LEAD:
Review Of
Current Science On Low-Dose Impacts,
Re-emerging Pathways Of Concern
Amended State Testing & Reporting Laws, &
Updated Case Management Guidelines

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Learning Objectives

- Discuss advancements in science of lead toxicity
- Identify recognized & re-emerging exposure pathways
- Recognize symptoms of mild and acute lead toxicity
- Implement relevant screening guidelines
- Understand LA’s amended testing & reporting laws
- Apply updated case management guidelines
Flint, MI Lead Water Crisis

Researchers: Lead levels up after Flint switches to cheaper water supply

Lead Poisoning in Flint
Children under 6 with elevated blood lead levels

- Above 5 m/d
- Above 10 m/d

Flint switches to water from Flint River
Flint switches back to water from Detroit

- Estimated 2000 children not born (high miscarriage risks)
- Estimated 200 fetal deaths (>28 weeks pregnancy)
- Hundreds of children lead poisoned >10 ug/dL
- Thousands of children lead poisoned >5 ug/dL

Source: Edwards 2009, 2014
Recent Poisonings Due to Lead in Drinking Water

Since 2004, drinking water implicated in several cases of high rates of childhood poisonings:

- Washington, DC
- Durham, NC
- Greenville, NC
- Providence, RI
- Flint, MI

(Source: Lambrinidou 2015)
What is Lead?

- Soft blue-gray metal
- Naturally occurring deep in earth's crust
Forms of Lead

Inorganic
- Form found in earth, paint, soil and water
- Most common form encountered form today

Organic
- Example: Tetraethyl lead in gasoline
- Form commonly found in work settings
- Can be more toxic because the body readily absorbs it
Uses of Lead

- Water pipes
- Paint
- Gasoline
- Consumer products
Properties

- **Soft** and pliable
  - Pipes bend, don’t break

- **Very stable**
  - Water pipes are resistant to corrosion
  - Paint is durable and resistant to moisture and mold
  - In gasoline raises temperature and pressure at which pre-ignition or engine knocking occurs

- **Very dense**
  - Effective shield against radiation
Used Since Antiquity

- Ancient Romans used it in plumbing
  - Latin word for lead “plumbus”
  - Pb = chemical symbol for lead
  - Where we “plumbing”

In modern times, added Ir to plumbing, paint, gasoline
  - Eliminated from paint in ‘70's
  - Banned from gas in ‘80s
  - Removed from brass plumbing in 2014
Properties Continued

- **Stable & accumulates** in body & environment
  - Does not degrade - stays in environment forever
  - Half-life of 20 years in bone
  - Found in everyone's body today
    - Levels in modern people are orders of magnitude greater than that of ancient times (Flegal 1995)

**Bioaccumulation**

![Bioaccumulation Diagram](image)
Where is it Found?

- Because of lead's stability, it is everywhere:
  - Peeling paint
  - House dust
  - Soil
  - Food
  - Water
  - Commercial products
Properties Continued

HIGHLY TOXIC

- **No safe level**
- **Affects all organ systems**
- **Developmental neurologic effects of greatest concern**
- **Effects can be permanent**

**High BLL (>70 µg/dL)**

- Convulsions
- Coma
- Death

**EFFECTS OF LEAD ON CHILDREN**

People ingest low levels of lead daily. Adults absorb relatively small amounts compared to that of children. Some of the health effects associated with lead exposure in children:

- Headaches, decreased IQ, attention-related problems and behavioral changes
- Hearing loss
- Anemia and hypertension
- Kidney problems
- Abdominal distress
- Constipation
- Muscle weakness

SOURCES: National Institutes of Health, Mayo Clinic, Frank Pompea, USA TODAY
‘Acceptable Levels’

CDC now acknowledges no safe BLL

- Current Reference Value is 5 ug/dL (as of 2012)
- 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.
No Safe Lead Dose

- Low BLLs cause learning deficits
  - Measurable deficits at BLL < 5 µg/dL
    - Lanphear et al. 2000
  - 7.4 point IQ reduction with BLL of 10 µg/dL
    - Canfield et al. 2003

- Nonlinear relationship between BLL & effects
  - First small BLL elevation may cause most of the neurological damage
    - Canfield et al. 2003

- Maternal BLL at population levels may effect fetus
  - Maternal BLL < 1 µg/dL associated with decrease in birth weight & gestational age
    - Rabito et al. 2014

Suggests more important role for relatively smaller exposures... like drinking water
Childhood Lead Poisoning Rates

Elevated Blood Lead (EBLL: \(\text{EBLL}: >5 \text{ ug/dL}\)) for children < 72 months

United States
- 5% EBLL
- 13% Tested
- 2010-2014

Louisiana
- 11% EBLL
- 5% Tested (<72 months)
- 2010-2014

New Orleans
- 8% EBLL (2011-2015)
- 16% tested (2011)

