Theme Papers

Environmental lead exposure: a public health problem of global dimensions

Shilu Tong,[1] Yasmin E. von Schirnding,[2] & Tippawan Prapamontol[3]

Lead is the most abundant of the heavy metals in the Earth's crust. It has been used since prehistoric times, and has become widely distributed and mobilized in the environment. Exposure to and uptake of this non-essential element have consequently increased. Both occupational and environmental exposures to lead remain a serious problem in many developing and industrializing countries, as well as in some developed countries. In most developed countries, however, introduction of lead into the human environment has decreased in recent years, largely due to public health campaigns and a decline in its commercial usage, particularly in petrol. Acute lead poisoning has become rare in such countries, but chronic exposure to low levels of the metal is still a public health issue, especially among some minorities and socioeconomically disadvantaged groups. In developing countries, awareness of the public health impact of exposure to lead is growing but relatively few of these countries have introduced policies and regulations for significantly combating the problem. This article reviews the nature and importance of environmental exposure to lead in developing and developed countries, outlining past actions, and indicating requirements for future policy responses and interventions.

Keywords: lead, adverse effects; lead toxicity; lead poisoning; environmental exposure; occupational diseases; epidemiologic studies.

Voir page 1074 le résumé en français. En la página 1075 figura un resumen en español.

Introduction

Lead, a ubiquitous and versatile metal, has been used since prehistoric times. It has become widely distributed and mobilized in the environment, and human exposure to and uptake of this non-essential element have consequently increased (*1*). At high levels of human exposure there is damage to almost all organs and organ systems, most importantly the central nervous system, kidneys and blood, culminating in death at excessive levels. At low levels, haeme synthesis and other biochemical processes are affected, psychological and neurobehavioural functions are impaired, and there is a range of other effects (*2–4*).

There is a long history of public exposure to lead in food and drink. Lead poisoning was common in Roman times because of the use of lead in water pipes and earthenware containers, and in wine storage. Lead poisoning associated with occupational exposure was first reported in 370 BC (*5*). It became common among industrial workers in the 19th and early 20th centuries, when workers were exposed to lead in smelting, painting, plumbing, printing and many other industrial activities. In 1767, Franklin obtained a list of patients in La Charité Hospital in Paris who had been admitted because of symptoms, which, although not recognized then, were evidently those of lead poisoning. All the patients were engaged in occupations that exposed them to lead (*1*, *5*).

In 1839, Tanqueral des Planches described the symptoms of acute lead poisoning on the basis of 1213 admissions to La Charité Hospital between 1830 and 1838. His study was so thorough that little has subsequently been added to the clinical picture of the symptoms and signs of acute lead poisoning in adults (*6*). In the mid-19th century, occupational lead poisoning was a common disorder in the United Kingdom, and in 1882, following the deaths of several employees in the lead industry, a parliamentary enquiry was initiated into working conditions in lead factories (*1*, *6*, *7*). This resulted in the 1883 Factory and Workshop Act (Prevention of Lead Poisoning), which required lead factories to conform to certain minimum standards, e.g. the provision of ventilation and protective clothing.

Various adverse effects of lead exposure on human health have been recognized (*1*, *2*, *5–10*). The working environment in the lead industry, especially in developed countries, has been much improved

[1] Acting Director, Centre for Public Health Research, Queensland University of Technology, Brisbane, Queensland, 4059, Australia (e-mail: s.tong@qut.edu.au). Correspondence should be addressed to this author.

[2] Focal Point Agenda 21, Health in Sustainable Development, World Health Organization, Geneva, Switzerland.

[3] Principal Research Scientist, Environmental Health and Toxicology Study Group, Research Institute for Health Sciences, Chiang Mai University, Chiang Mai, Thailand.

Ref. No. **0686**

(*2*, *5–9*). Acute occupational lead poisoning has largely been controlled in developed countries through improved working conditions. However, concern has grown over the possible adverse effects of exposure to low levels of environmental lead. In particular, lead poisoning in children experiencing non-occupational exposure has attracted much attention (*1*, *3*, *10*).

