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
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.

lead in dust & soil → Ingestion → Health outcomes e.g. reduced IQ, abdominal colic, anaemia
2 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 dispersed throughout the gut

Reference B.i.1
Lead accumulates in the body

- Bound to red blood cells and distributes to soft tissues and bone
- Stored in bone for many years (half-life = 10 – 25 years)
  - In adults 90% of body burden may be in bone
- Equilibrium between lead in bone and lead in blood
- Lead in bone is probably not physiologically active but 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

World Health Organization

LEAD PAINT ALLIANCE
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, 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. iron, increases bioavailability of lead
- Exposure may already occur in utero
Who is at risk? Children

• Foetal 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

• Children have more years of future life for expression of long-term effects
Who is at risk? Pregnant women

• Pregnancy mobilizes lead stored in bone so further exposure from the environment raises the blood lead concentration even higher

• Increased risk of hypertension during pregnancy – may result in pre-eclampsia

• 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.
No known threshold for toxic effects – 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 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

- 0.6% of global burden disease
- 143,000 deaths per year
- 8.977 million disability adjusted life years (DALYs)
  - 7.2 million DALYs – mild mental retardation
  - 1.8 million DALYs – cardiovascular disease
- Childhood lead exposure contributes ~ 600,000 new cases of children with intellectual disabilities per year

Reference B.i.3
Small IQ reduction has significant societal impact (1)

Reference B.i.4
Small IQ reduction has significant societal impact (2)

Reference B.i.4
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: $ 134.7 billion
  - Asia: $ 699.9 billion
  - Latin America & Caribbean: $ 142.3 billion
  - USA: $ 50.9 billion

Reference B.i.5
Economic benefits of action can be substantial

- In USA estimated cost of lead paint hazard control is US$ 1-11 billion

- Lead hazard control has benefits e.g. reduced health care costs, reduced need for special education, reduced crime, increased earnings and tax revenue

- Total saving estimated as US$ 192 – 270 billion

- Each US$ 1 invested in lead paint hazard control yields return of US$ 17 – 221

Reference B.i.6
Lead poisoning prevention policies have reduced population blood lead levels (USA)

- Lead-based Paint Poisoning Prevention Act 1971
- Lead Gasoline Phase-out 1973
- Residential Lead Paint Ban 1978
- Clean Water Act 1972
- Lead in plumbing banned 1986
- Lead Contamination Control Act Virtual Elimination of Lead in Gasoline 1988
- Ban on lead solder in food cans 1995
- Lead Title X 1992
- Lead in children’s products reduced to 100 ppm 2011
- Housing units with lead based paint hazards reduced by 40% since 1990
- Lead in children’s products reduced to 600 ppm 2009
- Lead in 2009
- Renovation and Repair Rule 2010
- Lead in children’s products reduced to 100 ppm 2011
- Lead in children’s products reduced to 600 ppm 2009

Reference B.i.7
Summary

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

• 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


B.i.2. National Toxicology Programme (2012) NTP evaluation of effects of low-level lead


References

B.i.5. Attina TM, Trasande L (2013) Economic Costs of Childhood Lead Exposure in Low- and Middle-Income Countries. Environ Health Perspect 121(9): 1097-1102
http://ehp.niehs.nih.gov/1206424/?utm_source=rss&utm_medium=rss&utm_campaign=1206424

http://ehp.niehs.nih.gov/0800408/

General references

B.i.8. Childhood Lead Poisoning
http://www.who.int/ceh/publications/childhoodpoisoning/en/

B.i.9. Lead poisoning and health, Fact sheet No 379, (in Arabic, Chinese, English, French, Russian and Spanish)
http://www.who.int/mediacentre/factsheets/fs379/en/
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