

# Update on Lead Poisoning

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# Case study

At 18 months, PICA with Venous lead 52 and irritability: chelated with succimer

Item Name	Goal	11Aug2016 12:00 AM	22Feb2016 12:00 AM	28Sep2015 12:00 AM	26Jun2015 12:00 AM	03Feb2015 4:21 PM	26Sep2014 12:00 AM	07Feb2014 12:00 AM	23Oct2013 12:00 AM	05Sep2013 12:00 AM	14Jun2013 10:53 AM
LEAD (RECORDED EXTERNAL LAB VALUE)		7	8	7	11	13	15	17	23	21	28

Father incarcerated, family separated, placement in Gma house, Parent substance and ETOH abuse

Family hx of BPD, LD, ADHD

Developmental evaluation at 24 months: head banging, pica, hyperactive, impulsive, delayed language

Treated intermittently for iron deficiency

36 months: ASQ-SE extraordinarily elevated

By kindergarten: academic and behavioral difficulties: Dx with ADHD

6 years: trial of adhd rx, has IEP, in mental health services

9 years: remains on meds, intermittent mental health support

10 years: admitted for depression and suicidal ideation

# Major Points

There is no identified threshold or safe level of lead in blood.

We have lessened the risk for thousands of children but not eliminated it.

Frequently there is an interplay between the lead source, the identified patient and the social setting

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# Lead poisoning is not gone

Prevention of Childhood Lead Toxicity  
COUNCIL ON ENVIRONMENTAL  
HEALTH

Pediatrics July 2016, 138 (1) e20161493; DOI:  
<https://doi.org/10.1542/peds.2016-1493>

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- Lead toxicity still accounts for an estimated total loss of 23 million IQ points among a 6-year cohort of contemporary US children.
- Approximately 1 in 5 cases of ADHD among US children have been attributed to lead exposure.
- It has been estimated that the annual cost of childhood lead exposure in the United States is \$50 billion.

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# How prevalent is the problem?

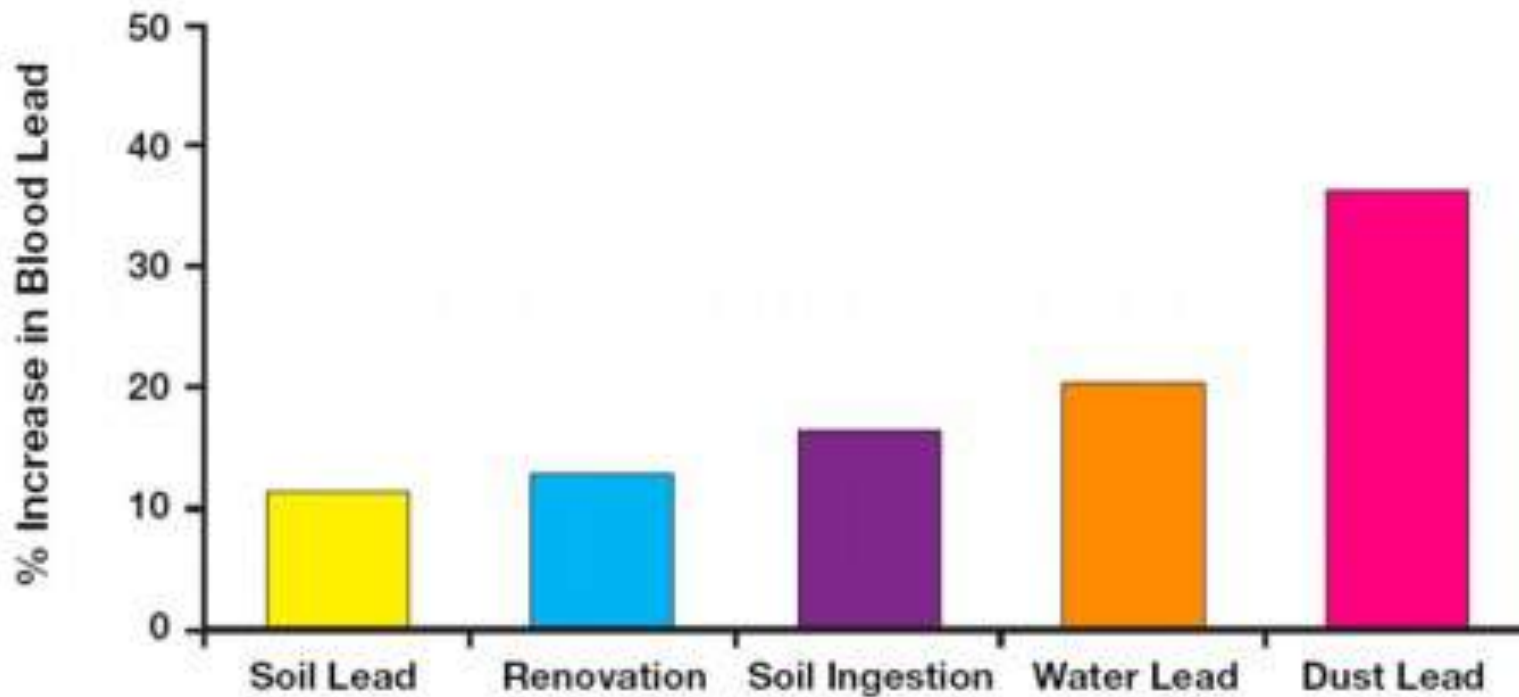
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- An estimated 3.6 million American homes with at least one child have significant lead paint hazards. As many as 500,000 US children (2.5%) under 6 years have BLLs  $\geq 5$   $\mu\text{g/dL}$ .
- Children living at or below the poverty line who live in older housing are at greatest risk of lead poisoning.
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5645046/>

