devices should be used only on capillary specimens, but the Department generally does not know the type of equipment used to perform BLL tests and cannot control for this source of uncertainty. The impact of this issue cannot be assessed, as the type of testing device used is not captured in the PA-NEDSS surveillance data sets.

High rates of children with EBLLs in one area may reflect a true higher exposure risk in that area, or it may reflect more robust and targeted testing in that area. The burden of childhood EBLLs is best understood through a series of metrics: the percentage of children tested; the percentage who go on to have retests where appropriate (and conversely the percentage who do not get appropriate testing and follow-up); and, finally, the percentage of children with BLLs ≥ 5 µg/dL and those ≥ 10 µg/dL. This report shows both the number and percentage of children tested with BLLs ≥ 5 µg/dL and those ≥ 10 µg/dL.

Discussion

Between 2017 and 2018. the percent of children under the age of 2 tested for lead increased from 29.55% to 30.88% (an increase of 2,159 children tested). The percent of children under the age of 6 tested increased from 17.79% to 19.01% (an increase of 9,230 children tested) from 2017 to 2018. Between 2017 and 2018, the percent of children under age 2 with a confirmed EBLL $\geq$ 5 µg/dL decreased from 3.27% to 3.03% of those tested (a decrease of 127 children), while the percent of children under age 6 with a confirmed EBLL decreased from 4.52% to 4.09% of those tested (a decrease of 269 children). The percent of children with an unconfirmed EBLL $\geq$ 5 µg/dL decreased from 1.33% to 1.18% for children under age 2 (a decrease of 98 children) and from 1.66% to 1.42% for children under age 6 (a decrease of 224 children), among those tested. The percent of children aged 0-15 who were appropriately retested after an elevated capillary test increased from 54.81% to 57.51% between 2017 and 2018. In summary, in 2018 compared to 2017, small gains were made in the percentages of children tested and reductions were seen in the percentages of Pennsylvania children with EBLLs and with the number of children who did not have the appropriate confirmatory follow-up testings.

Pennsylvania was able to more fully explore race and ethnicity data for the first time in 2018 by matching children's BLL testing data to birth certificate data to determine race for the nearly 60% of children who did not have race or ethnicity information provided on their BLL testing results data. For non-Hispanic black or African American children, testing rates were higher statewide than for non-Hispanic white children. Confirmed EBLL rates were also higher among non-Hispanic black or African American children as were the percentages of unconfirmed EBLLs, both as a percentage of children tested and as a percentage of the population, for both age groups. In general, Hispanic and non-Hispanic Asian children had testing rates and percentages of EBLLs in between values for non-Hispanic black or African American children and non-Hispanic white children.

In general, for children under the age of 2 and under the age of 6, municipalities/cities had a higher percentage of children tested for lead than in their respective counties. In general, the percentage of children with EBLLs among those tested and as a percentage of the population was also higher in all munipalities/cities than in their respective counties. For the largest counties, where race and ethnicity data are presented, most had higher testing rates among non-Hispanic black or African American and Hispanic children than among non-Hispanic white children, although that pattern was not seen in Allegheny, Erie, Luzerne, Westmoreland and York counties. In many of these counties, the percentage of those tested with EBLLs was highest among minority populations, but not all counties had this pattern.

As mentioned previously, not all of the point-of-care testing results were reported to PA-NEDSS. Because of this, for some areas, the testing rates may actually be higher than reported and the percent tested with EBLLs may actually be lower than what is in this report. As providers move toward point of care testing, the Department is working to facilitate reporting of test results so that an accurate understanding of the burden of childhood lead exposure is achieved. The Department is also working with laboratories to increase the use of electronic reporting of testing results to reduce the resource burden and errors associated with faxed results and hand-keyed data entry.

Definitions

Age: Age of the child at the time of the test, expressed in months. Children under age 2 are 0−23 months, and children under age 6 are 0−71 months.

Blood lead level (BLL): The numeric result of a blood lead test, expressed in micrograms per deciliter (µg/dL)

Capillary: A blood lead test with blood drawn by a finger stick

Confirmed EBLL ≥ 5 µg/dL: One venous blood lead test ≥ 5 µg/dL or two capillary blood lead tests ≥ 5 µg/dL drawn within 12 weeks of each other.

Confirmed EBLL ≥ 10 µg/dL: One venous blood lead test ≥ 10 µg/dL or two capillary blood lead tests ≥ 10 µg/dL drawn within 12 weeks of each other

Electronic lab reporting (ELR): The system by which blood lead reports are submitted electronically from a laboratory's system to PA-NEDSS

Elevated blood lead level (EBLL): A BLL ≥ 5 µg/dL

Ethnicity: Hispanic or non-Hispanic

Micrograms per deciliter (µg/dL): The amount of lead in the blood, measured by micrograms of lead per deciliter of blood

Municipality: A political subdivision of a state within which a municipal corporation has been established to provide general local government for a specific population concentration in a defined area.

Not elevated: A child with a confirmed venous or capillary BLL < 5 µg/dL, or who had an initial elevated capillary BLL that was found to be < 5 µg/dL on either a venous or capillary follow-up test

Online key entry: Manual entry of blood lead reports into PA-NEDSS

Pennsylvania National Electronic Disease Surveillance System (PA-NEDSS): the Pennsylvania Department of Health's online disease surveillance system. It serves as the Department's reporting system for all reportable conditions and has been utilized for childhood lead surveillance since 2003.

Race: White, black or African American, Asian, Other (multiracial children, American Indians, Alaska Native, and Pacific Islanders), or Unknown

Race/Ethnicity: Non-Hispanic white, non-Hispanic black or African American, Hispanic, and non-Hispanic Asian

Rural versus urban counties: The Center for Rural Pennsylvania defines rural and urban counties in terms of population density. Those counties with a population density above the state average (284 persons per square mile) are considered urban, and those below the state average are considered rural. For more information and definitions concerning rural and urban counties, please see the Center for Rural Pa's website at: http://www.rural.palegislature.us/demographics_rural_urban.html.

Findings

Statewide Summaries by Age:

Pennsylvania does not have a universal childhood BLL testing law, so there is no mandate for children to be tested by a certain age. However, the Early Periodic Screening, Diagnosis and Treatment (EPSDT) program (administered by the Pennsylvania Department of Human Services) requires providers to test children on Medical Assistance at ages 1 and 2. Furthermore, most clinical practice guidelines recommend testing children under age 7 and focusing on children at ages 1 and 2.

The following charts include statewide aggregate childhood lead testing data broken out by the age groupings of children tested, as well as the age at the time of their highest result. The charts also include breakouts of sex, race, ethnicity and the range of the highest BLL.

Table 1: Summary of Blood Lead Tests Performed in 2018 by Age Category

Age Category*	Total Number of Tests†	Capillary Test#		Venous Test	
		N	%	N	%
0−23 months (under 2 years)	90,737	49,708	54.78	41,029	45.22
0−71 months (under 6 years)	175,098	90,532	51.70	84,566	48.30
0−15 years	184,310	91,625	49.71	92,685	50.29

*Age at time of specimen collection
†Total number of deduplicated blood tests obtained on children within the age category. A blood lead test may be collected for screening, confirmation or follow-up. Many children had more than one test in any given year. The remainder of tables were analyzed on a per child basis rather than per test.
#Blood specimens of unknown source were treated as though they were capillary tests.
Data sources: Pennsylvania Department of Health, PA-NEDSS.

Table 2: Characteristics of Children Tested for Lead by Age Category, 2018

	Children Aged 0−23 months		Children Aged 0−71 months	
	N	% of total	N	% of total
Total number of children tested†	84,475	100.00	160,986	100.00
Age at time of maximum BLL				
Under 1 year	45,383	53.72	45,383	28.19
One year	39,092	46.28	38,578	23.96
Two years	-	-	47,669	29.61
Three years	-	-	11,533	7.16
Four years	-	-	9,252	5.75
Five years	-	-	8,571	5.32
Sex				
Female	40,843	48.35	77,603	48.20
Male	43,338	51.30	82,696	51.37
Unknown	294	0.35	687	0.43
Race				
Asian	8,532	10.10	16,753	10.41
Black or African American	15,361	18.18	32,189	19.99
White	50,911	60.27	90,585	56.27
Other^	2,621	3.10	4,390	2.73
Unknown	7,050	8.35	17,069	10.60
Ethnicity				
Hispanic	10,350	12.25	20,211	12.55
Non-Hispanic	64,576	76.44	117,723	73.13
Unknown or missing	9,549	11.30	23,052	14.32
Maximum BLL (µg/dL)*				
< 5	80,889	95.76	152,163	94.52
5–9.9	2,719	3.22	6,721	4.17
10–19.9	702	0.83	1,676	1.04
20–44.9	150	0.18	382	0.24
45–59.9	10	0.01	24	0.01
60–69.9	4	0.00	12	0.01
≥ 70	1	0.00	5	0.00

†Number of Pennsylvania children within the age category who had at least one blood lead test done with a specimen collection date in 2018
^Other race includes multiracial children, American Indians and Pacific Islanders.
*Highest venous blood lead level (BLL) obtained per child in 2018, or highest BLL from a capillary or unknown specimen source, if no venous test was performed
Data sources: Pennsylvania Department of Health, PA-NEDSS, Vital Records

Statewide Summaries by Confirmed Elevated Status:

The following charts display EBLL by confirmation status. Confirmation status can be: not elevated, elevated but not confirmed or confirmed elevated. Also included is data on how the results were confirmed. Children can be tested for lead by either a finger stick (capillary) or blood draw (venous). Because capillary tests are more subject to contamination, they are less reliable than venous tests, so venous tests are preferred to get the most accurate result. It is not always possible to perform a venous test, so elevated capillary results are confirmed with either another capillary test or a venous test. Venous testing requires a trained phlebotomist, and some clinical settings may not have this expertise; in addition, successfully getting a venous specimen in very small children can be difficult.

Table 3: Elevated Blood Lead Confirmation Status per 2016 CDC Case Definition* by Age Category, 2018

	Children Aged 0−23 months		Children Aged 0−71 months	
	N	% of total	N	% of total
Total number of children tested	84,475	100.00	160,986	100.00
Confirmation status				
Not elevated (< 5 µg/dL)**	80,918	95.79	152,113	94.49
Unconfirmed elevated (≥ 5 µg/dL)†	995	1.18	2,288	1.42
Confirmed 5−9.9 µg/dL	1,843	2.18	4,809	2.99
Confirmed ≥ 10 µg/dL	719	0.85	1,776	1.10

*CDC case definition defines a confirmed elevated BLL as one venous blood lead test ≥5 µg/dL, or two capillary blood lead tests ≥5 µg/dL drawn within 12 weeks of each other.
**The child had either no BLL ≥5 µg/dL or had an initially elevated capillary BLL that was found to be <5 µg/dL on either venous or capillary retest.
†Initial capillary test was ≥5 µg/dL, but test result was not confirmed by a venous or capillary retest within 12 weeks.
Data sources: Pennsylvania Department of Health, PA-NEDSS.

