## THE INFLUENCE OF ELEVATED BLOOD LEVELS ON PHYSICAL HEALTH

By: Sri Banerjee

Objectiv	/es	+ 0
Understand	Understand the deleterious effects of lead on the individual throughout the life course and how it is a major public health concern	
Assess	Assess the primary study which explores the association between lead levels and cardiovascular disease mortality	
Explain	Explain the complex narrative of NIOSH Adult Blood Lead Epidemiology and Surveillance (ABLES) and how this impacts treatment and preventative measures	
Understand	Understand how alternative surveillance can be used to further inform lead relate issues	d

## HIGH RATES OF LEAD CONCENTRATION

μg/dL, by state — State Adult Blood Lead Epidemiology a regularize (ABLES) programs, United States, 2013<sup>†</sup>



≥20.4 adults per 100,000 employed
 <20.4 adults per 100,000 employed</li>
 Not an ABLES state or did not submit BLLs ≥10 µg/dL data

ate per 100,000 employed adults aged ≥16 years. State-resident prevaler the might be lower for some states. Data from the Adult Blood Epidemiolo ad Surveillance (ABLES) Program, National Institute for Occupational Safe ad Health (NIOSH/CDC). Denominators for 2013 extracted from 2015 L epartment of Labor, Bureau of Labor Statistics, Local Area Unemployme tatistics program (http://www.bls.gov/lau/staadata.txt).

e national rate in 2013 was 20.4 cases per 100,000 employed adults ag 6 years. A total of 30 states submitted data in 2013: Alabama, Alaska, Arizo fornia, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana

## Pennsylvania versus United States

Of the 28 states reporting blood lead levels of greater than or equal to  $10\mu g/dL$  to the CDC under its Adult Blood Lead Epidemiology and Surveillance (ABLES) programs in 2013

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Pennsylvania had the third highest prevalence rate at 49.1 per 100,000 employed adults aged 16 or older (≥ the average of 20.4).

Pennsylvania had the highest prevalence rate for blood lead levels greater than or equal to 25µg/dL at 25.7.

Average rate at this blood lead level was 5.2. Recent studies have

Found decreased renal function associated with BLLs at  $<5\mu g/dL$  and increased risk of hypertension and essential tremor at BLLs  $<10\mu g/dL$ .



+.Major sources of adult lead exposure in the U.S.

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- Metal processing (52%)
- Nonroad engines and vehicles (13%) fuel combustion (13%)
- Waste disposal (16%)
- Other (6%)

# CHILD & ADULT LEVELS



#### Regulations Versus Recommendations Related to Adult Lead Exposure in the Workplace

Regulations	Blood lead levels (BLL)	Recommendations
Occupational Safety and Health Administration's (OSHA)	60 μg/dL	
OSHA's medical removal BLL <sup>*</sup> for construction —	50 μg/dL	
OSHA's return to work —	40 μg/dL	<ul> <li>Association of Occupational and Environmental Clinics (AOEC),</li> <li>California Department of Public Health (CDPH), American College of Occupational and Environmental Medicine (ACOEM)</li> <li>California Departmental Sofati and Health Administration</li> </ul>
	30 μg/dL	■ < (MIOSHA) recommend medical removal at 30 µg/dL.
	25 μg/dL	OSHA's National Emphasis Program for lead determined BLLs at 25 µg/dL among workers in high risk industries shall be considered serious and must be handled by inspection.
	20 μg/dL	<ul> <li>American Conference of Governmental Industrial Hygienists</li> <li>(ACGIH<sup>®</sup>) Biological Exposure Index states a typical worker can experience this level without adverse health effects.</li> </ul>
	15 μg/dL	MIOSHA recommends BLL testing every 2 months for employees found to have a BLL of 15 µg/dL or higher.
	10 μg/dL	ACOEM and CDPH recommends BLL testing every 2 months.
Case definition for an elevated BLL	5 μg/dL	■ ← Women should not exceed 5 µg/dL during pregnancy.
The average blood lead level among adults in 2015–2016. $\longrightarrow$	<b>0.92</b> μg/dL	

\*The OSHA Lead Standards state that the examining physician has broad flexibility to tailor protections to the worker's needs.

