NIEHS PEPH WEBINAR:
E-WASTE AND ENVIRONMENTAL HEALTH

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CHINA

• Guiyu Town, Shantou City, Guangdong Province

• Rural community, but with concentrated recycling activities in a town surrounded by farming land

• Population ~150,000, and up to ~100,000 migrant workers at its height

• E-waste recycling existed since 1990s, almost the largest on tonnage of e-waste recycled

• Before 2015: mostly home-run business, recycling in front of the house or on the first floor of the 3-4 story home building

• After 2015: still home-run business, recycling became mandatory to occur only in the industrial park with centralized ventilation and waste water treatment
THEN (2010)
POLICY CHANGES IN GUIYU (2015)

“Transportation of electronic waste and plastic prohibited. Violators will be investigated, retained, and materials confiscated.”

“Beginning Dec 1, 2015, any e-waste treating and plastics manufacturing outside of industrial park shall stop, or the electricity will be shut off”
E-waste recycling industrial park in Guiyu
Slogan says “Protecting environment is protecting ourselves.”
E-WASTE RECYCLING EXPOSURES AND COMMUNITY HEALTH (E-REACH), 2010-2013

Exposure Assessment

Exposed site: Guiyu
- 240 Air samples (30d x 4 seasons x 2 yrs)
- 80 Road dust & 80 Soil samples (10 locations x 4 seasons x 2 yrs)

Control site: Haojiang
- 56 Air samples (7d x 4 seasons x 2 yrs)
- 40 Road dust & 40 Soil samples (5 locations x 4 seasons x 2 yrs)

Environmental Samples: Pb, Cd, Cr, Mn

- 300 Pregnant women Questionnaires

Biological Markers

Maternal blood: Pb, Cd, Cr, Mn
Cord blood: Pb, Cd, Cr, Mn
Maternal urine: Cd, Cr, Mn

Pregnancy & Birth Outcomes

Outcomes: stillbirth, gestational length, birth weight, SGA, birth length, head circumference, anogenital distance

Thyroid Functions

Thyroid hormones in cord blood: TSH, T₄, T₃
APPROACH

• Collaboration built with Shantou University Medical Center, 25 miles away from Guiyu
• Focusing on community residents rather than recycling workers due to the extent of contamination in the community
• Studying metal exposure in pregnant women and children due to concerns of developmental toxicity
**AIR SAMPLES**

- Sampled air continuously (every day for a year) in Guiyu
  - Collected air samples in Haojiang for one week per season
  - Air samples: March 2012 - May 2013

<table>
<thead>
<tr>
<th></th>
<th>Guiyu</th>
<th>Haojiang</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=133)</td>
<td>(n=33)</td>
</tr>
<tr>
<td>GM</td>
<td>Range</td>
<td>GM</td>
</tr>
<tr>
<td>PM$_{2.5}$ ($\mu$g/m$^3$)</td>
<td>49.91 10.98 – 160.57</td>
<td>37.60 11.37 – 83.10</td>
</tr>
<tr>
<td>Pb (ng/m$^3$)</td>
<td>164.03 9.12 – 1046.9</td>
<td>69.26 9.12 – 293.66</td>
</tr>
<tr>
<td>Cd (ng/m$^3$)</td>
<td>5.69 0.40 – 55.71</td>
<td>3.39 0.28 – 22.71</td>
</tr>
<tr>
<td>Cr (ng/m$^3$)</td>
<td>4.51 0.01 – 387.86</td>
<td>3.81 0.01 – 26.43</td>
</tr>
<tr>
<td>Mn (ng/m$^3$)</td>
<td>16.93 0.71 – 143.75</td>
<td>15.64 0.71 – 85.19</td>
</tr>
</tbody>
</table>

SOIL & ROAD DUST SAMPLES

- Sampled soil & road dust samples each season in community areas
  - 10 scattered locations in Guiyu
  - 5 scattered locations in Haojiang
  - Road dust and soil: 4 seasons in 2012-2013

