The Biomonitoring and Health Outcome of Thai Students in Gold-mine Vicinity: A Cross Sectional Study

Ratchaneewan Sinitkul, MD, MSc
Ramrada Lekwutikarn, Siam Saetang, Anusara Pullkam, Adisak Plitponkarnpim
Department of Pediatrics, Faculty of Medicine Ramathibodi Hospital,
Mahidol University, Bangkok, Thailand
Email: rsinitkul@gmail.com, ratchaneewan.sin@mahidol.ac.th
Historically: Artisanal gold mining

2001: The starting of largest gold-mine in Thailand

2013: Produce gold 5.3 tonnes/year, the 48th rank of gold production

2015-2016: Environmental and health issues → leading to the cease of operation

*World Gold Council, 2016
• **Technique**: open pit, cyanidation, tailing disposal

• **Geographical background**: high level of heavy metal e.g. Manganese (Mn) and Arsenic (As)

• **Concerning pollution**: noise, particulate matter, cyanide and chemical leakage, heavy metal disperse and leaching

BACKGROUND

- Health impact assessment: biomonitoring
- Children: vulnerable group
  - Development
  - Academic achievement

OBJECTIVES

1) Evaluate the prevalence of hazards exposure that may related to gold mining activity in Thailand: Mn and iAs exposure

2) Determine the health effects: IQ, specific learning disabilities (SLD), and hematologic outcomes that might associated with those hazards

In school age children who studied nearby gold mine
METHODOLOGY

Phitsanulok
Phichit
Phetchabun

June - August 2016
IQ AND ACHIEVEMENT TESTS

• **Cognitive function**
  - IQ test by SPM and CPM*

• **Academic performance test**
  - WRAT-Thai**

• **Suspected SLD (DSM-V***)
  - IQ-achievement discrepancy and
    (Failed achievement test > 3 levels of actual class)
  - Excluded intelligence disability

*SPM: standard progressive matrices; CPM: colored progressive matrices
** WRAT-Thai: wide range achievement test in Thai version
*** DSM-V: Diagnostic and Statistical Manual of Mental Disorders, 5th edition
LABORATORY TESTS

• Blood manganese (BMn)
  - EDTA 3-5 mL
  - ICP-MS
  - LOD: 0.13 mcg/L
  - Level of exposure > 15 mcg/L*

• Complete blood count (CBC)

• Urinary inorganic arsenic (UiAs)+ methylate metabolite (MMA, DMA)
  - Random urine 20-50 mL
  - HPLC-ICP-MS
  - LOD: 0.5 mcg of As/L
  - Level of exposure > 35 mcg of As/L**

ICP-MS; inductively coupled plasma mass spectrometry, HPLC-ICP-MS; Chromatography and Inductively Coupled Plasma – Mass Spectrometry
• ATSDR, 2012
** American Conference of Governmental Industrial Hygienists 2004
### DEMOGRAPHIC DATA

<table>
<thead>
<tr>
<th>Variables</th>
<th>Non SLD (N = 94)</th>
<th>Suspected SLD (N = 99)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>64.9</td>
<td>43.4</td>
<td>0.003*(^a)</td>
</tr>
<tr>
<td>Male</td>
<td>35.1</td>
<td>56.6</td>
<td></td>
</tr>
<tr>
<td><strong>Age; mean (years ± SD)</strong></td>
<td>10.21 ± 0.83</td>
<td>11.05 ± 0.71</td>
<td>&lt;0.001*(^b)</td>
</tr>
<tr>
<td><strong>Body mass index; median (BMI) (Q1, Q3)</strong></td>
<td>16.5 (15.0, 18.9)</td>
<td>18.0 (15.4, 21.4)</td>
<td>0.061(^b)</td>
</tr>
<tr>
<td><strong>Intelligence quotient; mean (IQ) ± SD</strong></td>
<td>94.47 ±7.69</td>
<td>90.24 ± 8.80</td>
<td>0.001*(^b)</td>
</tr>
</tbody>
</table>

\(^a\) Chi-square test  \(^b\) Mann Whitney U test

Suspected of SLD prevalence 51.8％
## Socioeconomic Status (SES)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Non SLD (N = 94)</th>
<th>Suspected SLD (N = 99)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parent’s occupation (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>32.6</td>
<td>31.6</td>
<td>0.45&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>General employee/own business</td>
<td>44.6</td>
<td>38.8</td>
<td></td>
</tr>
<tr>
<td>Industrial factory related employee</td>
<td>4.3</td>
<td>10.2</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>18.5</td>
<td>19.4</td>
<td></td>
</tr>
<tr>
<td><strong>Family income (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 6,000 THB/month (&lt; 167 USD/month)</td>
<td>46.7</td>
<td>54.2</td>
<td></td>
</tr>
<tr>
<td>6,000 - 12,000 THB/month (167 - 333 USD/month)</td>
<td>43.5</td>
<td>36.5</td>
<td>0.58&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>&gt; 12,000 THB/month (&gt; 333 USD/month)</td>
<td>9.8</td>
<td>9.4</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Chi-square
## BIOMONITORING OUTCOME

