

The Health Impacts of Lead Exposure

Toolkit for establishing
laws to eliminate
lead paint

Second Edition

Module B-1



Global Alliance to
Eliminate Lead Paint

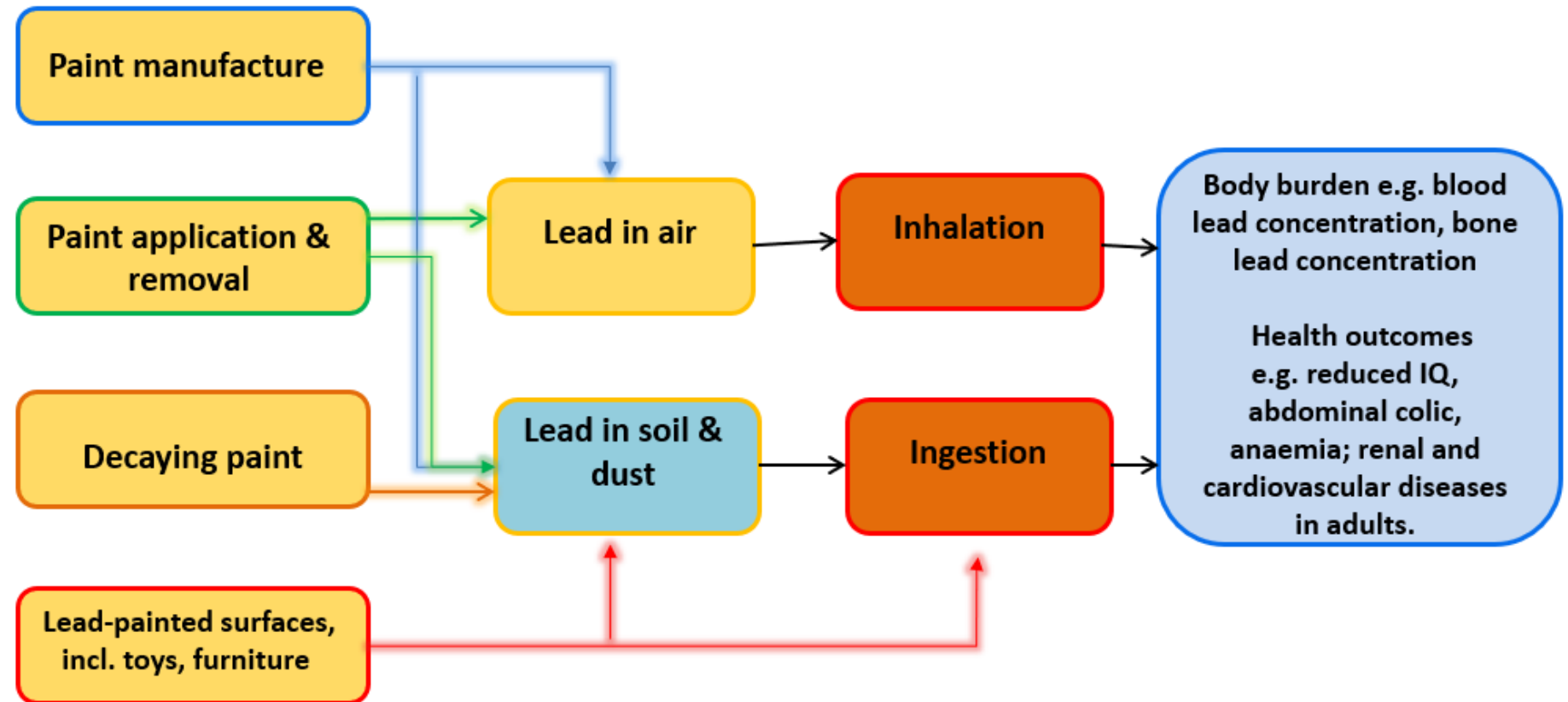
Outline

- Background
- Pathways and Routes of Exposure to Lead and Lead Paint
- Health Effects of Exposure
- Who is at Risk?
- Societal, Economic and Health Impacts of Control Measures
- Benefits of Action
- Summary