#### Environmental Protection Agency (2020)

Lowered the clearance levels for dust on floors and windowsills after lead removal activities from 40 micrograms ( $\mu$ g) of lead in dust per square foot (ft2) to 10  $\mu$ g/ft2 for floor dust and from 250  $\mu$ g/ft2 to 100  $\mu$ g/ft2 for windowsill dust. ╉

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EPA is proposing these new lower clearance levels to reduce the lead dust related risks to children specifically in pre-1978 homes and childcare facilities where lead abatement activities have taken place.

#### IN MANY PLACES OF THE WORLD, LEADED GASOLINE POSES A MAJOR SOURCE OF LEAD EXPOSURE

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# Lead and Health

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 Lead can accumulate in various parts of the body (i.e., in the blood, bones, muscles, and fat). Infants and children are most sensitive to lead—even low levels, especially before 72 months of life. Lead and Health

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- Lead exposure may damage organs including kidneys, liver, brain and nerves, and other organs
- Lead to osteoporosis, affect the brain and nerves, which can cause seizures, mental retardation, behavioral disorders, memory problems, and mood changes
- Affect the heart and blood, such as causing high blood pressure and increased heart disease or anemia

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#### The area of study on how a chemical substance enters the body and the course it takes while in the body

- The processes of toxicokinetics are
  - Absorption (entrance of the substance into the body), distribution (movement of the substance from where it enters the body to other sites in the body such as liver, blood and lymph circulation, kidney, and lungs)
  - Biotransformation (transformation produced by the body of the substance into new chemicals)
  - Excretion (ejection of the substance or metabolites from the body)

## Toxicokinetics

# BLOOD LEAD LEVELS



Federal Fiscal Year	Administration Request	Congress Appropriated			
FY2011	\$30.7 million*	\$35.0 million			
FY2012	\$2.0 million*	\$2.5 million			
FY2013	\$2.0 million*	\$2.3 million			
FY2014	\$5.0 million*	\$28.5 million			
FY2015	\$28.5 million*	\$28.5 million			
FY2016	\$28.5 million*	\$34.0 million			
FY2017	\$31.5 million*	\$34.0 million			
FY2018	\$17 million	\$34.9 million			
FY2019	\$17 million	\$35.0 million			
FY2020	\$17 million				
* indicates Obama Administration.					

## Cost of Lead Poisoning

- The Federal Government's cuts to CDC CLPPP budget were a mistake that took years for local and state programs to recover from.
- The cuts may also be responsible for the reversal in the NHANES data. Congress should never have acquiesced, but in the budget cutting frenzy of those years, they agreed.
- As a result, our country lost one of its most valuable tools to ensure children at high-risk for lead exposure are identified and protected and to spot emerging regional or local problems.

#### Regulations



OSHA STANDARD PPT-051-01 12 29 CFR 1910.1025 – "LEAD" (C)(1) - THE EMPLOYER SHALL ASSURE THAT NO EMPLOYEE IS EXPOSED TO LEAD AT CONCENTRATIONS GREATER THAN 50MG/M<sup>3</sup> PERMISSIBLE EXPOSURE LIMIT(PEL) AVERAGED OVER AN 8-HOUR PERIOD (TWA) (D)(1)(I) EMPLOYEE EXPOSURE – DEFINED AS THAT EXPOSURE THAT WOULD OCCUR IF AN EMPLOYEE WERE NOT WEARING A RESPIRATOR

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## Adult Symptoms

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Adults with blood lead levels in this range have experienced:

- Neurological effects
- Thyroid hormone alterations
- Decreased fertility
- Increased blood pressure
- Depressed kidney functions
- Anemia

## ETHNIC DISPARITIES WITH LEAD LEVELS



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Other racial and ethnic groups are included in the "total" only.

Information on the statistical significance of the trends in this exhibit is not presented here. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

## Issues with Surveillance

Anil Nair PhD, MPH Interview As of 2013, adult lead surveillance funding was slashed

ABLES Surveillance efforts were conducted by the student, but this was also slashed

State Public Health Lead Data Director said that currently they are trying to apply for the NIOSH agency in order to renew funding efforts

Currently, the allowable adult lead levels are less than 5  $\mu$ g/dL

The lead poisoning programmatic activities are cutback leading to only primary care providers and Medicaid recipients 2 and under to be tested

Only 29 states, Washington, D.C., and five cities were awarded 3year funding for such activities in 2014.