Flint MI
- 5% EBLL (2015)
LA’s Universal Blood Screening & Mandatory Reporting

LA Administrative Code: LAC 48: V. §7005, §7007, §7009

- **Mandatory screening** in ALL LA parishes
  - Children age 6-72 months

- **Mandatory reporting**
  - Regardless of BLL
  - By all health care providers and labs to LA Healthy Homes and Lead Poisoning Prevention Program by fax to (504) 568-8253

- BLL ≥ 10 ug/dL within 24 hours
- BLL < 10 ug/dL within 5 business days

- Medicaid and WIC children must be tested
- Lead Testing Kits can be obtained from Tamarac Medical Laboratories: 1-800-842-7069
LDHH’s NOLA Pediatrician Survey (2012)

- 54% did not think lead exposure was a problem in New Orleans
- 66% were not aware of LA’s requirements to report all cases
- 32% were not aware of LA’s screening requirements
- 33% do not routinely screen children at least once
- 21% had never received education on lead poisoning, diagnosis and treatment during their residency
Louisiana Provider Information

LA Dept of Health and Hospitals, Office of Public Health, Healthy Homes and Lead Poisoning Prevention Program

Provider Toolkit

How Are People Exposed?

**Exogenous exposure**
- Dust, paint, and/or soil
- Food or beverages
- Drinking water
- Home remedies
- Cosmetics and hair products

**Endogenous exposure**
- Leaching from bones and soft tissues
Lead in Food Products

Food or beverages contaminated via:

- Production
- Packaging
- Storage
Lead in Cosmetic & Commercial Products

Cosmetic & commercial products
- See CPSC for products with lead
- See FDA for cosmetics with lead

Products such as:
- Computers
- Ceramic glazes
- Fishing weights
- Bullets
- Jewelry
- Automotive batteries
- Airplane gasoline
- Bridge paint

Imported or pre-regulation products
Lead in Ethnic Products

**Mexican:**
Azarcon, greta, liga, Maria Luisa, alarcon, coral, rueda

**Asian:**
Chuifong, tokuwan, ghasard, bali goli, kandu, surma, ba-baw-san

**Middle Eastern:**
Alkohl, saoott, cebagin
Lead in Drinking Water

Lead enters water by leaching:
- Lead-containing pipes
- Brass faucets
- Solder

Boiling concentrates lead

Running water may (or may not) reduce exposure
Indirect Lead Exposure from Water is Underestimated

- Vegetables can absorb >90% of lead in water from cooking (Moore 1983)
  - Green vegetables, carrots, rice and spaghetti concentrate more lead than other foods (Smart et al 1983)

- Humans absorb lead more readily from drinking water more readily (30-50%) than via food (10-15%) (EPA 1986)
  - Concentration effect can outweigh the absorption factor

- Cases of lead poisoning from water documented in cases where water used for cooking only- not drinking (Triantafyllidou et al 2007)
Lead in Work Environments

- **Ingestion**
  - *Swallowing lead dust*

- **Inhalation**
  - *Breathing contaminated air*

- **Contact**
  - *Skin absorption (organic only-e.g., tetraethyl lead)*

- **Take home exposures**
  - *On clothes or skin*
What Jobs Involve Lead?

- Lead smelting or mining
- Construction/remodeling
- Automobile repair
- Plumbing
- Police officers/military
- Many others
What Hobbies Involve Lead?

- Car repair
- Artistic painting
- Stained glass
- Pottery glazing
- Soldering
- Target shooting
- Making bullets, slugs or fishing sinkers
Biologic Fate

- Most lead is excreted
- Rest is exchanged between the blood, soft tissues, & mineralizing tissues
BONES
- 95% remaining in body absorbed into long bones
- Half-life: 20 years
- Released during osteolysis

BRAIN, LIVER, KIDNEYS
- 4% in body goes to soft tissue
- Half-life: 40 days

BLOOD
- 1% circulates in blood
- Half-life: 25 days
- Crosses placenta & fetal blood brain barrier (open)
Release of Lead During Bone Breakdown

- Lead in mobilized from the skeleton during pregnancy, the post-natal period, menopause and in osteoporosis.

- Lead levels peak in childhood & middle age.

- More in men (work/hobby)? than women (post-menopause?) (NHANES 3).

