Module Bi & Bii
Health and Environmental Hazards of Lead

Adapted for: East Africa Workshop on the Development of National and Regional Regulations and Standards on Lead in Paints, 13-14 September 2016, Dar es Salaam, United Republic of Tanzania
Outline

• Sources of lead release
• Sources and routes of exposure to lead from paint
• Health effects in humans
• Who is at risk?
• Societal impact of lead
• Environmental impacts of lead
• Summary
Sources of lead release

• Natural (volcanic, weathering of rocks)

• Anthropogenic sources:
  - mobilization of lead in raw materials such as fossil fuels and other extracted and treated ores and metals
  - direct releases from waste to soil and aquatic environments
  - releases during the manufacture, use and disposal of products using lead (e.g. paint, batteries, toys)
    - prior to the removal of lead from gasoline in most countries, leaded gasoline was a significant source of lead

• Lead is mainly emitted in particle form, is transported through the atmosphere and settles on soil, plants, water etc
Multiple pathways of exposure to lead from paint

- Paint manufacture
- Paint application & removal
- Decaying paint
- Lead-painted toys, furniture

Body burden e.g. blood lead concentration.
Health outcomes e.g. reduced IQ, abdominal colic, anaemia
Ingestion is an important route of exposure for children

- Children may ingest contaminated dust and paint chips

- Children with pica are at particularly high risk – severe poisoning may occur

- Picture is a radiograph of a child with lead poisoning from eating lead paint, showing paint chips (white spots) dispersed throughout the gut

Figure 2 – A large quantity of lead paint chips can be seen in this radiograph of the abdomen and pelvis of a 2-year-old boy with lead poisoning.
Lead accumulates in the body

• Bound to red blood cells and distributes to soft tissues, e.g. brain and kidneys, and to bone

• Stored in bone for many years (half-life = 10 – 25 years)

• Lead in bone provides a pool from which lead can move back into blood and to target organs
  ▪ e.g. during pregnancy, lactation and the menopause
Lead is a multi-system toxicant

- Brain & nervous system damage
- Hearing problems
- Muscle & joint pain
- Anaemia
- High blood pressure
- Reproductive problems (adults)
- Decreased IQ
- Learning difficulties
- Speech, language and behaviour problems
- Slow or reduced growth
- Kidney damage
- Digestive problems

World Health Organization

LEAD PAINT ALLIANCE
No known threshold for toxic effects – US National Toxicology Program assessment of evidence

Table 1.1: NTP conclusions on health effects of low-level Pb by life stage

<table>
<thead>
<tr>
<th>Life Stage</th>
<th>Blood Pb Level</th>
<th>NTP Conclusion</th>
<th>Principal Health Effects</th>
<th>Bone Pb Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>&lt;5 µg/dL</td>
<td>Sufficient</td>
<td>Decreased academic achievement, IQ, and specific cognitive measures; increased blood pressure, increased risk of hypertension, and increased incidence of essential tremor</td>
<td>Tibia and dentin Pb are associated with attention-deficit hyperactivity disorder and cognition.</td>
</tr>
<tr>
<td></td>
<td>&lt;10 µg/dL</td>
<td>Limited</td>
<td>Decreased academic achievement, IQ, and decreased heart rate</td>
<td>Decreased birth weight and growth.</td>
</tr>
<tr>
<td></td>
<td>&lt;10 µg/dL</td>
<td>Sufficient</td>
<td>Decreased puberty, IQ, and decreased hearing</td>
<td>Reduced fetal growth.</td>
</tr>
<tr>
<td></td>
<td>Limited</td>
<td>Increased hypersensitivity to allergens and increased IgE</td>
<td>Tibia and dentin Pb are associated with attention-deficit hyperactivity disorder and cognition.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inadequate</td>
<td>Any age – asthma, eczema, cardiovascular disease</td>
<td>Reduced fetal growth.</td>
<td></td>
</tr>
<tr>
<td>Adults</td>
<td>&lt;5 µg/dL</td>
<td>Sufficient</td>
<td>Decreased academic achievement, IQ, and increased risk of cognitive decline</td>
<td>The association between bone Pb and cardiovascular effects is more consistent than for blood Pb.</td>
</tr>
<tr>
<td></td>
<td>&lt;10 µg/dL</td>
<td>Limited</td>
<td>Increased blood pressure, increased risk of hypertension, and increased incidence of essential tremor</td>
<td>Reduced fetal growth.</td>
</tr>
<tr>
<td></td>
<td>Sufficient</td>
<td>Psychological effects, decreased cognitive function, decreased hearing, increased incidence of ALS, and increased cardiovascular-related mortality; maternal blood Pb associated with increased incidence of spontaneous abortion and preterm birth</td>
<td>The association between bone Pb and cognitive decline is more consistent than for blood Pb.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limited</td>
<td>Immune function, stillbirth, endocrine effects, birth defects, fertility or time to pregnancy**, sperm parameters**</td>
<td>No data</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: ALS, amyotrophic lateral sclerosis; IgE, immunoglobulin E; IQ, intelligence quotient