In Australia, lead poisoning in children was first reported in 1892 (*11*), although it was not until 12 years later that the source, peeling lead-based paint, was identified in a series of ten children with lead colic (*12*). In 1943 a follow-up study of 20 schoolchildren in the USA who had experienced acute lead poisoning in infancy or early childhood found that exposure to environmental lead at levels insufficient to produce clinical encephalopathy was associated with long-term deficits in neuropsychological development (*13*). Case-control studies on mental retardation (*14*) and hyperactivity (*15*) in relation to environmental lead exposure showed that children who survived acute lead intoxication were often left with severe deficits in neurobehavioural function. It was subsequently recognized that longer-term sequelae were not limited to people affected by excessive exposure but also occurred in children who experienced relatively low-level exposure.

Much research over the last 30 years has demonstrated adverse health effects of moderately elevated blood lead levels, i.e. below 25 μg/dl. The permissible exposure level in the ambient (air, water, soil, etc.) environment, as well as in the working environment, has therefore been progressively lowered *(2*, *6–9)*. Although the problems of overt lead poisoning have largely receded in developed countries, chronic exposure to low levels of lead is still a significant public health issue, particularly among some minorities and disadvantaged groups. Furthermore, both occupational and environmental exposures have remained a serious problem in many developing and industrializing countries (*2*, *16*, *17*).

Global lead contamination and multiple sources

Exposure of human populations to environmental lead was relatively low before the industrial revolution but has increased with industrialization and large-scale mining. Lead contamination of the environment is high relative to that of other non-essential elements (*18*). Globally, the extensive processing of lead ores is estimated to have released about 300 million tonnes of lead into the environment over the past five millennia, mostly within the past 500 years.

Following the advent of motor vehicles at the beginning of the 20th century, there was a substantial increase in environmental lead contamination because of the use of lead in petrol (*1*, *8*, *9*). This resulted in an increase in community exposure to environmental lead throughout much of the century. World lead consumption rose steadily between 1965 and 1990, when it reached about 5.6 million tonnes (*19*). Between 1980 and 1990 the consumption of lead in developed countries increased only slightly, whereas between 1979 and 1990 in developing countries it increased from 315 000 tonnes to 844 000 tonnes per annum. Global lead contamination, attributable to the greatly increased circulation of lead in soil, water and air as a result of human activities, remains significant (*20*).

The pre-industrial or natural blood lead level in humans is estimated to have been about 0.016 μg/dl, 50–200 times lower than the lowest reported levels of people today people in remote regions of the southern and northern hemispheres (0.78 μg/dl and 3.20 μg/dl respectively) (*21*). This level is about 625 times lower than the current level of concern for children (i.e. 10 μg/dl) proposed by the Centers for Disease Control and Prevention in the USA (*8*). Lead levels in human skeletal remains indicate that the body lead burden of today's populations is 500–1000 times greater than that of their pre-industrial counterparts (*22*, *23*).

Lead and children

Much research has been conducted recently on children with moderately raised blood lead levels associated with environmental exposure. The potential for adverse effects of lead exposure in children is heightened because:

- intake of lead per unit body weight is higher for children than for adults;
- young children often place objects in their mouths, resulting in dust and soil being ingested and, possibly, an increased intake of lead;
- physiological uptake rates of lead in children are higher than those in adults;
- young children are undergoing rapid development, their systems are not fully developed, and consequently they are more vulnerable than adults to the effects of lead (*2*, *16*, *24*, *25*).

Elevated lead levels continue to be a particular problem among socially and economically deprived children. Poor people are more likely to live in substandard housing and be near industry and heavy traffic, to be exposed to lead dust brought home by lead workers, and to be nutritionally deprived and therefore susceptible.

Debate continues over the nature, magnitude and persistence of the adverse effects on human health of low-level exposure to environmental lead. However, the accumulated epidemiological evidence indicates that such exposure in early childhood causes a discernible deficit in cognitive development during the immediately ensuing childhood years (*2*, *10*, *26–28*). It used to be thought that neuropsychological manifestations disappeared or declined if the ingestion of lead was stopped or reduced (*29*). Recent data, however, show that such effects are largely irreversible (*30*, *31*).