<table>
<thead>
<tr>
<th>Variables</th>
<th>Median (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMn (mcg/L)</td>
<td>13.71 (2.27)</td>
</tr>
<tr>
<td>Mn exposure [BMn &gt; 15 mcg/L (%)]</td>
<td>31.2</td>
</tr>
<tr>
<td>UiAs (mcg of As/L)</td>
<td>28.37 (23.92)</td>
</tr>
<tr>
<td>MMA (mcg of As/L)</td>
<td>2.35 (3.54)</td>
</tr>
<tr>
<td>DMA (mcg of As/L)</td>
<td>25.6 (19.91)</td>
</tr>
<tr>
<td>iAs exposure [UiAs &gt; 35 mcg/L (%)]</td>
<td>35.6</td>
</tr>
</tbody>
</table>

BMn; blood manganese, UiAs; random urinary inorganic arsenic plus methylated metabolites
BIOMONITORING OUTCOME

**Mn exposure**

- **p = 0.49**
- Mean: 14.6 for Non SLD, 13.9 for Suspected SLD

**iAs exposure**

- **p = 0.04**
- Mean: 25.0 for Non SLD, 30.3 for Suspected SLD
## Association of Mn or As exposures and suspected SLD

<table>
<thead>
<tr>
<th>Metal exposures</th>
<th>Non SLD (N = 94)</th>
<th>Suspected SLD (N = 99)</th>
<th>P value</th>
<th>OR, (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mn exposure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMn &gt; 15 mcg/L</td>
<td>28, 48.3%</td>
<td>30, 51.7%</td>
<td>0.94</td>
<td>1.025, (0.55, 1.90)</td>
</tr>
<tr>
<td>BMn ≤ 15 mcg/L</td>
<td>66, 48.9%</td>
<td>69, 51.1%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BMn; blood manganese, UiAs; random urinary inorganic arsenic plus methylated metabolites

* $P < 0.05$
**Association of the iAs + Mn co-exposure and suspected SLD**

<table>
<thead>
<tr>
<th>iAs</th>
<th>Exposures</th>
<th>Mn</th>
<th>OR $^a$</th>
<th>(95% CI)</th>
<th>p value</th>
<th>OR $^a$</th>
<th>(95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (&gt; 35 mcg of As/L)</td>
<td>High (&gt; 15 mcg/L)</td>
<td>1.67</td>
<td>(0.64-4.35)</td>
<td>0.297</td>
<td></td>
<td>2.27</td>
<td>(1.08 – 4.74)</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>Low (≤15 mcg/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 (reference)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (≤35mcg of As/L)</td>
<td></td>
<td>1.18</td>
<td>(0.55 – 2.55)</td>
<td>0.666</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ simple logistic regression
Pearson’s correlation (r):
Metal exposure vs Cognitive function & hematological outcomes

<table>
<thead>
<tr>
<th>Metal exposures</th>
<th>IQ</th>
<th>CBC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hb</td>
</tr>
<tr>
<td></td>
<td>r</td>
<td>p value</td>
</tr>
<tr>
<td>iAs</td>
<td>0.02</td>
<td>0.74</td>
</tr>
<tr>
<td>(UiAs &gt; 35 mcg of As/L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>0.07</td>
<td>0.38</td>
</tr>
<tr>
<td>(BMn &gt; 15 mcg/L)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(BMn; blood manganese, CBC; complete blood count, IQ; Intelligence quotient, Hb; hemoglobin, UiAs; random urinary inorganic arsenic plus methylated metabolites, WBC; white blood cell)
DISCUSSION

• Mn & iAs exposure were up to 1/3 of this population

• Concerning problems - cancer (iAs) & neurotoxicity risks (iAs, Mn)


  ➢ iAs associated with suspected SLD (OR 1.95)

  ➢ High iAs + low Mn exposure (OR 2.27)
DISCUSSION

• No Thai national data available of Mn & iAs exposure

• Lack of certain level of exposure references in children

• Neurotoxicity of Mn & iAs exposure:
  
dose & time dependence, endpoint of outcome
LIMITATIONS

• Diagnosis of SLD
  ➔ Long-term follow up study

• Biomarkers of recent exposure VS chronic outcome?
  ➔ Hair, nail: past exposure
  ➔ Cohort study
  ➔ Neuro-imaging: structural deposit of Mn & As
CONCLUSION

• Prevalence of Mn, iAs exposure, and suspected SLD in the Thai school age children studying nearby gold mine were noticeable.

• iAs exposure are significantly associated with suspected SLD in this population.

• Thus, the environmental inventory and the mitigation modality should be applied to rectify the negative impact.
ACKNOWLEDGEMENT

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