World Health Organization

PREVENTING DISEASE THROUGH HEALTHY ENVIRONMENTS

EXPOSURE TO LEAD: A MAJOR PUBLIC HEALTH CONCERN

Lead is a toxic metal whose widespread use has caused extensive environmental contamination and health problems in many parts of the world. It is a cumulative toxicant that affects multiple body systems, including the neurological, haematological, gastrointestinal, cardiovascular and renal systems. Children are particularly vulnerable to the neurotoxic effects of lead, and even relatively low levels of exposure can cause serious and, in some cases, irreversible neurological damage.[1,2] Lead exposure causes a significant burden of disease: the Institute for Health Metrics and Evaluation has estimated that in 2017, lead exposure accounted for 1.06 million deaths and 24.4 million disability-adjusted life years (DALYs[*]) due to long-term effects on health.[4] Reductions in the use of lead in petrol (gasoline), paint, plumbing and solder have resulted in substantial reductions in blood lead concentrations globally.[5] However, significant sources of exposure to lead still remain, particularly in developing countries and those in economic transition. Further efforts are required to continue to reduce the use and releases of lead, and to reduce environmental and occupational exposures, particularly for children and women of childbearing age.

Sources of exposure to lead

Lead is found at low levels in Earth's crust, mainly as lead sulfide (galena).[6] However, the widespread occurrence of lead in the environment is largely the result of human activity, such as mining, smelting, refining and recycling of lead; use of leaded petrol (gasoline) and aviation fuel; use of lead in manufacturing, such as for lead-acid batteries, paints, glazes and leaded glass; in jewellery making, soldering and ceramics; as part of electronic waste; in various kinds of informal and cottage (home-based) industries; and use in water pipes and solder.[6,7] Other sources of lead in the environment include natural activities, such as volcanic activity, geochemical weathering and sea spray emissions, and remobilization of historic sources, such as lead in soil, sediment and water from mining areas.[6]

As lead is an element, once it is released into the environment, it persists. Because of this persistence and potential for global atmospheric transport of lead, atmospheric emissions affect even the most remote regions of the world.[8]

Industrial processes

Lead is used mainly in the production of lead-acid batteries, plumbing materials and alloys. Other uses are in cable sheathing, paints, glazes and ammunition.[6,7] The manufacture of these products can result in human occupational exposure. Occupational exposure can also occur during the application and removal of lead-containing paints; during the grinding, welding and cutting of materials coated with lead-containing paints, such as in shipbuilding, construction and demolition industries; and in the fabrication and carving of lead crystal glassware.[6] Mining, smelting, and formal and informal

[*] The DALY combines the burden due to death and disability in a single index. Use of such an index permits the comparison of the burden due to various environmental risk factors with those from other risk factors or diseases. One DALY can be thought of as 1 lost year of healthy life.[3]

processing and recycling of electric and electronic waste can also be significant sources of exposure.

Lead has been used widely in the form of tetraethyl and tetramethyl lead as antiknock and lubricating agents in petrol, although most of the lead is emitted from vehicles in the form of inorganic particles. This use has been phased out in almost all countries,[9] which has resulted in a significant reduction of human exposure and mean blood lead concentrations. Lead additives continue to be used in some aviation fuels for piston-engine aircraft and this is a source of exposure to lead around airfields.[10] Old industrial hotspots that have not been cleaned up can also represent a hazard even years after contamination has stopped, particularly to children who might ingest contaminated soil or dust as a result of their hand-to-mouth behaviour.

Food and smoking

For the non-smoking general population, the largest contribution to the daily intake of lead is derived from the ingestion of food, dirt and dust.[11] Lead contamination of food can occur from environmental sources, and from food processing and packaging.[12] Atmospheric contamination from industrial emissions and leaded fuel can result in deposition and uptake of lead by plants, including food crops.[1,12] There is also some transfer of lead from soil to crop tissues.[1] Water can be a further source of lead contamination of food. The use of lead-soldered food and beverage cans (which is now diminishing), lead-glazed ceramics for storing or preparing food, and packaging and wrappings printed with lead inks can considerably increase the lead content of the food or beverage concerned. Acidic foods and drinks are particularly likely to leach lead from contact materials. Some foods – for example, spices[13] – may be deliberately adulterated with lead or may become contaminated during processing.

Tobacco plants take up lead from environmental sources; therefore, smoking tobacco increases lead intake.[1,2]

Drinking-water[11]

Lead present in tap water is rarely the result of its dissolution from natural sources but is mainly due to household plumbing systems containing lead pipes, solders and fittings. Polyvinyl chloride (PVC) pipes also contain lead compounds that can leach into water. The amount of water dissolved from plumbing materials depends on a number of factors, including the temperature, pH and standing time of the water. Soft, acidic waters are the most plumbosolvent. Water that has been in contact with lead-containing plumbing materials for an extended period (e.g. overnight) will have a higher concentration, and lead concentrations can vary throughout the day, depending on water usage.

