Module Bi

Health Hazards of Lead

LEAD PAINT ALLIANCE

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

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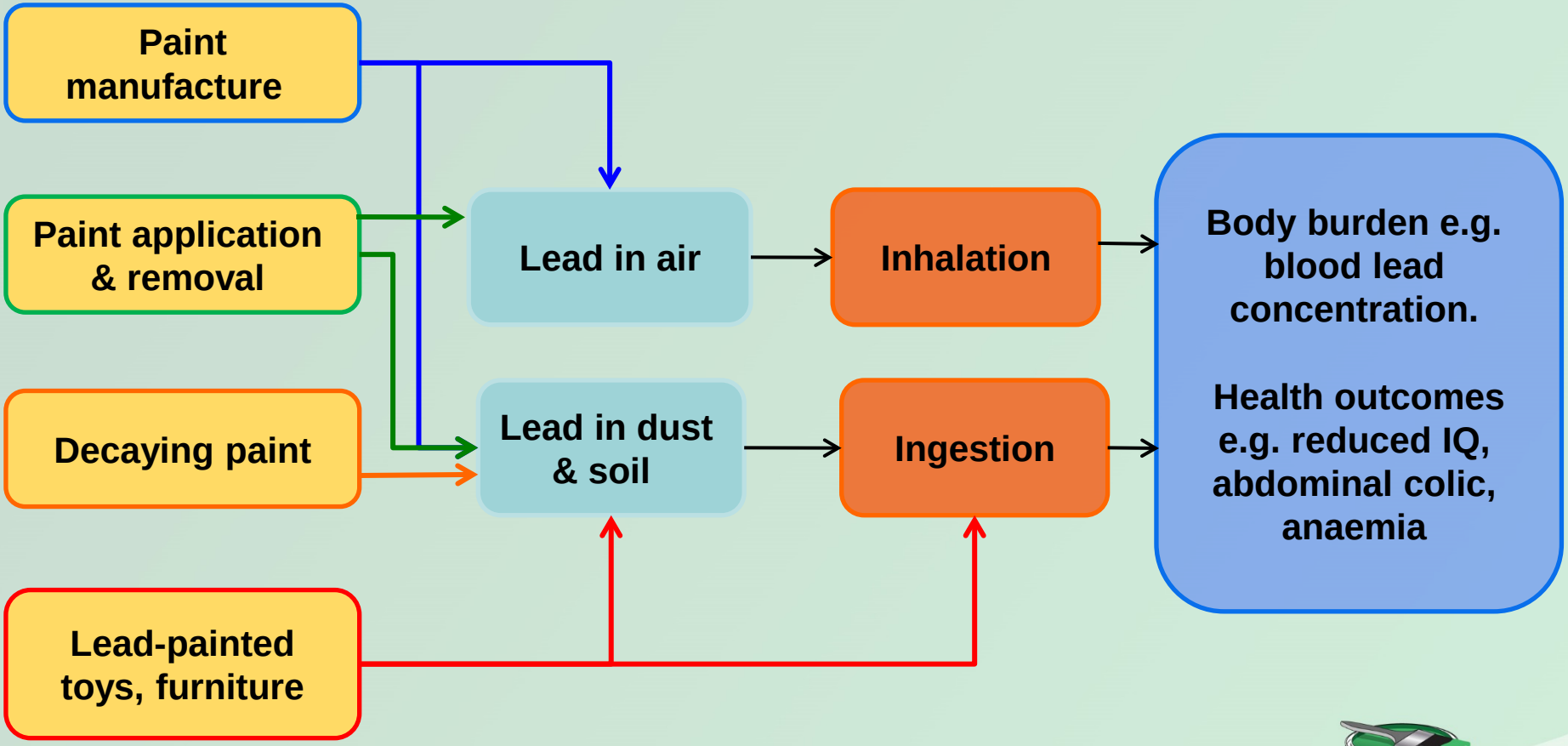
Multiple pathways of exposure to lead from paint



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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.