#### Lead Surveillance Limitations

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Blood lead levels can give an idea of recent exposure to lead, 3 to 5 weeks before being tested. However, it is not an effective indicator of body burden of lead resulting from long-term exposure.

These data are based on an adult lead surveillance system that uses laboratory and health care provider reporting.

The Federal Occupational Safety and Health Administration (OSHA) lead regulations require monitoring blood lead levels for workers when air concentrations of lead exceed a certain limit. OSHA regulations do not require blood lead testing for all workers who handle lead. These data are therefore subject to significant underreporting.

### Methods-1

- We used data from the National Health and Nutrition Examination Survey (NHANES), six cycles between 1999 and 2010 (Centers for Disease Control and Prevention [CDC], 2020).
- Every year approximately 5,000 infants, children, and adults from the United States are selected to participate in the NHANES.
- Survey participants are asked to complete the in-person household interview by completing an intervieweradministered questionnaire.
- Next, the health examination components of the survey are administered in Mobile Examination Centers throughout the United States.

## Methods-2

- The laboratory component of the health examination includes an extensive array of laboratory tests that are performed on blood, urine, and other types of specimens.
- Sample weights were derived to account for oversampling of young children, adults 60 years of age and older, non-Hispanic Black individuals, and individuals of Mexican American ethnic origin in the NHANES survey.
- The analysis sample is representative of noninstitutionalized U.S. adults 20 years and older, to restrict the analysis to adults.
- The procedures and protocols for NHANES are approved by the National Center for Health Statistics before data collection. Data are available for public use through the CDC website.



### Lead Collection Methodology

- Whole blood Pb concentrations were determined using inductively coupled plasma-mass spectrometry (ICP-MS). This multi-element analytical technique is based on quadrupole ICP-MS technology.
- In this method of analyzing whole blood Pb concentrations, blood samples were diluted with 18 Mega-ohm water and with diluent, which contained 1% v/v tetramethylammonium hydroxide (TMAH), 0.5% disodium ethylenediamine tetraacetate (EDTA), 10% ethyl alcohol, 0.05% Triton X-100.
- Bismuth (Bi) was added for internal standardization of Pb. The samples were prepared with the following ratio: Sample:Water:Diluent = 1:1:48 correspondingly.

# Adult Lead Levels and Mortality



# Food Security



	95% Confidence Interval			
Variable	HR	Lower	Upper	Р
Lead Levels (µg/dL)				
Tertile 1 (≤ 1.09)	Reference	Reference	Reference	Reference
Tertile 2 (1.10-1.89)	0.97	0.81	1.16	0.74
Tertile 3 (≥1.90)	1.32	1.14	1.52	<0.001
Diabetes	1.73	1.53	1.95	<0.001
Cardiovascular Diseaseª	1.71	1.54	1.88	<0.001
Obesity (Reference: BMI < 30)	1.26	1.14	1.40	<0.001
Education				
Some High School	1.46	1.30	1.63	<0.001
High School Grad	1.23	1.11	1.37	<0.001
Some College	Reference	Reference	Reference	Reference
Age	1.08	1.07	1.08	<0.001
Gender (Reference: Female)	1.38	1.25	1.52	<0.001
Ethnicity				
Non-Hispanic White	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.11	0.99	1.25	0.07
Hispanic	1.01	0.87	1.18	0.88
Other	0.69	0.48	0.98	0.04
Poverty-Income- Ratio (Reference: PIR > 1)	1.38	1.20	1.58	0.001

## Elevated Blood Lead Mortality

- Multivariable Cox Hazard Model for Blood Lead Levels and All-Cause Mortality after controlling for Demographic and Medical Risk Factors (n=16,352).
- <sup>a</sup>Cardiovascular disease was defined by self-reported positive response to congestive heart failure, stroke, angina, coronary heart disease, or heart attack.

# Our Research Findings

Blood lead levels should be considered an independent risk factor for clinician risk scoring models in all-cause mortality.

Health practitioners should potentially monitor blood lead levels throughout the lifecourse in order to determine overall health.

#### References

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