Table 4: Details of Elevated Blood Lead Confirmation Status* by Age Category, 2018

		Children Aged 0−23 months		Children Aged 0−71 months	
		N	% of total	N	% of total
Total number of children tested		84,475	100	160,986	100
Confirmation status	**Outcome**				
Not elevated (< 5 µg/dL)	BLL< 5 µg/dL	79,926	94.61	150,072	93.22
	Repeat capillary test did NOT confirm initial elevated capillary test.	54	0.06	94	0.06
	Venous test did NOT confirm initial elevated capillary test.	938	1.11	1,947	1.21
Unconfirmed elevated (≥ 5 µg/dL)†	Not retested appropriately	995	1.18	2,288	1.42
Confirmed 5–9.9 µg/dL	Capillary confirmed by repeat capillary test	23	0.03	37	0.02
	Capillary confirmed by venous test	363	0.43	714	0.44
	Venous test	1,457	1.72	4,058	2.52
Confirmed ≥ 10 µg/dL	Capillary confirmed by repeat capillary test	4	0	13	0.01
	Capillary confirmed by venous test	174	0.21	320	0.20
	Venous test	541	0.64	1,443	0.90

*Per CDC 2016 Confirmed Elevated Blood Lead case definition
† Initial capillary test was ≥5 µg/dL, but test result was not confirmed by a venous or capillary retest within 12 weeks.
Data sources: Pennsylvania Department of Health, PA-NEDSS.

Table 5: Confirmation After an Elevated Capillary Blood Lead Test by Capillary Test Level, Children Aged 0-15 years, 2018

Blood Lead Level of Initial Elevated Capillary Test (µg/dL)	Number of Children*	Children with a Diagnostic Venous Test Within 12 weeks†		Children with Either a Venous or Capillary Retest Within 12 weeks†	
		N	%	N	%
5–9.9	4,247	2,109	49.66	2,224	52.37
10–19.9	962	672	69.85	694	72.14
20–44.9	250	205	82.00	212	84.80
45–59.9	19	17	89.47	17	89.47
60–69.9	8	5	62.50	6	75.00
≥ 70	5	5	100.00	5	100.00
Overall	5,491	3,013	54.87	3,158	57.51

*Children aged 0–15 years
†Retest results may not be in the same blood lead level range as the initial capillary test.
Data sources: Pennsylvania Department of Health, PA-NEDSS.

Reporting by Method and Organization:

The chart below displays data on how BLL reports were submitted to PA-NEDSS and who submitted the report. By law, all BLL tests analyzed by laboratories on children under 16 years of age are required to be reported to the Department. Reports can be submitted by ELR or by online key-entry. ELR is the preferred method of receiving reports, as the information is usually more accurate, complete and timely. From 2013 to 2018, the number of laboratories reporting through electronic laboratory reporting increased from 20 to 23, and the proportion of lead reports received via ELR increased from 87% to 90%.

Table 6: Blood Lead Reporting by Method of Report and Type of Reporting Organization, 2013–2018

	Method of Report	2013	2014	2015	2016	2017	2018
Number of reports submitted†	ELR*	147,522	149,334	146,104	160,488	169,675	175,802
	Online key-entry by lab	21,225	16,978	14,997	14,561	13,011	11,720
	Online key-entry by provider#	1,440	2,065	2,642	3,401	2,775	7,423
	Total	170,187	168,377	163,743	178,450	185,461	194,945
% ELR		86.68	88.69	89.23	89.93	91.49	90.18

*ELR=electronic laboratory reporting
†The same test result may be reported by the ordering provider, the receiving laboratory and/or the reference lab that performs the test. The data in this table are not deduplicated. Also, reports may contain more than one test result.
#Online key-entry by provider includes some test results key-entered by Department staff on behalf of providers.
Data sources: Pennsylvania Department of Health, PA-NEDSS.

Testing Summaries by Race and Ethnicity:

The following are summaries of children under age 2 and under age 6 tested by race and ethnicity, including number of children tested, the percent of population tested and confirmation status. For children ages 0-23 months, non-Hispanic black or African American children and Hispanic children were more often tested than non-Hispanic white children (36.94% and 28.32% versus 25.39%, respectively). Among those tested, non-Hispanic black or African American and Hispanic children had higher percentages of EBLLs of 5-9.9 µg/dL than non-Hispanic white children (3.83% and 2.63% versus 1.61%, respectively). Percentages of tests results ≥ 10 µg /dL were also higher among non-Hispanic black or African American and Hispanic children than non-Hispanic white children (1.42% and 1.15% versus 0.62%, respectively). Among those tested, non-Hispanic black or African American and Hispanic children also had higher percentages of unconfirmed elevated results among those tested than did non-Hispanic white children. These same relationships were seen for children ages 0-71 months.

Table 7: Number of Children Aged 0–23 Months by Race/Ethnicity and Elevated Blood Lead Confirmation Status,* 2018

Race/Ethnicity	Population of Children Aged 0–23 Months†	Children Tested**		Unconfirmed elevated (≥ 5 µg/dL)			Confirmed 5–9.9 µg/dL			Confirmed ≥ 10 µg/dL		
		N	% of population ***	N	% of tested	% of population	N	% of tested	% of population	N	% of tested	% of population
Total	273,577	84,475	30.88	995	1.18	0.36	1,843	2.18	0.67	719	0.85	0.26
Race/Ethnicity^												
Non-Hispanic white	186,034	47,237	25.39	513	1.09	0.28	762	1.61	0.41	292	0.62	0.16
Non-Hispanic black or African-American	39,272	14,507	36.94	203	1.40	0.52	556	3.83	1.42	206	1.42	0.52
Hispanic	36,546	10,350	28.32	132	1.28	0.36	272	2.63	0.74	119	1.15	0.33
Non-Hispanic Asian	11,197	3,716	33.19	33	0.89	0.29	84	2.26	0.75	33	0.89	0.29

*Per CDC 2016 Confirmed Elevated Blood Lead case definition
**Note that Pennsylvania does not mandate universal screening of children; screening of children is recommended between 9 and 12 months and at 24 months. Allegheny County is currently the only county with mandatory testing.
***Percent was calculated as number of children tested divided by the population of children in the county for the specified age range.
†2018 intercensal estimate
^Other and Unknown are not included in table
Data sources: Pennsylvania Department of Health, PA-NEDSS., Vital Records, National Center for Health Statistics

Table 8: Number of Children Aged 0–71 Months by Race/Ethnicity and Elevated Blood Lead Confirmation Status,* 2018

Race/Ethnicity	Population of Children Aged 0–71 Months†	Children Tested**		Unconfirmed elevated (≥ 5 µg/dL)			Confirmed 5–9.9 µg/dL			Confirmed ≥ 10 µg/dL		
		N	% of population***	N	% of tested	% of population	N	% of tested	% of population	N	% of tested	% of population
Total	847,012	160,986	19.01	2,288	1.42	0.27	4,809	2.99	0.57	1,776	1.10	0.21
Race/Ethnicity^												
Non-Hispanic white	568,234	83,998	14.78	1,111	1.32	0.20	1,626	1.94	0.29	624	0.74	0.11
Non-Hispanic black or African-American	127,175	30,520	24.00	509	1.67	0.40	1,813	5.94	1.43	618	2.02	0.49
Hispanic	113,909	20,211	17.74	310	1.53	0.27	686	3.39	0.60	279	1.38	0.24
Non-Hispanic Asian	35,915	7,011	19.52	95	1.36	0.26	183	2.61	0.51	79	1.13	0.22

*Per CDC 2016 Confirmed Elevated Blood Lead case definition
**Note that Pennsylvania does not mandate universal screening of children; screening of children is recommended between 9 and 12 months and at 24 months. Allegheny County is currently the only county with mandatory testing.
***Percent was calculated as number of children tested divided by the population of children in the county for the specified age range.
†2018 intercensal estimate
^Other and Unknown are not included in table
Data sources: Pennsylvania Department of Health, PA-NEDSS., Vital Records, National Center for Health Statistics

Testing Summaries by Major Municipality:

The following are summaries of children under age 2 and under age 6 tested in major municipalities, including number of children tested, the percent of population tested and confirmation status. Testing rates and percentages of children with EBLLs among major municipalities/cities were generally higher than for their respective county (except for Bethlehem), for both children under the age of 2 and under the age of 6. This finding likely highlights the historical burden of older housing stock and other urban sources of lead in Pennsylvania municipalities/cities. For children 0-23 months, testing rates were highest in Pittsburgh and lowest in Harrisburg, and the percentages of EBLL ≥ 5 µg/dL as a percentage of those tested were highest in the cities of York and Reading. Pittsburgh's testing rates may be higher due to the fact that in 2018, Allegheny County started mandatory blood lead testing for children between 9 and 12 months and at 24 months.

Table 9: Number of Children Aged 0–23 Months by Major Municipality and Elevated Blood Lead Confirmation Status,* 2018

Residence		Population of Children Aged 0–23 Months†	Children Tested**		Unconfirmed ≥ 5 µg/dL			Confirmed ≥ 5 µg/dL		
Municipality	**County**		**N**	**% of population*** **	**N**	**% of tested**	**% of population**	**N**	**% of tested**	**% of population**
Philadelphia city	Philadelphia	44,338	17,958	40.50	148	0.82	0.33	845	4.71	1.91
Pittsburgh city	Allegheny	6,265	2,717	43.37	66	2.43	1.05	97	3.57	1.55
Allentown city	Lehigh	3,667	1,575	42.95	35	2.22	0.95	48	3.05	1.31
Reading city	Berks	3,065	1,020	33.28	30	2.94	0.98	86	8.43	2.81
Erie city	Erie	2,575	1,076	41.79	33	3.07	1.28	38	3.53	1.48
Upper Darby township	Delaware	2,625	1,091	41.57	13	1.19	0.50	40	3.67	1.52
Harrisburg city	Dauphin	1,903	460	24.18	8	1.74	0.42	30	6.52	1.58
Scranton city	Lackawanna	1,825	498	27.28	20	4.02	1.10	35	7.03	1.92
Lancaster city	Lancaster	1,786	631	35.33	6	0.95	0.34	49	7.77	2.74
Bethlehem city	Northampton/ Lehigh	1,686	428	25.38	6	1.40	0.36	6	1.40	0.36
York city	York	1,424	402	28.24	0	0.00	0.00	52	12.94	3.65
Wilkes-Barre city	Luzerne	932	386	41.43	22	5.70	2.36	16	4.15	1.72
Pennsylvania Total		273,577	84,475	30.88	995	1.18	0.36	2,562	3.03	0.94

*Per CDC 2016 Confirmed Elevated Blood Lead case definition
**Note that Pennsylvania does not mandate universal screening of children; screening of children is recommended between 9 and 12 months and at 24 months. Allegheny County is currently the only county with mandatory testing.
***Percent was calculated as number of children tested divided by the population of children in the county for the specified age range.
†2017 American Community Survey
Data sources: Pennsylvania Department of Health, PA-NEDSS., 2017 American Community Survey