Background

- Lead is a versatile and widely used naturally occurring element
- Human activities result in environmental contamination:
 - Mining and smelting, manufacturing, use, recycling and disposal of products made with lead
- Lead compounds can be used in the manufacture of paint to give properties e.g. colour, rapid drying, corrosion resistance; continue to be used in some countries (see Module A-3)
- Lead is a human health hazard
- Lead paint is a significant source of human exposure

Sources and Routes of Exposure to Lead from Paint



Two Main Routes of Exposure to Lead Paint

- Individuals can become exposed to lead from paint through environmental and occupational sources.
- The most important routes of exposure are:
 - **Ingestion** of dust and paint chips – the main route of children’s exposure
 - **Inhalation** of fine particles and fumes – the main route of occupational exposure.



Photo credit: WHO/SEARO/Hayley Goldbach



Photo credit: IPEN

Source: World Health Organization. (2020). *Global elimination of lead paint: why and how countries should take action: technical brief*. World Health Organization. <https://apps.who.int/iris/handle/10665/333840> – Reference 1.

Source: World Health Organization. (2020). *Global elimination of lead paint: why and how countries should take action: policy brief*. World Health Organization. <https://apps.who.int/iris/handle/10665/333812> – Reference 2.

A Major Source of Exposure: Lead in Dust

- Isotopic studies confirm that lead in paint contributes to lead in dust
- Deteriorating lead paint is associated with higher amounts of lead in household dust and soil
- Lead content in paint correlates with lead content in dust:
 - 50% increase in window paint lead was associated with a 5% increase in floor dust lead (Dixon 2007)
 - exterior railings with a lead loading of ≥ 2.6 mg/cm² associated with approx. 50% higher lead loading in household dust (Lucas 2014)

Source: Dixon S, Wilson J, Galke G (2007). Friction and impact surfaces: are they lead-based paint hazards? *J Occup Environ Hyg.* 4(11):855–63. doi:10.1080/15459620701655770 – Reference 6.

Source: Lucas JP, Bellanger L, Le Strat Y, Le Tertre A, Glorennec Ph, Le Bot B et al. (2014). Source contributions of lead in residential floor dust and within-home variability of dust lead loading. *Sci Total Environ.* 470(471):768– 79. doi:10.1016/j.scitotenv.2013.10.028 – Reference 7.



Photo credit: WHO/Yoshi Shimizu

Lead in Dust Associated with Increased Blood Lead

- Pooled analysis of 12 studies showed lead-contaminated house dust is major source of intake for children with blood lead concentration of 10-25 $\mu\text{g}/\text{dL}$

(Lanphear et al., 1998)