One of the reasons for past uncertainty about the health effects of low-level exposure to lead was the methodological pitfalls that beset many cross-sectional studies, in which exposures and outcomes are measured approximately simultaneously. Many of the earlier studies failed to control for the effects of confounding factors, e.g. parental intelligence, socio-economic status, and quality of the home environment. A single measure of contemporary exposure also provided limited scope for answering questions on the natural history of the association between lead exposure and outcomes. Such questions included those related to the possibility of critical periods of exposure and to the persistence or reversibility of lead-associated deficits.

More recent prospective studies, e.g. the Cincinnati and Boston cohort studies in the USA and the Port Pirie cohort study in Australia, have used highly sophisticated longitudinal designs to examine the effects of antenatal and postnatal blood lead levels on childhood development (*31–33*). These studies employed common and more sensitive measures of exposure and developmental outcomes, considered a wide range of covariates and confounding variables, and used stringent quality control measures. Children have been followed up prospectively from birth, and the nature of the relationship between exposure and outcome has been more readily determinable than previously. Despite the methodological problems associated with the earlier cross-sectional studies, the associations they suggested have in many instances been confirmed by the subsequent prospective studies (*31–36*).

These epidemiological findings, considered in conjunction with animal data, stimulated discussion and debate among scientists, consumers, industrialists and decision-makers during the 1980s and 1990s, leading to a shift in public and expert opinion about the dangers of lead. It is now known that exposure to lead during the early stages of a child's development is linked, inter alia, to deficits in later neurobehavioural performance. For blood lead levels < 25 µg/dl it appears that the size of the effect on IQ, as assessed at 3 years of age and above, is probably 1–3 points for each 10-µg/dl increment in blood lead level, with no definitive evidence of a threshold (*2*, *26*, *27*). In addition to neurobehavioural effects, there have been reports of effects on haeme synthesis and on a number of enzymes and biochemical parameters, as well as of reduced gestational age (*2*, *8*, *24*). A spectrum of effects of lead has been clearly identified (Fig. 1).

Sources of lead in the environment

Unlike overt lead toxicity, where there is usually one identifiable source, low-level environmental exposure to lead is associated with multiple sources (petrol, industrial processes, paint, solder in canned foods, water pipes) and pathways (air, household dust, street dirt, soil, water, food). Evaluation of the relative contributions of sources is therefore complex and likely to differ between areas and population groups (*36*).

Where lead derived from petrol comprises the major part of atmospheric lead it is a significant contributor to the body lead burden and is the most widely distributed source of the metal in the environment. It is thus desirable to phase out the use of lead additives in fuels as quickly as possible on the global scale. Atmospheric lead that is deposited in soil and dust may then be ingested by children and may substantially raise their blood lead levels. For the population at large, which is not occupationally exposed, food and water are important sources of baseline exposure to lead, in addition to atmospheric lead that is inhaled. Table 1 shows the relationship between the median level of blood lead and the intake of lead for the general population (*2*).

Even in countries where considerable efforts have been made to control lead, vast reservoirs of the metal still exist in soil, dust and house paint, and these sources will continue to affect populations for many years. Lead exposure is clearly a global public health issue, but it is only just being recognized as a potential problem in many developing countries, with studies only now being reported from Africa, Asia and South America.

Occupational exposure

Although the occurrence of severe lead poisoning has largely receded in many countries, occupational exposure to lead resulting in moderate and clinically symptomatic poisoning is still common. Among adults, exposure is normally greatest for those who come into closest contact with lead in production processes. Workers are exposed to lead in many occupations, including motor vehicle assembly, panel beating, battery manufacture and recovery, soldering, lead mining and smelting, lead alloy production, and in the glass, plastics, printing, ceramics and paint industries. In most highly industrialized countries, stricter controls and improvements in industrial methods have helped to ensure that occupational lead poisoning is less prevalent than formerly. In developing countries, however, it remains a problem of potentially huge dimensions (*36*).