Table 10: Number of Children Aged 0–71 Months by Major Municipality and Elevated Blood Lead Confirmation Status,* 2018

Residence		Population of Children Aged 0–71 Months†	Children Tested**		Unconfirmed ≥ 5 µg/dL			Confirmed ≥ 5 µg/dL		
Municipality	**County**		**N**	**% of population *****	**N**	**% of tested**	**% of population**	**N**	**% of tested**	**% of population**
Philadelphia city	Philadelphia	127,072	37,520	29.53	372	0.99	0.29	2,496	6.65	1.96
Pittsburgh city	Allegheny	17,576	5,366	30.53	139	2.59	0.79	203	3.78	1.15
Allentown city	Lehigh	10,921	3,038	27.82	82	2.70	0.75	116	3.82	1.06
Reading city	Berks	9,223	2,476	26.85	80	3.23	0.87	270	10.9	2.93
Erie city	Erie	7,633	1,936	25.36	64	3.31	0.84	103	5.32	1.35
Upper Darby township	Delaware	7,403	2,093	28.27	19	0.91	0.26	90	4.30	1.22
Harrisburg city	Dauphin	5,524	1,012	18.32	38	3.75	0.69	64	6.32	1.16
Scranton city	Lackawanna	5,381	1,195	22.21	46	3.85	0.85	117	9.79	2.17
Bethlehem city	Northampton/ Lehigh	5,051	883	17.48	13	1.47	0.26	15	1.70	0.30
Lancaster city	Lancaster	5,011	1,187	23.69	15	1.26	0.30	109	9.18	2.18
York city	York	4,220	707	16.75	0	0.00	0.00	111	15.70	2.63
Wilkes-Barre city	Luzerne	2,744	840	30.61	38	4.52	1.38	45	5.36	1.64
Pennsylvania Total		847,012	160,986	19.01	2,288	1.42	0.27	6,585	4.09	0.78

*Per CDC 2016 Confirmed Elevated Blood Lead case definition
**Note that Pennsylvania does not mandate universal screening of children; screening of children is recommended between 9 and 12 months and at 24 months. Allegheny County is currently the only county with mandatory testing.
***Percent was calculated as number of children tested divided by the population of children in the county for the specified age range.
†2017 American Community Survey
Data sources: Pennsylvania Department of Health, PA-NEDSS., 2017 American Community Survey

Testing Summaries by County and Race/Ethnicity for Selected Counties:

The following are summaries of children under age 2 and under age 6 by county and race/ethnicity, including number of children tested, the percent of population tested and confirmed EBLLs of ≥5 µg/dL. Other, unknown, Asian, Pacific Islander, American Indian and Alaska Native races are not included. The 17 counties with the largest populations were selected to include the largest cities and the counties with county or municipal health departments

Table 11: Number of Children with Confirmed EBLL* by County of Residence and Race/Ethnicity, Children Aged 0–23 Months, 2018 for Select Counties**

County of Residence	Race/Ethnicity	Population 0-23 Months†	Children Tested*		Confirmed EBLL ≥ 5		
			N	% of population**	N	% of tested	% of population
Allegheny	Non-Hispanic black or African American	4,745	2,251	47.44	88	3.91	1.85
Allegheny	Hispanic	757	202	26.68	6	2.97	0.79
Allegheny	Non-Hispanic white	18,814	7,183	38.18	92	1.28	0.49
Berks	Non-Hispanic black or African American	518	100	19.31	6	6.00	1.16
Berks	Hispanic	3,803	984	25.87	78	7.93	2.05
Berks	Non-Hispanic white	4,900	810	16.53	49	6.05	1.00
Bucks	Non-Hispanic black or African American	790	167	21.14	1	0.60	0.13
Bucks	Hispanic	1,221	351	28.75	9	2.56	0.74
Bucks	Non-Hispanic white	9,157	1,613	17.61	9	0.56	0.10
Chester	Non-Hispanic black or African American	780	229	29.36	1	0.44	0.13
Chester	Hispanic	1,669	511	30.62	13	2.54	0.78
Chester	Non-Hispanic white	7,487	1,522	20.33	16	1.05	0.21
Cumberland	Non-Hispanic black or African American	353	58	16.43	0	0.00	0.00
Cumberland	Hispanic	319	46	14.42	1	2.17	0.31
Cumberland	Non-Hispanic white	4,381	503	11.48	12	2.39	0.27
Dauphin	Non-Hispanic black or African American	1,586	393	24.78	14	3.56	0.88
Dauphin	Hispanic	1,129	188	16.65	8	4.26	0.71
Dauphin	Non-Hispanic white	3,670	543	14.80	16	2.95	0.44
Delaware	Non-Hispanic black or African American	3,763	1,443	38.35	39	2.70	1.04
Delaware	Hispanic	853	311	36.46	11	3.54	1.29
Delaware	Non-Hispanic white	7,454	2,140	28.71	23	1.07	0.31

County of Residence	Race/Ethnicity	Population 0-23 Months†	Children Tested*		Confirmed EBLL ≥ 5		
			N	% of population**	N	% of tested	% of population
Erie	Non-Hispanic black or African American	732	267	36.48	12	4.49	1.64
Erie	Hispanic	495	127	25.66	1	0.79	0.20
Erie	Non-Hispanic white	4,568	1432	31.35	25	1.75	0.55
Lackawanna	Non-Hispanic black or African American	245	70	28.57	5	7.14	2.04
Lackawanna	Hispanic	782	165	21.10	11	6.67	1.41
Lackawanna	Non-Hispanic white	3,275	574	17.53	18	3.14	0.55
Lancaster	Non-Hispanic black or African American	831	169	20.34	22	13.02	2.65
Lancaster	Hispanic	2,232	562	25.18	26	4.63	1.16
Lancaster	Non-Hispanic white	10,325	1,480	14.33	86	5.81	0.83
Lehigh	Non-Hispanic black or African American	696	232	33.33	7	3.02	1.01
Lehigh	Hispanic	3,522	1,077	30.58	24	2.23	0.68
Lehigh	Non-Hispanic white	3,977	568	14.28	16	2.82	0.40
Luzerne	Non-Hispanic black or African American	416	193	46.39	4	2.07	0.96
Luzerne	Hispanic	1,773	455	25.66	17	3.74	0.96
Luzerne	Non-Hispanic white	4,057	1,246	30.71	28	2.25	0.69
Montgomery	Non-Hispanic black or African American	1,989	583	29.31	15	2.57	0.75
Montgomery	Hispanic	1,734	650	37.49	44	6.77	2.54
Montgomery	Non-Hispanic white	12,054	3,233	26.82	33	1.02	0.27
Northampton	Non-Hispanic black or African American	448	100	22.32	2	2.00	0.45
Northampton	Hispanic	1,334	299	22.41	3	1.00	0.22
Northampton	Non-Hispanic white	3,748	508	13.55	13	2.56	0.35
Philadelphia	Non-Hispanic black or African American	16,709	7,308	43.74	504	6.90	3.02
Philadelphia	Hispanic	9,366	3,232	34.51	101	3.13	1.08
Philadelphia	Non-Hispanic white	12,526	4,244	33.88	105	2.47	0.84

County of Residence	Race/Ethnicity	Population 0-23 Months†	Children Tested*		Confirmed EBLL ≥ 5		
			N	% of population**	N	% of tested	% of population
Westmoreland	Non-Hispanic black or African American	295	89	30.17	4	4.49	1.36
Westmoreland	Hispanic	137	23	16.79	1	4.35	0.73
Westmoreland	Non-Hispanic white	5,226	1,820	34.83	22	1.21	0.42
York	Non-Hispanic black or African American	863	112	12.98	14	12.50	1.62
York	Hispanic	1,351	299	22.13	18	6.02	1.33
York	Non-Hispanic white	7,358	1,090	14.81	39	3.58	0.53
Pennsylvania Total	Non-Hispanic black or African American	39,727	14,507	36.94	762	5.25	1.92
Pennsylvania Total	Hispanic	36,546	10,350	28.32	391	3.78	1.07
Pennsylvania Total	Non-Hispanic white	186,034	47,237	25.39	1,054	2.23	0.57
Pennsylvania Total		273,577	84,475	30.88	2,562	3.03	0.94

*Note that Pennsylvania does not mandate universal screening of children; screening of children is recommended between 9 and 12 months and at 24 months. Allegheny County is currently the only county with mandatory testing.
**Percent was calculated as number of children tested divided by the population of children in the county for the specified age range.
****Per CDC 2016 Elevated Blood Lead case definition
†2018 intercensal estimate
Data sources: Pennsylvania Department of Health, PA-NEDSS., Vital Records, National Center for Health Statistics

Table 12: Number of Children with Confirmed EBLL* by County of Residence and Race/Ethnicity, Children Aged 0–71 Months, 2018, for Select Counties**

County of Residence	Race/Ethnicity	Population 0-71 Months†	Children Tested*		Confirmed EBLL ≥ 5		
			N	% of population**	N	% of tested	% of population
Allegheny	Non-Hispanic black or African American	15,457	4,568	29.55	214	4.68	1.38
Allegheny	Hispanic	2,498	394	15.77	11	2.79	0.44
Allegheny	Non-Hispanic white	54,358	15,149	27.87	181	1.19	0.33
Berks	Non-Hispanic black or African American	1,662	228	13.72	19	8.33	1.14
Berks	Hispanic	11,422	2,133	18.67	218	10.22	1.91
Berks	Non-Hispanic white	15,648	1,295	8.28	84	6.49	0.54
Bucks	Non-Hispanic black or African American	2,410	281	11.66	5	1.78	0.21
Bucks	Hispanic	3,726	628	16.85	11	1.75	0.3
Bucks	Non-Hispanic white	28,520	2,370	8.31	16	0.68	0.06
Chester	Non-Hispanic black or African American	2,389	480	20.09	17	3.54	0.71
Chester	Hispanic	4,870	975	20.02	22	2.26	0.45
Chester	Non-Hispanic white	24,878	2,435	9.79	30	1.23	0.12
Cumberland	Non-Hispanic black or African American	1,184	107	9.04	2	1.87	0.17
Cumberland	Hispanic	1,048	80	7.63	2	2.50	0.19
Cumberland	Non-Hispanic white	13,218	878	6.64	20	2.28	0.15
Dauphin	Non-Hispanic black or African American	5,123	780	15.23	40	5.13	0.78
Dauphin	Hispanic	3,681	395	10.73	20	5.06	0.54
Dauphin	Non-Hispanic white	10,587	998	9.43	28	2.81	0.26
Delaware	Non-Hispanic black or African American	11,582	2,948	25.45	122	4.14	1.05
Delaware	Hispanic	2,488	604	24.28	24	3.97	0.96
Delaware	Non-Hispanic white	23,201	3,585	15.45	52	1.45	0.22