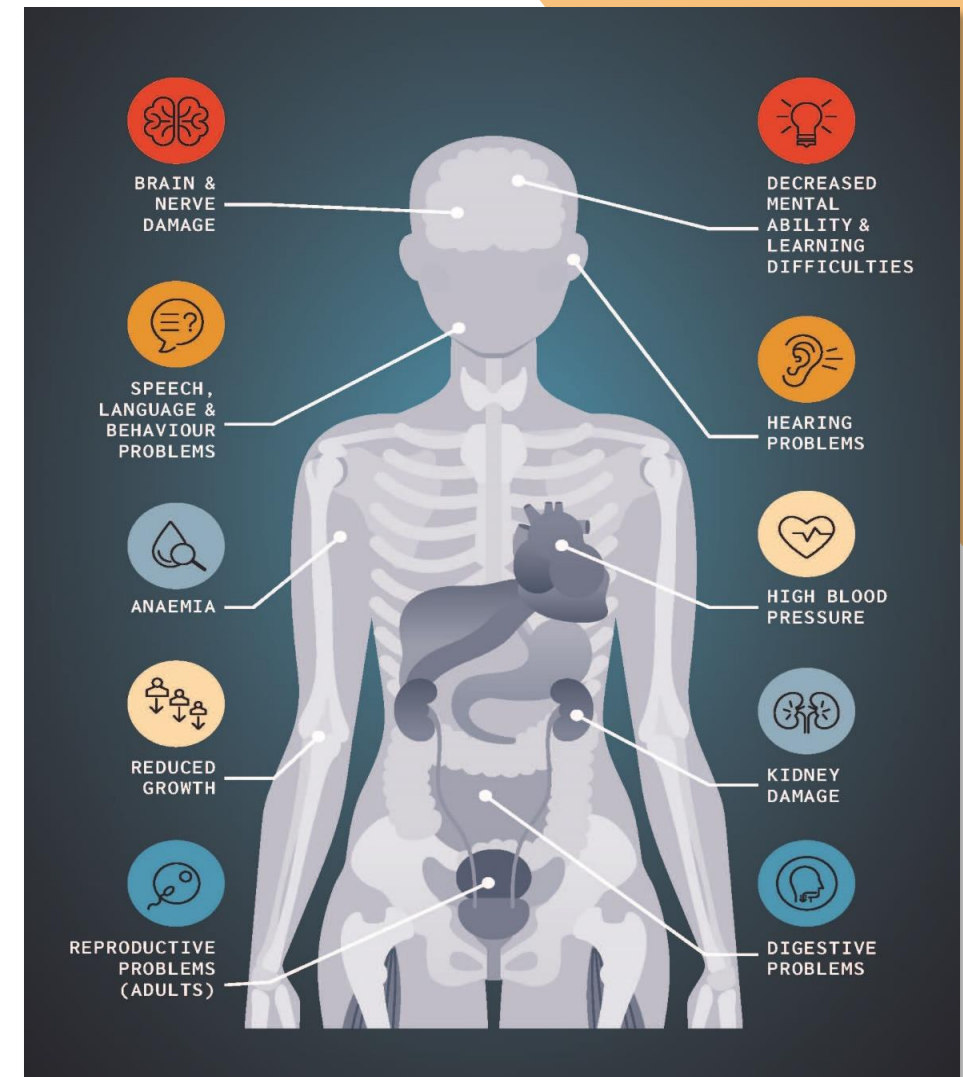
Source: Lanphear BP, Matte TD, Rogers J, Clickner RP, Dietz B, Bornschein RL et al. (1998). The contribution of lead-contaminated house dust and residential soil to children's blood lead levels. A pooled analysis of 12 epidemiologic studies. Environ Res. 79:51-68 (<https://doi.org/10.1006/enrs.1998.3859>, accessed 13 April 2020) – Reference 8.



Photo credit: WHO PhotoLibrary

Health Effects of Lead Exposure

- Lead is a multi-system toxicant. No known level of exposure without harmful effects
- Mimics calcium and iron in the body so has effects in multiple body systems
- Accumulates in bone
- Long-term effects include reduced IQ, antisocial behaviour, cardiovascular & renal disease in adults
- Often onset of symptoms are insidious, such as anaemia, colic, etc.



Lead Accumulates in the Body

- Lead binds 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.
- Lead is 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.

Low-Level and Chronic Exposure

- 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.
 - Low-level and chronic exposure is often the type of exposure caused by lead paint

Acute and Sub-Acute Lead Poisoning

- 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).
 - *Note: pica is a syndrome of an appetite for non-nutritional substances*

Source: Thurtle N, Grieg J, Cooney L, Amitai Y, Ariti C, Brown MJ, Kosnett MJ, Moussally K, Sani-Gwarzo N, Akpan H, Shanks L, Dargan PI (2014). Description of 3180 courses of chelation with dimercaptosuccinic acid in children .5 years with severe lead poisoning in Zamfara, northern Nigeria: a retrospective analysis of programme data. *PLOS Medicine*, 11(10):1-18. – Reference 3

Who Is At Risk?

- Children are especially vulnerable due to greater exposure risks from:
 - Spending more time on the ground and in contact with contaminated soil and dust,
 - Hand-to-mouth activity, mouthing,
 - Absorbing 4–5 times more lead from the gut than adults, and
 - All children have nutritional deficiency (e.g. calcium, iron) which increases bioavailability of lead.
- Exposure may already occur through maternal cord blood (*in utero*)



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.

