The Effects of Lead Exposure on school outcome among children living and attending Public Schools in Detroit, MI

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DHWP/DPS Research Partnership

- Infrastructure
  - DHWP Office of Health Information, Planning, Policy, Evaluation, and Research (HIPPER)
  - Departmental priorities and research agenda
  - DPS Office of Research, Evaluation, Assessment and Accountability (OREA)
  - DHWP Research Review Committee
  - City of Detroit Law Department
Purpose

• Raise awareness about the issue of lead exposure on educational achievement and behavioral outcomes in the city of Detroit.

• Advance interventions to address the long-term effects of childhood lead poisoning on lifetime learning in educational settings.

• Effective use of cross-disciplinary data to address cross-cutting preventable public health issues.
Lead in Detroit

- Over the years, childhood lead poisoning in Detroit has consistently accounted for more than 50% of the State level total lead burden.

- In 2007, 57% (1154) of the statewide total was from Detroit-- there were 2,031 children reported with EBL statewide.

- In 2008, 58% (983) of the statewide burden was from Detroit-- there were 1,686 children with EBL statewide.

- Nationally, Detroit ranks fourth among large cities for childhood lead poisoning (CDC 2004).
Prevalence of Lead in Detroit:

Number and Percentage of Children (<6) with a Blood Lead Level of ≥ 10 ug/dl
2006 - 2008

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Children with BLL &gt;= 10 ug/dl</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1388</td>
<td>4.2%</td>
</tr>
<tr>
<td>2007</td>
<td>1154</td>
<td>3.6%</td>
</tr>
<tr>
<td>2008</td>
<td>983</td>
<td>3.1%</td>
</tr>
</tbody>
</table>
Lead Incidence in Detroit:

Number and Percentage of Incident Elevated Blood Lead Level Cases among Children (<6) 2006 – 2008

- **2006**: 827 cases, 59.6% of total EBLL cases
- **2007**: 742 cases, 64.3% of total EBLL cases
- **2008**: 634 cases, 64.4% of total EBLL cases
Aim of the Study

• To explore and determine the association between childhood blood lead levels and academic and behavioral performances as measured by standardized testing, special education status, and school behavioral records among children living in the city of Detroit and attending Detroit Public Schools.
Background: The Effects

• Environmental lead exposure to/in children
  – Increased risk for reading problems, school failure, delinquency, criminal behavior, attention deficit hyperactivity disorder, and antisocial behavior.

• In adults, lead exposure has been associated with diseases such as cardiovascular disease, tooth decay, spontaneous abortion, renal disease, cognitive decline, and cataracts.

• There is no safe threshold for lead exposure. Lower level lead exposure including prenatal exposure are linked to decrements in intellectual function.
# Historic Overview

<table>
<thead>
<tr>
<th>CDC Level of Concern</th>
<th>Lead Level in Blood (ug/dL)</th>
<th>Adverse Effect</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>150</td>
<td>Death</td>
<td>Tertiary</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>Brain Damage</td>
<td>Tertiary</td>
</tr>
<tr>
<td></td>
<td>80 - 60</td>
<td>Abdominal pain</td>
<td>Tertiary</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Anemia</td>
<td>Tertiary</td>
</tr>
<tr>
<td>1985</td>
<td>25</td>
<td>• Reduced Growth</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Attention deficits</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Learning Disabilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>• Reduced IQ</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Behavior</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• problems</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>10</td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Primary</td>
<td></td>
</tr>
</tbody>
</table>

**Managing children w/EBL**
- chelation
- improve nutrition
- eliminating lead hazards

**Mixed between tertiary and primary**

**Focus on exposure**
Background: Risk

- The magnitude of racial and socioeconomic disparities has declined, but levels above 10ug/dL remain much more common
  - among minority children,
  - children in low-income families,
  - and children living in older homes.
Background: Previous Studies

- **Kaiser et al. 2008**
  - Examined the relationship between selected developmental disabilities and childhood blood lead levels in a population-based sample.
  - Results indicated that children screened for lead poisoning were more than likely to be receiving services for behavior problems, mental retardation, learning disabilities, or a speech language impairment than other children attending the same school.