County of Residence	Race/Ethnicity	Population 0-71 Months†	Children Tested*		Confirmed EBLL ≥ 5		
			N	% of population**	N	% of tested	% of population
Erie	Non-Hispanic black or African American	2,528	510	20.17	39	7.65	1.54
Erie	Hispanic	1,537	242	15.74	9	3.72	0.59
Erie	Non-Hispanic white	13,673	2,371	17.34	46	1.94	0.34
Lackawanna	Non-Hispanic black or African American	830	157	18.92	19	12.1	2.29
Lackawanna	Hispanic	2,313	352	15.22	22	6.25	0.95
Lackawanna	Non-Hispanic white	9,863	1,175	11.91	56	4.77	0.57
Lancaster	Non-Hispanic black or African American	2,528	275	10.88	41	14.91	1.62
Lancaster	Hispanic	6,775	1,021	15.07	56	5.48	0.83
Lancaster	Non-Hispanic white	31,698	2,200	6.94	132	6.00	0.42
Lehigh	Non-Hispanic black or African American	2,272	424	18.66	16	3.77	0.70
Lehigh	Hispanic	10,811	1,909	17.66	67	3.51	0.62
Lehigh	Non-Hispanic white	12,184	1,074	8.81	38	3.54	0.31
Luzerne	Non-Hispanic black or African American	1,461	396	27.10	16	4.04	1.10
Luzerne	Hispanic	5,373	770	14.33	48	6.23	0.89
Luzerne	Non-Hispanic white	12,401	2,277	18.36	67	2.94	0.54
Montgomery	Non-Hispanic black or African American	6,097	1,096	17.98	54	4.93	0.89
Montgomery	Hispanic	5,333	1,238	23.21	90	7.27	1.69
Montgomery	Non-Hispanic white	38,187	5,056	13.24	59	1.17	0.15
Northampton	Non-Hispanic black or African American	1,512	205	13.56	8	3.90	0.53
Northampton	Hispanic	4,236	623	14.71	14	2.25	0.33
Northampton	Non-Hispanic white	11,574	1,003	8.67	29	2.89	0.25
Philadelphia	Non-Hispanic black or African American	55,171	16,165	29.30	1,664	10.29	3.02
Philadelphia	Hispanic	28,889	6,740	23.33	274	4.07	0.95
Philadelphia	Non-Hispanic white	32,128	7,237	22.53	214	2.96	0.67

County of Residence	Race/Ethnicity	Population 0-71 Months†	Children Tested*		Confirmed EBLL ≥ 5		
			N	% of population**	N	% of tested	% of population
Westmoreland	Non-Hispanic black or African American	1,034	191	18.47	10	5.24	0.97
Westmoreland	Hispanic	483	38	7.87	2	5.26	0.41
Westmoreland	Non-Hispanic white	17,229	3,155	18.31	49	1.55	0.28
York	Non-Hispanic black or African American	2,841	217	7.64	40	18.43	1.41
York	Hispanic	4,465	463	10.37	33	7.13	0.74
York	Non-Hispanic white	22,897	1,871	8.17	80	4.28	0.35
Pennsylvania Total	Non-Hispanic black or African American	127,175	30,520	24.00	2,431	7.97	1.91
Pennsylvania Total	Hispanic	113,909	20,211	17.74	965	4.77	0.85
Pennsylvania Total	Non-Hispanic white	568,234	83,988	14.78	2,250	2.68	0.40
Pennsylvania Total		847,012	160,986	19.01	6,585	4.09	0.78

*Note that Pennsylvania does not mandate universal screening of children; screening of children is recommended between 9 and 12 months and at 24 months. Allegheny County is currently the only county with mandatory testing.
**Percent was calculated as number of children tested divided by the population of children in the county for the specified age range.
****Per CDC 2016 Elevated Blood Lead case definition
†2018 intercensal estimate
Data sources: Pennsylvania Department of Health, PA-NEDSS., Vital Records, National Center for Health Statistics

Testing Summaries by County:

The following are summaries of children under age 2 and under age 6 tested by county, including number of children tested, the percent of population tested, and BLLs of 5−9.9 and ≥ 10 µg/dL by maximum blood level and by confirmed blood level for all 67 counties.

Table 13: Number of Children Tested for Lead by Maximum Blood Lead Level and County of Residence, Children Aged 0–23 Months, 2018

County of Residence	Population of Children Aged 0–23 Months†	Children Tested*		Maximum BLL 5–9.9 µg/dL			Maximum BLL ≥ 10 µg/dL		
		N	% of population**	N	% of tested	% of population	N	% of tested	% of population
Adams	1,849	551	29.80	16	2.90	0.87	4	0.73	0.22
Allegheny	25,690	11,267	43.86	278	2.47	1.08	97	0.86	0.38
Armstrong	1,305	550	42.15	16	2.91	1.23	3	0.55	0.23
Beaver	3,274	970	29.63	22	2.27	0.67	3	0.31	0.09
Bedford	1,000	345	34.50	15	4.35	1.50	2	0.58	0.20
Berks	9,359	2,161	23.09	147	6.80	1.57	47	2.17	0.50
Blair	2,449	842	34.38	34	4.04	1.39	8	0.95	0.33
Bradford	1,362	297	21.81	8	2.69	0.59	3	1.01	0.22
Bucks	11,899	2,535	21.30	23	0.91	0.19	5	0.20	0.04
Butler	3,667	1,364	37.20	20	1.47	0.55	9	0.66	0.25
Cambria	2,609	819	31.39	51	6.23	1.95	13	1.59	0.50
Cameron	73	37	50.68	3	8.11	4.11	2	5.41	2.74
Carbon	1,203	292	24.27	16	5.48	1.33	4	1.37	0.33
Centre	2,443	630	25.79	8	1.27	0.33	1	0.16	0.04
Chester	10,702	2,788	26.05	53	1.90	0.50	16	0.57	0.15
Clarion	750	198	26.40	9	4.55	1.20	5	2.53	0.67
Clearfield	1,432	485	33.87	10	2.06	0.70	3	0.62	0.21
Clinton	769	193	25.10	6	3.11	0.78	1	0.52	0.13
Columbia	1,122	202	18.00	3	1.49	0.27	4	1.98	0.36
Crawford	1,770	434	24.52	20	4.61	1.13	5	1.15	0.28
Cumberland	5,360	739	13.79	17	2.30	0.32	4	0.54	0.07
Dauphin	6,748	1,440	21.34	51	3.54	0.76	23	1.60	0.34

County of Residence	Population of Children Aged 0–23 Months†	Children Tested*		Maximum BLL 5–9.9 µg/dL			Maximum BLL ≥ 10 µg/dL		
		N	% of population**	N	% of tested	% of population	N	% of tested	% of population
Delaware	12,918	4,634	35.87	110	2.37	0.85	29	0.63	0.22
Elk	593	130	21.92	1	0.77	0.17	1	0.77	0.17
Erie	5,973	2,155	36.08	64	2.97	1.07	34	1.58	0.57
Fayette	2,567	648	25.24	6	0.93	0.23	1	0.15	0.04
Forest	51	14	27.45	0	0.00	0.00	1	7.14	1.96
Franklin	3,703	839	22.66	26	3.10	0.70	9	1.07	0.24
Fulton	302	90	29.80	4	4.44	1.32	1	1.11	0.33
Greene	732	269	36.75	5	1.86	0.68	3	1.12	0.41
Huntingdon	748	229	30.61	1	0.44	0.13	3	1.31	0.40
Indiana	1,626	471	28.97	14	2.97	0.86	4	0.85	0.25
Jefferson	869	210	24.17	7	3.33	0.81	6	2.86	0.69
Juniata	566	133	23.50	6	4.51	1.06	3	2.26	0.53
Lackawanna	4,497	959	21.33	51	5.32	1.13	13	1.36	0.29
Lancaster	13,760	2,565	18.64	119	4.64	0.86	46	1.79	0.33
Lawrence	1,720	566	32.91	14	2.47	0.81	4	0.71	0.23
Lebanon	3,225	624	19.35	32	5.13	0.99	13	2.08	0.40
Lehigh	8,493	2,310	27.20	82	3.55	0.97	20	0.87	0.24
Luzerne	6,350	2,054	32.35	80	3.89	1.26	24	1.17	0.38
Lycoming	2,301	652	28.34	20	3.07	0.87	14	2.15	0.61
McKean	702	337	48.01	15	4.45	2.14	3	0.89	0.43
Mercer	2,230	684	30.67	30	4.39	1.35	5	0.73	0.22
Mifflin	1,075	285	26.51	7	2.46	0.65	3	1.05	0.28
Monroe	2,984	590	19.77	7	1.19	0.23	1	0.17	0.03
Montgomery	17,413	5,390	30.95	100	1.86	0.57	34	0.63	0.20
Montour	423	108	25.53	3	2.78	0.71	0	0.00	0.00
Northampton	5,716	1,136	19.87	41	3.61	0.72	9	0.79	0.16
Northumberland	1,794	529	29.49	18	3.40	1.00	13	2.46	0.72
Perry	1,009	227	22.50	9	3.96	0.89	4	1.76	0.40
Philadelphia	41,407	18,330	44.27	768	4.19	1.85	218	1.19	0.53

County of Residence	Population of Children Aged 0–23 Months†	Children Tested*		Maximum BLL 5–9.9 µg/dL			Maximum BLL ≥ 10 µg/dL		
		N	% of population**	N	% of tested	% of population	N	% of tested	% of population
Pike	886	200	22.57	0	0.00	0.00	1	0.50	0.11
Potter	325	149	45.85	6	4.03	1.85	0	0.00	0.00
Schuylkill	2,702	947	35.05	47	4.96	1.74	11	1.16	0.41
Snyder	866	112	12.93	6	5.36	0.69	1	0.89	0.12
Somerset	1,323	410	30.99	8	1.95	0.6	5	1.22	0.38
Sullivan	63	25	39.68	2	8.00	3.17	0	0.00	0.00
Susquehanna	688	119	17.30	2	1.68	0.29	1	0.84	0.15
Tioga	781	174	22.28	6	3.47	0.77	0	0.00	0.00
Union	821	176	21.44	12	6.82	1.46	1	0.57	0.12
Venango	1,015	217	21.38	16	7.37	1.58	4	1.84	0.39
Warren	762	203	26.64	12	5.91	1.57	6	2.96	0.79
Washington	3,965	1,273	32.11	28	2.20	0.71	7	0.55	0.18
Wayne	817	219	26.81	5	2.28	0.61	0	0.00	0.00
Westmoreland	5,742	2,055	35.79	40	1.95	0.70	11	0.54	0.19
Wyoming	480	76	15.83	0	0.00	0.00	1	1.32	0.21
York	9,759	1,813	18.58	63	3.47	0.65	37	2.04	0.38
Total	273,577	84,475	30.88	2,719	3.22	0.99	867	1.03	0.32

*Note that Pennsylvania does not mandate universal screening of children; screening of children is recommended between 9 and 12 months and at 24 months. Allegheny County is currently the only county with mandatory testing.
**Percent was calculated as number of children tested divided by the population of children in the county for the specified age range.
†2018 intercensal estimate
Data sources: Pennsylvania Department of Health, PA-NEDSS., National Center for Health Statistics

