

Lead Poisoning—A Severe Threat to the Nation's Health

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Thailand is now facing serious problems of lead proliferation in the environment. High levels of lead, emitted by industry or the soaring number of automobiles, expose us to the risks of lead blood poisoning daily. This is a most unfortunate by-product of rapid industrialization and economic growth.

When lead enters the blood system, it can cause serious health problems in adults. In children, however, the effects can be devastating. Children can sustain lead in their bodies for 16 to 20 years, thus destroying the central nervous system and causing chronic toxicity in the entire body. Particularly at risk are children under six years of age, as this is the most important period in the development of a child's brain. Studies have concluded that early exposure to lead can result in lower intelligence quotients, accompanied by learning disabilities.

Developed countries have long realized the widespread detrimental effects of lead poisoning and hence have conducted extensive research and drawn up new and stronger measures to control lead levels in air, water and food.

In Thailand, however, this issue has received little attention. The highest risk to the nation is from atmospheric lead and, other than the sole exception of introducing and promoting unleaded gasoline, no other measure has been taken to protect Thai citizens from being irreversibly damaged by this poisonous substance.

This article summarizes information from international and domestic studies on environmental lead poisoning.¹ The data provided will hopefully foster awareness of this problem in Thai policymakers, so they can design policies to minimize the country's lead emissions. It is also hoped that it will encourage cooperation between the public and private sectors in finding solutions, so that the nation's health, particularly that of its children, can be better protected.

WHAT IS LEAD? WHERE IS IT FOUND?

Lead is a heavy and malleable metal, dark blue-gray in color, which can be melted at very high temperatures. There are two types:

Organic Lead

If the gasoline used in a car has a too-low octane level, then "knocking" in the engine will be experienced. Gasoline from the primary distillation process has very low octane, and one of the methods used to raise the octane level is by adding lead in the form of tetraethyl or tetramethyl.

Organic lead is emitted in the combustion of benzene. One percent is released in the form of organic lead (70-75 percent is in the form of inorganic lead salt), which vaporizes into the atmosphere. Organic lead is relatively more dangerous and widespread than inorganic lead because of its better evaporation properties.

Inorganic Lead

Inorganic lead, used in compound metal, is always found in the form of salt. Among its many uses, lead oxide is used as protection against rust in metal paint and for making electrodes for car batteries. Inorganic lead also comes in the form of arsenate lead, used as a pesticide, and cillitate lead, which is mixed into ceramics to give a smooth and shiny finish.

Many industries use lead, including publishing, toys, electric cables, bullets, tube lead, and rubber processing. Most of us, therefore, run high risks of being exposed to lead during our daily life. Inorganic lead is also emitted when benzene containing a lead chemical compound is used in motor vehicles. The difference is that inorganic lead is released in higher amounts and in particles that are smaller than vaporized organic lead particles. Inorganic lead particles in the air can be as small as only one to 50 microns.

On emission, a lead particle has a diameter of around 0.15 micron and, when merged with other particles in the air, will rapidly increase in size. When large enough to be visible, lead particles are called "dust." Dust particles vary in size and, the smaller they are, the more harmful they are to human health. Particles of less than 10 microns in diameter are particularly harmful as they are small enough to reach the lower part of the respiratory system.

HOW DOES LEAD ENTER THE BODY?

Lead can enter the body in various ways—through the respiratory system, dietary route, or pores in the skin.

A U.S. study found that in big cities adults absorb approximately 100-350 micrograms of lead per day. An estimated 50 micrograms per day is inhaled through the respiratory system and of this 20-50 percent will accumulate in the body, raising blood lead levels.

Inorganic lead emitted from motor vehicles is more easily absorbed by the lungs. Hence, it accounts for 40 percent of the total lead inhaled. The effectiveness of lead absorption depends on such factors as the size of the lead particles, age, physical condition and respiratory habits.

A 1977 World Health Organization study of the relation between lead absorption and age found that children under five years of age can absorb up to 50 percent more than adults of the total intake of compound lead substances. In comparison, an adult's dietary route system absorbs approximately 20-30 percent of the lead intake. A 1981 study found that the lack of iron, calcium, protein and manganese in the body accelerates the speed of lead absorption.

