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Lead: a lasting legacy

When reports of cognitive effects in children with low blood lead levels emerged earlier this year, alarm was the first reaction from Canada's lead workers.

Of particular concern was the potential for long-term and irreversible neurological damage at 10 micrograms of lead per deciliter of blood (ug/dL) or less. Yet another reminder, as far as workers and their representatives were concerned, of the dangers of lead, at levels once thought safe.

What is lead?

Lead is found naturally in the ore galena and transformed into the metallic form by roasting or smelting. Soft and malleable, lead is easily melted, cast, rolled or molded into shape. Resistant to corrosion with sound absorbing capabilities, lead has been used for centuries in a wide range of applications. Today, as in the past, lead may be used in its pure form or combined chemically with other elements. This metal is employed industrially as metallic, organic and/or inorganic lead.

The primary use of metallic lead is in the production of lead-acid batteries and sheathing for electric cable. This metal is also employed in radiation shields around x-ray equipment and nuclear reactors. Metallic lead may be combined with other metals such as copper, tin and antimony, to make alloys for welding, ammunition and plumbing materials.

Organic lead compounds contain lead and carbon. Until banned in the late 1980s, the most common use of organic lead compounds, particularly tetraethyl lead, was as an octane enhancer in gasoline. Today, organic lead compounds, including lead oleate and stearate, are used as heat stabilizers in plastic production. Lead napthenate finds application primarily as an additive in high-pressure lubricants in industrial motors.

When lead is combined with an element other than carbon, inorganic lead compounds (lead salts) are created. In the past, lead salts were used extensively as pigments in specialty paints. Currently, only red lead oxide is still employed, and predominately in the protective paint for structural iron and steel. Lead oxide is also used in the manufacture of fine crystal glassware and flint glass for specialized magnifying lenses.

How is one exposed?

Lead may enter the body through ingestion, inhalation or absorption. The growing fetus may also be exposed to lead from the mother via the placenta. For the general population, ingestion and inhalation are the primary routes of exposure with ingestion the more common of the two. Occupationally, workers are most likely to be exposed through inhalation.

The greatest exposure for the general public comes as a result of deteriorating household lead based paint or contamination of drinking water by lead piping or soldering. Lead paint, not regulated in North America until the 1970s, continues to be a significant source of lead exposure. Occupants are particularly at risk during building renovations that generate dust. The general population may also be exposed to lead in food and/or water. Lead deposited on and retained by crops, particularly leafy vegetables, is yet another potential source of exposure as are acidic foods stored in cans soldered with lead or cooked in lead glazed pottery. Lead in drinking water is often the result of leaching from lead pipes or pipes soldered with lead. Lead may also dissolve from PVC piping where lead salts are used as stabilizers.

Children are at an increased risk for lead exposure as a result of both behaviour and physiology. Frequent hand-to-mouth activity and tendency to chew items exposes children to products that may contain lead, (toys made from PVC), or materials (soil or paint) contaminated with the metal. Greater food intake and respiratory volume also places children at increased exposure. Additionally, children absorb more lead than adults and distribute it differently in the body. In children, lead tends not to accumulate in the bones, but rather circulates in the blood where it can collect and impair kidney, liver, and brain function.

Occupational exposure to metallic lead is most likely during lead smelting, lead-acid battery manufacture and the production and handling of lead piping, sheets, ammunition, solder and cable sheathing. Exposure can also occur during refining of lead ore or recycled lead products and during building construction and renovation projects. Workers may be exposed to lead mist, vapour, dust or fume.

Exposure to lead mist is possible during the spraying, foaming, bubbling or boiling of lead compounds. Workers may be exposed to lead vapour when liquid organic lead compounds evaporate. Mining, crushing and separation of lead ore and grinding and sanding or polishing of lead products can expose workers to lead dust. Dust may also evolve wherever powdered forms of inorganic lead compounds are used, as in the manufacture of lead acid batteries and production of PVC. Exposure to lead fume is most common during the smelting and casting of lead from ore and welding with lead based alloys.

What happens to lead in the body?

Depending on lead particle size, solubility, density and individual ventilation rate, approximately 30 to 50 per cent of lead inhaled by an adult is retained, of which more than 80 per cent may be absorbed to the blood. In adults with a normal diet, three to 15 per cent of lead ingested can be transferred to the blood by the intestine. In children under the age of ten, approximately 50 per cent of lead may be absorbed. Regardless of the route of entry, however, lead is absorbed directly from the blood into body tissue. Once absorbed, lead circulates in the bloodstream and either accumulates in tissues or is excreted as waste. The majority of lead absorbed is transferred to the bones and teeth where it accumulates and remains over time. The remainder locates to the liver, kidneys, pancreas and lungs. The half-life of lead in the human body is approximately 25 years. Even after lead exposure ceases, however, high blood lead levels remain. During physiological stress, such as pregnancy or illness or during aging, lead moves from the bones back to the blood stream with the potential, once again, to affect critical body organs and functions.

Workers Health & Safety Centre

Information Bulletins for health, safety and environmental representatives

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How does lead effect health?