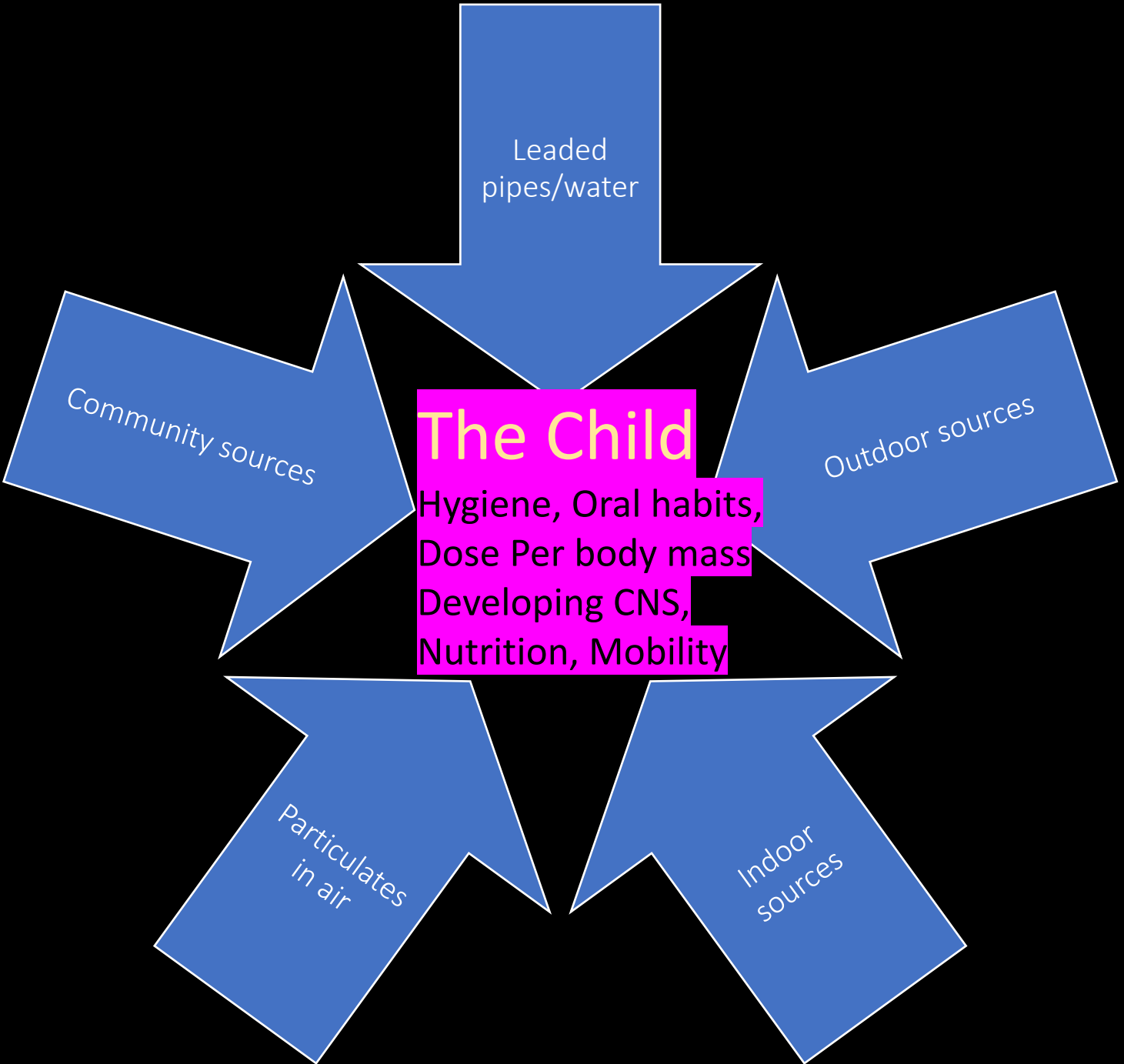
# Global Morbidity

- 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.
- IHME also estimated that in 2016, lead exposure accounted
  - 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 ischemic heart disease
  - 6.2% of the global burden of stroke.

# Where Do Children Get Their Lead?



**Figure 1. Sources of Contribution of Lead Exposure to Children's Blood Lead Concentrations** [AAP 2016, adapted from Lanphear et al. 2012, and Spanier et al. 2013]



Leaded  
pipes/water

Community sources

**The Child**

Hygiene, Oral habits,  
Dose Per body mass  
Developing CNS,  
Nutrition, Mobility

Outdoor sources

Particulates  
in air

Indoor  
sources



# Water Sources

- The primary sources of lead in water, which can be dissolved or particulate, consist of lead service lines, lead solder, and brass fittings that contain high concentrations of lead.
- Plumbing installed before 1986, the year a federal ban was issued is more likely to contain higher concentrations of lead.
- Lead services lines that are being replaced, are undergoing maintenance, or are damaged can release particles of lead that can be ingested.

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

<https://www.cdc.gov/breastfeeding/breastfeeding-special-circumstances/environmental-exposures/lead.html>

- If a pregnant or lactating woman has blood lead levels (BLLs)  $\geq 5 \mu\text{g/dL}$ : find the source
- Mothers with BLLs  $< 40 \mu\text{g/dL}$  should breastfeed and babies monitored
- Mothers with BLLs  $\geq 40 \mu\text{g/dL}$  are encouraged to pump and discard their milk until their BLLs drop below  $40 \mu\text{g/dL}$ .

There is no identified  
threshold or safe level of  
lead in blood.

# Lead Toxicity

# Update of the Blood Lead Reference Value — United States, 2021

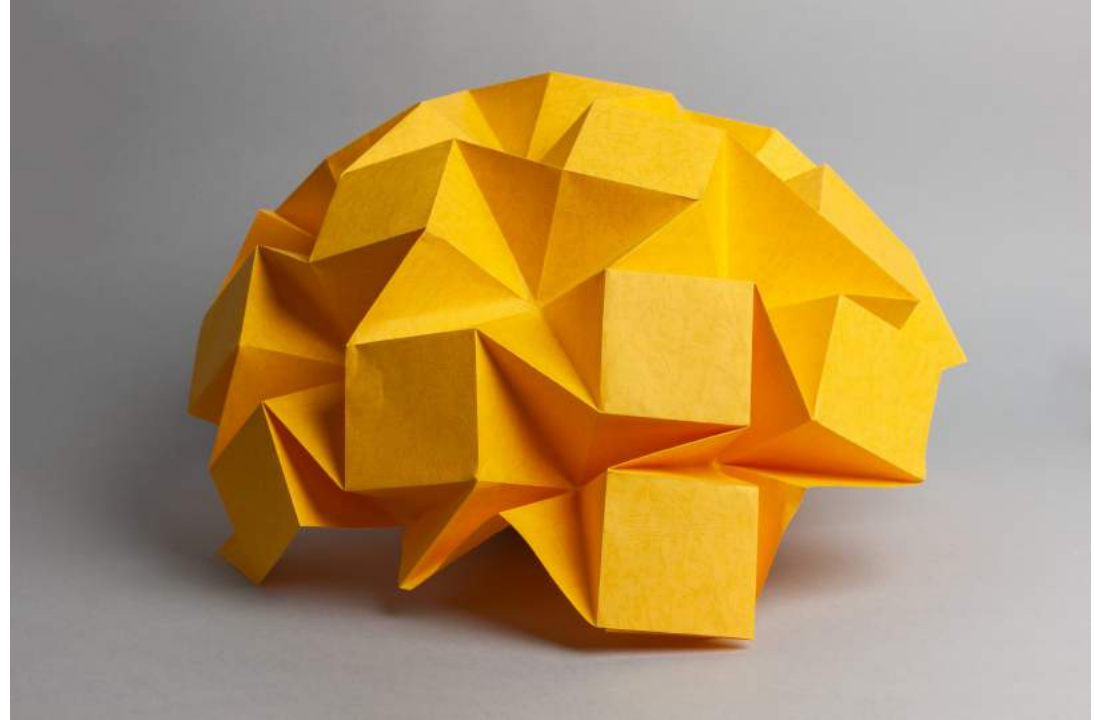
*MMWR Weekly* / October 29,  
2021 / 70(43);1509–1512

- CDC updated the blood lead reference value (BLRV) to **3.5  $\mu\text{g}/\text{dL}$** , which provides an opportunity for additional progress in addressing longstanding disparities in lead exposure and BLLs in children.

## Lead care 2

- Reportable range 3.3 – 65  $\mu\text{g}/\text{dL}$

No effective treatments ameliorate the permanent developmental effects of lead toxicity.



# Lead Distribution: Easily Absorbed in Children and Stays a Long Time

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- Children absorb a higher percentage of ingested lead than adults.
- Lead is primarily distributed in blood, mineralizing tissue, and soft tissues. The bones and teeth of adults contain more than 95% of total lead in the body.
- In times of stress (particularly pregnancy and lactation), the body can mobilize lead stores, thereby increasing the level of lead in the blood. It crosses the placenta.
- The body accumulates lead over a lifetime and normally releases it very slowly.