- Lead follows calcium into and out of bone.
State of the Evidence: Low Dose Health Effects

- Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention. CDC Work Group of the Advisory Committee on Childhood Lead Poisoning Prevention (2012)

- Eliminated “BLL of concern”
  - No safe level identified
  - Irreversible damage

- Reference value = 5 ug/dL
  - Elevated BLL
    - 97.5th percentile of NHANES BLL distribution for children 1-5 yrs old

- Primary prevention emphasized
  - Interventions for high BLLs no longer acceptable

- Medical Actions
  - Education
  - Environmental investigations
  - Medical monitoring
  - Iron deficiency
  - Nutrition (CA, Vitamin C)
  - Prenatal counseling
Health Effects of Low Dose Lead

- National Toxicology Program Monograph (2012)
  - Evaluated evidence on health effects in children and adults associated with <10 and 5 micrograms of Pb per deciliter of blood (ug/dl)

- Sufficient evidence
  - Chance, bias and confounding ruled out

- BLLs < 10 and 5 ug/dL associated with health effects in adults and children
  - Neurological
  - Immunological
  - Cardiovascular
  - Renal
  - Reproductive or developmental
  - Endocrine
Sufficient Evidence

< 5 ug/dL

**Children**
- Decreased academic achievement, IQ, cognitive measures
- Increase in attention-related
- Problem behaviors

**Adults**
- Decreased kidney function
- Reduced fetal growth

< 10 ug/dL

**Children**
- Delayed puberty
- Reduced postnatal growth
- Decreased IQ
- Decreased hearing

**Adults**
- Increased blood pressure and risk of hypertension
- Increased tremor
Limited Evidence

< 5 ug/dL

Children
- Delayed puberty
- Decreased kidney function

Adults
- Increased tremor

< 10 ug/dL

Children
- Increased allergy

Adults
- Psychological effect
- Decreased cognitive function
- Decreased hearing
- Increase in ALS
- Increase cardiovascular-related mortality
- Spontaneous abortion
- Preterm birth
Childhood Lead Exposure

-- EARLY LIFE EXPOSURES CAN RESULT IN LONG TERM PROBLEMS --

- Low Grades
- Absenteeism
- Reading Disability
- High School Drop Out

![Graph showing special education status by blood lead level](image)
ATMOSPHERIC LEAD EMISSIONS AND AGGRAVATED ASSAULT

(New Orleans)

Fig. 3. The data of two series on the X axis for New Orleans, Y1 axis indicating the annual incremental increases and decreases of atmospheric Pb emissions (total = 10,179 mT) and the Y2 axis showing the annual aggravated assault rate as reported to the FBI by the New Orleans police.
Toxicology of Lead

- Lead disrupts structural components of blood-brain barrier.

- Within brain, lead damage occurs in prefrontal cerebral cortex, hippocampus and cerebellum.

- Although molecular targets for lead unknown, evidence suggests that lead disrupts processes regulated by calcium.

- At a neuronal level, lead alters the release of neurotransmitter from presynaptic nerve endings.

- Disruption of neuronal activity may alter developmental processes of synapse formation.

- Can result in a less efficient brain with cognitive deficits.
Lead and Dementia

- Tetraethyl lead intoxication in rabbits was followed by formation of neurofibrillar tangles in degenerating neurons, a characteristic of Alzheimer's pre-senile dementia.
  - *Nildowitz, 1971. Neurology*

- BLLs as low as 8 micrograms/dl were significantly associated with poorer cognitive function. Even a slight decrement in cognition would have a large public health impact due to the large number of elderly at risk.

- Low levels of lead contribute to impairments in cognitive function among elderly men.
Cardiovascular Effects

Increases risk of high blood pressure and **hypertension**

**High Blood Pressure**

High blood pressure is a sign that the heart and blood vessels are being overworked.

Untreated, the disease can lead to atherosclerosis and congestive heart failure.

- **Enlarged heart** (heart failure)
- **Atherosclerosis**
Hematologic Effects

- Interferes with production of hemoglobin
  - Can induce two kinds of anemia:
    - Acute exposure → hemolytic
    - Chronic exposure → synthetic

- Threshold for adults: 50 µg/dL

- Threshold for children: 40 µg/dL
Complete Blood Count

May show **basophilic stippling*** in patients with extended significant exposure.

*Also seen in arsenic poisoning, basophilic stippling refers to the small dots of ribosomes at the periphery of erythrocytes in a blood smear.*
Renal Effects

- Acute exposure (short exposure)
  - Reversible effects

- Chronic exposure (long exposure)
  - Nephropathy
    - Spaces between kidney tubules become swollen (inflamed)
  - Childhood exposures $\rightarrow$ adult renal disease
Endocrine Effects

Chronic exposure may affect thyroid function

- Breathing
- Heart rate
- CNS & PNS
- Body weight, etc
- Muscle strength
- Menstrual cycles
- Body temperature
- Cholesterol levels
Who is Most at Risk?