Table 14: Number of Children Aged 0–23 Months by County of Residence and Elevated Blood Lead Confirmation Status,* 2018

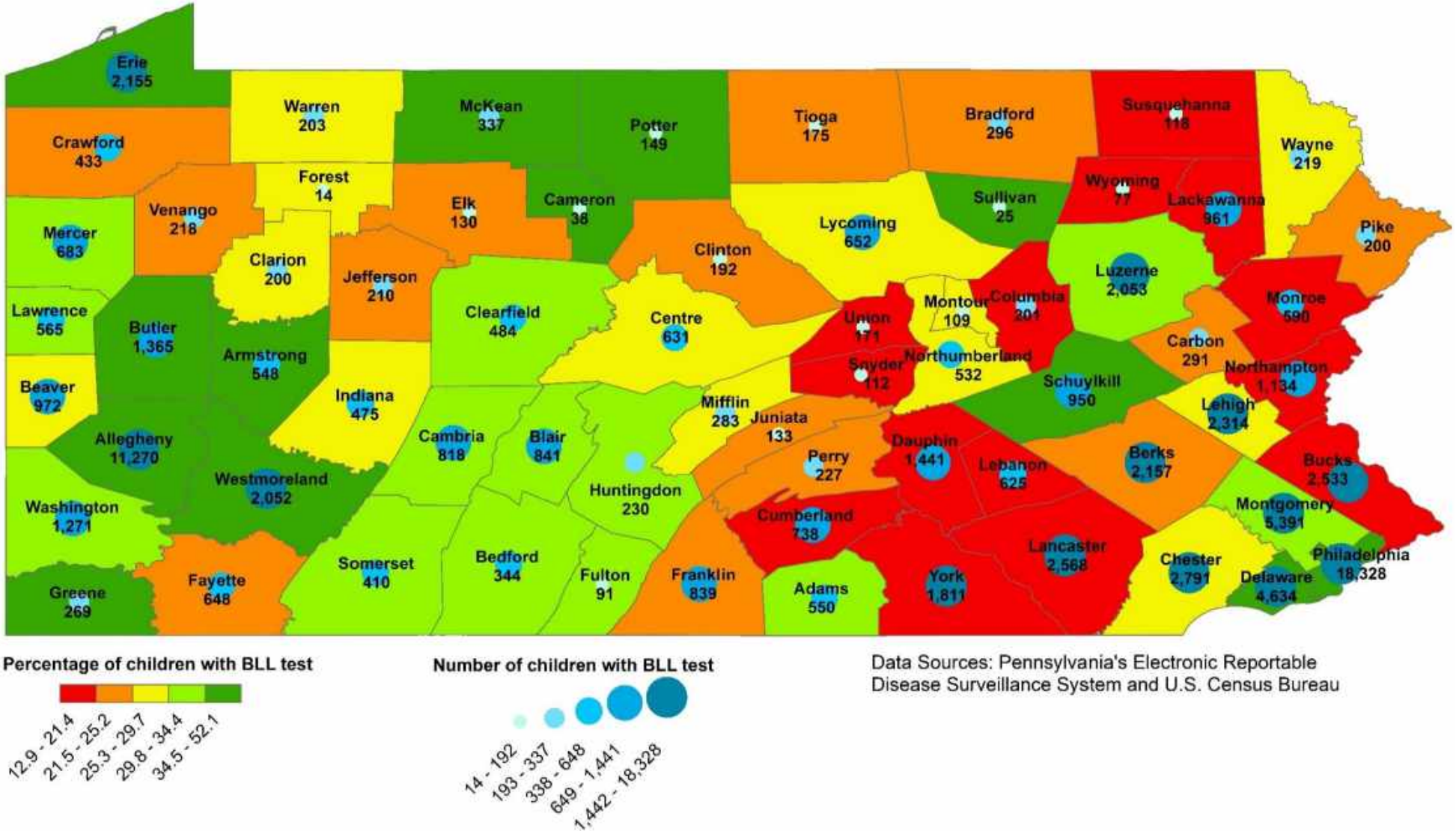
County of Residence	Population of Children Aged 0–23 Months†	Children Tested**		Unconfirmed elevated (≥ 5 µg/dL)			Confirmed 5–9.9 µg/dL			Confirmed ≥ 10 µg/dL		
		N	% of population^	N	% of tested	% of population	N	% of tested	% of population	N	% of tested	% of population
Adams	1,849	550	29.75	5	0.91	0.27	9	1.64	0.49	4	0.73	0.22
Allegheny	25,690	11,270	43.87	147	1.30	0.57	143	1.27	0.56	74	0.66	0.29
Armstrong	1,305	548	41.99	4	0.73	0.31	11	2.01	0.84	2	0.36	0.15
Beaver	3,274	972	29.69	18	1.85	0.55	6	0.62	0.18	2	0.21	0.06
Bedford	1,000	344	34.40	2	0.58	0.20	11	3.20	1.10	1	0.29	0.10
Berks	9,359	2,157	23.05	40	1.85	0.43	113	5.24	1.21	40	1.85	0.43
Blair	2,449	841	34.34	11	1.31	0.45	24	2.85	0.98	7	0.83	0.29
Bradford	1,362	296	21.73	1	0.34	0.07	7	2.36	0.51	3	1.01	0.22
Bucks	11,899	2,533	21.29	7	0.28	0.06	17	0.67	0.14	5	0.20	0.04
Butler	3,667	1,365	37.22	9	0.66	0.25	12	0.88	0.33	5	0.37	0.14
Cambria	2,609	818	31.35	43	5.26	1.65	11	1.34	0.42	4	0.49	0.15
Cameron	73	38	52.05	1	2.63	1.37	2	5.26	2.74	2	5.26	2.74
Carbon	1,203	291	24.19	8	2.75	0.67	10	3.44	0.83	2	0.69	0.17
Centre	2,443	631	25.83	4	0.63	0.16	4	0.63	0.16	0	0.00	0.00
Chester	10,702	2,791	26.08	27	0.97	0.25	30	1.07	0.28	10	0.36	0.09
Clarion	750	200	26.67	0	0.00	0.00	9	4.50	1.20	4	2.00	0.53
Clearfield	1,432	484	33.80	5	1.03	0.35	4	0.83	0.28	3	0.62	0.21
Clinton	769	192	24.97	2	1.04	0.26	4	2.08	0.52	1	0.52	0.13
Columbia	1,122	201	17.91	1	0.50	0.09	3	1.49	0.27	4	1.99	0.36
Crawford	1,770	433	24.46	16	3.70	0.90	8	1.85	0.45	3	0.69	0.17
Cumberland	5,360	738	13.77	7	0.95	0.13	11	1.49	0.21	4	0.54	0.07
Dauphin	6,748	1,441	21.35	21	1.46	0.31	33	2.29	0.49	19	1.32	0.28
Delaware	12,918	4,634	35.87	39	0.84	0.30	75	1.62	0.58	24	0.52	0.19
Elk	593	130	21.92	1	0.77	0.17	1	0.77	0.17	1	0.77	0.17
Erie	5,973	2,155	36.08	50	2.32	0.84	25	1.16	0.42	23	1.07	0.39

County of Residence	Population of Children Aged 0–23 Months†	Children Tested**		Unconfirmed elevated (≥ 5 µg/dL)			Confirmed 5–9.9 µg/dL			Confirmed ≥ 10 µg/dL		
		N	% of population^	N	% of tested	% of population	N	% of tested	% of population	N	% of tested	% of population
Fayette	2,567	648	25.24	1	0.15	0.04	4	0.62	0.16	1	0.15	0.04
Forest	51	14	27.45	0	0.00	0.00	0	0.00	0.00	1	7.14	1.96
Franklin	3,703	839	22.66	17	2.03	0.46	14	1.67	0.38	4	0.48	0.11
Fulton	302	91	30.13	0	0.00	0.00	4	4.40	1.32	1	1.10	0.33
Greene	732	269	36.75	1	0.37	0.14	4	1.49	0.55	3	1.12	0.41
Huntingdon	748	230	30.75	0	0.00	0.00	1	0.43	0.13	3	1.30	0.40
Indiana	1,626	475	29.21	6	1.26	0.37	6	1.26	0.37	3	0.63	0.18
Jefferson	869	210	24.17	3	1.43	0.35	4	1.90	0.46	4	1.90	0.46
Juniata	566	133	23.50	2	1.50	0.35	4	3.01	0.71	3	2.26	0.53
Lackawanna	4,497	961	21.37	22	2.29	0.49	36	3.75	0.80	11	1.14	0.24
Lancaster	13,760	2,568	18.66	18	0.70	0.13	108	4.21	0.78	44	1.71	0.32
Lawrence	1,720	565	32.85	6	1.06	0.35	9	1.59	0.52	3	0.53	0.17
Lebanon	3,225	625	19.38	14	2.24	0.43	20	3.20	0.62	8	1.28	0.25
Lehigh	8,493	2,314	27.25	43	1.86	0.51	42	1.82	0.49	17	0.73	0.20
Luzerne	6,350	2,053	32.33	49	2.39	0.77	41	2.00	0.65	15	0.73	0.24
Lycoming	2,301	652	28.34	3	0.46	0.13	18	2.76	0.78	12	1.84	0.52
McKean	702	337	48.01	6	1.78	0.85	9	2.67	1.28	2	0.59	0.28
Mercer	2,230	683	30.63	16	2.34	0.72	13	1.90	0.58	4	0.59	0.18
Mifflin	1,075	283	26.33	0	0.00	0.00	7	2.47	0.65	3	1.06	0.28
Monroe	2,984	590	19.77	2	0.34	0.07	5	0.85	0.17	1	0.17	0.03
Montgomery	17,413	5,391	30.96	26	0.48	0.15	76	1.41	0.44	32	0.59	0.18
Montour	423	109	25.77	0	0.00	0.00	3	2.75	0.71	0	0.00	0.00
Northampton	5,716	1,134	19.84	28	2.47	0.49	13	1.15	0.23	7	0.62	0.12
Northumberland	1,794	532	29.65	6	1.13	0.33	16	3.01	0.89	12	2.26	0.67
Perry	1,009	227	22.50	3	1.32	0.30	7	3.08	0.69	3	1.32	0.30
Philadelphia	41,407	18,328	44.26	155	0.85	0.37	633	3.45	1.53	204	1.11	0.49
Pike	886	200	22.57	1	0.50	0.11	0	0.00	0.00	1	0.50	0.11

