Is childhood lead poisoning still a public health problem?

Rad Cunningham, MPH MPA
Environmental Epidemiology, Environmental Public Health
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We will cover:

- State and national data
- Cognitive and social impacts
- Screening tools and the lead risk map
State and National Data
Major Sources of Lead Exposure

Lead Paint Banned

*Laidlaw et al. 2008*
US Totals Blood Lead Surveillance, 1997-2013

Source: [http://www.cdc.gov/nceh/lead/data/index.htm](http://www.cdc.gov/nceh/lead/data/index.htm)
Source: A Review of Evidence of Health Effects of Blood Lead Levels <10 ug.dL in Children Reported by a Work Group of the Advisory Committee on Childhood Lead Poisoning Prevention
Washington: Among Children under 6 who are tested, percentage who have reported blood lead levels $\geq 5 \text{ mcg/dL}$
Childhood Lead Screening Tests and Elevated Results in Children 6 and Under in Washington State 1993-2013

- 1991: CDC sets level of concern at ≥10 mcg/dL
- 2000: CLP becomes Notifiable Condition in WA
- 2000: DOH convenes Expert Panel
- 2008: DOH convenes Expert Panel
- 2009: DOH launches public outreach & education campaign
- 20012: CDC sets reference value at ≥5 mcg/dL
- 2014: WA reporting rule changes EBB:L to ≥5 mcg/dL

Number of cases

0 100 200 300 400 500 600 700 800

Year

1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013

Number of tests

0 2000 4000 6000 8000 10000 12000 14000 16000 18000 20000

Test Results

- >10 mcg/dL
- 5-9.9 mcg/dL
Proportion of Pre-1950 Housing in Washington State Compared to states that do universal screening

Data Source: ACS 5-year estimates 2009-2013
Lead wipe results in NY vs OR

Lead Program in WA State

- 2.0 FTE’s, with Support
  - Elizabeth Long, Epidemiologist
  - Amanda Jones, Health Services Consultant
- Surveillance: Receives all lead tests performed in the state
- Outreach
  - Mailing in Child Profile
  - Website
How much does it take to poison a child?

- 5 μg/dL – Definition of childhood lead poisoning
- 2 liters – estimated blood volume of a 2 year old

\[
\frac{5\mu g}{dl} \times \frac{10\;dl}{1\;L} \times 2L = 100\;mcg \times \frac{1\;gram}{1000000\;mcg} = 0.0001\;grams
\]

- Reference 1: one grain of salt weighs 0.0003 grams
- Reference 2: a cubic centimeter of water weighs 1 gram
Cognitive and Social Impacts
The Ongoing Search for a Threshold Lead Toxicity and IQ Deficits

IQ Loss for Various Risk Factors

- Pre-term Birth
- Lead
- Organophosphate Pesticides
- ADHD
- Iron Deficiency
- ASDs
- Methylmercury
- Congenital Heart Disease

Millions of IQ points Lost

0 5 10 15 20 25 30 35
Blood Pb at 78 months, adjusted for sex
Regions with decreased volume

FM factor, adjusted for sex
Regions with increased volume

FM factor, adjusted for sex and Pb78
Regions with increased volume
Risk of Conduct Disorder by Blood Lead Concentration in US Children, 8 to 15 years, NHANES 2001-2004

The Prevention Paradox

The majority of IQ points lost due to lead exposure occur in children who have low to moderate blood lead levels.

Estimated Loss of IQ in US Children at Different Intervals of Blood Lead

- Current Reference Value = 5 μg/dL
- .5 Million
- 2.10 μg/dL
- 5.7 Million
- 6.4 Million
- 1.43 μg/dL
- 6.1 Million
- 1.6 Million
- 0.9 Million
- 5.7 Million
- 4.7 Million
- 0.3 Million
- 12.7 Million

No. of Children in Distribution x IQ Loss Average = Estimated IQ Points Lost

Using the current reference value of 5 μg/dL we will only protect 3.1 million IQ points (about 18% of the total). Adapted from Bellinger D. EHP 2011:120:501-507.
Lead and Crime

- USA Average Preschool Blood Lead
- Violent Crime Rate in Nevin (2000) Analysis
- Violent Crime Rate in 1998-2011

Lead Year: Violent Crime Year (23 year lag)

www.ricknevin.com
Cost of Lead Poisoning – USA

- What Does Lead Poisoning Cost?

<table>
<thead>
<tr>
<th>Total Cost (Billions of Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
</tr>
<tr>
<td>IQ &amp; Earnings</td>
</tr>
<tr>
<td>$28.1</td>
</tr>
<tr>
<td>Behavioral</td>
</tr>
<tr>
<td>Crime</td>
</tr>
<tr>
<td>$46.0</td>
</tr>
<tr>
<td>Health</td>
</tr>
<tr>
<td>Adult Health</td>
</tr>
<tr>
<td>$126.9</td>
</tr>
</tbody>
</table>

Total: $209

Putting 200 Billion into Perspective

- Market Capitalization of Pfizer, Verizon, or Toyota
- GDP of the Czech Republic, Iraq, or New Zealand
- The EPA’s budget for 20+ years
- About $600 for every person in America
Cost of Lead Poisoning – WA

Annual income lost in Washington from BLLs > 2ug/dl estimated to be between: $675 Million to $2.3 Billion.

Estimated cost per house for:
- Average cost for interior & exterior assessment -- $636
- Interim controls -- $12,000
- Full abatement -- $19,000

Estimated cost to fully abate lead–based paint in all Washington homes: $5.9 Billion.

The Affordable Care Act requires insurers (except those that are “grand–fathered”) to cover lead screening for young children and pregnant women without cost to the consumer.