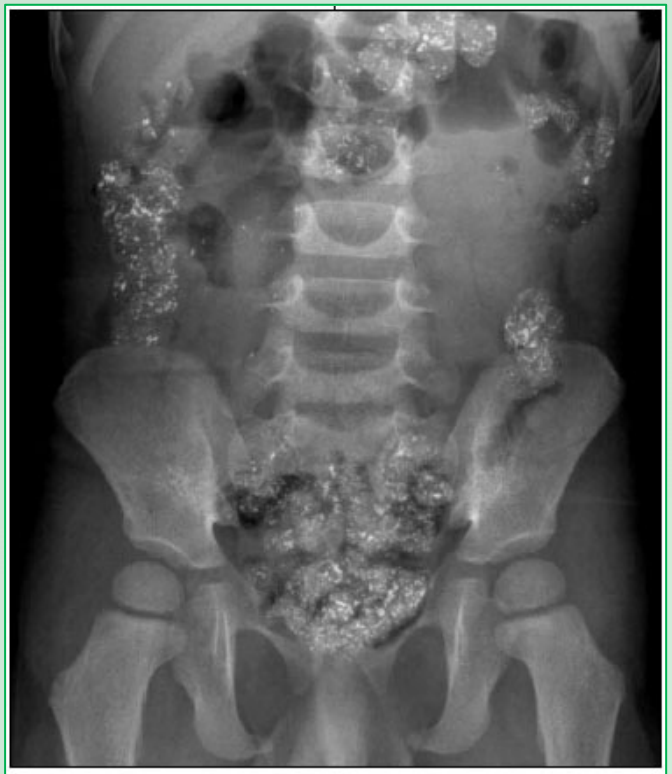

Figure 2 – A large quantity of lead paint chips can be seen in this radiograph of the abdomen and pelvis of a 2-year-old boy with lead poisoning.

(Reference 1)

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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.

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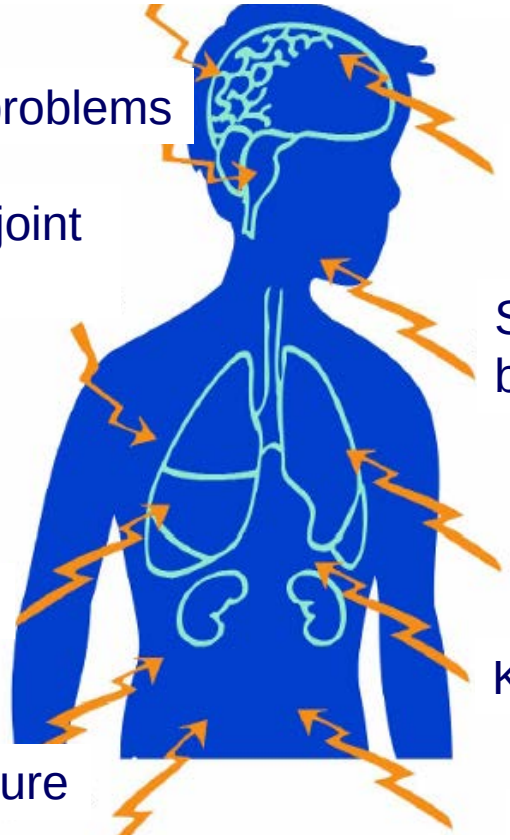
Lead is a multi-system toxicant



Brain & nervous system damage

Decreased IQ

Hearing problems

Learning difficulties

Muscle & joint pain

Speech, language and behaviour problems

Slow or reduced growth

Anaemia

Kidney damage

High blood pressure

Digestive problems

Reproductive problems (adults)

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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.

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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).

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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)

Photo credit: WHO/SEARO /Hayley Goldbach

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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)

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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.

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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

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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

Life Stage	Blood Pb Level	NTP Conclusion	Principal Health Effects	Bone Pb Evidence
Children	<5 µg/dL	*Sufficient*	Decreased academic achievement, IQ, and specific cognitive measures; increased incidence of attention-related behaviors and problem behaviors	Tibia and dentin Pb are associated with attention-related behaviors, problem behaviors, and cognition.
		Limited	Delayed puberty and decreased kidney function in children ≥12 years of age	The one available study of bone Pb in children does not support an association with postnatal growth.
	<10 µg/dL	*Sufficient*	Delayed puberty, reduced postnatal growth, decreased IQ, and decreased hearing	No data
		Limited	Increased hypersensitivity/allergy by skin prick test to allergens and increased IgE* (not a health outcome)	No data
		Inadequate	*Any age* – asthma, eczema, nonallergy immune function, cardiovascular effects; *<12 years of age* – renal function	No data
Adults	<5 µg/dL	*Sufficient*	Decreased glomerular filtration rate; maternal blood Pb associated with reduced fetal growth	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.
		Limited	Increased incidence of essential tremor	No data
	<10 µg/dL	*Sufficient*	Increased blood pressure, increased risk of hypertension, and increased incidence of essential tremor	The association between bone Pb and cardiovascular effects is more consistent than for blood Pb.
		Limited	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	The association between bone Pb and cognitive decline is more consistent than for blood Pb.
		Inadequate	Immune function, stillbirth, endocrine effects, birth defects, fertility or time to pregnancy**, sperm parameters**	No data

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**.