Children, pregnant women & fetuses

CDC’s recommendations:
- Managing blood lead levels (BLLs) in children
- Managing BLLs in pregnant and lactating women
Developmental & Reproductive Effects

Crosses placental barrier

Children:
- Delayed puberty
- Impaired neurologic development

Women:
- Reduced fetal growth
- Miscarriages & still birth
- Preterm birth

Men:
- Decreased fertility
- Decreased sex drive
Children’s Vulnerability

CHILDREN more vulnerable than ADULTS

- **Size**
  - Consume more food per size
  - Inhale more air per size

- **Developing**
  - Nervous system
  - Increased need for calcium

- **Absorb lead well orally**
  - ~50% absorbed in kids vs ~10% for adults

- **Hand to mouth activity**
  - Pica- appetite for substances that are largely non-nutritive
Clinical Evaluation

Preventive screening

Exposure history

Physical evaluation

Signs and symptoms
Screening and Case Management Guidelines for Health Care Providers

Children
- CDC’s Guidelines: Managing Elevated BLLs Among Young Children (2002)
- Update (2005)
- Low Dose Lead Management (2007)
- Screening of Medicaid Children (2009)
- Update on BLL Reference Level (5 ug/dL) (2012)

Pregnant & Lactating Women
Exposure History

Home
• Age and condition
• Home remodeling activities

Family history
• Maternal exposure
• Unusual medicines or home remedies
• Imported or glazed ceramics or lead crystal
• Siblings or playmates with lead poisoning

Occupations

Hobbies
Risk Factors

- Renovating or remodeling home
  - Children in old housing at risk
    - 83% of NOLA built before 1978 ban on lead-paint
    - Lead-based paint in 1/3 of US homes (pre-1978)
- City with lead service lines or corrosive water
- Recent immigrant
- Near industrial source
- Use lead-glazed ceramic pottery
- Pica (eat or mouth non-food)
- Use alternative medicines/herbs
- Use imported cosmetics/food
- High-risk hobbies
- History of lead exposure
- Child, friend, co-worker or relative with elevated lead
- Racial and socioeconomic disparities persist
Physical Examination

- Neurologic
- Hematologic
- Cardiovascular
- Gastrointestinal
- Renal
- For children: hearing and nutritional status
Observable Symptoms from lead are rare!

<table>
<thead>
<tr>
<th>MODERATE</th>
<th>SEVERE</th>
<th>MEDICAL EMERGENCY</th>
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<tbody>
<tr>
<td>Children &gt; 25 µg/dL (1.2 µmol/L)</td>
<td>Children 55 to 70 µg/dL (2.64 to 3.38 µmol/L)</td>
<td>Children &gt; 70 µg/dL+ (3.38+ µmol/L)</td>
</tr>
<tr>
<td>Adults &gt; 60 µg/dL</td>
<td>Adults &gt; 80 µg/dL+</td>
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<tr>
<td>Muscle pains</td>
<td>Arthralgia</td>
<td>Paresis or paralysis</td>
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<tr>
<td>Paresthesia</td>
<td>General fatigue</td>
<td>Paralysis</td>
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<tr>
<td>Mild fatigue</td>
<td>Poor concentration</td>
<td>Brain oedema</td>
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<tr>
<td>Aggressiveness</td>
<td>Tremor</td>
<td>Stupor or coma</td>
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<tr>
<td>Irritability</td>
<td>Headache</td>
<td>Fits and vomiting</td>
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<tr>
<td>Lethargy</td>
<td>Diffuse abdominal pain</td>
<td>Gingival lead line</td>
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<tr>
<td>Abdominal discomfort</td>
<td>Constipation</td>
<td>Colic</td>
</tr>
<tr>
<td></td>
<td>Weight loss</td>
<td>Death</td>
</tr>
</tbody>
</table>
Signs and Symptoms

- Patient may appear asymptomatic
  - Symptoms vary by exposure level

- Impaired abilities may include
  - Decreased learning & memory
  - Lowered IQ
  - Decreased verbal ability
  - Impaired speech and hearing functions
  - Early signs of hyperactivity or ADHD
Signs and Symptoms: **Low Toxicity**

- Myalgia (muscle pain)
- Paresthesia (pins and needles)
- Irritability
- Lethargy
Signs and Symptoms: Moderate Toxicity

Symptoms for low toxicity and.....

- Arthralgia (joint pain)
- Hearing loss
- Difficulty concentrating
- Hypertension

- Tremor
- Headache
- Vomiting
- Weight loss
- Constipation
- Anemia
Signs and Symptoms: Severe Toxicity

Fore-mentioned symptoms and...

