Module Bi
Health Hazards of Lead
Outline

• Sources and routes of exposure
• Health effects
• Who is at risk?
• Societal impact of lead
• Economic and health impacts of control measures
• Summary
• References
• Point of Contact
Multiple pathways of exposure to lead from paint

Paint manufacture

Paint application & removal

Decaying paint

Lead-painted toys, furniture

Lead in air

Inhalation

Body burden e.g. blood lead concentration.

Health outcomes e.g. reduced IQ, abdominal colic, anaemia

Lead in dust & soil

Ingestion
Two main routes of exposure to lead

• **Inhalation** of fine particles and fumes e.g. from sanding or burning lead paint

• **Ingestion** of dust and paint chips
  - Children with pica are at particularly high risk.
  - Picture is a radiograph of a child with lead poisoning from eating lead paint, showing paint chips (white spots) dispersed throughout the gut.

(Reference 1)
Lead accumulates in the body

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

• Lead absorption is increased when there is nutritional deficiency e.g. calcium or iron deficiency.

• Stored in bone for many years (half-life = 10–25 years)
  ▪ In adults 90% of body burden may be in bone.

• Lead in bone provides a store from which lead can move back into blood and to target organs.
  ▪ Lead can remobilize from bone 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
Features of lead poisoning may be non-specific

• Low-level exposure – features of poisoning may be subtle e.g. reduced IQ, impaired hearing, increased risk of hypertension.

• Features of overt poisoning include: anorexia, abdominal colic, constipation, fatigue, mood changes, anaemia and developmental regression in young children.

• Lead poisoning may be misdiagnosed e.g. as appendicitis, psychiatric illness.
Lead poisoning can be life-threatening

• High dose acute/sub-acute exposure can cause lead encephalopathy with irritability, ataxia, coma, convulsions, death:
  ▪ e.g. >400 children have died in NW Nigeria from environmental exposure to lead.

• Severe lead poisoning is possible from repeated ingestion of lead paint chips (pica).
Who is at risk? Children

• Children are especially vulnerable
• Children have greater exposure:
  ▪ hand-to-mouth activity, mouthing objects
  ▪ consume more food and drink, and breathe more air per kg body weight than adults
  ▪ absorb 4–5 times more lead from the gut than adults
  ▪ nutritional deficiency, e.g. calcium, iron, increases bioavailability of lead.
• Exposure may already occur in utero

(Reference 2)
Who is at risk? Children

• 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 including aggression.

• Children have more years of future life for expression of long-term effects.

(Reference 2 & 3)
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.

• Further exposure from the environment raises the blood lead concentration even higher.

• Increased risk of hypertension during pregnancy.

• Exposure of pregnant women can result in exposure of the fetus – may cause reduced fetal growth.
Who is at risk? Other adults

• Most adult exposures are occupational e.g. manufacturing lead paint, stripping paint using unsafe methods, recycling lead-containing materials.

• Non-occupational exposure can occur in the home from house paint that has flaked or chalked as it has aged or been disturbed during home renovations, or from the use of lead paints and metal in hobbies and crafts.

Picture credit: IPEN
**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 incidence of attention-related behaviors and problem behaviors</td>
<td>Tibia and dentin Pb are associated with attention-related behaviors, problem behaviors, and cognition.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited</td>
<td>Delayed puberty and decreased kidney function in children ≥12 years of age</td>
<td>The one available study of bone Pb in children does not support an association with postnatal growth.</td>
</tr>
<tr>
<td></td>
<td>&lt;10 µg/dL</td>
<td>Sufficient</td>
<td>Delayed puberty, reduced postnatal growth, decreased IQ, and decreased hearing</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited</td>
<td>Increased hypersensitivity/allergy by skin prick test to allergens and increased IgE* (not a health outcome)</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inadequate</td>
<td>Any age – asthma, eczema, nonallergy immune function, cardiovascular effects; &lt;12 years of age – renal function</td>
<td>No data</td>
</tr>
<tr>
<td>Adults</td>
<td>&lt;5 µg/dL</td>
<td>Sufficient</td>
<td>Decreased glomerular filtration rate; maternal blood Pb associated with reduced fetal growth</td>
<td>The one available study of bone Pb in the general population supports an association between bone Pb and decreased kidney function. Maternal bone Pb is associated with reduced fetal growth.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited</td>
<td>Increased incidence of essential tremor</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td>&lt;10 µg/dL</td>
<td>Sufficient</td>
<td>Increased blood pressure, increased risk of hypertension, and increased incidence of essential tremor</td>
<td>The association between bone Pb and cardiovascular effects is more consistent than for blood Pb.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limited</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>
</tr>
<tr>
<td></td>
<td></td>
<td>Inadequate</td>
<td>Immune function, stillbirth, endocrine effects, birth defects, fertility or time to pregnancy**, sperm parameters**</td>
<td>No data</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.
Lead causes significant burden of disease