<table>
<thead>
<tr>
<th>Matrices</th>
<th>Metal</th>
<th>Geometric Mean of Metal Concentrations</th>
<th>Ratio of Guiyu/Haojiang Area Metal Concentrations</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Guiyu (mg/kg, n=44)</td>
<td>Haojiang (mg/kg, n=20)</td>
<td>Estimate</td>
</tr>
<tr>
<td>Soil</td>
<td>Pb</td>
<td>213.61</td>
<td>91.92</td>
<td>2.32</td>
</tr>
<tr>
<td></td>
<td>Cd</td>
<td>0.32</td>
<td>0.07</td>
<td>4.34</td>
</tr>
<tr>
<td></td>
<td>Cr</td>
<td>38.56</td>
<td>31.76</td>
<td>1.21</td>
</tr>
<tr>
<td></td>
<td>Mn</td>
<td>606.63</td>
<td>614.98</td>
<td>0.99</td>
</tr>
<tr>
<td>Road Dust</td>
<td>Pb</td>
<td>392.58</td>
<td>95.72</td>
<td>4.10</td>
</tr>
<tr>
<td></td>
<td>Cd</td>
<td>1.14</td>
<td>0.36</td>
<td>3.18</td>
</tr>
<tr>
<td></td>
<td>Cr</td>
<td>55.46</td>
<td>64.93</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>Mn</td>
<td>529.35</td>
<td>493.26</td>
<td>1.07</td>
</tr>
</tbody>
</table>

# METAL CONCENTRATIONS IN BIOLOGICAL SAMPLES

<table>
<thead>
<tr>
<th>Metals</th>
<th>LODa (µg/dL)</th>
<th>Guiyu (n = 314)</th>
<th>Haqijiang (n = 320)</th>
<th>Guiyu vs. Haqijiang concentration ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n Missing</td>
<td>n &lt; LOD</td>
<td>GM</td>
<td>Min</td>
</tr>
<tr>
<td><strong>Maternal blood</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>0.20</td>
<td>0</td>
<td>0</td>
<td>6.66</td>
</tr>
<tr>
<td>Cd</td>
<td>0.20</td>
<td>0</td>
<td>0</td>
<td>1.72</td>
</tr>
<tr>
<td>Cr</td>
<td>1.67</td>
<td>1</td>
<td>0</td>
<td>13.78</td>
</tr>
<tr>
<td>Mn</td>
<td>1.12</td>
<td>1</td>
<td>0</td>
<td>25.93</td>
</tr>
<tr>
<td><strong>Cord blood</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>0.20</td>
<td>20</td>
<td>0</td>
<td>5.03</td>
</tr>
<tr>
<td>Cd</td>
<td>0.20</td>
<td>21</td>
<td>171</td>
<td>0.18</td>
</tr>
<tr>
<td>Cr</td>
<td>1.67</td>
<td>108</td>
<td>39</td>
<td>4.02</td>
</tr>
<tr>
<td>Mn</td>
<td>1.12</td>
<td>28</td>
<td>0</td>
<td>52.93</td>
</tr>
<tr>
<td><strong>Maternal urine (µg/g creatinine)c</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>0.04</td>
<td>68</td>
<td>2</td>
<td>1.06</td>
</tr>
<tr>
<td>Cr</td>
<td>0.08</td>
<td>107</td>
<td>8</td>
<td>1.66</td>
</tr>
<tr>
<td>Mn</td>
<td>0.06</td>
<td>82</td>
<td>0</td>
<td>7.62</td>
</tr>
</tbody>
</table>