- **Miranda et al. 2007**
  - Examined the association between early childhood blood lead level and educational achievement.
  - Findings indicated that blood lead levels of 5ug/dL is associated with end-of-grade reading and mathematics scores and this impact is significant in comparison with known educational outcomes covariates.

- **Stretesky et al. 2001**
  - Evaluated the association between air lead concentrations and homicide rates.
  - Found that after controlling for confounding factors and 9 measures of air pollution, lead was the only pollution associated with homicide.
Background: Previous Studies

• **Canfield et al. 2003**
  – Investigated neurobehavioral functioning at lower levels lead concentrations.
  – Canfield found that BLL below 10ug/dL were inversely associated with children’s IQ and associated declines were greater at lower concentrations than higher concentrations.

• **Chen et al. 2007**
  – Analyzed the association between lead and behavior while taking IQ into account and examine the relative strength of the association between blood lead concentrations, IQ and behavior.
  – Found that concurrent blood lead concentrations was associated with externalizing and school problems at 7 years old, and the effect was not entirely mediated through the lead effect on IQ. On the other hand, higher lead concentrations at 2 years was not associated with behavior at 7 years of age.
Study Methods

• Using the ArcGIS geographic information systems (GIS) software linked blood lead testing surveillance data for Detroit resident children to education and behavioral outcome data and birth records.

• Matching criteria
  – Name, DOB, Sex, Address

• Inclusion criteria
  – Reside in the city of Detroit at the time of blood lead screening
  – Detroit Public School enrollees
  – Venous blood lead test between ages 0 – 5 years
  – State of Michigan MEAP testing score at grade 3rd, 5th, or 8th
  – Special Education status

• Excluded children reporting English as a second language

• Link matched dataset to city of Detroit birth records to explore covariates
  – Known confounders: SES, low-birth weight, parity, maternal IQ, gestational age, prenatal smoking, prenatal alcohol use
Preliminary Findings:

• 44,866 matched records
  – Current student population is 92,688 students, 48% of the current DPS student population.

• Excluded
  – 396 students who lived outside Detroit
  – 5,271 students older than 5 yrs @ time of blood lead test

• Total of 39,199 children
Point Distribution of DPS Lead Study Student Population

* DPS Student with Blood Lead Data N = 43,891
Point Density of DPS Lead Study Student Population

Density of DPS Blood Lead Tested Students
Students per Sq. Mile
- 11 - 62
- 63 - 174
- 175 - 265
- 266 - 336
- 337 - 417
- 418 - 499
- 500 - 599
- 601 - 682
- 683 - 743
Basic School Demographics

• Sex
  – Females: 19,347 (49.4)
  – Males: 19,852 (50.6)

• Grade
  – Preschool: 3,956 (10.2)
  – Elementary School: 24,351 (62.8)
  – Middle School: 6,351 (16.4)
  – High School: 4,118 (10.6)

• SES status
  – Free lunch: 26,462 (74.9)
  – Reduced lunch: 896 (2.5)
  – Pay for lunch: 7,991 (22.6)
Basic Blood Level Demographics

• Lead Poisoning
  • < 10 ug/dl: 29,478 (75.2)
  • ≥ 10 ug/dl: 9,721 (24.8)

• Age at Test

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>1,400</td>
<td>3.6</td>
</tr>
<tr>
<td>1</td>
<td>8,519</td>
<td>21.7</td>
</tr>
<tr>
<td>2</td>
<td>8,053</td>
<td>20.6</td>
</tr>
<tr>
<td>3</td>
<td>9,367</td>
<td>23.9</td>
</tr>
<tr>
<td>4</td>
<td>8,477</td>
<td>21.6</td>
</tr>
<tr>
<td>5</td>
<td>3,377</td>
<td>8.6</td>
</tr>
</tbody>
</table>
Number of Children by Blood Lead Level Category

Mean = 7.6 ug/dl
Sd = 7.2 ug/dl
Examined Outcomes

• Examined the relation between two education marks and blood lead level:

  – Special education status
    • Yes/No

  – MEAP scores
    • Taken in the 3rd, 5th and 8th grade
Special Education and Lead Exposure

- 6,756 DPS students of the 44,649, 15.1%, are identified as needing Special Education Services
- 2,572 of the Special Education identified students, 38%, had a blood lead level of less than 5 ug/dL while 46% of the overall test population were less than 5 ug/dL
- 2,035 of the Special Education identified students, 30.1%, had a blood lead level of greater than 5 ug/dL and less than 10 ug/dL while 31.5% of the overall test population was in this group
- 2,149 of the Special Education identified students, 31.8%, had a blood lead level of greater than 10 ug/dL while 22.6% of the overall test population was in this group
Blood Lead Level and Special Education Status

• Lead levels and Special Education
  – There is significance difference in the mean blood lead levels between child in special education and those children not in special education

  – Those children in special education classes had a higher mean blood lead level:
    • 9.7 ug/dl CI (9.4,10.0) vs. 7.3 ug/dl CI (7.2,7.4)
    • T-value = 23.9; P-value < 0.0001
Special Education Status: Comparison of Means

- No Special Education: 7.3 ug/dl
- Special Education: 9.7 ug/dl
Special Education Status by Blood Lead Level

Proportion of Students in Special Education with a BLL of at least 1 ug/dl

- 1 - 4 ug/dl: 89.2%
- 5 - 9 ug/dl: 86.1%
- 10 - 14 ug/dl: 81.0%
- 15 - 19 ug/dl: 78.4%
- 20 - 44 ug/dl: 74.3%
- 45 - 60 ug/dl: 72.2%
- 60+ ug/dl: 64.3%

Legend:
- Green: No Special Education
- Blue: Special Education
About Detroit Public School Student Records

- Michigan Education Assessment Program (MEAP) testing for 3rd, 5th, and 8th graders
  - 1 = Advanced
  - 2 = Proficient
  - 3 = Partially Proficient
  - 4 = Not Proficient

- 7,255 student records of 3rd, 5th and 8th Grade students not working at grade level based upon at least one Michigan Education Assessment Program – MEAP Test in Math, Reading, Science and Writing with a score of 3 or 4 were directly matched to CDHD Blood Lead test data.
MEAP Data

- Identified 7,255 DPS students in 3rd, 5th and 8th grade that are not working at grade level

- 2,881 student records, 39.7%, had a blood lead level of less than 5 ug/dL

- 2,633 student records, 36.3%, had a blood lead level of greater than 5 ug/dL and less than 10 ug/dL

- 1,741 student records, 23.9%, had a blood lead level of greater than 10 ug/dL
End of Grade Tests

• Subset of 7,255 children with MEAP scores
  – 7,155 math scores
  – 4,603 science scores (3rd graders not tested in science)
  – 7,114 reading scores
  – 7,156 writing scores
MEAP Scores:
Reading Level by Mean BLL

<table>
<thead>
<tr>
<th>MEAP Score</th>
<th>Mean BLL (ug/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.4 ug/dl</td>
</tr>
<tr>
<td>2</td>
<td>7.2 ug/dl</td>
</tr>
<tr>
<td>3</td>
<td>7.7 ug/dl</td>
</tr>
<tr>
<td>4</td>
<td>8.6 ug/dl</td>
</tr>
</tbody>
</table>
MEAP Scores:
Science Level by Mean BLL

- MEAP Score 1: 6.7 ug/dl
- MEAP Score 2: 7.5 ug/dl
- MEAP Score 3: 8.3 ug/dl
- MEAP Score 4: 8.6 ug/dl
MEAP Scores:
Writing Level by Mean BLL

- MEAP Score 1: 0 ug/dl
- MEAP Score 2: 7.9 ug/dl
- MEAP Score 3: 7.3 ug/dl
- MEAP Score 4: 8.4 ug/dl
MEAP Scores:
Partially Proficient, Not Proficient by Mean BLL