(Reference 3)

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)

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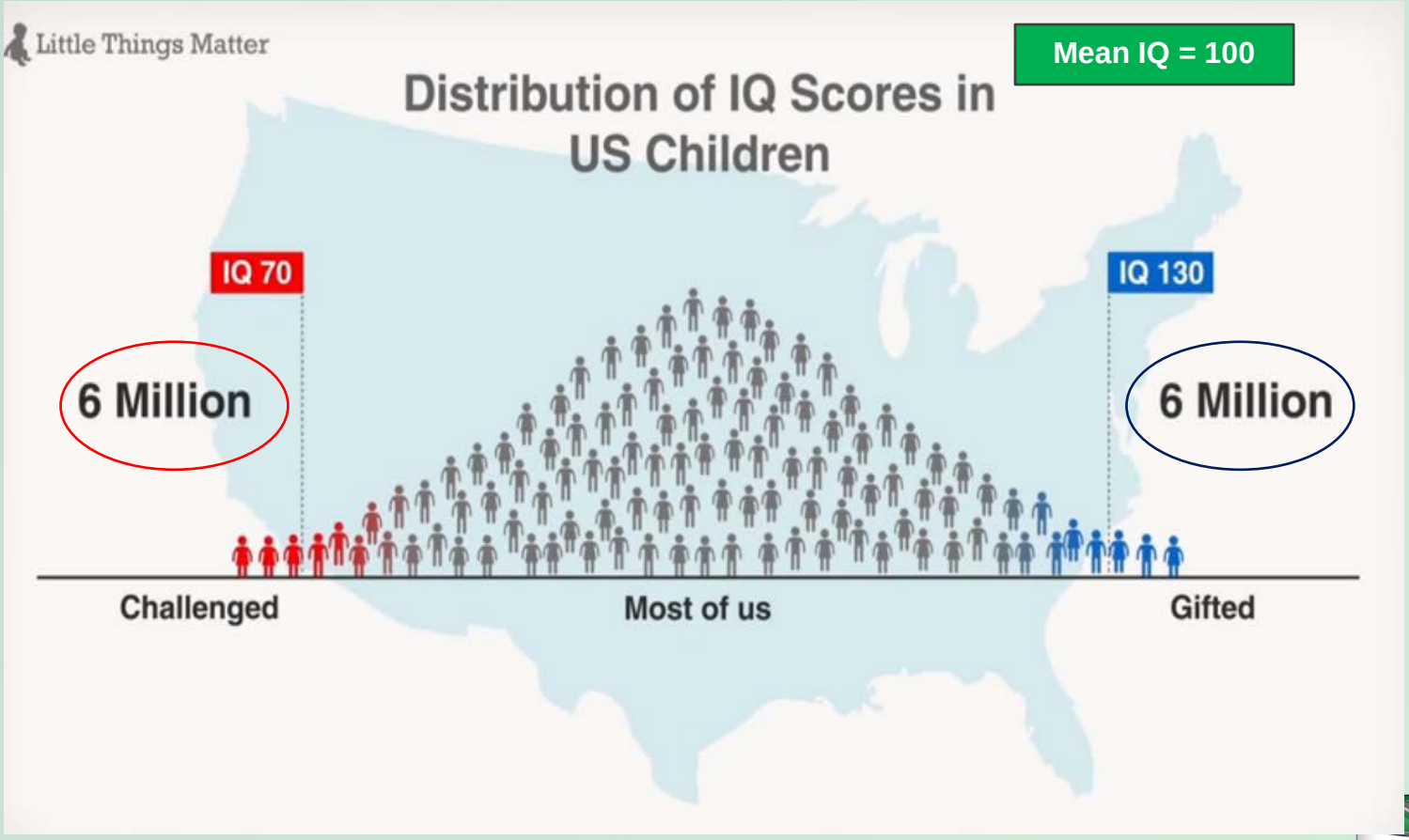
Small IQ reduction has significant societal impact (mean IQ 100)



(Reference 5)