Unlike organic lead, inorganic lead cannot be absorbed through human skin. Large dust particles only reach the upper part of the respiratory system, later to be dispelled as phlegm. Smaller particles first pass through to the air pouches in the lungs and then go into the blood stream.

When lead passes into the blood stream, it spreads throughout the body. Some 95 percent will accumulate in the various parts of the body, particularly the teeth, liver, lungs, kidneys, brain and spleen. In cases of exposure over a long period of time, most of the lead will remain in the bones. This does not cause bone deterioration, but the lead can remobilize and cause lead poisoning symptoms, even when the person is removed from further exposure.

Measuring the uptake, distribution and equilibration of lead in the blood, bones and body tissue is quite complex. It is difficult, using existing models, to predict precisely how the body tissue will alter under various circumstances. Blood lead levels, for example, rapidly increase, then decrease, after initial exposures at high concentrations. A reduction in blood lead may, however, come from redistribution rather than ejection.

Lead has a "half-life" of up to 10 years in adults. This means that if the blood contains, for example, 10 micrograms of lead, it will take up to 10 years for the body to reduce this to 5 micrograms. As a result,

high levels of lead are sustained in the blood over long periods.

Five percent of the lead that enters the body will be discharged via the kidneys, 78 to 80 percent will be emitted in the feces, and the remaining 5 percent may be ejected as perspiration or through the hair and nails. Even in people with normal health, for every 100 millimeters of urine, 5-8 percent consists of lead.

According to current Thai law, lead levels in adults whose employment involves working with lead should not exceed 60 micrograms per deciliter. For other adults, the level should not exceed 40 micrograms per deciliter and, for pregnant women and children, the level should not exceed 25 micrograms per deciliter.

HOW DOES LEAD CAUSE TOXIC HARM TO THE BODY?

Adults absorb lead mainly from air and water— normally absorbing only 10 percent into the blood stream. In children, however, lead accumulates in the body for up to 20 years and spreads to many organs, such as the brain, lungs, liver, spleen and bones. The parts of the body that are most affected are:

The blood system in the bone marrow. Lead lessens the production of hemoglobin by up to three points, causing anemia in patients. Moreover, it disturbs the function of the hemoglobin's wall so that it becomes fragile and easily broken.

The central nervous system. Lead damages nerve cells and causes inflammation of the blood vessels. It can also cause the brain to become swollen, while destroying its chemical substances and nerve tissue. In severe cases, high blood pressure in the skull will cause headaches, dizziness or unconsciousness.

Children whose nerve cells have been completely destroyed may demonstrate abnormal behavior, becoming more and more irritable and mentally backward. Small children show slow intellectual development. Adults who ingest the toxin over a long period of time, will suffer pain, have weak legs and arms, feel disorientated, and their faculties will become blunted.

The kidneys. In patients with severe symptoms, the body becomes incapable of creating kidney vessels. For those experiencing lead toxin over a long period, the kidneys may become deformed.

The heart. Heart muscles will swell and become inflamed, spreading to the connective tissues.

Other symptoms. High levels of lead in the body can cause sterility in males because of the toxic effects on sperm. Pregnant women will suffer high blood pressure, which may cause them to give birth prematurely. Moreover, the lead substance can accumulate in many tissues, and approximately 80 to 90 percent will accumulate in the bones. Some studies have even found lead in mothers' milk.

WHAT ARE THE EXPOSURE RISKS FOR CHILDREN?

In present-day Thailand, children are surrounded by lead—in household paint, gasoline, utensils, and particles in the air. Food and water can also be contaminated, particularly when bought from open-air markets or from street vendors along roads with heavy traffic.

Because of their tendency to put foreign objects into their mouths, children ingest much more lead into their bodies than adults do. Dyes with high lead contents are often used in materials for making toys. Children who play with such toys are, therefore, at high risk.

SYMPTOMS OF LEAD POISONING

As with most illnesses, the symptoms of lead poisoning are more severe in children. In adults, blood lead levels of over 10 micrograms per deciliter can prevent the body's enzymes from building hemoglobin. They may experience high blood pressure with blood lead levels of 10-15 micrograms per deciliter.