- Kidney damage
- Infertility
- Paresis (weakness of movement) or paralysis
- Encephalopathy (brain disease or damage)
  - Seizures, coma and death
- Blue-black gums

- Colic
  - Intermittent, severe abdominal cramps

Burtonian line (blue line on gums) is seen in lead poisoning
New Orleans late 1850s:
- Lead in pipes

Dr. Fenner - Editor of Southern Medical Reports
- People with colic improved once stopped drinking city water

NOLA Colic epidemics: 1838, 1849, 1850
- Years when lead pipe laid out in New Orleans

In subsequent years:
- Doctors in CA, AL and TX link colic epidemics to lead pipes
- Galveston banned lead pipes

(Source: Troesken 2006. The Great Lead Water Pipe Disaster)
# Lead Pipes, USA (by 1990)

<table>
<thead>
<tr>
<th>City</th>
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<tbody>
<tr>
<td>New Orleans</td>
<td>Pittsburgh</td>
<td>Kansas City</td>
<td>Fall River</td>
<td>Grand Rapids</td>
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<td>New York</td>
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<td>Hartford</td>
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<td>Baltimore</td>
<td>Jersey City</td>
<td>Columbus</td>
<td>Lowell</td>
<td>Reading</td>
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<tr>
<td>Cleveland</td>
<td>Louisville</td>
<td>Worchester</td>
<td>Albany</td>
<td>Etc, etc......</td>
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<tr>
<td>Buffalo</td>
<td>Minneapolis</td>
<td>Syracuse</td>
<td>Cambridge</td>
<td>Some cities required use of LSLs</td>
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<tr>
<td>San Francisco</td>
<td>Providence</td>
<td>New Haven</td>
<td>Portland</td>
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<td>Cincinnati</td>
<td>Indianapolis</td>
<td>Paterson</td>
<td>Atlanta</td>
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</table>
Laboratory Tests

**CDC Guidelines** (see also)

Children must be tested
Covered by Medicaid and most private insurance
BLLs are generally highest in summer

**Blood Tests**
- **Capillary** or finger stick
  Prone to contamination
- **Venous** blood sample
  To confirm elevated capillary

**Others to test:**
- Pregnant women
- Couples with reproductive difficulties
- People with:
  - High blood pressure
  - Kidney disease
  - People with diseases of the kidney
  - Diseases of the immune system
  - Diseases of the nervous systems
  - Anemia
  - GI tract conditions
BLL Testing

For adults
- **OSHA guidelines** for workers
  - ≥50 µg/dL - remove from job
  - ≥ 40 µg/dL - notify
  - > 10 µg/dL - remove pregnant woman

- **CDC guidelines** for pregnant women

For children
- **CDC guidelines**
  - Test children at ages 1 & 2
  - Test children annually to age six if high-risk

State or local guidance
- For blood testing and reporting requirements
### CDC’s Management Guidelines for Children

<table>
<thead>
<tr>
<th>Iron Level</th>
<th>Actions</th>
</tr>
</thead>
</table>
| ≤ 5 μg/dL  | • Education  
|            |   • Dietary  
|            |   • Environment  
|            |   • Follow up testing |
| 5 – 45 μg/dL | • See previous  
|            |   • History  
|            |   • Physical exam  
|            |   • Lab work: iron levels, hemoglobin and hematocrit  
|            |   • Environmental investigation  
|            |   • Neurodevelopmental monitoring  
|            |   • Abdominal X-ray if indicated |
| 45 – 69 μg/dL | • See previous  
|            |   • Consider chelation therapy and hospitalization if safe environment cannot be provided |
| > 70 μg/dL   | • See previous  
|            |   • Hospitalize  
|            |   • Chelation therapy in consultation with toxicologist |
## CDC’s Retesting Guidelines for Children

<table>
<thead>
<tr>
<th>If BLL (ug/dL):</th>
<th>Confirmatory testing in:</th>
<th>Continue tests if after intervention, BLL is (ug/dL):</th>
<th>Re-tests (2-4 tests) after source identification in:</th>
<th>Follow-up test (after BLL decline) in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 – 9</td>
<td>1-3 months</td>
<td>5-9</td>
<td>3 months</td>
<td>6-9 months</td>
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<tr>
<td>10 – 44</td>
<td>1 week – 1 month</td>
<td>10-19</td>
<td>1-3 months</td>
<td>3-6 months</td>
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<tr>
<td>45 – 49</td>
<td>48 hours</td>
<td>20-24</td>
<td>1-3 months</td>
<td>1-3 months</td>
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<tr>
<td>60 – 69</td>
<td>24 hours</td>
<td>25-44</td>
<td>2 weeks-1 month</td>
<td>1 month</td>
</tr>
<tr>
<td>&gt; 70</td>
<td>Urgently</td>
<td>≥45</td>
<td>ASAP</td>
<td>ASAP</td>
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Greater exposures in summer may necessitate more frequent follow-ups.
CDC Recommendations for Screening Pregnant and Lactating Women

- CDC’s Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women
  - Recommendations for
    - Exposure prevention
    - Blood testing
    - Medical management
    - Breastfeeding
    - Follow-up