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# Lead Toxicity

Lead has been implicated  
in diverse processes

It has only toxic effects in  
living organisms

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- mitochondrial dysfunction
- oxidative stress
- deregulation of protein turnover
- brain inflammation
- decreased cellular energy metabolism
- lipid peroxidation
- altered activity of first and second messenger system
- abnormal neurotrophic factor expression
- altered regulation of gene transcription



# Lead metabolic effects

- Lead substitutes for calcium and zinc triggering processes reliant on calcium sensing proteins
- Lead interferes with neurotransmitter release, disrupting the function of GABAergic, dopaminergic, and cholinergic systems as well as inhibiting NMDA-ion channels during the neonatal period
- Lead activates protein kinase C in capillary cells and inhibits Na<sup>+</sup>/K<sup>+</sup>-ATPase in the cell membrane, interfering with energy metabolism
- Lead interferes with calcium release from the mitochondria, resulting in formation of reactive oxygen species, speeding mitochondrial self-destruction

Developmental  
Outcomes: There is  
NO SINGLE Signature  
Injury.

All  
Neuropsychological  
Functions are at  
Risk.

- Attention
- Memory
- General executive functioning
- Affect
- Social judgment
- Verbal IQ
- Performance IQ
- Visual/spatial skills
- Fine and gross motor skills
- Language skills.

# Practical Developmental Effects

- Academic achievement
- High school attendance
- Class rank
- Vocabulary
- Grammatical reasoning scores
- Social Skills

# Early lead exposure and children's academic success

- Among 8600 fourth-grade students in North Carolina, inverse associations were found between blood lead levels as low as 2mg/dl, measured between 0 and 5 years of age, and end-of-grade reading and mathematics achievement scores
- Current Opinion in Pediatrics 2008, 20:172–177

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# “LOW” exposure outcomes

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- Children with blood lead levels of 5–10mg/dl scored 5.9–8.7 points lower than children with levels of 1–2mg/dl on academic skills such as word reading, reading comprehension, listening comprehension, math reasoning and math calculations.
- Very low lead exposures and children’s neurodevelopment David C. Bellinger *Current Opinion in Pediatrics* 2008, 20:172–177

# “Low” exposure outcomes

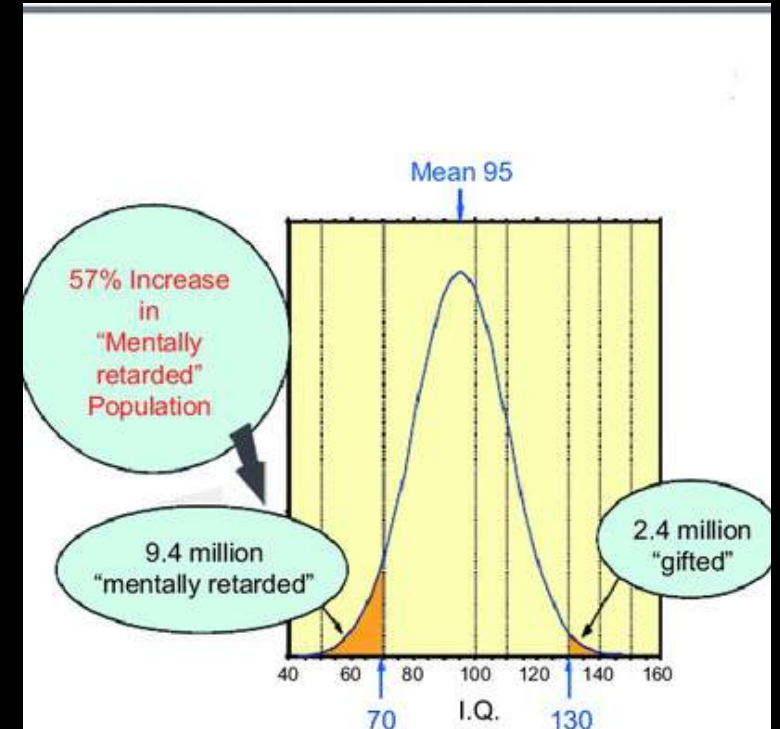
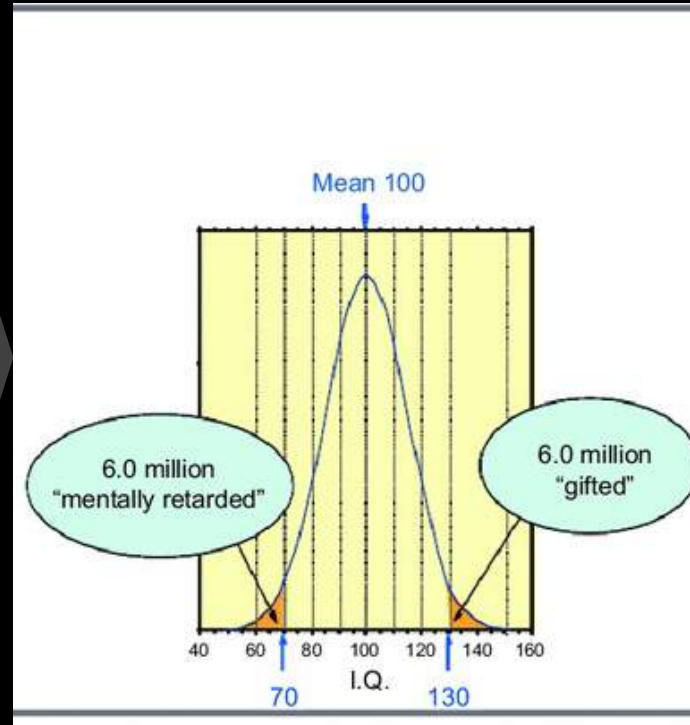
- There is a negative slope relating BLL and IQ down to concurrent BLLs of 1 g/dL.
- An increase in concurrent BLL from 1.0 to 4.0 g/dL is associated with a change in mean IQ of approximately -2.3 to -5.2 IQ points, with a best estimate of -3.7 IQ points.
- Lead toxicity, vulnerable subpopulations and emergency preparedness Radiat Prot Dosimetry 2009 Jun;134(3-4):143-51

# Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention

Report of the Advisory Committee on  
Childhood Lead Poisoning Prevention of  
the Centers for Disease Control and  
Prevention January 4, 2012

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 g/dL can shift the entire population IQ distribution





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# Epigenetics and the aging brain

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Click to add text

- Lead has the ability to alter DNA methylation and histone function
- These findings implicate epigenetics in lead induced toxicity, and long-term changes in individuals.
- NeuroToxicology Volume 56, September 2016, Pages 254-261

# Long term brain changes

Longitudinal prospective cohort study of 564 New Zealand children followed up to midlife, greater lead exposure in childhood was significantly associated with differences in MRI measurements of brain structure at age 45 years, including smaller cortical surface area, smaller hippocampal volume, lower global fractional anisotropy, and an older estimated brain age.