Table 2 indicates occupations and operations in which lead may be a hazard for workers (*37*). In developing countries, occupational lead exposure is commonly unregulated and little monitoring of exposure is carried out. The potential for hazardous exposure to lead during smelting and refining of the metal is well recognized, both for primary new metal and secondary metal, i.e. scrap lead, smelters and refineries. Small domestic secondary smelters in many countries are typically located close to people's homes. The lead fumes and dust generated from such operations can pose an exceptional health hazard to children and adults living nearby.

Workers are also at particular risk in battery manufacture, demolition work, welding, pottery and ceramic ware production (often a home-based occupation involving women and children), small businesses repairing automobile radiators, and the production of jewellery and decorative items by artisans. The last-mentioned category is of particular concern since the work is predominantly carried out at home or in unregulated workshops, often by women and children. Although adults are mainly involved, in many countries, especially those with developing industries, and in small home-based industries, there is little distinction between home and the workplace, and children are consequently exposed to lead. Because of the transfer of lead to the fetus in utero and the introduction of lead into people's homes on clothing, where young children thus become exposed, problems of occupational exposure become community problems (*36*).

Environmental exposure

Developed countries

In most developed countries, concerted efforts have led to a reduction in the introduction of lead into the ambient environment in recent years, reflecting a decline in the commercial use of lead, particularly in petrol (*8*, *38*). Blood lead levels in the general population in these countries have fallen dramatically over the past 20 years, thanks to the phasing out of lead from petrol and the reduction of environmental exposure to the metal (*38–41*). This trend, illustrated by the examples given below, is likely to continue.

In the USA between 1976 and 1991 the mean blood lead level of persons aged 1–74 years dropped by 78%, from 12.8 µg/dl to 2.8 µg/dl (*41*). Mean blood lead levels of children aged 1–5 years declined by 77% (from 13.7 µg/dl to 3.2 µg/dl) for non-Hispanic white children and by 72% (from 20.2 µg/dl to 5.6 µg/dl) for non-Hispanic black children. The prevalence of blood lead levels of $\geqslant$10 µg/dl for children aged 1–5 years declined from 85.0% to 5.5% for non-Hispanic white children, and from 97.7% to 20.6% for non-Hispanic black children. Similar declines were found in population subgroups defined by age, sex, race/ethnicity, income level and urban status. The major cause of the observed decline in blood lead levels was the removal of lead from petrol.

The Third National Health and Nutrition Examination Survey, a representative survey of the civilian, non-institutionalized population of the USA, showed that, up to 1994, the overall mean blood lead level in people aged $\geqslant$1 year was 2.3 µg/dl; 2.2% of the population had levels of 10 µg/dl, the level of health concern for children, or above (*42*). Among American children aged 1–5 years the mean blood lead level was 2.7 µg/dl, with 890 000 of such children (4.4%) having elevated blood lead levels. Sociodemographic factors associated with higher blood lead levels in children were non-Hispanic black race/ethnicity, low income and living in older housing. It was concluded that programmes for the prevention of lead poisoning should target high-risk

Fig. 1. **Dose-effect relationships for adverse health effects of lead exposure.** (Adapted from ref. *24,* with updating) ALA-U = δ–aminolevulinic acid in urine; CP-U = coproporphyxin in urine; NCV = nerve conduction velocity; CNS = central nervous system