- Fetal lead exposure at levels found in US results in
  - Low birth weight
  - Later life health conditions in adults exposed in utero

- Further research needed:
  - Lead kinetics across the placenta and in breast milk
  - Their relationship to long-term health effects
  - Effectiveness of chelating agents in pregnant woman
  - Optimal timing of blood lead testing during pregnancy

- Prenatal exposure impairs children’s neurodevelopment:
  - Developmental delay
  - Reduced IQ
  - Behavioral problems
Risk Factor Screening for Pregnant and Lactating Women

- In **high-risk** populations
  - Conduct *routine testing* of pregnant women

- In **low-risk** populations
  - Conduct screening and perform blood *testing if a single risk factor is identified*

- Risk factors for pregnant women:
  - Recent immigration
  - Pica practices
  - Occupational exposure
  - Nutritional status
  - Use of traditional remedies, imported cosmetics, lead-glazed pottery
  - Reside in older homes
    - Lead-based paint- If renovating or remodeling
    - Water- Cities with historical use of lead service lines
    - Soil- Near well traveled roads or industrial sources
Pregnant and Lactating Women

**BLL ≥5 µg/dL**
- Follow-up testing
- Environmental & occupational history
- Behavioral interventions to reduce exposures
- **Nutritional** intervention
  - Provide prenatal vitamins
  - Calcium and iron intake

**BLL > 10 µg/dL**
- In occupational settings, pregnant workers should be removed from source

**BLLs ≥15 µg/dL**
- ID source with local health department, which will conduct an environmental investigation of the home

**BLL ≥45 µg/dL**
- Chelation therapy during pregnancy or early infancy may be warranted
- Consultation with expert in lead poisoning
Chelation Therapy

Risk: Remobilizing lead from bones!

• Little knowledge of benefits or hazards
  • Consult with physicians or medical centers with chelation therapy experience

• Use only when:
  • Adults: BLL >45 ug/dL
  • Child: BLL >45 ug/dL & exhibiting signs of encephalopathy

Chelators

• Ca EDTA
  • Only intravenous IV chelating agent recommended for children

• Na₂EDTA
  • Can cause hypocalcemia (low Ca in blood serum) and death

• Dimercaprol or BAL
  • Has toxic effects

• Succimer
  • Failed to improve neurodevelopmental scores
Breastfeeding

CDC encourages mothers with BLLs $<40 \mu g/dL$ to breastfeed

Mothers with higher BLLs encouraged to pump and discard their breast milk until BLLs drop below 40 $\mu g/dL$
Lead - Nutrition

To reduce lead absorption:
• Calcium and Iron
  • Lead absorption increases if diet is poor in iron or calcium

To reduce lead storage in bone:
• Vitamin D (from sun)
  • Enhances intestinal absorption of calcium and iron

To increase excretion:
• Vitamin C
  • Has chelating properties and can increase excretion
• B1 (thiamine or thiamin)
  • Increases excretion from brain
• B9 (folate or folic acid)
  • Increases excretion more than is increases absorption
Clinical Management

Most important step is removal of lead exposure

- Referral to health department
- Environmental Investigations
- Other potential sources of lead
- Education about prevention
Reduction of Home Hazards

- **Food**
  - Wash before eating

- **Paint**
  - Avoid renovation sites & paint over old paint

- **Water**
  - NSF-certified filter

- **Dust**
  - Wet wash and HEPA vacuum

- **Toys/other**
  - Wash toys
  - Remove recalls
    - CPSC’s site
  - Lead check swabs

- **Soil**
  - Remove shoes at door
  - Wash outdoor pets
  - Plant grass over soil
Household Interventions for Preventing Domestic Lead Exposure in Children (2014)

Reviewed 14 randomized and quasi-randomized studies of interventions for lead poisoning

- Specialized cleaning, repairs, maintenance
- Soil abatement (removal and replacement)
- Painting and temporary containment of lead hazards.

Results

- Educational and dust control interventions were not effective in reducing BLLs in children
- Insufficient evidence that soil abatement or combination interventions reduce BLLs
- Water-based interventions were not evaluated

Trials are needed to evaluate interventions for multiple sources
Ways to Reduce Lead Exposure from Water

Free
- Clean home faucet aerators once every 1-2 weeks
- Use only cold tap water collected at low flow for cooking, drinking & baby formula
- Flushing > 5 minutes

Expensive (> $100)
- Reverse osmosis
- Water distilling systems

Very expensive (> $3000)
- Replace entire lead service line (LSL)

Low to medium cost (< $100)
- Get water filter
  - Be sure it’s an NSF-certified filter
  - Be sure to replace filter as directed

Faucet aerator screens collect lead solder particles
Sources of Lead in Drinking Water