Average cost for BLL screening with a follow–up test: $21.50.
Screening tools and the lead risk map
CDC Risk Questionnaire*

- Does your child live in or regularly visit a house that was built before 1950?

- Does your child live in or regularly visit a house built before 1978 with recent or ongoing renovations or remodeling (within the last 6 months)?

- Does your child have a sibling or playmate who has or did have lead poisoning?

*CDC: Screening Young Children for Lead Poisoning 1997: CH3 P.67
Sensitivity + Specificity – Does the CDC risk questionnaire work?

Lead Risk Questionnaire*

MRI for bone infection**


**Lee K, Gibson G. 2009. A Meta Analysis of FDG PET/CT versus MRI in Diagnosing Diabetic Foot Osteomyelitis
Creating a Risk Map
Spatial epidemiology: the “Where”

- The analysis of the spatial/geographical distribution of the incidence of disease

Objectives:
- Description of spatial patterns
- Identification of disease clusters
- Explanation or prediction of disease risk
Geographic Information Systems (GIS)

- GIS lets us visualize, question, analyze, interpret, and understand data to reveal relationships, patterns, and trends
How we chose the variables

- Literature
  - Mostly focuses on 10 mcg/dL and up

- Previous analyses
  - Some not published, incomplete documentation

- Analysis of combined dataset
  - Non-random sample
  - Incomplete matching
  - Missing addresses
  - Generalized risk factors
- Age of housing – Pre 1940
- Black race
- Low income
- Proximity to an airport
- Proximity to a major roadway

- Hispanic ethnicity
- Tacoma smelter

- American Indian/Alaska Native race
- Previous elevated case

- Proximity to lead emitting industry
- Land use type
How we got the data

Dataset used for analysis
Model formulation

- Simplest way is to average all values
  \[ HSI = \frac{(SV1 + SV2 + SV3 + SV4)}{4} \]

- Weights can be incorporated to give some criteria priority over others
  \[ HSI = \frac{(2SV1 + SV2 + SV3 + SV4)}{5} \]

- Multiplication can be used to have a reduction effect
  - 0 * anything = 0; 50% * anything reduces the value by half
  - Gives some variables greater control over final value
    \[ HSI = SV1 \times \frac{(SV2 + SV3 + SV4)}{3} \]
## Risk variable weights

<table>
<thead>
<tr>
<th>Variable</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre–1940 housing</td>
<td>35%</td>
</tr>
<tr>
<td>Census blocks with elevated cases</td>
<td>15%</td>
</tr>
<tr>
<td>Income</td>
<td>10%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>10%</td>
</tr>
<tr>
<td>Black</td>
<td>5%</td>
</tr>
<tr>
<td>American Indian</td>
<td>5%</td>
</tr>
<tr>
<td>High traffic roadway proximity</td>
<td>5%</td>
</tr>
<tr>
<td>Airport proximity</td>
<td>5%</td>
</tr>
<tr>
<td>Toxic release site proximity</td>
<td>5%</td>
</tr>
<tr>
<td>Historic Tacoma smelter proximity</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
# Land use variable weights

<table>
<thead>
<tr>
<th>Land Cover Type</th>
<th>Weighted value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium intensity residential</td>
<td>1.0</td>
</tr>
<tr>
<td>Low intensity residential</td>
<td>0.61</td>
</tr>
<tr>
<td>Developed open space</td>
<td>0.11</td>
</tr>
<tr>
<td>High intensity residential</td>
<td>0.11</td>
</tr>
<tr>
<td>Evergreen forest</td>
<td>0.02</td>
</tr>
<tr>
<td>Cultivated crops</td>
<td>0.02</td>
</tr>
<tr>
<td>Pasture</td>
<td>0.02</td>
</tr>
<tr>
<td>All other land cover</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Final Model

- \( RI = RV_1 \times [RV_2 + RV_3 + RV_4 + RV_5 + RV_6 + RV_7 + RV_8 + RV_9 + RV_{10} + RV_{11}] \)

- Risk Index = Land Use Weight \( \times [\text{Housing} + \text{Previous Elevated} + \text{Income} + \text{Hispanic} + \text{Black} + \text{American Indian} + \text{Roadways} + \text{Airport} + \text{Toxic Release Site} + \text{Tacoma Smelter Plume}] \)
Risks we can’t map

Azarcon

Greta

Limitations

- The predictive power of the map is only as good as the data and the data are:
  - non-random
  - Have missing addresses
  - Are generalized to block group and census tract levels
  - Overfit? – We have some ‘noise’ variables in there
  - Underfit? – We are missing some ‘signal’ variables
Validation

<table>
<thead>
<tr>
<th>Sample</th>
<th>n</th>
<th>Min</th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006–2012 Cases</td>
<td>1933</td>
<td>0</td>
<td>0.36</td>
<td>0.36</td>
<td>0.94</td>
</tr>
<tr>
<td>2013–2014 Cases</td>
<td>255</td>
<td>0</td>
<td>0.29</td>
<td>0.28</td>
<td>0.82</td>
</tr>
<tr>
<td>Random locations</td>
<td>19296</td>
<td>0</td>
<td>0.18</td>
<td>0.07</td>
<td>0.89</td>
</tr>
</tbody>
</table>

*Mann–Whitney P-Value < 0.001*
Next Steps

- Put it on the Washington Tracking Network
- Improve the map as we get more data – parcel data, improved screening data, more exposure data
- Do outreach to providers targeting those that are in both high-risk & low-screening rate neighborhoods
Thank You

Rad Cunningham
rad.cunningham@doh.wa.gov
360–236–3359