Each 5- $\mu\text{g}/\text{dL}$  higher level of blood lead in childhood was associated with a 1.61-point lower score in adult IQ

Association of Childhood Lead Exposure With MRI Measurements of Structural Brain Integrity in Midlife Aaron Reuben JAMA. 2020;324(19):1970-1979. doi:10.1001/jama.2020.19998

# Long Term Brain Changes

- Each 5- $\mu\text{g}/\text{dL}$  higher level of blood lead in childhood was associated with a 1.79-unit lower score (95% CI, -3.17 to -0.40) in socioeconomic status.
- An association between greater blood lead levels and a decline in IQ and socioeconomic status from childhood to adulthood was observed with 40% of the association with downward mobility mediated by cognitive decline from childhood.

• Association of Childhood Blood Lead Levels With Cognitive Function and Socioeconomic Status at Age 38 Years and With IQ Change and Socioeconomic Mobility Between Childhood and Adulthood. 2017 Mar 28;317(12):1244-1251.  
doi: 10.1001/jama.2017.1712

# A Short History on Pediatric Approach to Lead

Treat children with encephalopathy

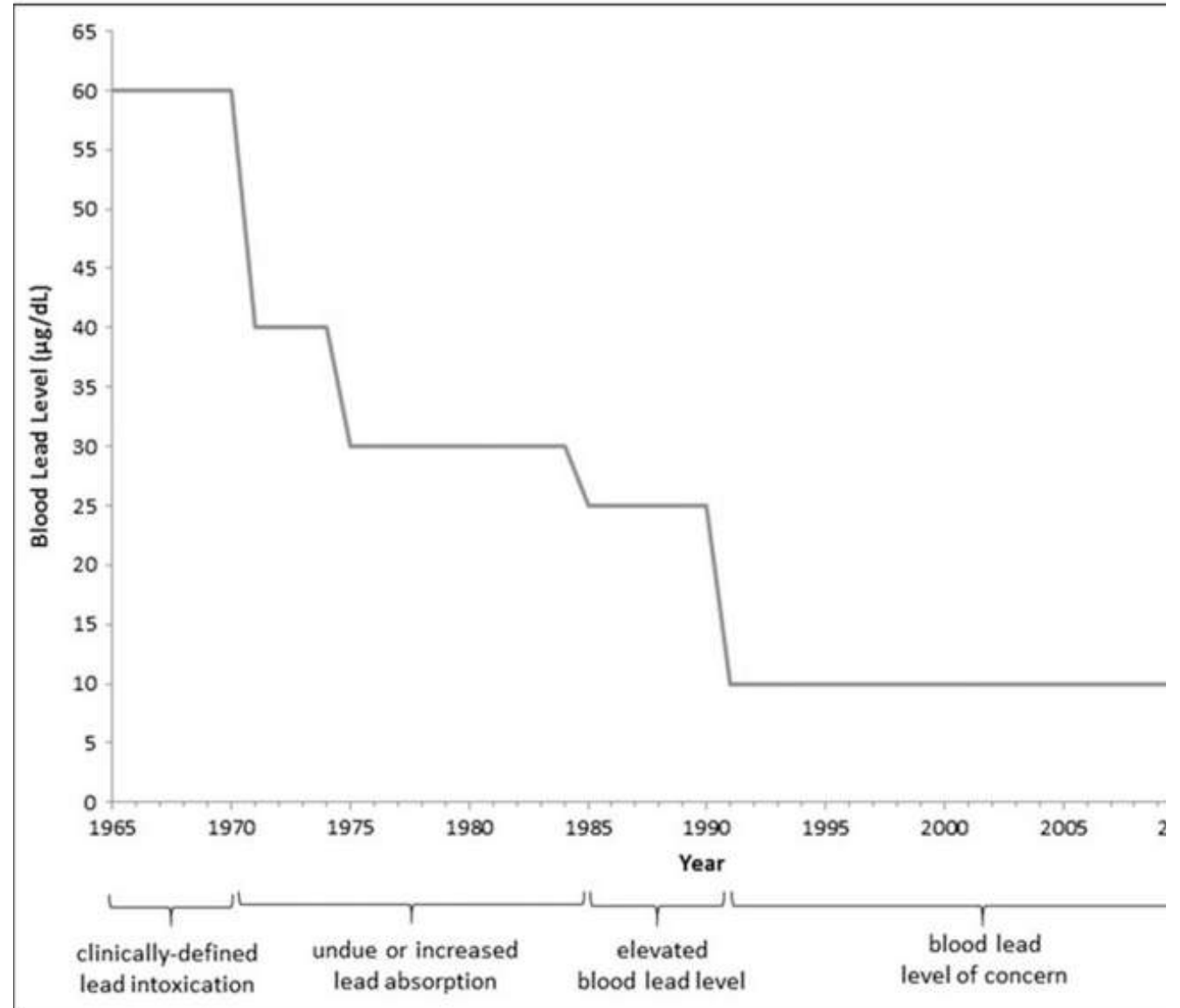
Screen high risk

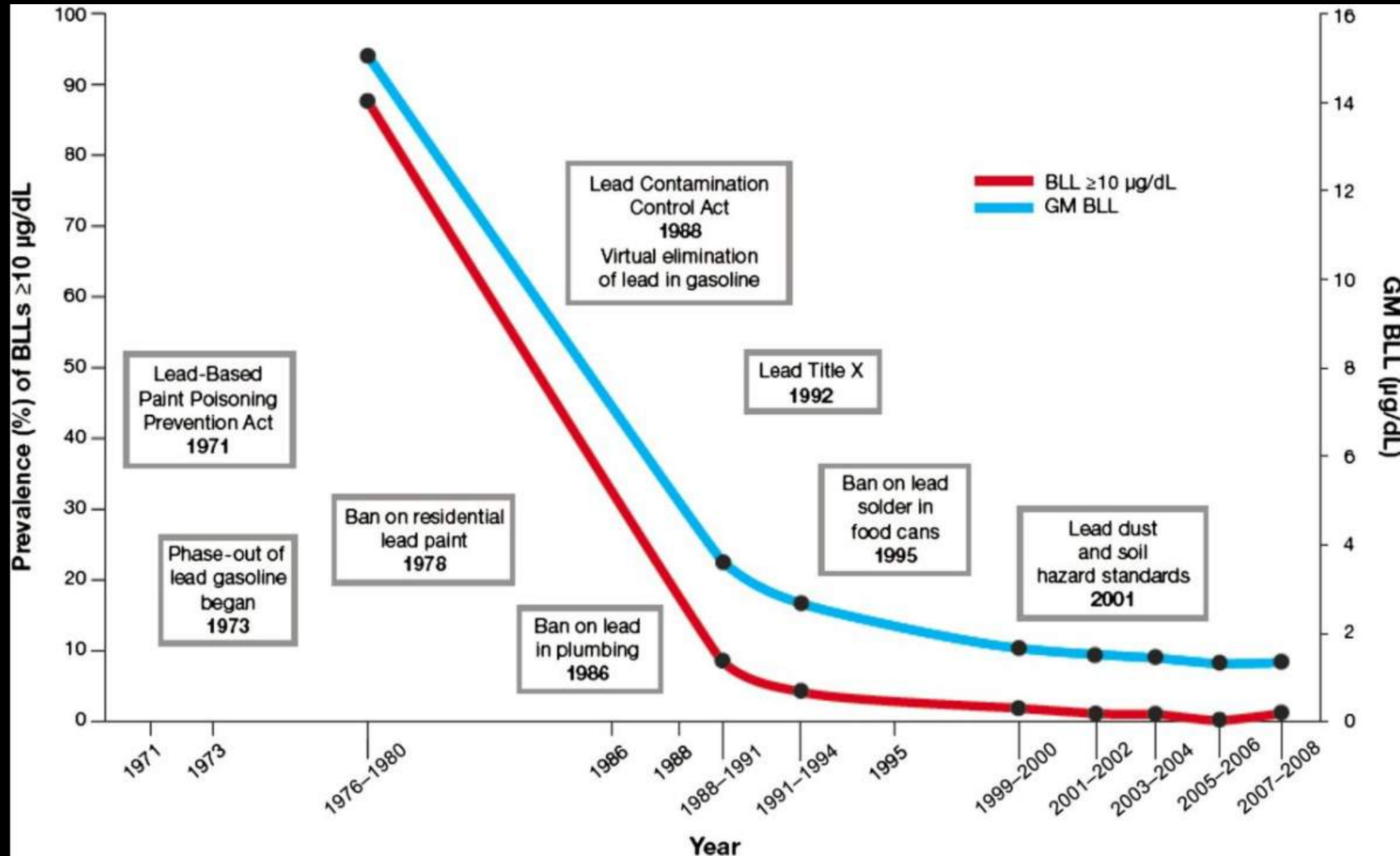
Universal screening

Advocacy for removal of lead access to children

# Changes to Definitions for Interpreting Children's Blood Lead Levels Over Time

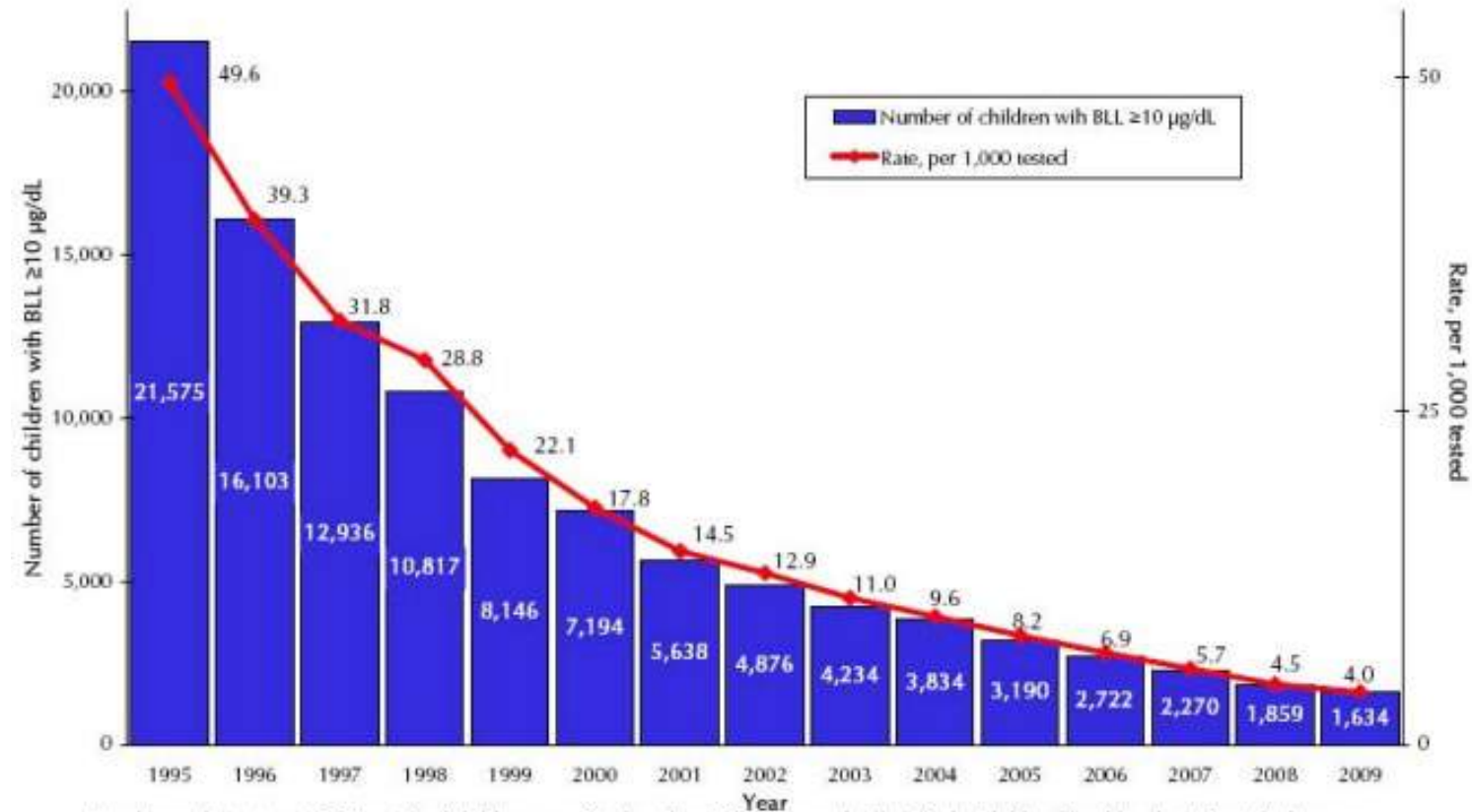