*Increased serum IgE is associated with hypersensitivity; however, as described in Section 1.4.3, increased IgE does not equate to disease.

**The NTP concludes that there is inadequate evidence that blood Pb levels <10 µg/dL are associated with fertility, time to pregnancy, and sperm parameters; however, given the basis of the original nomination, the NTP evaluated the evidence that higher blood Pb levels (i.e., >10 µg/dL) are associated with reproductive and developmental effects, and those conclusions are discussed in Section 1.4.6 and presented in Table 1.2.

<5 µg/dL
Decreased academic achievement & IQ, & increased problem behaviours
Effects on kidney, reduced fetal growth
Who is at risk? Children

- Children have greater exposure:
  - play on the ground, hand-to-mouth activity, mouthing objects
  - absorb 4-5 times more lead from the gut than adults
- Fetal period and early childhood are critical periods for neurological and other organ development
- Damage to the neurological system may be permanent
  - reduces a child's potential for intellectual development
  - increases the likelihood of behavioural disorders
Who is at risk? Pregnant women

• Pregnancy mobilizes lead stored in bone, releasing it back into blood where it can be circulated to maternal tissues and the fetus

• Increased risk of hypertension during pregnancy – may be greater risk of pre-eclampsia

• Exposure of pregnant women can result in exposure of the fetus – may cause reduced fetal growth
Lead causes significant burden of disease

- 853,000 deaths in 2013 from long-term effects
- Estimated to account for:
  - 9.3% of the global burden of idiopathic intellectual disability
  - 6.6% of the global burden of stroke
  - 4% of the global burden of ischaemic heart disease

(estimates by Institute for Health Metrics and Evaluation 2015)
Small IQ reduction has significant societal impact (mean IQ 100)

Distribution of IQ Scores in US Children

6 Million
Challenged
Most of us
Gifted

6 Million
IQ 70
IQ 130

(Reference 4)
Small IQ reduction has significant societal impact (mean IQ 95)
Environmental impacts of lead
Impacts on the ecosystem

• Terrestrial exposure to lead is greatest near point sources (e.g. smelters)

• Plants absorb lead from the soil and retain most of the lead in their roots

• Aquatic exposure to lead is strongly dependent on environmental conditions (pH, salinity, etc)

• Lead bioaccumulates in organisms, in particular those that feed primarily on particulate matter

• Secondary poisoning may occur e.g. in predators feeding on contaminated animals
Impacts on organisms

- Effects on micro-organisms from soil with lead concentrations as low as 10 mg/kg (10 ppm)
- Ingestion of lead-contaminated bacteria and fungi by nematodes can cause impaired reproduction
- In higher animals lead is shown to damage multiple organ systems (blood, central nervous system, kidneys, reproductive & immune systems)
- Fish can develop spinal deformity and blackening of the skin in the caudal region (black tail)
- Birds may be poisoned by eating lead shot and sinkers
Summary

• Lead exposure causes toxic effects in multiple body systems; some effects are permanent

• There is no known level of lead exposure that is considered safe

• Lead exposure has both a personal and a societal impact

• Lead has negative environmental impacts
Additional information

• More information and references are in the Toolkit for Establishing Laws to Control the Use of Lead in Paint
  http://web.unep.org/chemicalsandwaste/noleadinpaint/toolkit

• Module Bi Health hazards of lead (WHO)

• Module Bii Environmental impact of lead (UNEP)