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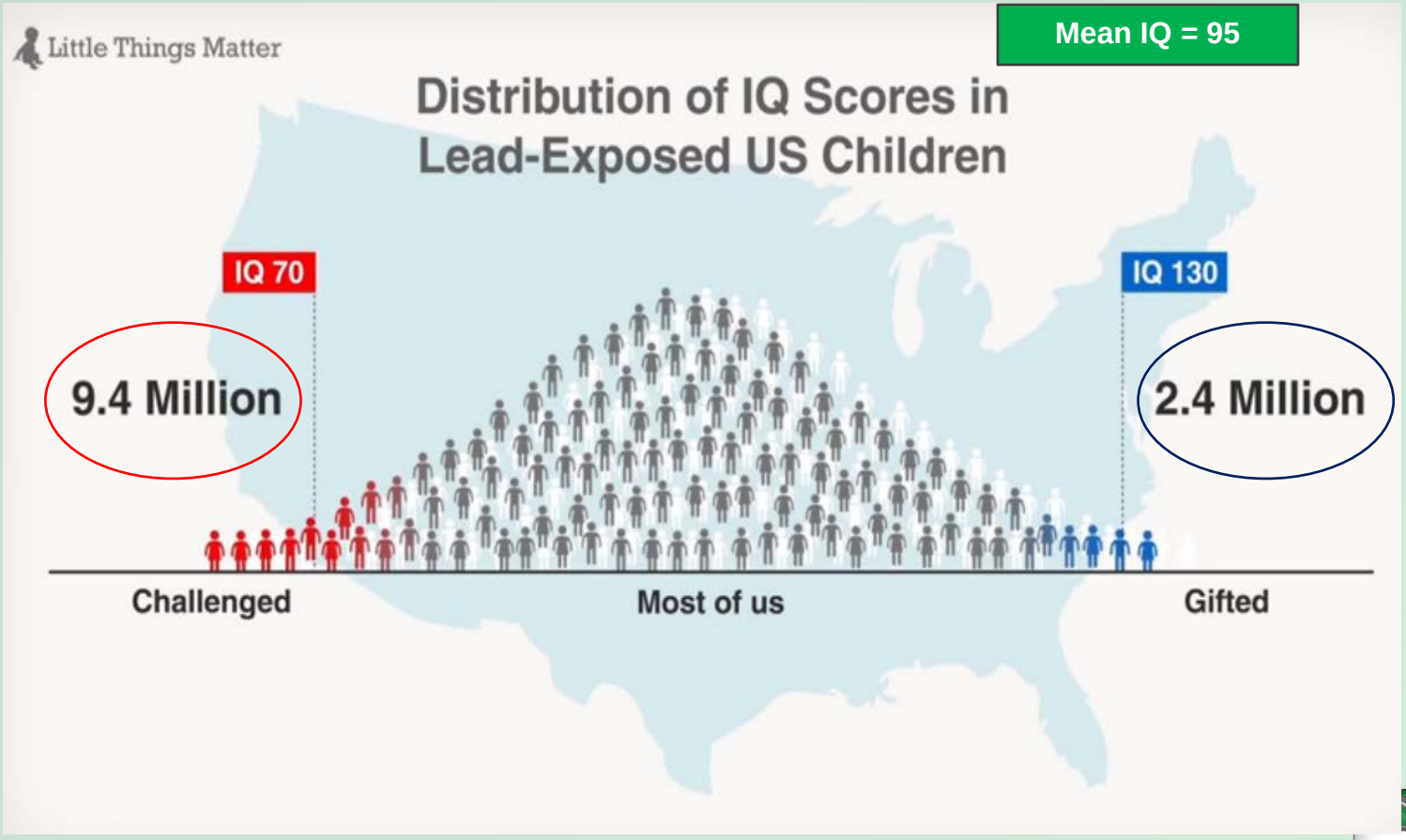
Small IQ reduction has significant societal impact (mean IQ 95)



(Reference 5)

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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)

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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.

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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)