<table>
<thead>
<tr>
<th>Subject</th>
<th>Mean BLL (ug/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M3</td>
<td>7.3</td>
</tr>
<tr>
<td>M4</td>
<td>10.1</td>
</tr>
<tr>
<td>R3</td>
<td>6.4</td>
</tr>
<tr>
<td>R4</td>
<td>6.5</td>
</tr>
<tr>
<td>S3</td>
<td>8.8</td>
</tr>
<tr>
<td>S4</td>
<td>8.6</td>
</tr>
<tr>
<td>W3</td>
<td>6.6</td>
</tr>
<tr>
<td>W4</td>
<td>8.7</td>
</tr>
</tbody>
</table>
MEAP Scores:
Partially Proficient and Not Proficient by Mean BLL

Mean BLL (ug/dl)

M3R3S3W3: 7.87 ug/dl
M4R4S4W4: 8.13 ug/dl
MEAP Scores:
Partially Proficient and Not Proficient by Mean BLL

Composite MEAP Score

<table>
<thead>
<tr>
<th>Composite MEAP Score</th>
<th>Mean BLL (ug/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M3R3</td>
<td>8.0 ug/dl</td>
</tr>
<tr>
<td>M4R4</td>
<td>18.4 ug/dl</td>
</tr>
<tr>
<td>M3S3</td>
<td>7.0 ug/dl</td>
</tr>
<tr>
<td>M4S4</td>
<td>7.5 ug/dl</td>
</tr>
<tr>
<td>M3W3</td>
<td>6.8 ug/dl</td>
</tr>
<tr>
<td>M4W4</td>
<td>6.2 ug/dl</td>
</tr>
</tbody>
</table>
Point Density of DPS 3rd Graders not at Grade Level
Point Density of DPS 5th Graders not at Grade Level
Point Density of DPS 8th Graders not at Grade Level

DPS 8th Graders Not at Grade Level by MEAP Students per Sq. Mile
- 1 - 10
- 11 - 18
- 19 - 25
- 26 - 31
- 32 - 37
- 38 - 43
- 44 - 51
- 52 - 60
- 61 - 74

Legend:
- Very Low Density
- Low Density
- Medium Density
- High Density
- Very High Density

Map Scale:
- 0 - 6 Miles

Legend:
- 1 - 10
- 11 - 18
- 19 - 25
- 26 - 31
- 32 - 37
- 38 - 43
- 44 - 51
- 52 - 60
- 61 - 74
Point Density of DPS not at Grade Level with blood lead level of less than 5 ug/dL
Point Density of DPS not at Grade Level with blood lead level of greater than 5 ug/dL and less than 10 ug/dL.
Point Density of DPS not at Grade Level with blood lead level of greater than 10 ug/dL
Summary

• Lead is highly prevalent in our population
  – 99% of children a blood lead level of at least 1 ug/dl
  – 22,755 DPS students with BLL greater than 5 ug/dL is 25% of the current Detroit Public Schools Active student population

• Our preliminary findings match previous research showing the detrimental effects of lead
  – Population-based achievement outcome
  – Those student with special education status had significantly higher blood lead levels
  – **Mean blood lead levels increase as MEAP proficiency decreases**
Next Steps

- Call for a National Roundtable/Conference that includes the U.S. Department of Education, Centers for Disease Control and Prevention, Public Health Agencies and Public Education Agencies to further address the need for Early Childhood educational interventions for children adversely affect by elevated Blood Lead Levels.

- Continue to link matched BLL data to behavioral outcome and birth data sets.

- Conduct regression analyses, multivariate models and apply advanced Geospatial analyses to derive final results.

- Communicate findings to Administrators and Advocates for feedback.

- Publish findings.
Discussion

• Challenges
  – Conducting research in a public health/education settings
  – Developing Memorandums of Understanding
  – Resources
  – Political Environment
Discussion

• Opportunities
  – Cross Collaboration with other Public Health agencies and the local school districts
  – Provides exploratory opportunities
  –unities for assessment of other public health issues
  – Acquire support from other funding agencies to advance the research

• ESRI
  – Collaboration with the latest available Geospatial analysis tools
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