County of Residence	Population of Children Aged 0–23 Months†	Children Tested**		Unconfirmed elevated (≥ 5 µg/dL)			Confirmed 5–9.9 µg/dL			Confirmed ≥ 10 µg/dL		
		N	% of population^	N	% of tested	% of population	N	% of tested	% of population	N	% of tested	% of population
Potter	325	149	45.85	0	0.00	0.00	5	3.36	1.54	0	0.00	0.00
Schuylkill	2,702	950	35.16	22	2.32	0.81	27	2.84	1.00	8	0.84	0.30
Snyder	866	112	12.93	5	4.46	0.58	1	0.89	0.12	1	0.89	0.12
Somerset	1,323	410	30.99	3	0.73	0.23	4	0.98	0.30	4	0.98	0.30
Sullivan	63	25	39.68	0	0.00	0.00	2	8.00	3.17	0	0.00	0.00
Susquehanna	688	118	17.15	0	0.00	0.00	2	1.69	0.29	1	0.85	0.15
Tioga	781	175	22.41	3	1.71	0.38	3	1.71	0.38	0	0.00	0.00
Union	821	171	20.83	1	0.58	0.12	9	5.26	1.10	1	0.58	0.12
Venango	1,015	218	21.48	5	2.29	0.49	10	4.59	0.99	4	1.83	0.39
Warren	762	203	26.64	10	4.93	1.31	5	2.46	0.66	3	1.48	0.39
Washington	3,965	1,271	32.06	17	1.34	0.43	15	1.18	0.38	5	0.39	0.13
Wayne	817	219	26.81	0	0.00	0.00	5	2.28	0.61	0	0.00	0.00
Westmoreland	5,742	2,052	35.74	24	1.17	0.42	20	0.97	0.35	8	0.39	0.14
Wyoming	480	77	16.04	1	1.30	0.21	0	0.00	0.00	0	0.00	0.00
York	9,759	1,811	18.56	7	0.39	0.07	55	3.04	0.56	35	1.93	0.36
Total	273,577	84,475	30.88	995	1.18	0.36	1,843	2.18	0.67	719	0.85	0.26

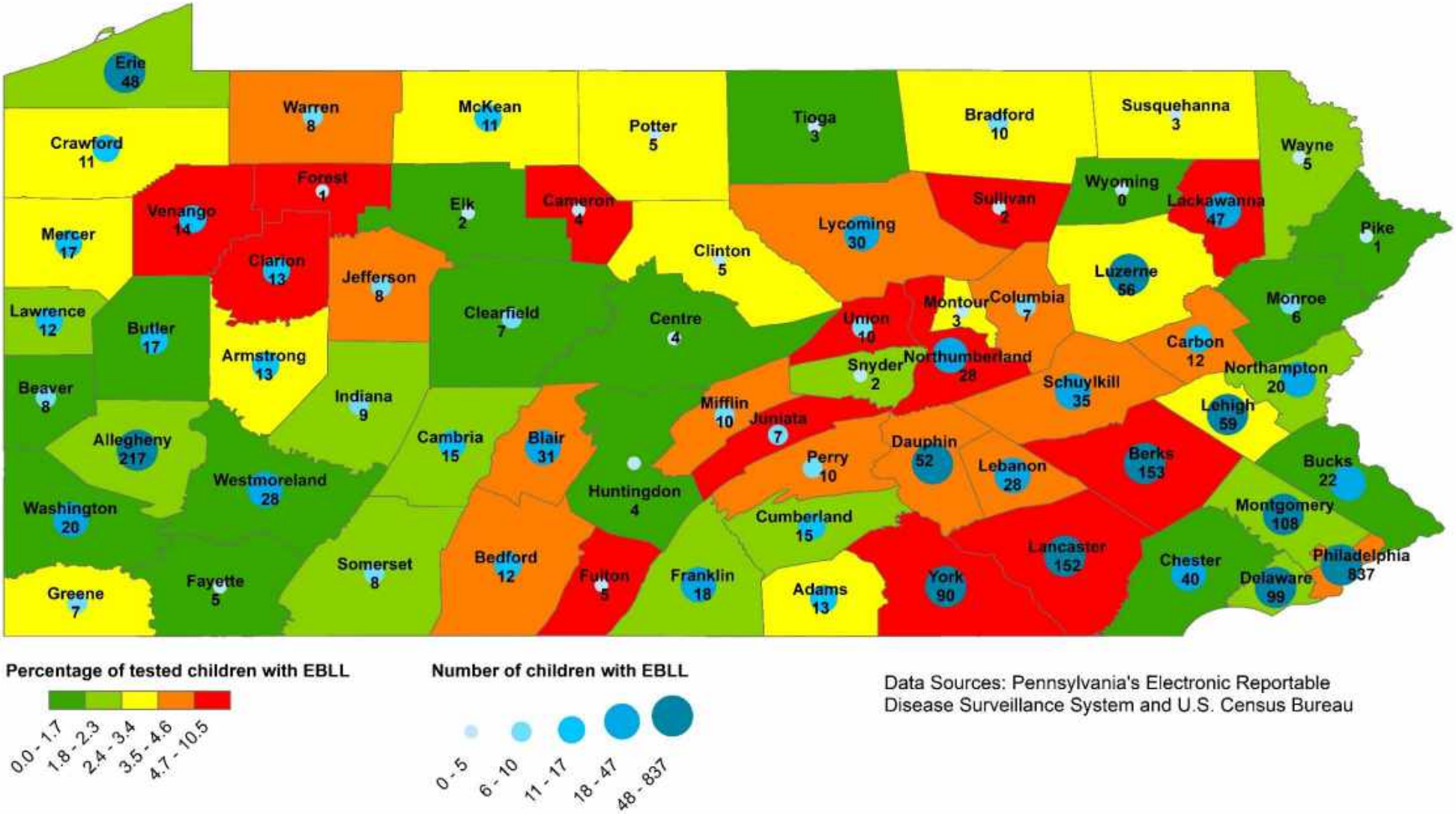
*Per CDC 2016 Confirmed Elevated Blood Lead case definition
**Note that Pennsylvania does not mandate universal screening of children; screening of children is recommended between 9 and 12 months and at 24 months. Allegheny County is currently the only county with mandatory testing.
^Percent was calculated as number of children tested divided by the population of children in the county for the specified age range.
†2018 intercensal estimate
Data sources: Pennsylvania Department of Health, PA-NEDSS., National Center for Health Statistics

Figure 2: Number and Percentage* of Children Aged 0–23 Months Tested for Blood Lead Level by County, 2018



*Percentage was calculated by dividing the number of children aged 0−23 months tested in each county by the 2018 intercensal estimate of the number of children aged 0−23 months residing in the county

Figure 3: Number and Percentage* of Children Aged 0–23 Months with Confirmed Elevated Blood Lead Level by County, 2018



*Percentage was calculated by dividing the number of children aged 0−23 months with EBLL by the total number of children aged 0−23 months tested for blood lead level in 2018.

Table 15: Number of Children Tested for Lead by Maximum Blood Lead Level and County of Residence, Children Aged 0–71 Months, 2018

County of Residence	Population of Children Aged 0–71 Months†	Children Tested*		Maximum BLL 5–9.9 µg/dL			Maximum BLL ≥ 10 µg/dL		
		N	% of population**	N	% of tested	% of population	N	% of tested	% of population
Adams	6,270	1,072	17.10	27	2.52	0.43	6	0.56	0.10
Allegheny	76,592	23,862	31.15	649	2.72	0.85	197	0.83	0.26
Armstrong	3,880	1,020	26.29	31	3.04	0.80	10	0.98	0.26
Beaver	10,183	1,705	16.74	37	2.17	0.36	8	0.47	0.08
Bedford	2,926	638	21.80	32	5.02	1.09	6	0.94	0.21
Berks	29,154	4,435	15.21	372	8.39	1.28	112	2.53	0.38
Blair	7,772	1,361	17.51	67	4.92	0.86	23	1.69	0.30
Bradford	4,329	576	13.31	19	3.30	0.44	12	2.08	0.28
Bucks	37,125	3,994	10.76	39	0.98	0.11	13	0.33	0.04
Butler	11,709	2,412	20.60	36	1.49	0.31	10	0.41	0.09
Cambria	7,949	1,601	20.14	122	7.62	1.53	35	2.19	0.44
Cameron	254	66	25.98	5	7.58	1.97	2	3.03	0.79
Carbon	3,699	570	15.41	45	7.89	1.22	9	1.58	0.24
Centre	7,669	795	10.37	11	1.38	0.14	2	0.25	0.03
Chester	34,849	4,795	13.76	117	2.44	0.34	34	0.71	0.10
Clarion	2,405	342	14.22	18	5.26	0.75	9	2.63	0.37
Clearfield	4,493	793	17.65	25	3.15	0.56	8	1.01	0.18
Clinton	2,490	341	13.69	13	3.81	0.52	3	0.88	0.12
Columbia	3,580	352	9.83	14	3.98	0.39	6	1.70	0.17
Crawford	5,529	856	15.48	40	4.67	0.72	12	1.40	0.22
Cumberland	16,417	1,379	8.40	31	2.25	0.19	11	0.80	0.07
Dauphin	20,658	2,888	13.98	130	4.50	0.63	45	1.56	0.22
Delaware	40,097	8,565	21.36	250	2.92	0.62	83	0.97	0.21
Elk	1,851	247	13.34	2	0.81	0.11	1	0.40	0.05
Erie	18,391	3,717	20.21	153	4.12	0.83	65	1.75	0.35
Fayette	7,998	1,259	15.74	29	2.30	0.36	9	0.71	0.11

County of Residence	Population of Children Aged 0–71 Months†	Children Tested*		Maximum BLL 5–9.9 µg/dL			Maximum BLL ≥ 10 µg/dL		
		N	% of population**	N	% of tested	% of population	N	% of tested	% of population
Forest	185	26	14.05	0	0.00	0.00	1	3.85	0.54
Franklin	11,107	1,626	14.64	47	2.89	0.42	18	1.11	0.16
Fulton	901	173	19.20	7	4.05	0.78	1	0.58	0.11
Greene	2,292	471	20.55	21	4.46	0.92	6	1.27	0.26
Huntingdon	2,434	444	18.24	12	2.70	0.49	6	1.35	0.25
Indiana	4,860	838	17.24	33	3.94	0.68	6	0.72	0.12
Jefferson	2,923	382	13.07	17	4.45	0.58	15	3.93	0.51
Juniata	1,684	200	11.88	8	4.00	0.48	4	2.00	0.24
Lackawanna	13,640	2121	15.55	143	6.74	1.05	53	2.50	0.39
Lancaster	42,235	4,175	9.89	222	5.32	0.53	91	2.18	0.22
Lawrence	5,358	1,002	18.70	34	3.39	0.63	9	0.90	0.17
Lebanon	10,086	1,232	12.21	64	5.19	0.63	26	2.11	0.26
Lehigh	26,269	4,483	17.07	178	3.97	0.68	62	1.38	0.24
Luzerne	19,623	3774	19.23	190	5.03	0.97	58	1.54	0.30
Lycoming	7,369	1,041	14.13	61	5.86	0.83	22	2.11	0.30
McKean	2,378	642	27.00	29	4.52	1.22	11	1.71	0.46
Mercer	6,579	1,090	16.57	58	5.32	0.88	16	1.47	0.24
Mifflin	3,392	417	12.29	16	3.84	0.47	4	0.96	0.12
Monroe	9,246	1,074	11.62	7	0.65	0.08	1	0.09	0.01
Montgomery	55,005	9,017	16.39	220	2.44	0.40	73	0.81	0.13
Montour	1,277	375	29.37	8	2.13	0.63	1	0.27	0.08
Northampton	17,934	2,362	13.17	108	4.57	0.60	16	0.68	0.09
Northumberland	5,640	1,005	17.82	68	6.77	1.21	32	3.18	0.57
Perry	3,192	419	13.13	17	4.06	0.53	4	0.95	0.13
Philadelphia	124,751	37,874	30.36	2,253	5.95	1.81	628	1.66	0.50
Pike	2,594	415	16.00	5	1.20	0.19	1	0.24	0.04
Potter	1,063	273	25.68	10	3.66	0.94	1	0.37	0.09
Schuylkill	8,433	1,668	19.78	114	6.83	1.35	38	2.28	0.45