In children, however, blood lead levels of only 10 micrograms per deciliter are related to low intelligence levels, nervous system development disorders and erratic behavior. Lead, even at this low level, also affects body growth, hearing ability and can cause children to have difficulty with balance. They may also have difficulty in synthesizing their thoughts and actions.

Children with lead levels of more than 25 micrograms per deciliter will have a small head radius, small chest radius and short height, and those with lead levels of 30 micrograms per deciliter will have difficulty in processing vitamin D within the body.

As for lead levels of over 40 micrograms per deciliter, children will be anemic and suffer exhaustion, while adults will face an increasing array of disorders in many of the body's systems, such as sterility in males, malfunction of the kidneys, and a slowing of signals to the nerve ends. Adults will also experience high blood pressure and reduction in hearing ability. In some cases, they will suffer exhaustion, headaches and chronic stomach aches.

With lead levels of 50-80 micrograms per deciliter, children will have severe symptoms, such as acute stomach pains, permanent nerve damage, and blindness, eventually leading to death. Adults will be anemic and suffer severe headaches, while chronic kidney deterioration will cause fits of shivering throughout the body. If lead levels exceed 100 micrograms per deciliter, adults may suffer brain damage, or may even become unconsciousness and die.

DO LOW LEVELS OF LEAD IN THE BLOOD AFFECT CHILDREN'S LEARNING ABILITIES?

Since 1970 in the U.S. and other developed countries, alarming increases in incidences of lead blood poisoning has launched extensive research to find more and more ways to reduce lead emission levels. In the U.S., for example, blood lead levels were reduced from 60 micrograms per deciliter in 1969 to 40 micrograms in 1970, dropping to 10 micrograms per deciliter by 1991.

Research into the effects of lead poisoning on the central nervous system for the low level of 10 micrograms per deciliter has been continuous in the U.S. since 1976. Studies support the theory that even with blood lead levels of under 25 micrograms per deciliter, children will still have learning disabilities ([Figure 1](#)).

Another U.S. study compares the academic accomplishments of children and the lead levels in their milk teeth. Children with lead levels of more than 20 micrograms per deciliter in their teeth are seven times more likely to be unable to complete high school ([Figure 2](#)). They are six times more prone to have problems with reading, interpretation of words, in concentration, and in completing complex tasks. It has also been found that children with high lead levels in their milk teeth have blood lead levels of 35 micrograms per deciliter.

ATMOSPHERIC LEAD

Industrial plants emit high levels of lead, but half of the lead in the atmosphere comes from cars run on gasoline that contains lead. A study of atmospheric lead in the rural areas of many countries shows high variation in levels, depending, of course, on how close they are to urban areas. In 1984, the atmospheric lead level in U.S. urban areas was found to be 0.36 micrograms per cubic meter.

A TDRI research study in 1986 by Chongpeerapien et al. compared atmospheric pollution from many different types of activities in Thailand. Results showed that 80 percent of Bangkok's air pollution is caused by vehicles. In 1987 alone, Bangkok consumed a reported 962 million liters of benzene. Around 384 tons of lead was emitted during 1987, or 1,052 kilograms per day. From these figures, it is clear that air pollution from traffic has for some time been high enough to have detrimental effects on human health. A report by the Department of Land Transport shows that the number of cars in the Bangkok area has increased tremendously, from 500,000 cars in 1978 to 2 million in 1989. When considering the one-year period from 1988 to 1989, the number of cars increased by more than 200,000, or approximately 13.3 percent.

Increases of such magnitude, of course, certainly suggest that there will be dramatic rises in the amount of fuel burned. In 1991, the government announced its new policy of reducing the amount of lead emitted into the atmosphere. However, despite government subsidies making unleaded gasoline cheaper than leaded grades, the country's unleaded gasoline consumption is still only 13.6 percent of the total gasoline consumed.

The National Environment Board has set the air standard at no more than 10 micrograms per cubic meter. At night, Bangkok's lead levels drop to around 2 micrograms per cubic meter, while at noon heavy traffic causes levels of more than 7 micrograms per cubic meter. The most chronically congested thoroughfares are Petchburi Road, Yaovaraj Road and Rajdamnern Road, where lead levels are 16, 11.5, and 9.7 micrograms per cubic meter, respectively, during rush hour. In comparison, day-time levels in the U.S. are only 1-3 micrograms per cubic meter in urban areas and 0.1-0.5 in rural areas.