- J Public Health Manag Pract. 2019 Jan-Feb; 25(Suppl 1 LEAD POISONING PREVENTION): S5–S12.





We Have Much  
to Be Proud Of

Figure 4. Steady Decline in Number of Lead-Poisoned Children



Number and rate (per 1,000 tested) of children, age 0 to less than 18 years, newly identified with blood lead levels  $\geq 10$   $\mu\text{g}/\text{dL}$ , by year: NYC, 1995-2009.

# The Politics of Leaded Gas

- The Reagan Administration originally proposed to revoke the program to phase out leaded gasoline but changed its policy after widespread public protest.
- The Environmental Protection Agency then planned to move quickly toward a near-total ban on the use of lead in gasoline. The agency had determined that both health and cost considerations required that the policy be changed, and that lead be eliminated.
- NY Times Feb. 29, 1984



# The Politics of Lead and Water

- During April 25, 2014–October 15, 2015, approximately 99,000 residents of the City of Flint, MI, were exposed to lead when the drinking water source was switched from the Detroit Water Authority to the Flint Water System (FWS). On December 14, 2015, lead contamination in the FWS was declared a state of emergency (from CDC)
- Further studies cannot clearly demonstrate a significant rise in BLL for that population during the crisis period but it is clear that there are children who were directly harmed by the change in water systems.