• 495 550 deaths in 2015 from long-term effects.
• 9.3 million disability adjusted life years (DALYs).
• Estimated to account for:
  ▪ 12.4% of the global burden of idiopathic intellectual disability (i.e. disability other than that from known causes such as genetic factors)
  ▪ 2.5% of the global burden of ischaemic heart disease
  ▪ 2.4% of the global burden of stroke.

(Estimates from Institute for Health Metrics and Evaluation - Reference 4)
Small IQ reduction has significant societal impact (mean IQ 100)

(Reference 5)
Small IQ reduction has significant societal impact (mean IQ 95)

(Reference 5)
Economic costs of lead exposure are high

• Estimated economic losses due to reduced IQ from preventable lead exposure is approx 1.2% of global GDP.

• Largest economic burden of lead exposure is borne by low and middle income countries.

• Economic losses by region (in international dollars):
  - Africa: I$ 134.7 billion
  - Asia: I$ 699.9 billion
  - Latin America & Caribbean: I$ 142.3 billion
  - USA: I$ 50.9 billion

(Reference 6. See also module Biii)
Economic benefits of action can be substantial

• Economic benefits of action to ban **new** lead-containing paint:
  - avoids future costs of lead exposure to new paint e.g. from reduced IQ;
  - avoids future costs of hazard controls for legacy paint e.g. remediation.
Economic benefits of action can be substantial

- Economic benefits of action to control hazards of legacy lead-containing paint (USA data).
  - Estimated cost of lead paint hazard control is US$ 1–11 billion.
  - Benefits of lead hazard control e.g.: reduced health care costs, reduced need for special education, reduced crime, increased earnings and tax revenue.
  - Total annual saving (costs minus benefits) estimated as US$ 192–270 billion.
  - Each US$ 1 invested in lead paint hazard control yields return of US$ 17–221.

(Reference 7)
Lead poisoning prevention policies have reduced population blood lead levels (USA)

Mean blood lead levels (µg/dL)

Year

- Lead-based Paint Poisoning Prevention Act 1971
- Lead gasoline phase-out 1973
- Lead limit in residential & decorative paint & on children’s products: 600 ppm 1978
- Safe Drinking Water Act 1974
- Lead in plumbing banned 1986
- Lead and Copper Rule (drinking water) 1991
- Lead Contamination Control Act (Drinking Fountains) 1988
- Virtual elimination of lead in gasoline 1988
- Ban on lead solder in food cans 1995
- Residential Lead-Based Paint Hazard Reduction Act 1992
- Housing units with lead based paint hazards reduced by 40% since 1990
- Renovation, Repair and Painting Rule (Lead Paint) 2008
- Total lead in children’s products limited to 100 ppm 2011
- Lead limit in residential & decorative paint & on children’s products reduced to 90 ppm 2009
- Lead limit in children’s products limited to 100 ppm 2011

(Reference 8)
Summary

• Lead exposure causes toxic effects in multiple body systems; some effects are permanent; children are especially vulnerable.

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

• Lead exposure has both a personal and a societal impact.

• Lead poisoning is preventable: implementation of lead control measures has significantly reduced population-level blood lead concentrations.

• Removing lead paint as a source of exposure will have significant health and economic benefits.
References


Additional references

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