Source: *Childhood lead poisoning*. Geneva: World Health Organization; 2010
(<https://apps.who.int/iris/handle/10665/136571> , accessed 12 February 2021) – Reference 4

Who Is At Risk? (Continued)

- The foetal period and early childhood are critical periods for neurological and organ development
- Damage to the neurological system may be irreversible
 - Reduced potential for intellectual development
 - Increased likelihood of behavioural disorders
- Children can even express long-term effects in adulthood



Photo credit: Calonzo/EcoWaste Coalition

Source: 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 12 February 2021) – Reference 5

Pregnant Women Are Also Vulnerable

- Pregnancy mobilizes lead stored in bone, releasing it back into blood where it can be circulated to maternal tissues and the fetus
- Lead exposure may cause reduced fetal growth
- Lead exposure in pregnancy increases risk of complications e.g., hypertension, premature birth

Workers Also Need Protecting

- Study in Kenya found significant lead exposure in workers making paint
 - 78% of air samples exceeded US 8-hour permissible exposure limit ($50 \mu\text{g}/\text{m}^3$)
 - 75.6% of blood samples $>30 \mu\text{g}/\text{dL}$ lead
- Workers spraying and stripping lead paint, as well as home renovators can have high exposures

Source: Were FH, Moturi MC, Gottesfeld P, Wafula GA, Kamau GN, Shiundu PM. (2014) Lead exposure and blood pressure among workers in diverse industrial plants in Kenya. *J Occup Environ Hyg.* 2014; 11(11):706–15 doi:10.1080/15459624.2014.908258 – Reference 9.



Lead Exposure Causes Significant Burden of Disease

Estimates from Institute for Health Metrics and Evaluation (IHME), 2019 data:

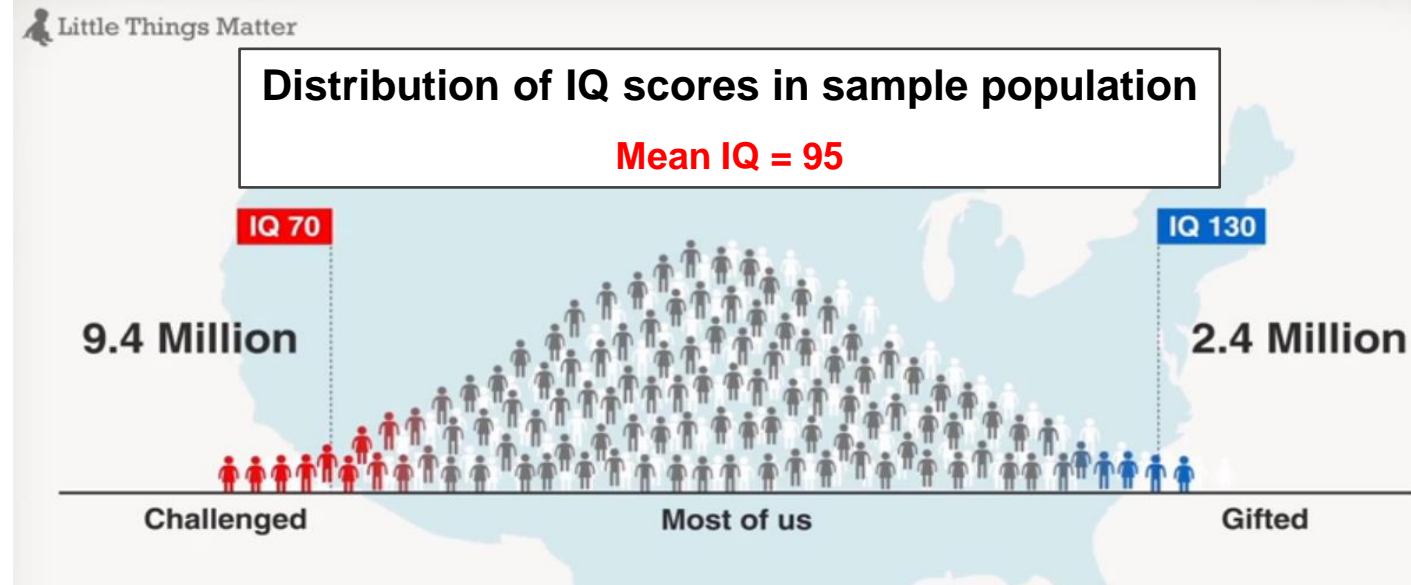
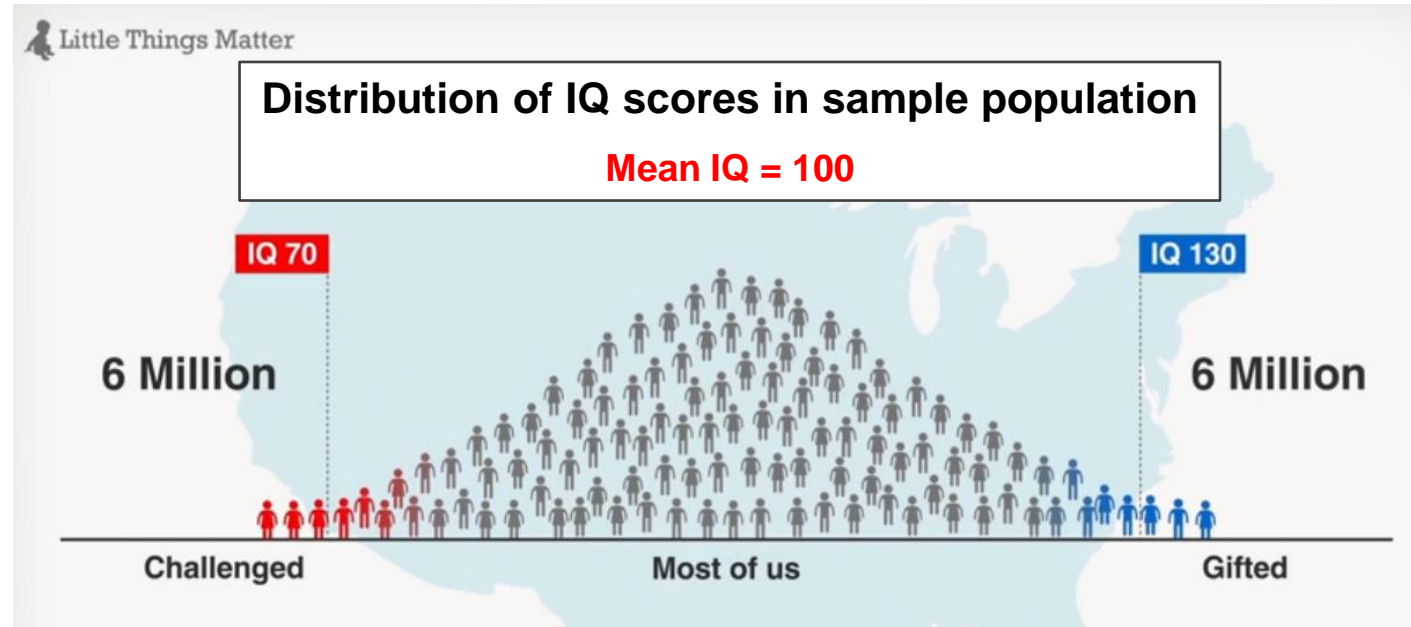
- 0.90 million deaths from long-term effects
- 21.7 million disability adjusted life years (DALYs) lost
- Estimated to account for:
 - 62.49% of the global burden of idiopathic developmental intellectual disability
 - 7.19% of the global burden of ischaemic heart disease
 - 8.21% of hypertensive disease
 - 5.65% of the global burden of stroke

Source: Estimates from Institute for Health Metrics and Evaluation – Reference 10

Small Average IQ Reduction Can Have Large Societal Impacts

A 5-point loss in IQ (intelligence quotient) might not affect the ability of an individual to live a productive life. But if that loss is experienced by a large proportion of a population, the implications for that society could be profound.

Source: Little things matter. Canadian Environmental Health Atlas; 2014 (<https://www.youtube.com/watch?v=E6K0MAbz1Bw>, accessed 9 February 2021). Images reproduced with permission – Reference 11.



Small Average IQ Reduction Can Have Large Societal Impact (Notes, Slide 17)

- Professor Bernard Weiss, a behavioural toxicologist at the University of Rochester, New York, USA, examined the societal impact of seemingly small losses of intelligence. Imagine an unaffected population numbering 260 million people (such as that of the USA) with an average IQ of 100 and a standard deviation of 15 (left-hand graph). In that population there would be 6 million people with IQs above 130 and 6 million below 70.
- A decrease in average IQ of 5 points would shift the distribution to the left (right-hand graph). The number of people scoring above 130 would decline by 3.6 million while the number below 70 would increase by 3.4 million.