County of Residence	Population of Children Aged 0–71 Months†	Children Tested*		Maximum BLL 5–9.9 µg/dL			Maximum BLL ≥ 10 µg/dL		
		N	% of population**	N	% of tested	% of population	N	% of tested	% of population
Snyder	2,642	197	7.46	9	4.57	0.34	4	2.03	0.15
Somerset	4,039	728	18.02	27	3.71	0.67	8	1.10	0.20
Sullivan	205	48	23.41	3	6.25	1.46	0	0.00	0.00
Susquehanna	2,205	223	10.11	9	4.04	0.41	2	0.90	0.09
Tioga	2,599	338	13.01	12	3.55	0.46	1	0.30	0.04
Union	2,509	326	12.99	16	4.91	0.64	6	1.84	0.24
Venango	3,074	590	19.19	49	8.31	1.59	16	2.71	0.52
Warren	2,393	405	16.92	35	8.64	1.46	8	1.98	0.33
Washington	12,642	2,520	19.93	64	2.54	0.51	16	0.63	0.13
Wayne	2,620	440	16.79	10	2.27	0.38	5	1.14	0.19
Westmoreland	19,045	3,632	19.07	80	2.20	0.42	30	0.83	0.16
Wyoming	1,555	139	8.94	3	2.16	0.19	1	0.72	0.06
York	30,765	3,140	10.21	140	4.46	0.46	69	2.20	0.22
Total	847,012	160,986	19.01	6,721	4.17	0.79	2,101	1.31	0.25

*Note that Pennsylvania does not mandate universal screening of children; screening of children is recommended between 9 and 12 months and at 24 months. Allegheny County is currently the only county with mandatory testing.
**Percent was calculated as number of children tested divided by the population of children in the county for the specified age range.
†2018 intercensal estimate
Data sources: Pennsylvania Department of Health, PA-NEDSS., National Center for Health Statistics

Table 16: Number of Children Aged 0–71 Months by County of Residence and Elevated Blood Lead Confirmation Status,* 2018

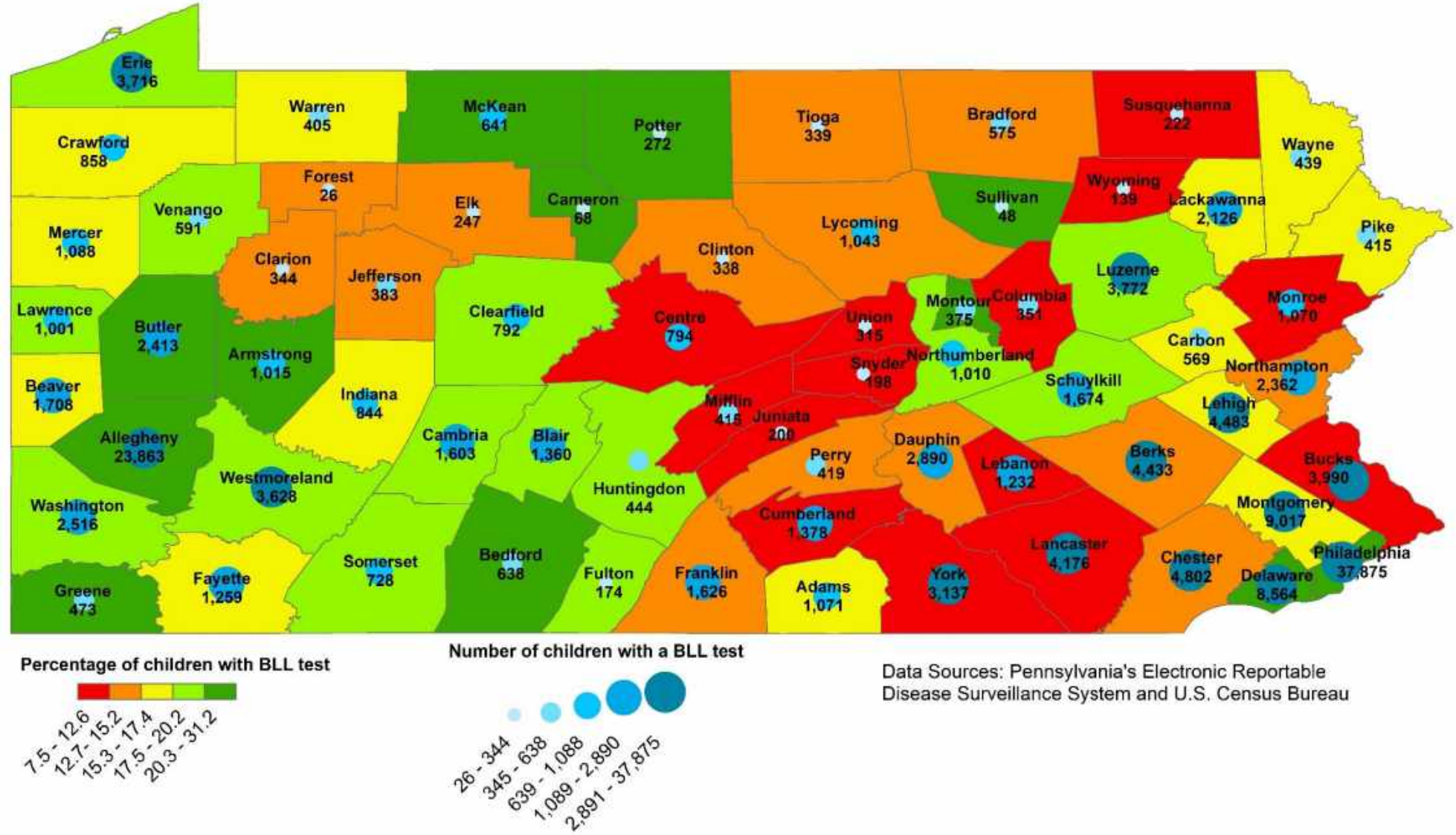
County of Residence	Population of Children Aged 0–71 Months†	Children Tested**		Unconfirmed elevated (≥ 5 µg/dL)			Confirmed 5–9.9 µg/dL			Confirmed ≥ 10 µg/dL		
		N	% of population^	N	% of tested	% of population	N	% of tested	% of population	N	% of tested	% of population
Adams	6,270	1,071	17.08	13	1.21	0.21	14	1.31	0.22	4	0.37	0.06
Allegheny	76,592	23,863	31.16	344	1.44	0.45	340	1.42	0.44	147	0.62	0.19
Armstrong	3,880	1,015	26.16	13	1.28	0.34	20	1.97	0.52	7	0.69	0.18
Beaver	10,183	1,708	16.77	28	1.64	0.27	18	1.05	0.18	3	0.18	0.03
Bedford	2,926	638	21.80	10	1.57	0.34	21	3.29	0.72	4	0.63	0.14
Berks	29,154	4,433	15.21	108	2.44	0.37	283	6.38	0.97	98	2.21	0.34
Blair	7,772	1,361	17.51	22	1.62	0.28	51	3.75	0.66	20	1.47	0.26
Bradford	4,329	575	13.28	3	0.52	0.07	16	2.78	0.37	12	2.09	0.28
Bucks	37,125	3,990	10.75	11	0.28	0.03	29	0.73	0.08	12	0.30	0.03
Butler	11,709	2,413	20.61	17	0.70	0.15	24	0.99	0.20	5	0.21	0.04
Cambria	7,949	1,603	20.17	85	5.30	1.07	47	2.93	0.59	26	1.62	0.33
Cameron	254	68	26.77	2	2.94	0.79	4	5.88	1.57	2	2.94	0.79
Carbon	3,699	569	15.38	15	2.64	0.41	31	5.45	0.84	7	1.23	0.19
Centre	7,669	794	10.35	5	0.63	0.07	5	0.63	0.07	1	0.13	0.01
Chester	34,849	4,802	13.78	70	1.46	0.20	60	1.25	0.17	25	0.52	0.07
Clarion	2,405	344	14.30	3	0.87	0.12	17	4.94	0.71	8	2.33	0.33
Clearfield	4,493	792	17.63	12	1.52	0.27	11	1.39	0.24	8	1.01	0.18
Clinton	2,490	338	13.57	4	1.18	0.16	10	2.96	0.40	2	0.59	0.08
Columbia	3,580	351	9.80	2	0.57	0.06	13	3.70	0.36	6	1.71	0.17
Crawford	5,529	858	15.52	27	3.15	0.49	21	2.45	0.38	7	0.82	0.13
Cumberland	16,417	1,378	8.39	9	0.65	0.05	24	1.74	0.15	11	0.80	0.07
Dauphin	20,658	2,890	13.99	63	2.18	0.30	84	2.91	0.41	35	1.21	0.17
Delaware	40,097	8,565	21.36	81	0.95	0.20	178	2.08	0.44	73	0.85	0.18
Elk	1,851	247	13.34	1	0.40	0.05	2	0.81	0.11	1	0.40	0.05
Erie	18,391	3,716	20.21	99	2.66	0.54	75	2.02	0.41	51	1.37	0.28