# The Politics of Lead and Water

- Residents of Benton Harbor, Michigan, a predominantly Black city that has dealt with elevated lead levels in its water for at least three years, have welcomed an announcement by the governor that all lead lines in the city would be replaced over the next 18 months. Whitmer had previously proposed removing the service lines within five years – a timetable residents and environmental groups said was unacceptable.
- In 2018, testing revealed a lead content of 22 parts per billion – higher than that of nearby Flint at the height of the crisis that made that city a symbol of US environmental injustice.
- 2021 Guardian News & Media Limited

Consider the interplay between the lead source, the identified patient and the social setting

# Pre-existing Developmental concerns and Pica

Among preschool-aged children,  
the prevalence of pica

- 28% in children who had both ASD and co-occurring ID
  - 14% in children who had ASD without ID
  - 10% in children who had ID without ASD or autism symptoms
  - Less than 4% of children in the general population had pica.
- [https://www.cdc.gov/eis/conference/dpk/Prevalence\\_of\\_Pica\\_in\\_Preschoolers.html](https://www.cdc.gov/eis/conference/dpk/Prevalence_of_Pica_in_Preschoolers.html)

# Nutritional Practices

Food deserts

Food insecurity

Challenges in caregiving, meal planning

The fast food/convenience food culture

Child's personality

## Regularly Eat Healthy Foods

### The Importance of Iron, Calcium, and Vitamin-C

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Children with empty stomachs absorb more lead than children with food in their stomachs. Provide your child with four to six small meals during the day. The following nutrients can help protect your child from lead poisoning:

#### Foods with Iron

Normal levels of iron work to protect the body from the harmful effects of lead. Good sources of dietary iron include:

- Lean red meats, fish, and chicken
- Iron-fortified cereals
- Dried fruits (raisins, prunes)

#### Foods with Calcium

Calcium reduces lead absorption and also helps make teeth and bones strong. Good sources of dietary calcium include:

- Milk
- Yogurt
- Cheese
- Green leafy vegetables (spinach, kale, collard greens)

#### Foods with Vitamin C

Foods with vitamin C and iron work together to reduce lead absorption. Good sources of vitamin C include:

- Oranges, orange juice
- Grapefruits, grapefruit juice
- Tomatoes, tomato juice
- Green peppers

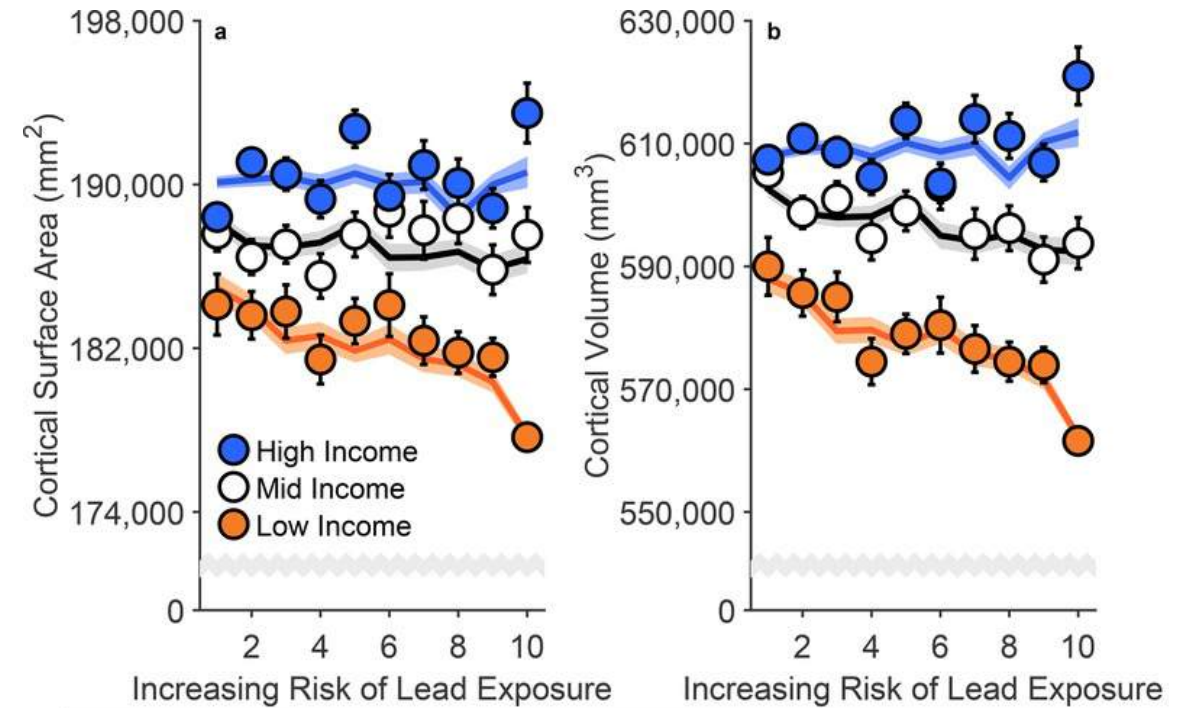
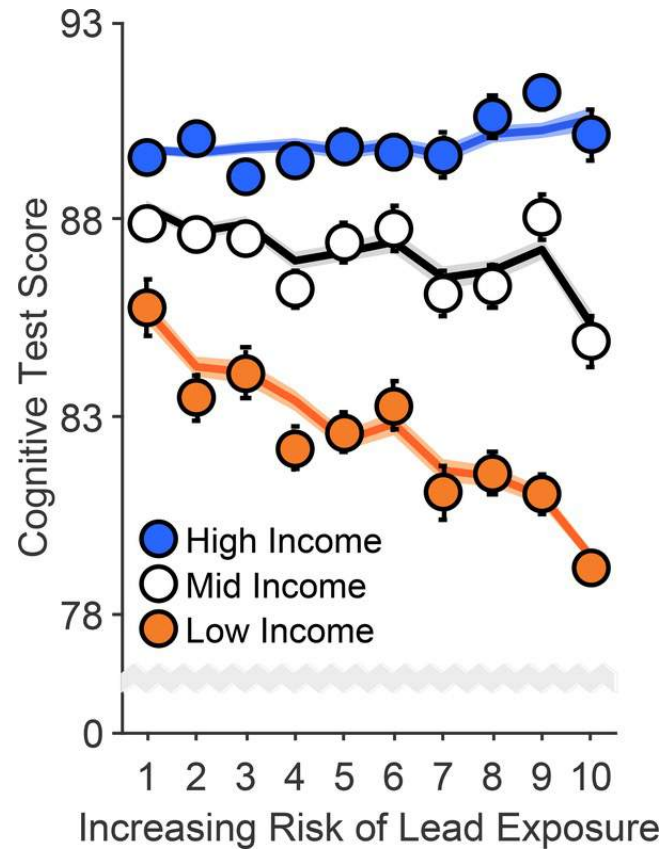
A **healthy diet** can help protect your child from the harmful effects of **LEAD**.