*a* LOD limit of detection, *CB* cord blood, *MB* maternal blood

*b* We used the machine-reading values of those below LOD

*c* Adjusted for maternal age, maternal BMI, maternal education, gravidity, ETS

*d* The unit of limit of detection in maternal urine was µg/L

*e* *p < 0.05
## % Elevated Blood Lead and Cadmium Levels in Pregnant Women

<table>
<thead>
<tr>
<th>Variable</th>
<th>Guiyu $n$ (%)</th>
<th>Haojiang $n$ (%)</th>
<th>Unadjusted RR [RR (95% CI)]</th>
<th>Adjusted RR$^b$ [RR (95% CI)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLL $\geq$ 5 µg/dL</td>
<td>232 (73.9)</td>
<td>64 (20.0)</td>
<td>3.70 (2.94, 4.64)$^*$</td>
<td>4.03 (3.07, 5.29)$^*$</td>
</tr>
<tr>
<td>BLL $\geq$ 10 µg/dL</td>
<td>50 (15.9)</td>
<td>5 (1.6)</td>
<td>10.19 (4.12, 25.22)$^*$</td>
<td>8.75 (2.85, 26.86)$^*$</td>
</tr>
<tr>
<td>BCd $\geq$ 1.7 µg/L</td>
<td>160 (50.9)</td>
<td>117 (36.6)</td>
<td>1.39 (1.16, 1.67)$^*$</td>
<td>1.49 (1.16, 1.91)$^*$</td>
</tr>
</tbody>
</table>

$^a$Cadmium levels from the CDC Fourth Report 95th percentile of adults in the United States

$^b$Adjusted for maternal age, maternal BMI, gravidity, and ETS

$^* p < 0.01$
THE BASIS OF E-WASTE RECYCLING POLICY CHANGE IN GUIYU, CHINA

• Widespread environmental contaminations to the community
  • Metals, organic compounds including flame retardants, PAHs, and dioxins

• Concerns of developmental toxicity in children and long-term health effects in both children and adults
  • Fetal growth restriction, preterm birth
  • Child lung function development
  • Child neurobehavioral development
  • DNA damage and cancer development
  • Health impact in local and migrant workers: respiratory, cardiovascular, neurological

• Established fortune from e-waste recycling and the prospect of increasing e-waste tonnage in China

• Technological possibility to safely recycle e-waste or at least reduce contaminations

WORKING WITH COMMUNITY

- Need to understand the environmental health problem better
- Overall low awareness of toxicants in e-waste before training
- Inadequate exposure monitoring
- Health effect research lacking
- Local communities not ready accepting of academic research study
  - Recycling is an income stream for the family
  - Resources very limited in the e-waste recycling business
- Over-crowded community and a large amount of children around recycling locations
WORKING WITH COMMUNITY (CONT’D)

• Local dialect different from Mandarin or Cantonese

• Local students and staff are the key to community outreach

• Educated local residents and health care workers share concerns of environmental contamination

• Not intended to disrupt business interest and income stream for local residents and migrant workers
WORKING IN AN INTERNATIONAL SETTING

• Language barrier and translation of study documents
• Time zone difference for conference calls
• Equipment transfer between countries (air samplers)
• Remote data capture with REDCap
• Messenger for policy change at local level more important than international collaborators
LESSONS LEARNED

• Communication, communication, communication!

• Be as prepared as possible

• Need to have a Plan B
NEW CHALLENGES WITH CENTRALIZED RECYCLING

• Continued monitoring of environment and biospecimens

• Health effects in residents and workers from cumulative exposures in the past 2-3 decades

• Exposure and health effects in industry park workers

• Clean up of the contaminated environment in Guiyu
FURTHER INTERVENTIONS

• Needed evaluations on a larger scale
• Workers and vulnerable populations are the targets for prevention
• Recycling communities center of the intervention design and implementation
COLLABORATORS & FUNDING

Shantou University Medical College

- Dr. Xia Huo (now at Jinan University School of Environment, Guangzhou, China)
- Dr. Xijin Xu
- Ms. Yuling Zhang
- Mr. Xiangbin Zheng

University of Cincinnati College of Medicine

- Dr. Kim Dietrich
- Dr. Tiina Reponen
- Dr. Shuk-mei Ho

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