County of Residence	Population of Children Aged 0–71 Months†	Children Tested**		Unconfirmed elevated (≥ 5 µg/dL)			Confirmed 5–9.9 µg/dL			Confirmed ≥ 10 µg/dL		
		N	% of population^	N	% of tested	% of population	N	% of tested	% of population	N	% of tested	% of population
Fayette	7,998	1,259	15.74	7	0.56	0.09	23	1.83	0.29	9	0.71	0.11
Forest	185	26	14.05	0	0.00	0.00	0	0.00	0.00	1	3.85	0.54
Franklin	11,107	1,626	14.64	36	2.21	0.32	24	1.48	0.22	8	0.49	0.07
Fulton	901	174	19.31	1	0.57	0.11	6	3.45	0.67	1	0.57	0.11
Greene	2,292	473	20.64	7	1.48	0.31	14	2.96	0.61	6	1.27	0.26
Huntingdon	2,434	444	18.24	4	0.90	0.16	8	1.80	0.33	6	1.35	0.25
Indiana	4,860	844	17.37	18	2.13	0.37	15	1.78	0.31	5	0.59	0.10
Jefferson	2,923	383	13.10	10	2.61	0.34	9	2.35	0.31	11	2.87	0.38
Juniata	1,684	200	11.88	2	1.00	0.12	6	3.00	0.36	4	2.00	0.24
Lackawanna	13,640	2,126	15.59	55	2.59	0.40	105	4.94	0.77	43	2.02	0.32
Lancaster	42,235	4,176	9.89	34	0.81	0.08	199	4.77	0.47	85	2.04	0.20
Lawrence	5,358	1,001	18.68	12	1.20	0.22	23	2.30	0.43	7	0.70	0.13
Lebanon	10,086	1,232	12.21	29	2.35	0.29	41	3.33	0.41	20	1.62	0.20
Lehigh	26,269	4,483	17.07	98	2.19	0.37	103	2.30	0.39	48	1.07	0.18
Luzerne	19,623	3,772	19.22	106	2.81	0.54	108	2.86	0.55	38	1.01	0.19
Lycoming	7,369	1,043	14.15	8	0.77	0.11	56	5.37	0.76	20	1.92	0.27
McKean	2,378	641	26.96	12	1.87	0.50	18	2.81	0.76	8	1.25	0.34
Mercer	6,579	1,088	16.54	31	2.85	0.47	30	2.76	0.46	13	1.19	0.20
Mifflin	3,392	415	12.23	1	0.24	0.03	16	3.86	0.47	4	0.96	0.12
Monroe	9,246	1,070	11.57	2	0.19	0.02	5	0.47	0.05	1	0.09	0.01
Montgomery	55,005	9,017	16.39	60	0.67	0.11	164	1.82	0.30	67	0.74	0.12
Montour	1,277	375	29.37	3	0.80	0.23	5	1.33	0.39	1	0.27	0.08
Northampton	17,934	2,362	13.17	61	2.58	0.34	47	1.99	0.26	13	0.55	0.07
Northumberland	5,640	1,010	17.91	19	1.88	0.34	57	5.64	1.01	30	2.97	0.53
Perry	3,192	419	13.13	4	0.95	0.13	15	3.58	0.47	3	0.72	0.09
Philadelphia	124,751	37,875	30.36	374	0.99	0.30	1,933	5.10	1.55	586	1.55	0.47

County of Residence	Population of Children Aged 0–71 Months†	Children Tested**		Unconfirmed elevated (≥ 5 µg/dL)			Confirmed 5–9.9 µg/dL			Confirmed ≥ 10 µg/dL		
		N	% of population^	N	% of tested	% of population	N	% of tested	% of population	N	% of tested	% of population
Pike	2,594	415	16.00	4	0.9	0.15	2	0.48	0.08	1	0.24	0.04
Potter	1,063	272	25.59	1	0.37	0.09	9	3.31	0.85	1	0.37	0.09
Schuylkill	8,433	1,674	19.85	65	3.88	0.77	65	3.88	0.77	22	1.31	0.26
Snyder	2,642	198	7.49	9	4.55	0.34	3	1.52	0.11	2	1.01	0.08
Somerset	4,039	728	18.02	14	1.92	0.35	15	2.06	0.37	7	0.96	0.17
Sullivan	205	48	23.41	0	0.00	0.00	3	6.25	1.46	0	0.00	0.00
Susquehanna	2,205	222	10.07	3	1.35	0.14	6	2.70	0.27	2	0.90	0.09
Tioga	2,599	339	13.04	5	1.47	0.19	7	2.06	0.27	1	0.29	0.04
Union	2,509	315	12.55	1	0.32	0.04	13	4.13	0.52	4	1.27	0.16
Venango	3,074	591	19.23	18	3.05	0.59	36	6.09	1.17	12	2.03	0.39
Warren	2,393	405	16.92	20	4.94	0.84	19	4.69	0.79	4	0.99	0.17
Washington	12,642	2,516	19.90	40	1.59	0.32	31	1.23	0.25	11	0.44	0.09
Wayne	2,620	439	16.76	3	0.68	0.11	8	1.82	0.31	5	1.14	0.19
Westmoreland	19,045	3,628	19.05	47	1.30	0.25	38	1.05	0.20	25	0.69	0.13
Wyoming	1,555	139	8.94	1	0.72	0.06	3	2.16	0.19	0	0.00	0.00
York	30,765	3,137	10.20	16	0.51	0.05	123	3.92	0.40	66	2.10	0.21
Total	847,012	160,986	19.01	2,288	1.42	0.27	4,809	2.99	0.57	1,776	1.10	0.21

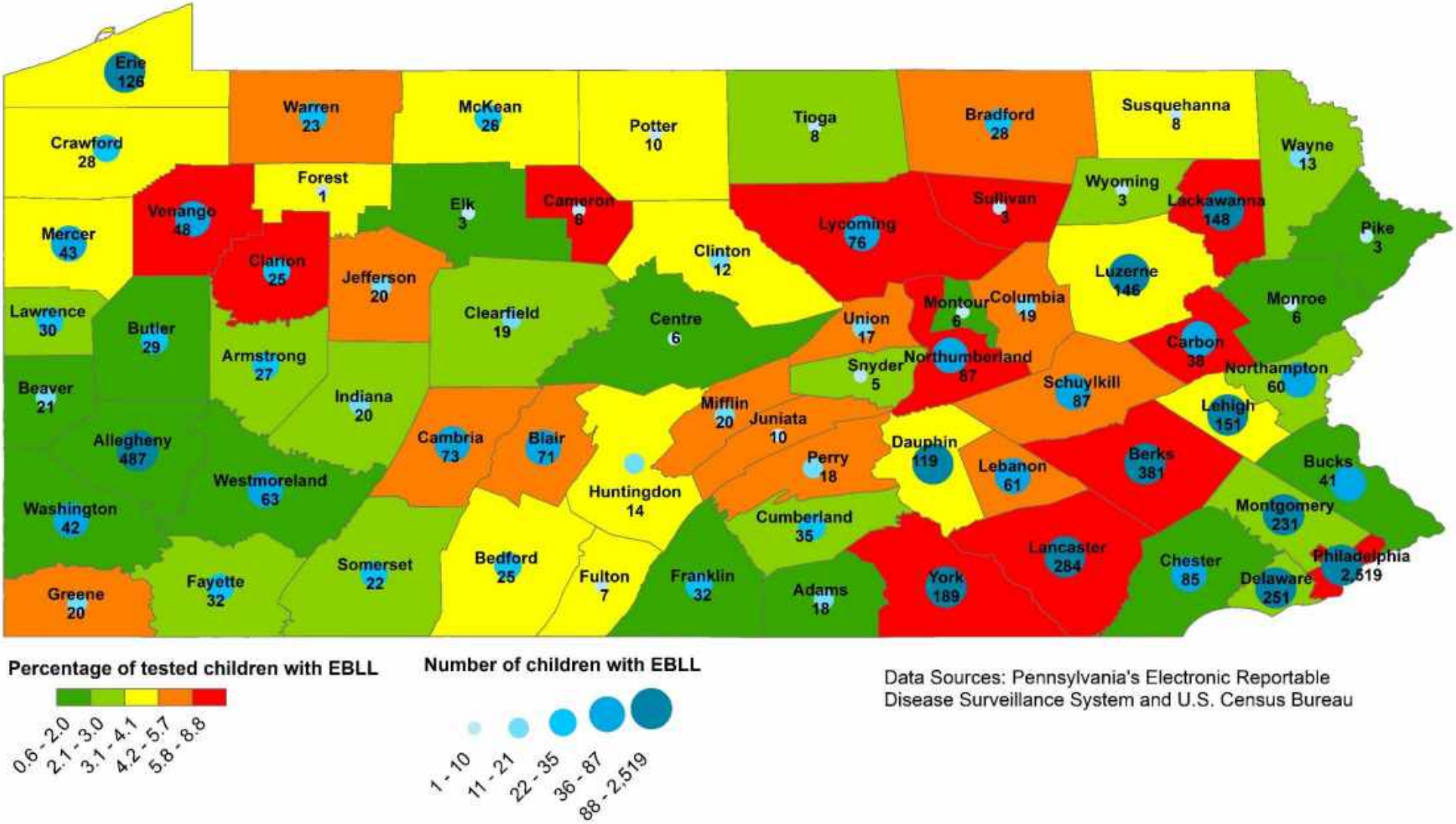
*Per CDC 2016 Confirmed Elevated Blood Lead case definition
**Note that Pennsylvania does not mandate universal screening of children; screening of children is recommended between 9 and 12 months and at 24 months. Allegheny County is currently the only county with mandatory testing.
^Percent was calculated as number of children tested divided by the population of children in the county for the specified age range.
†2018 intercensal estimate
Data sources: Pennsylvania Department of Health, PA-NEDSS., National Center for Health Statistics

Figure 4: Number and Percentage* of Children Aged 0–71 Months Tested for Blood Lead Level by County, 2018



*Percentage was calculated by dividing the number of children aged 0−71 months tested in each county by the 2018 intercensal estimate of the number of children aged 0−71 months residing in the county.

Figure 5: Number and Percentage* of Children Aged 0–71 Months with Confirmed Elevated Blood Lead Level by County, 2018.



*Percentage was calculated by dividing the number of children aged 0−71 months with EBLL by the total number of children aged 0−71 months tested for blood lead level in 2018.

Testing in Rural and Urban Counties:

The chart below contains testing data on children under 6, broken out by residence in either a rural or urban county. The chart also further displays results broken out by EBLL and whether they were confirmed.

Table 17: Number of Children Aged 0–71 Months by Urban/Rural Status of County of Residence and Elevated Blood Lead Confirmation Status,* 2018

Status of County of Residence	Population of Children Aged 0–71 Months**	Children Tested		Unconfirmed elevated (≥ 5 µg/dL)			Confirmed 5–9.9 µg/dL			Confirmed ≥ 10 µg/dL		
		N	% of population†	N	% of tested	% of population	N	% of tested	% of population	N	% of tested	% of population
Rural	204,193	33,832	16.57	595	1.75	0.29	857	2.53	0.42	330	0.98	0.16
Urban	642,819	127,154	19.78	1,693	1.33	0.26	3,952	3.11	0.61	1,446	1.14	0.22
Total	847,012	160,986	19.01	2,288	1.42	0.27	4,809	2.99	0.57	1,776	1.10	0.21

*Per CDC 2016 Elevated Blood Lead case definition
**2018 intercensal estimate
†Percent was calculated as number of children tested/population of children in county for specified age range.
Data sources: Pennsylvania Department of Health, PA-NEDSS., National Center for Health Statistics

Note: A county is rural when the number of persons per square mile within the county is less than 284. Counties that have 284 persons or more per square mile are considered urban. The current mix of 48 rural and 19 urban counties has remained unchanged since 1970. Population projections from the Pennsylvania State Data Center shows that this current mix of rural/urban counties will remain the same until 2040. Urban counties are Allegheny, Beaver, Berks, Bucks, Chester, Cumberland, Dauphin, Delaware, Erie, Lackawanna, Lancaster, Lebanon, Lehigh, Luzerne, Montgomery, Northampton, Philadelphia, Westmoreland and York.

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This report can be found at: https://www.health.pa.gov/Pages/default.aspx.