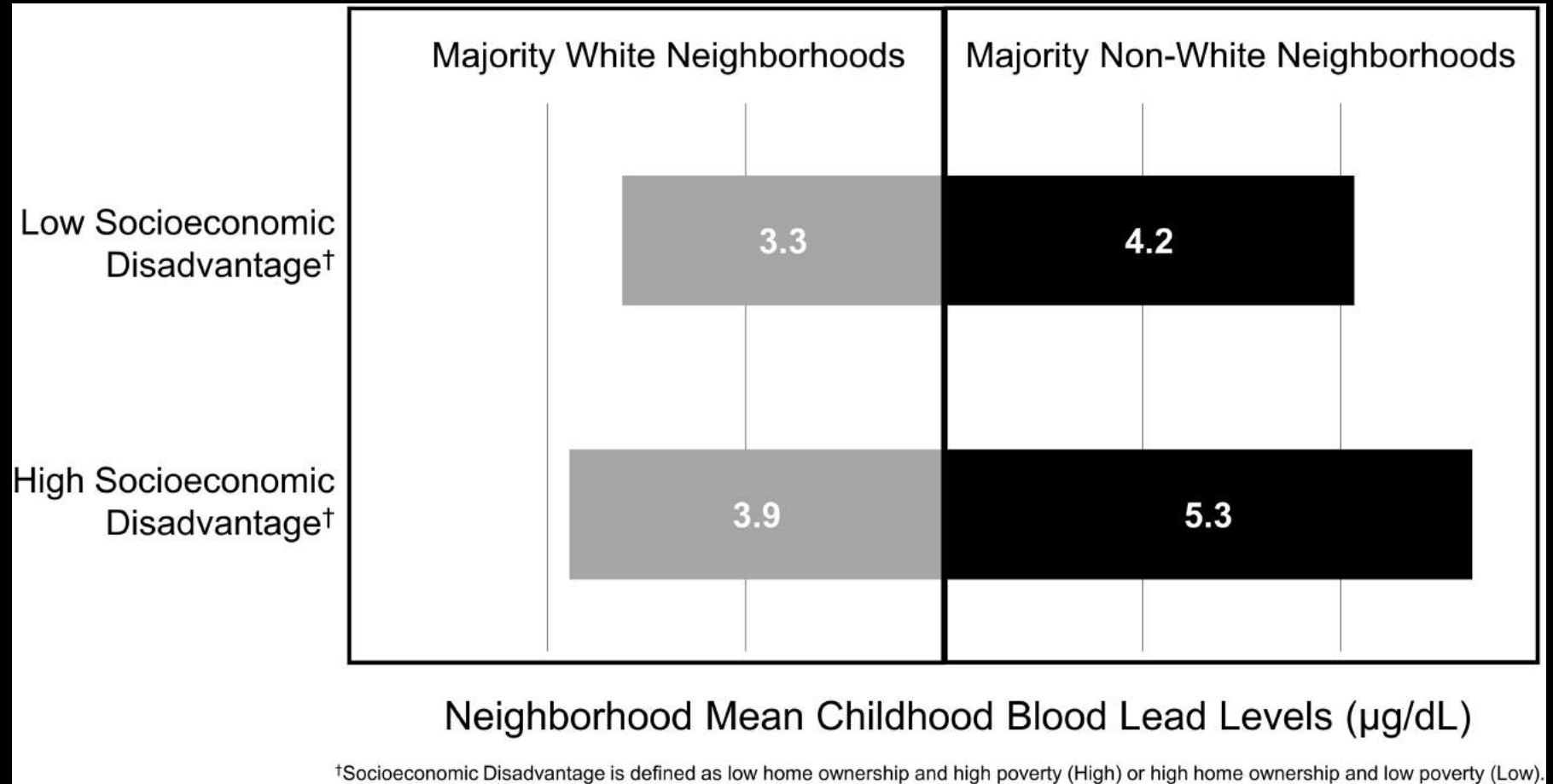
# Association of lead-exposure risk and family income with childhood brain outcomes

Nat Med. 2020 Jan; 26(1): 91–97.

**Higher Economic Status appears to give a protective effect**



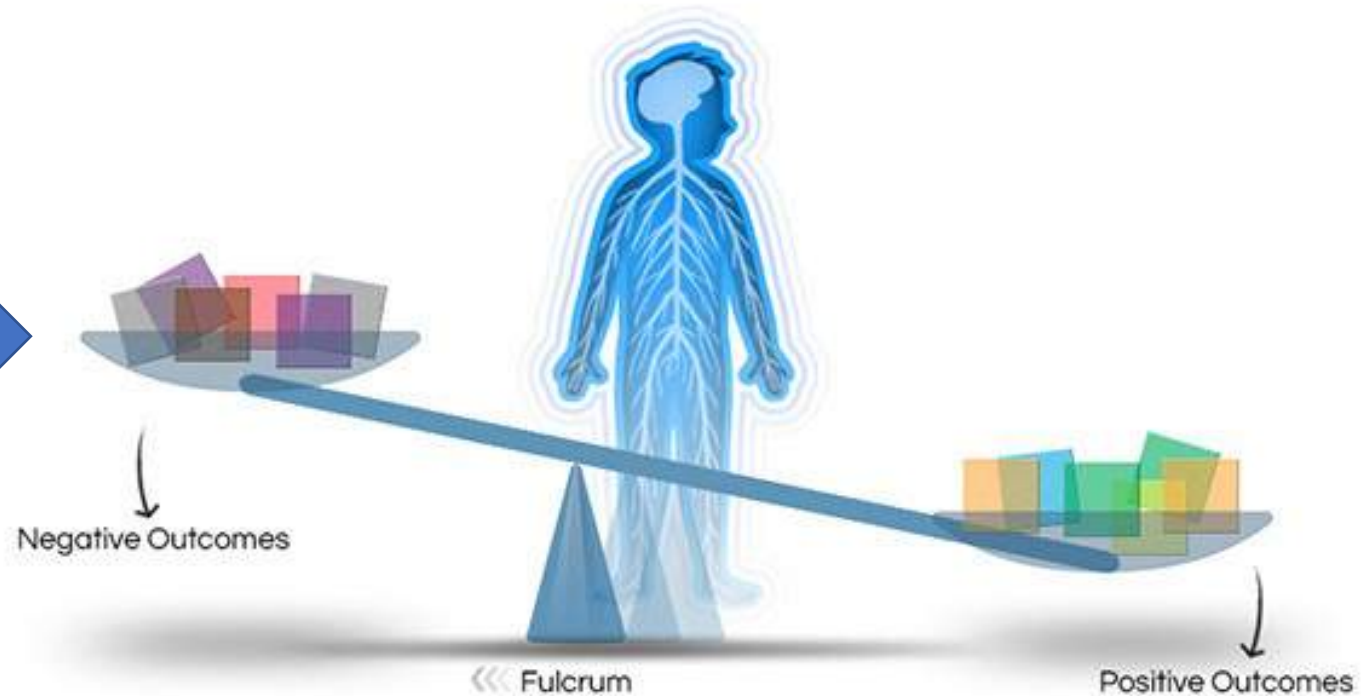
Risk of elevated blood lead level is greatest in neighborhoods with multiple risk factors, including high poverty, low home ownership, and majority non-White residents



# Lead, Childhood Resilience and ACES

## Lead Effects

- Diminished Attention
- Difficulty with prioritization
- Diminished ability to regulate
- Increased irritability
- Less judgement
- Increased impulsivity





How do we  
further reduce  
exposures?