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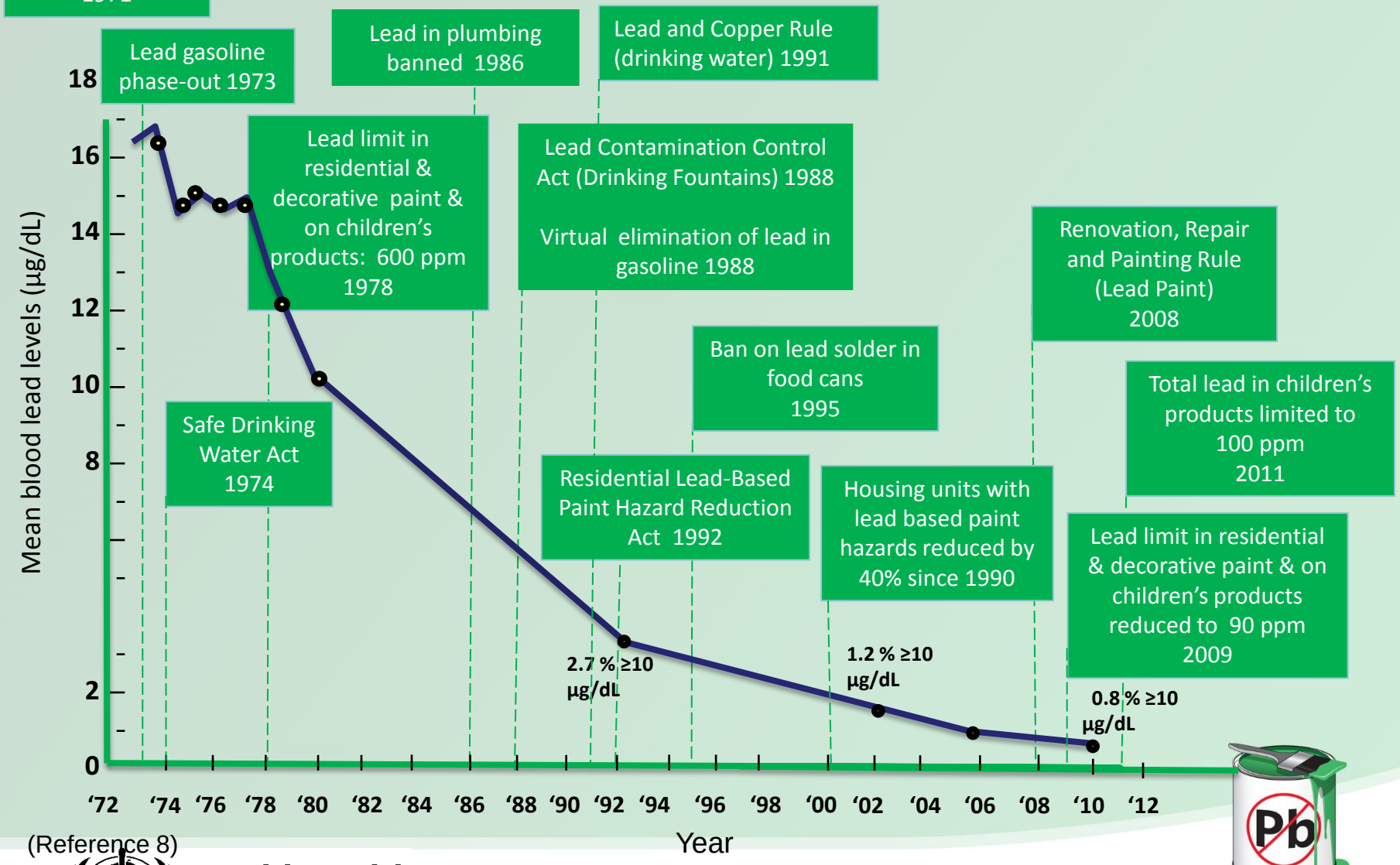
Lead poisoning prevention policies have reduced population blood lead levels (USA)



(Reference 8)

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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.

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References

1. Daubert GP (2006). Lead poisoning in a young boy. Consultant for Pediatricians. 5(3):147-149. Picture reproduced with permission

2. Childhood lead poisoning. Geneva: World Health Organization; 2010 (http://www.who.int/ceh/publications/childhoodpoisoning/en/, accessed 9 February 2017)

3. Health effects of low-level lead. National Toxicology Program Monograph. Bethesda (MD): National Institutes of Health; 2012 (http://ntp.niehs.nih.gov/pubhealth/hat/noms/lead/index.html, accessed 9 February 2017)

4. Global lead exposure. In: GBD Compare [website]. Seattle (WA): Institute for Health Metrics and Evaluation, University of Washington; 2016 (http://vizhub.healthdata.org/gbd-compare, accessed 9 February 2017)

5. Little things matter (2014). Canadian Environmental Health Atlas (https://www.youtube.com/watch?v=E6KoMAbz1Bw, accessed 9 February 2017). Images reproduced with permission.

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6. Attina TM, Trasande L.Economic Costs of Childhood Lead Exposure in Low- and Middle-Income Countries. Environ Health Perspect. 2013; 121(9): 1097-1102 (http://ehp.niehs.nih.gov/1206424/?utm_source=rss&utm_medium=rss&utm_campaign=1206424, accessed 9 February 2017)

7. Gould E. Childhood Lead Poisoning: Conservative Estimates of the Social and Economic Benefits of Lead Hazard Control. Environ Health Perspect. 2009; 117: 1162-1167. (http://ehp.niehs.nih.gov/0800408/, accessed 9 February 2017)

8. Brown MJB, Falk, H. US Centers for Disease Control and Prevention, personal communication, June 2015

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Lead poisoning and health, Fact sheet. Geneva: World Health Organization; 2016 (in Arabic, Chinese, English, French, Russian and Spanish) (http://www.who.int/mediacentre/factsheets/fs379/en/, accessed 9 February 2017)

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