Source: Gilbert , Weiss B. A rationale for lowering the blood lead action level from 10 to 2 ug/dL. *Neurotoxicology*. 2006 September ; 27(5): 693–701 <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2212280/pdf/nihms37310.pdf>

By Bruce Lanphear and the Canadian Environmental Health Atlas.

Economic Costs of Lead Exposure Are High

- Estimated economic losses due to reduced IQ is ~1.2% of global GDP (see Module B-3 for additional information)
 - Largest economic burden is borne by low- and middle- income countries – approx. \$977 billion
 - Regional economic losses:
 - In Africa approx. \$134.7 billion (4.03% of regional GDP)
 - In Latin America and the Caribbean approx. \$142.3 billion (2.04% of regional GDP)
 - In Asia approx. \$699.9 billion (1.88% of regional GDP).

Source: Attina TM, Trasande L. Economic costs of childhood lead exposure in low- and middle-income countries. Environ Health Perspect. 2013 Sep;121(9):1097-102 – Reference 12

Economic Benefits of Action Are Significant

- Banning lead paint now saves costs in future
 - Avoids future costs of lead exposure resulting from use of lead paint now, such as cost of reduced IQ, cost of criminality
 - Avoids future remediation costs
 - Estimated costs of remediating lead-painted homes:
 - France: US\$ 194 – 499 million
 - USA: US\$ 1 – 11 billion

Source: Pichery C et al. *Childhood lead exposure in France: benefit estimation and partial cost-benefit analysis of lead hazard control. Environmental Health. 2011;10:44 – Reference 13*

Source: Gould E. *Childhood Lead Poisoning: Conservative Estimates of the Social and Economic Benefits of Lead Hazard Control. Environ Health Perspect, 2009;117: 1162-1167 – Reference 14*

The Lower the Lead Content, the Lower the Hazard

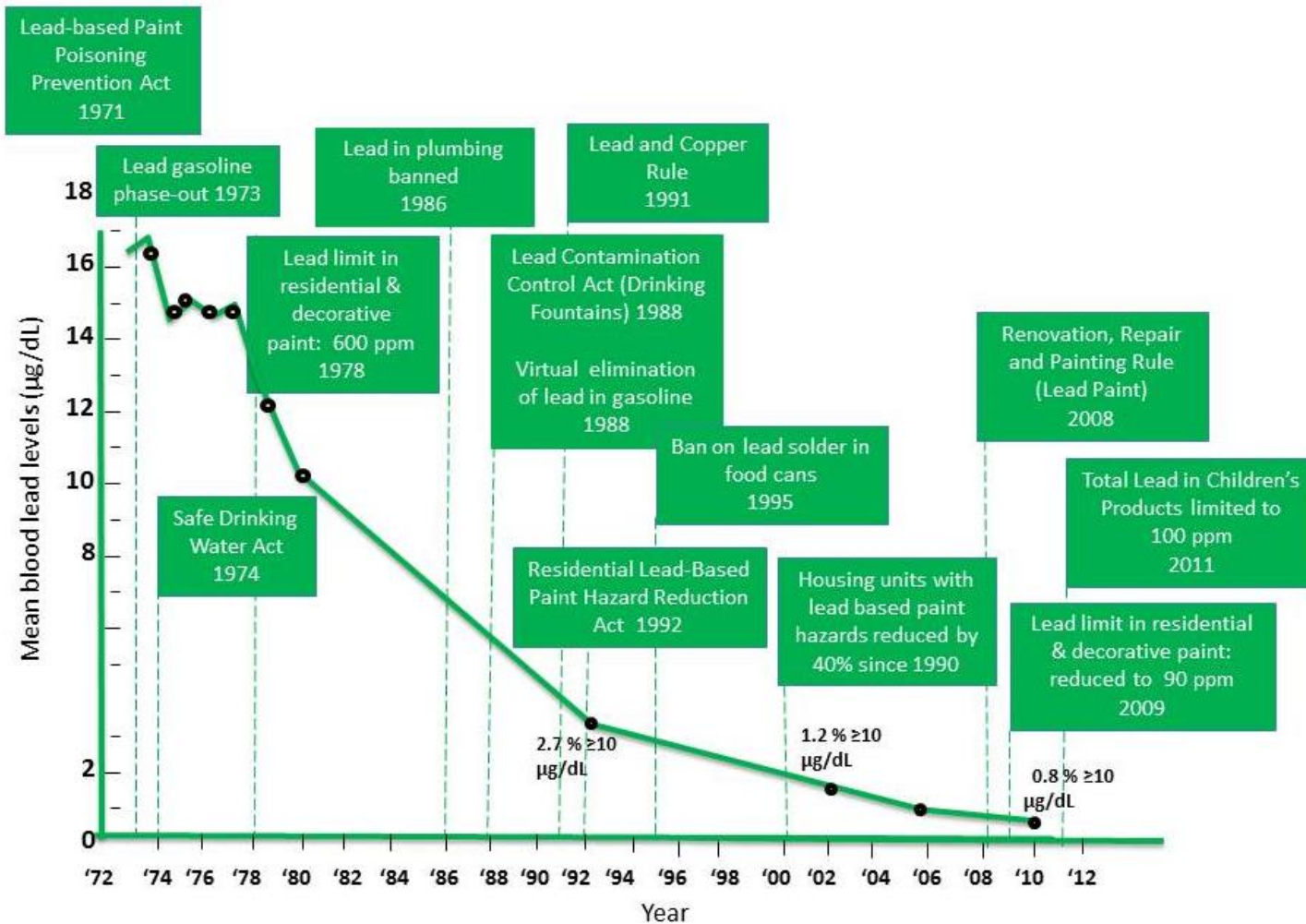
By reducing lead in paint, we can protect vulnerable populations and public health. For example:

- Children who eat flakes of lead paint can develop lead poisoning
- The lower the lead content the less likely a child will eat enough paint to cause harm
 - 500 ppm of lead in paint – regular ingestion of 6-7 flakes of paint could reduce IQ
 - 90 ppm of lead in paint – harmful dose is ~31 flakes
- Similar reasoning applies to lead in dust originating from paint



Photo credit: Lushomo communications

Lead Poisoning Prevention Policies Have Proven to Reduce Population Blood Lead Levels (USA)



Source: Brown MJB, Falk, H (2015) US Centers for Disease Control and Prevention, personal communication

Summary

- Lead exposure causes toxic effects in multiple body systems; some effects are irreversible; children, pregnant women and some occupational groups are particularly vulnerable.
- There is no known level of lead exposure without harmful effects.
- Lead exposure has both an individual and a societal impact.
- Lead poisoning is preventable: implementation of lead control measures has significantly reduced population-level blood lead concentrations in several countries.
- Removing lead paint as a source of exposure will have significant health and economic benefits.

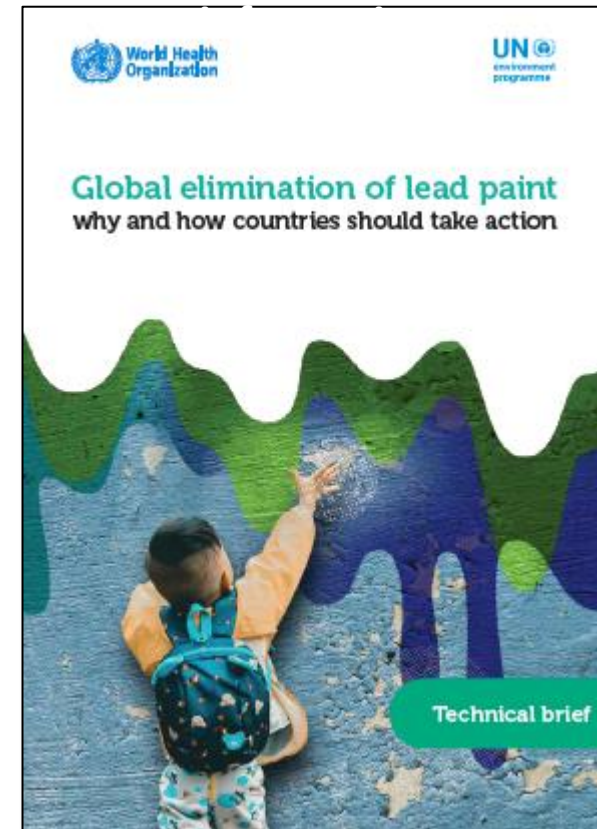
More Details Are Available on the WHO Website in Six UN Languages