- **Ductile iron main**

- **Lead service lines (LSLs)**
  - Banned in 1986
  - Source of 50-75% of lead at tap (Sandvig 2008)

- **Leaded brass**
  - Meters, faucets, valves, connectors, etc
  - 8% lead allowed in “non-leaded” pipe (pre-2014)
  - Discharged enough lead to produce 2.4 IQ deficit in children consuming 2L of water/day (Maas 2005)

- **Leaded solder**
  - Common in homes before 1986
Low Dose Lead in Water Impacts

“Low level but widespread lead exposures from drinking water may have disproportionately large health effects” (Maas ‘05)

- Water lead levels (WLLs) as low as 5 µg/L significantly increased BLL in young women- excluding tap water resulted in 37% BLL drop (Fertmann 2004)

- Cumulative exposure to WLLs of 1 µg/L could lead to 35% increase in childhood BLL after 150 days (Ngueta ’15)
EPA Alerts

“Compliance with [EPA’s Lead and Copper Rule] ... does not guarantee, or even imply, that all individuals in the city are protected from lead-in-water hazards”

EPA Alerts

“The drinking water industry lacks the knowledge or methods to completely prevent or control particulate lead release.”

Ineffective Control of Particulate Lead

- Utility strategies to reduce soluble lead by lowering pH increases particulate lead (Masters and Edwards 2015)

- Highly erratic and difficult to monitor

- Easily dissolved by stomach acid
- Can lodge in intestine for long periods

A) Pure lead, B) Lead (IV), C) Solder (50:50 lead: tin); D Red brass, E) Yellow brass. All particles small enough to pass through the 1.0 mm openings of a faucet aerator screen (Source Triantafyllidou et al 2007).
Utility Sampling Instructions

“Current sampling protocols will often considerably underestimate the peak lead levels and overall mobilized mass of waterborne lead in a system with lead service lines.”

- Miguel Del Toral, EPA Reg. 5
The Guardian reviewed water sampling instructions from 81 cities east of Mississippi River:

- **33 cities & 2 states defied EPA guidance**
- **21 cities pre-flushed pipes**
- **7 cities removed aerator**
- **23 cities collected water at low flow**

### Source

LCR Compliance Sampling Inconsistently Effective at Detecting Highest Water Lead Levels

First Draw Versus Flushed Sample

- Higher Flush Sample
- Higher First Draw Sample

1:1 line
- 30 sec
- 2 min
- 3 min

Flushed Lead (ug/L)
First Draw Lead (ug/L)
Ineffective Detection of Particulate Lead

- Compliance testing methods with brief low acid digestions after sample transfer into new bottles can miss up to 96-98% of lead—mostly particulate lead

(Triantafyllidou et al 2007, ‘11, ‘12)

Reddish-colored particles were observed on the bottom of plastic sampling bottles even after three months’ exposure to 0.15% nitric acid.

Source: Triantafyllidou et al 2007
Ineffective Oversight

- **Government Accountability Office 2006**
  - ‘Drinking Water: EPA Should Strengthen Ongoing Efforts to Ensure that Consumers are Protected from Lead Contamination’

  - “Key data on the status of water systems' efforts to implement the lead rule, including required corrective actions, were incomplete.”

  - “EPA's data on lead rule violations were questionable because of potential underreporting by the states.”

  - “EPA, should take a number of steps to further protect the American public from elevated lead levels in drinking water.”

- Two aspects of LCR could benefit from improved oversight:
  - Ensuring sampling sites reflect areas at highest risk
  - Deciding which water systems are eligible for less frequent monitoring
10% of tap water samples collected by water utilities are allowed to have any lead level over EPA’s Action Level (AL)
Example of LCR-Compliant City

- ~1% of homes in city of 500k with large proportion of high risk homes predicted to have average WLL ≥70 ppb (5000 homes)
  - ~70% of these households may have 1-2 children (~3500-7000 children)
  - ~60% of these kids may have elevated blood lead levels (>5 ud/dL) just from water (≥ 70 ppb) alone (EPA’s IEUBK model)

- May translate into estimated 2,100-4,200 lead-poisoned children
LCR Revisions

EPA estimates it will release a revised Lead and Copper Rule in 2017... or 2018
New Orleans’ Water Distribution System

• 1,700 mile pipe network with > 160k service connections

• 65-80% New Orleans water service lines are pure lead pipes, (Mayes 1989)

• Over time NOLA turned to cast iron pipes caulked with lead

Figure 1. Part of a lead service line removed from a New Orleans home (May 2, 2016).
Lead Detections

Percent with Detected Lead

- Sample %: 86
- Home %: 95

- Undetected (<0.2 ppb):
  - Sample %: 14
  - Home %: 5

- Detected (>0.2 ppb):
  - Sample %: 72
  - Home %: 95
Exceedance of Water Lead Standards

95% > Cal-EPA PHG:
CA’s Public Health Goal based on neuro-developmental effects in fetuses & infants (2009)

23% > FDA AL:
US Food & Drug Administration’s Allowable Level, bottled water (1994)

9% > WHO-GV:
WHO’s Provisional Guidance Value based on treatment & analytical achievability (2011)

5% > EPA-AL:
US EPA’s Action Level based on projected distribution of US WLLs (water lead levels) (1991)
Inadequate Exposure Reduction Recommendations

53% of sites sampled had increased water lead levels after flushing according to one of the prevailing guidelines for flush times to reduce exposures.