Domestic sources

Contaminated dust and soil are important sources of exposure for infants because of their hand-to-mouth behaviour.[14] The weathering, peeling or chipping of lead-based paints, mainly found in older houses, contribute to the lead content of household dust; moreover, some young children pick off and eat the fragments of paint.[14] Lead-containing dust may be brought into the home on the clothes of those who work in industries using lead. Some toys either are made from lead or contain lead (e.g. some plastics or paints). Some traditional medicines and makeup (e.g. kohl) contain lead.[2]

World Health Organization (WHO) lead guidelines
Tolerable intake level In a review of the latest scientific evidence, conducted in 2010, the Joint Food and Agriculture Organization of the United Nations (FAO)/WHO Expert Committee on Food Additives (JECFA) estimated that the previously established provisional tolerable weekly intake (PTWI) of 25 µg/kg body weight per week could no longer be considered health protective and withdrew it. As the dose–response analyses did not provide any indication of a threshold for the key adverse effects of lead, the Committee concluded that it was not possible to establish a new PTWI that would be health protective. The dose–response analyses conducted by the Committee should be used as guidance to identify the magnitude of effect associated with identified levels of dietary lead exposure in different populations.[12]
Drinking-water The guideline value is 10 µg/L.[15]
Air The guideline value is 0.5 µg/m^3 (annual average).[16]

Health effects

- The Institute for Health Metrics and Evaluation has estimated that in 2017, lead exposure accounted for 1.06 million deaths and 24.4 million DALYs due to long-term effects on health, such as cardiovascular and renal disease and neurological and intellectual deficits.[4]

- Lead in the body is distributed to the brain, liver, kidney and bones. It is stored in the teeth and bones, where it accumulates over time. Human exposure can be assessed directly through measurement of lead in blood or bone (bone lead reflects cumulative exposure).[1,12]

Effects in children and pregnant women

- Young children absorb 4–5 times as much lead as adults (apart from pregnant women). Infants, young children (especially those less than 5 years of age) and pregnant women are most susceptible to the adverse effects of lead.[14]

- The potential for adverse effects of lead exposure is greater for children than for adults, because in children: 1) the intake of lead per unit body weight is higher; 2) more dust may be ingested; 3) lead absorption in the gastrointestinal tract is higher; 4) the blood–brain barrier is not yet fully developed; 5) their neurological system is still developing and is vulnerable to the toxic effects of lead; and 6) children have more years of life ahead of them and thus a longer time to develop the delayed effects of early lead exposure.[14]

- The most critical effect of lead in young children is that on the developing nervous system. Subtle effects on intelligence quotient (IQ) can be associated with blood lead concentrations below 5 µg/dL (50 µg/L), and the effects gradually increase with increasing levels of lead in blood.[1] Recent reviews of the latest scientific evidence indicating effects at lower levels did not provide any indication of a threshold for the key adverse effects of lead.[1,12] Lead exposure has also been linked epidemiologically to attention deficit disorder and aggression.[1]

- Exposure of pregnant women to high levels of lead can cause miscarriage, stillbirth, premature birth and low birth weight, as well as minor malformations.[1]

Acute effects

- Lead is classically a chronic or cumulative toxin; hence, acute adverse effects are usually observed only following short-term exposures to high doses. Acute exposures to lead may cause gastrointestinal disturbances (anorexia, nausea, vomiting, abdominal pain), hepatic and renal damage, hypertension and neurological effects (malaise, drowsiness, encephalopathy) that may lead to convulsions and death.[2]

Effects following chronic exposure[1]

- Chronic lead exposure causes a wide range of effects. These include: haematological effects, such as anaemia; neurological disturbances, including headache, irritability, depression, lethargy, convulsions, muscle weakness, ataxia, tremors and impaired hearing; gastrointestinal disorders, in particular abdominal colic; and kidney dysfunction. Chronic exposure is also associated with an increased risk of hypertension, ischaemic heart disease and stroke.

- There is some evidence that long-term occupational exposure to lead may contribute to the development of cancer. The International Agency for Research on Cancer (IARC) has classified inorganic lead compounds as *probably carcinogenic to humans* (Group 2A), meaning that there is limited evidence for carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals. According to IARC, organic lead compounds are not classifiable as to their carcinogenicity to humans (Group 3), meaning that there is inadequate evidence for their carcinogenicity to humans.[17]

- In men, the reproductive effects of lead include decreased sperm count and increased number of abnormal sperm.[1]

Risk mitigation recommendations

Primary prevention (i.e. the elimination of exposure to lead at its source) is the single most effective intervention against lead poisoning. The following actions are needed:

Eliminating use

- Phase out the use of lead additives in motor and aviation fuels in countries where this has not yet been done.

- Phase out the use of lead in paints on a worldwide basis.

- Eliminate the use of leaded solder in food and drink cans, as well as in water pipes.

- Eliminate the use of lead in homes, schools, school materials and children’s toys.

- Eliminate the use of lead glazing for pottery intended for cooking, eating or drinking.

- Encourage the removal of plumbing and fittings containing lead (as this is costly; other measures – such as corrosion control and minimizing the dissolving of lead in water systems

– should be implemented in the meantime).

- Identify and eliminate lead use in traditional medicines and cosmetics.

Preventing exposure

- Put in place occupational standards to protect workers from exposure.
- Prevent exposure to lead from electronic waste (e.g. lead-acid batteries, computers), particularly for children.
- Ensure that the recycling of lead-containing waste is undertaken only in the presence of appropriate industrial hygiene measures and that informal recycling and use of lead-containing waste are discouraged.
- Identify contaminated sites and take necessary action to prevent human exposure to lead from these areas.

Monitoring

- Monitor blood lead concentrations during occupational exposure. Extend the monitoring of blood lead levels in children and women of childbearing age by use of sensitive analytical methods.[18]
- Enhance the collection of data on lead in foodstuffs and make this information publicly available so that appropriate action can be taken; identify foodstuffs with high lead content and the sources of lead contamination, and use this information to support appropriate action.[12]

Education

- Educate the public regarding the dangers of misusing lead-containing products.
- Promote preventive and educational measures to protect young children from lead in their environment.

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