Policy Brief – Summary Information



<https://www.who.int/publications/i/item/9789240005143>

Technical Brief – Detailed



<https://www.who.int/publications/i/item/9789240005143>

References

1. World Health Organization. (2020). Global elimination of lead paint: why and how countries should take action: technical brief. World Health Organization. <https://apps.who.int/iris/handle/10665/333840>.
2. World Health Organization. (2020). Global elimination of lead paint: why and how countries should take action: policy brief. World Health Organization. <https://apps.who.int/iris/handle/10665/333812>.
3. *Thurtle N, Grieg J, Cooney L, Amitai Y, Ariti C, Brown MJ, Kosnett MJ, Moussally K, Sani-Gwarzo N, Akpan H, Shanks L, Dargan PI (2014). Description of 3180 courses of chelation with dimercaptosuccinic acid in children .5 years with severe lead poisoning in Zamfara, northern Nigeria: a retrospective analysis of programme data. PLOS Medicine, 11(10):1-18*
4. Childhood lead poisoning. Geneva: World Health Organization; 2010 (<https://apps.who.int/iris/handle/10665/136571>, accessed 12 February 2021)
5. 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 12 February 2021)

References (Continued)

6. Dixon S, Wilson J, Galke G (2007). Friction and impact surfaces: are they lead-based paint hazards? *J Occup Environ Hyg.* 4(11):855–63. doi:10.1080/15459620701655770
7. Lucas JP, Bellanger L, Le Strat Y, Le Tertre A, Glorennec Ph, Le Bot B et al. (2014). Source contributions of lead in residential floor dust and within-home variability of dust lead loading. *Sci Total Environ.* 470(471):768– 79. doi:10.1016/j.scitotenv.2013.10.028
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9. Were FH, Moturi MC, Gottesfeld P, Wafula GA, Kamau GN, Shiundu PM. (2014) Lead exposure and blood pressure among workers in diverse industrial plants in Kenya. *J Occup Environ Hyg.* 2014; 11(11):706–15 doi:10.1080/15459624.2014.908258.
10. Global lead exposure. In: GBD Compare [website]. Seattle (WA): Institute for Health Metrics and Evaluation, University of Washington; 2019 <https://vizhub.healthdata.org/gbd-compare/>, accessed 12 February 2021

References (Continued)

11. 11. Little things matter. Canadian Environmental Health Atlas; 2014 (<https://www.youtube.com/watch?v=E6KoMABz1Bw>, accessed 9 February 2021)
12. 12. Attina TM, Trasande L. Economic costs of childhood lead exposure in low- and middle-income countries. Environ Health Perspect. 2013 Sep;121(9):1097-102
13. 13. Pichery C et al. Childhood lead exposure in France: benefit estimation and partial cost-benefit analysis of lead hazard control. Environmental Health. 2011;10:44
14. 14. Gould E. Childhood Lead Poisoning: Conservative Estimates of the Social and Economic Benefits of Lead Hazard Control. Environ Health Perspect, 2009;117: 1162-1167

Additional References

- **Lead poisoning and health, Fact sheet.** Geneva: World Health Organization; 2019 (in Arabic, Chinese, English, French, Russian and Spanish) (<https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health>, accessed 12 February 2021)
 - Preventing disease through healthy environments. **Exposure to lead: a major public health concern;** Geneva: World Health Organization; 2019 (<https://www.who.int/publications/i/item/WHO-CED-PHE-EPE-19.4.7-eng>, accessed 12 February 2021)
 - Chemical safety: Lead and lead paint, **Questions and answers.** Geneva: World Health Organization; 2020 (in Arabic, Chinese, English, French, Russian and Spanish, <https://www.who.int/news-room/q-a-detail/chemical-safety-lead-and-lead-paint>, accessed 12 February 2021)

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