<table>
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<th>Condition</th>
<th>Percentage</th>
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</tr>
<tr>
<td>Decreased with any flush</td>
<td>42</td>
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<tr>
<td>Increased with any flush</td>
<td>53</td>
</tr>
<tr>
<td>Same 2 min</td>
<td>6</td>
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<tr>
<td>Decreased 2 min</td>
<td>50</td>
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<tr>
<td>Increased 2 min</td>
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<tr>
<td>Same 30 sec</td>
<td>5</td>
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<tr>
<td>Decreased 30 sec</td>
<td>44</td>
</tr>
<tr>
<td>Increased 30 sec</td>
<td>51</td>
</tr>
</tbody>
</table>

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**Figure 3. Percent of Sites by Water Lead Level vs 1st Draw Sample**

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**S&W&B Consumer Confidence Report (2014)**

**EPA’s Current Public Notification Handbook**

**ATSDR Public Health Statement for Lead**

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Childhood lead poisoning is associated with multiple sources

At-risk Areas

- Bywater/St Claude/7th Ward/Marigny/Treme
- Garden District/Irish Channel/St Thomas/Central City/Touro/Riverside
- MidCity/Bayou St John
- Uptown
- Algiers

Media Childhood Blood Lead Level (ug/dL) (2015)

- 0.500000 - 1.100000
- 1.100001 - 1.800000
- 1.800001 - 2.700000
- 2.700001 - 4.300000
- 4.300001 - 6.800000

Maximum Water Lead Level (ug/L) (2015-2016)

- 0.0 - 4.9
- >4.9 - 10.0
- >10.0 - 15.0
- >15.0 - 49.2
- >49.2 - 220.2

Soil map courtesy of Dr. Howard Mielke, Tulane University (2006-2015)

Childhood blood lead data courtesy of LA Department of Health and Hospitals
Lead highest in stagnant water

Can occur in schools/daycares & blighted homes

New Orleans: 21% blighted (2012) empty or blighted lots

We’ve seen water lead levels as high as 195 ppb at a low-use site
FEMA- Funded Water Line Replacements

- 135 miles of NOLA pipes being replaced
  - 16,000 partial service line replacements (PLSLRs)

- PLSLRs can dislodge high lead scales and sediment

- Can increase water lead levels for up to 6 months or more
  - 121 ppb 2 days post-PLSLR

- High cost of service lines replacements can create environmental justice issues
State Lead Poisoning Prevention Programs
Overlook Water

**CDC’s “Managing EBLLs Among Young Children” (2002)**
- “If prior testing of a public water system shows that lead contamination is not a problem ... no additional testing is necessary, unless no other source of a child’s EBLL can be found.”

Many lead poisoning programs **never test water** during home investigations

- 2006-17 cities/states (Edwards ‘09)
  - 24% never test water
- 2008-38 programs (Renner ‘09)
  - 18% never test water
ATSDR

Everything you ever wanted to know about lead but were afraid to ask

**Lead Toxicity Profile:**
- What is lead
- Where is it found
- Exposure routes
- At risk populations
- US standards
- Biological fate
- Physiological effects
- How to evaluate patients
- Testing to diagnose
- Treatment and case management
- Instructions for patients
- Patient education sheets
- Information sources
How can I get more Information?

- Regional poison control center
- Your local or state health department
- National Lead Information Center: 1-800-424-LEAD www.epa.gov/lead/nlic.htm
- Information on lead safe work practices: www.epa.gov/lead/epahudrrmodel.htm
- Alliance for Healthy Homes: (202) 543-1147 www.afhh.org
**Additional Information**

- Agency for Toxic Substances and Disease Registry (ATSDR)  
  www.atsdr.cdc.gov

- Association of Occupational and Environmental Clinics (AOEC)  
  www.aoec.org

- Pediatric Environmental Health Specialty Units (PEHSUs)  
  www.aoec.org/PEHSU.htm

- American College of Occupational and Environmental Medicine  
  www.acoem.org

- American College of Medical Toxicologists www.acmt.net

- American College of Preventive Medicine www.acpm.org
QUESTIONS?

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Krewe Du Vieux, Mardi Gras, New Orleans 2015