On examining the data on lead concentration in Bangkok's atmosphere from 1988 to 1993 ([Table 1](#)), it is apparent that lead levels in the air continued to rise to a peak level in 1991, then began to decrease in 1992.

An important point to consider is that Thailand's standard of atmospheric lead level is set at six times that of the United States. This figure was arrived at many years ago, before the harmful effects of lead poisoning became apparent. This standard must, therefore, be revised to adjust to the more accurate information now available.

LEAD IN FOOD

The World Health Organization sets lead levels in food at no more than 425 micrograms per deciliter. In 1991, Thailand's citizens ingested approximately 50 to 250 micrograms per deciliter from food. [Table 2](#) shows data on lead from different food sources. It is estimated that many Thais ingest 1.9 micrograms per kilogram per day of lead from food. If this increases by even one microgram per day, it will raise blood lead levels by 0.04 microgram per deciliter in adults, or 0.2 microgram per deciliter in children.

In 1990, it was found that 14 percent of Thai ceramic utensils contained higher than the standard safe lead level. In 1992, a joint Science Department and Ministry of Public Health study found that, although public transport drivers in Thailand ingest 88 milligrams of lead per day through the dietary system, lead from food is generally not yet a major source of lead poisoning in Thailand. Studies are continuing, however, on the effects of lead in food bought from street vendors. It is speculated that this type of food may contain high levels of lead.

LEAD IN WATER

The WHO standard, set in 1971, permits no more than 0.5 microgram per liter of lead in water. In Thailand, studies by the Environment Health Division of the Ministry of Public Health in 1988 found that lead levels in Bangkok's water supply equaled 0.001 microgram per liter, still within the safety level. Analysis of the Chao Phraya River in 1992, however, yielded the worrying results shown in [Table 3](#). In 1978-1988, the testing of water from 35 river routes (1,818 samples) in every region of Thailand found that in 30.6 percent of the sites sampled, lead levels exceeded the safety standard. The Pattanee River had the highest level, at 15.1 micrograms per liter. As shown in [Table 4](#), of the rivers tested throughout Thailand in a 1991 study, the eastern region had the highest proportion of samples exceeding the standard levels of lead.

A 1984 Gulf of Thailand study by Songkla University's Faculty of Medicine found lead levels in the sea water of 7 ppb (parts per billion) and of 188 ppb in the sediment soil. These figures are significantly higher than the WHO standard of 4 ppb for sea water and 20 ppb for sediment soil.

BLOOD LEAD LEVELS IN THAI CHILDREN

All studies conducted from 1986-1991 suggest that lead levels in the blood of Thai children are below the national standard of 25 micrograms per deciliter. But many studies indicate levels that far exceed the U.S. standard of 10 micrograms per deciliter, beyond which the brain and the central nervous system will be affected.

Since 1991, blood lead levels of children both in Bangkok and in rural areas have declined. The main reason for this seems to be the result of the government's campaign encouraging people to use unleaded gasoline. But this does not mean there is room for complacency. As demand for transportation increases, more lead will be generated. Lead poisoning, therefore, remains a serious problem, particularly in Bangkok.

CONCLUSIONS

In comparing sources of lead poisoning, it is apparent that the greatest risk in Thailand is from lead in the atmosphere, particularly in over-crowded and traffic-tortured Bangkok. The picture of lead levels in Thailand's water is not quite so alarming. Many, but not all, water sources still appear to meet acceptable standards although levels do seem to be rising.

It is, therefore, urgent that measures are implemented to drastically reduce atmospheric lead. Reducing traffic congestion, promoting unleaded gasoline consumption, and imposing a higher tax on leaded gasoline, are all steps in the right direction. Reappraisals of the standards for water, food and air, as well as establishing lead content standards for paints, are urgently needed.

It is every child's birthright to be able to breath clean air and have as full and healthy a life span as possible. The government will have to invest large sums of money to fight lead pollution. But when the health and intellectual faculties of a nation's children are at stake, it is money that must be spent and must be spent now. As our most valuable asset, we owe it to our children to do everything possible to clean up our fast deteriorating atmosphere.

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