Lead is a potent systemic poison, exerting serious and significant effects on several major body systems and organs. This includes the central and peripheral nervous systems, the blood, endocrine, gastrointestinal and reproductive systems as well as the heart, liver and kidneys.

In the past, the primary health effects associated with exposure to lead were believed to manifest at a blood lead level of 20 ug/dL. Today, there is growing evidence of effects below 20 ug/dL and in some cases, at blood lead levels of 10 ug/dL or less. Blood lead levels can reflect recent exposure to lead or lead released from bone. The health effects associated with lead exposure generally emerge after accumulation of lead in the body over an extended period. At low blood lead levels workers may experience central nervous system damage, evidenced by behaviour changes, increased fatigue and impaired concentration. Damage to the peripheral nervous system, primarily motor, is also possible.

Lead affects the blood system by interfering with enzymes critical to the synthesis of heme. Acute exposure to high levels of lead has been associated with low iron levels or anemia. In chronic lead poisoning, lead interferes with the development and functioning of the red blood cells. Lead also affects the endocrine system, impacting cell maturation and skeletal growth. Long-term exposure to lead can lead to kidney damage.

The International Agency for Research on Cancer (IARC) has classified lead and lead compounds as possibly carcinogenic to humans. Research to date suggests occupational exposure to lead may cause cancer of the lung, brain, stomach and kidneys.

Studies assessing the developmental impacts of lead have shown lead exposure in utero can result in premature births, lower birth weight and smaller head circumference. Lead has also been implicated in reduced stature and impaired hearing.

Research into neurological effects after birth has focused on impacts on perception, memory and reasoning and to a lesser extent, changes in behaviour. The current literature reports a positive association between low blood lead levels and poor performance in tests of cognitive ability and motor skills. In other studies, reduced attention span, increased activity levels, impaired sleep patterns, aggression, depression and low self esteem have either been observed or suspected as a result of exposure to low lead levels. Still other investigations have found lead exposure associated with increased risk for anti-social and delinquent behaviour, with effects more apparent at certain developmental stages and more serious in boys than in girls.

What can be done?

While knowledge that lead may be poisonous dates back to the Roman Empire, regulations to restrict both environmental and occupational exposure to lead were not established until well into the 21st century. Some of the first initiatives were introduced in Europe in the early 1900s and involved lead level restrictions in indoor paint. With the introduction of unleaded gasoline in Canada in 1975, lead concentrations in air have declined significantly, falling even further when leaded gasoline was banned altogether in 1990. In 1985, Ontario classified lead as a designated substance (O. Reg. 843/90), requiring employers to assess and control worker exposure to both lead and lead compounds. In 2002, The Ontario Ministry of Labour published draft guidelines aimed at controlling worker exposure to lead on construction projects. In the U.S., the Occupational Safety and Health Administration (OSHA) has introduced measures to reduce the severity of lead exposure and blood lead levels in selected industries by 15 per cent over the next five years.

Most recently, attention has turned to eliminating lead from consumer products, particularly computer electronics and children's toys. In 1997, Health Canada introduced at strategy to reduce lead levels in consumer products. Europe has recently elected to eliminate lead from electronics by 2008. Many multinational companies have embraced this shift, voluntarily phasing out lead in computer components and participating in local lead recycling programs. In several member countries, there are restrictions on the lead content in fertilizers and initiatives to eliminate lead in cable and solder. In Japan, some electronic companies have increased market share as a result of going lead free. In 1999, Boeing began use of a non-lead finish for many of its aircraft parts. Matsushita (Panasonic) eliminated use of all lead solder in 2000. In 2001, all Hitachi products were free of lead and since 2002, no cell phone manufactured by Toshiba contained lead. On another front, the U.S. Ecology Centre and Environmental Defense organization recently called for a phase-out of lead in cars, most notably in batteries.

While significant progress has been made over the past 30 years to address the hazards of lead, much work remains. Multiple sources and exposure pathways continue to cause concern. Today, the average blood lead level of the North American population is less than 10 ug/dL, a decline from between 16 and 20 ug/dL in the 1970s. But effects continue to occur over a wide range of blood lead levels, with signs and symptoms of exposure being discovered in adults and children at lower and lower levels. In fact, it is now widely believed that there is no safe blood lead level in children. With these developments, it is incumbent upon industry, government and labour to ensure current exposure and emission levels reflect not the latest science, but the precautionary principle, thereby ensuring protection against one of the most prevalent and toxic metals known to man.

- More details on the toxicity of lead can be found online at the Centre for Disease Control: **www.cdc.gov/niosh/topics/lead/**.
- A general overview of the causes and effects of lead exposure is available at: **www.leadpoison.net/general/impact.htm**.
- Many lead free alternatives for electronics and other products is accessible at: **www.leadfree.org**.
- Ontario's designated substance regulation can be found at: **www.e-laws.gov.on.ca/DBLaws/Regs/English/900843_e.htm**.
- The draft guideline on lead on construction projects can be downloaded from: **www.gov.on.ca/LAB/english/hs/guidelines/lead/**.

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