Infrastructure  
changes

## 2021 Infrastructure Bill

- \$15 billion for lead pipe/service remediation.
- \$9 billion to help with lead reduction in disadvantaged communities
- \$970 million for rural water and waste-water programs, including lead remediation
- The actual cost of fully replacing lead pipes/lead services could be \$60 billion

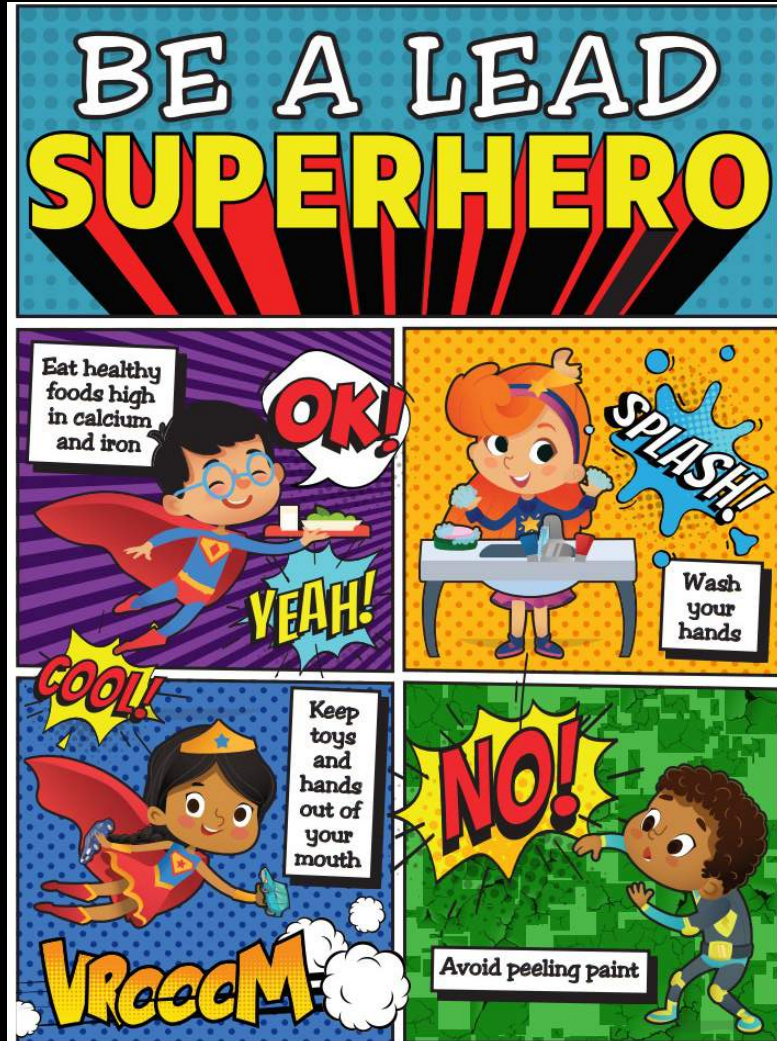
How do we  
further reduce  
exposures?

Litigation

- A judge in Michigan has approved a \$626 million settlement for Flint residents and others who were exposed to lead-contaminated water. The state is providing \$600 million of the settlement. The state was accused of repeatedly overlooking the devastating risks of switching Flint's water source in 2014 without treating the water to prevent contamination.

Posted at 5:19 PM, Nov 10, 2021 (AP MODIFIED)

The Personal Approach:  
Protect the Target



The Societal Approach:  
Get Rid of the Toxin

**Lead Policy & the Law:**

*It's more than Newark,  
It's more than water.*

**Wednesday, November 6**

**9 am – 1 pm**

**Seton Hall Law School**

Long before the recent headlines about lead contamination in Newark's drinking water, advocates have focused on the problem of lead poisoning from paint and the impact of poor housing conditions, particularly on children across the state.

This half-day symposium will address the current legal landscape for lead, lead hazard control enforcement, and tenant protections. We will consider the legal tools available and draw on experience from other states to determine best practices to improve the lives of all residents and end lead poisoning.

**SETON HALL | LAW**



Sponsored by:



# Regional Lead Poisoning Centers



# When you discover an elevation

- Develop a written plan for yourself and the family
- Consider evaluation for learning and development problems.
- Find the lead sources.
- Don't remodel or renovate until the home has been inspected for lead.
- Clean up lead dust using wet paper towels and all purpose cleaner
  - Windows, play areas, and floors.
- Wash hands and toys often with soap and water. Always wash hands before eating and sleeping.
- Have a nutritional plan
- Develop follow up plan: labs and clinical assessments
- Collaborate with local health department



# Primary Care Responsibilities

NYS DOH

- All children must get a blood lead test at or around age 1 and again at or around age 2 and whenever a potential risk of lead exposure is present.
- Any blood lead levels of 5 ug/dL or greater must be followed up. If it was a capillary/finger-stick level then the follow up must be a venous draw.
- For children with venous levels of 5 ug/dL or greater, the health care provider must complete a clinical lead exposure assessment on the patient and provide the local health departments with the following information:
  - Hemoglobin/hematocrit or CBC - Physical with complete neuro exam
  - Nutritional assessment including an assessment of iron, calcium, and Vitamin C intake and consideration of checking labs for iron deficiency
  - Developmental assessment using a standardized tool
- Two venous tests less than 5 ug/dL greater than 3 months apart for discharge from case management by the local health department.

# Nutritional support for lead exposure and prevention

1 serving of lean red meat or other iron rich foods. Iron fortified cereals are a good source.

2 servings of vitamin C rich fruit juices or fruits daily.

2 servings daily of dairy products or other calcium-rich foods are recommended.

One a day vitamin with iron and Zinc (Centrum Jr, Flintstones)

# Consider Hospitalization

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- Hospitalization may be necessary for symptomatic children and for those with BLL  $\geq$  45  $\mu\text{g}/\text{dL}$ . Hospital admission is also determined by several considerations:
  1. Is the child symptomatic?
  2. Are there unabsorbed lead-containing foreign bodies in the stomach or small intestine?
  3. Are there parental or other external factors making a safe discharge and timely follow-up difficult?
  4. Is the home unsafe with respect to sources of lead contamination readily accessible to the child?





in Syracuse

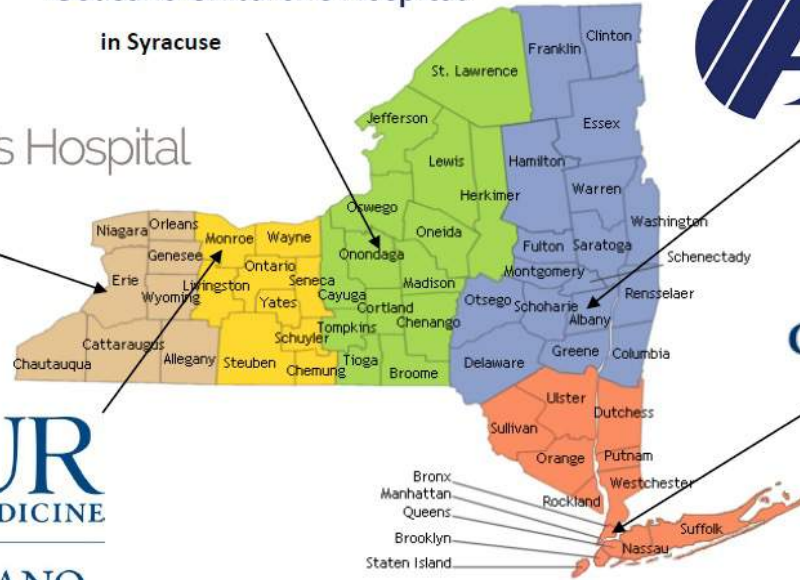


in Buffalo



GOLISANO  
CHILDREN'S HOSPITAL

in Rochester



ALBANY  
MEDICAL  
CENTER



in Bronx