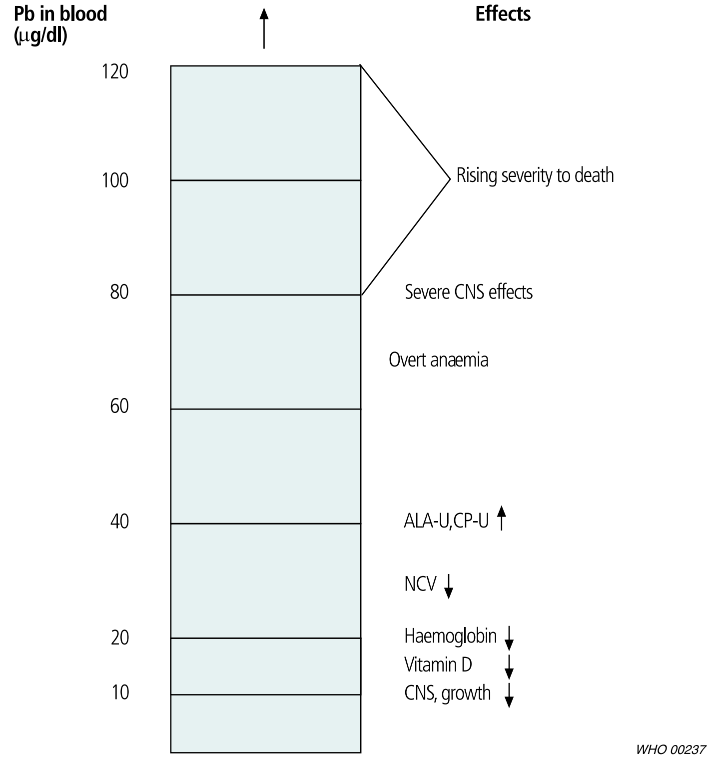

Table 1. **Representative relationships of blood lead median level to intake of lead for the general population[a]** (Source ref. *2*)

Medium	Median blood lead level among:	
	Children	Adults
Air[b]	0.09 µmol Pb per litre (1.92 µg P Pb/dl) per µg Pb/m^3 air	0.079 µmol Pb/litre (1.64 µg Pb/dl)[c] per µg Pb/m^3 air
Water	–	0.003 µmol Pb/litre (0.06 µg Pb/dl) per µg Pb/litre
Food	0.01 µmol Pb/litre per µg Pb/day (0.16 µg Pb/dl)	0.002–0.003 µmol Pb/litre (0.04–0.06 µg Pb/dl) per µg Pb/day [c]
Dust[b]	0.09 µmol Pb/litre (1.8 µg Pb/dl) per 1000 µg Pb/g dust	–
Soil[b]	0.11 µmol Pb/litre (2.2 µg Pb/dl) per 1000 µg Pb/g soil	

[a] These data are provided for illustrative purposes only. The relationships are curvilinear and are broad guidelines that are not applicable at lower or higher levels of exposure.

[b] A value in the range 0.144–0.24 µmol Pb/litre or in the range 3–5 µg Pb/dl per µg/m^3 is obtained when one considers indirect contribution through deposition on soil/dust.

[c] The air to blood lead relationship in occupational settings is best described by a curvilinear relationship with slopes in the range 0.02–0.08 µg/m^3 air. The slope is variable but lower than that for humans in the general environment (1.6–1.9 µg/m^3).

Table 2. **Operations that may present lead hazards for workers** (Source ref. *37*).

Primary and secondary lead smelting	Lead mining
Welding and cutting of lead-painted metal constructions	Plumbing
Welding of galvanized or zinc silicate coated sheets	Cable making
Other welding	
Shipbreaking	Wire patenting
Nonferrous founding	Lead casting
Storage battery manufacture: pasting, assembling, welding of battery connectors	Type founding in printing shops
Production of lead paints	Sterotype setting
Spray painting	Assembling of cars
Mixing (by hand) of lead stabilizers into polyvinyl chloride	Shot making
Mixing (by hand) of crystal glass mass	
Sanding or scraping of lead paint	Lead glass blowing
Burning of lead in enamelling workshops	Pottery/glass making
Repair of automobile radiators	

persons, such as children living in old houses, belonging to minority groups, and living in families with low incomes.

In Australia, blood samples were taken during 1995–96 from 1575 children aged 1–4 years (*43*). The geometric mean blood lead level was 5.05 µg/dl. For 115 of these children (i.e. 7.3%) the blood lead level was ⩾10 µg/dl. Only 27 children (1.7%) had levels ⩾15 µg/dl. It is difficult, however, to assess the trends of lead exposure in Australia in relation to the control of sources because the available data are limited.

Between 1978 and 1988, marked decreases in the average blood lead levels of adults were noted in many countries, including Belgium, Federal Republic of Germany, New Zealand, Sweden, and the United Kingdom (*36*). Recently, lead exposure was examined among the population of Barcelona and the changes that had occurred during the previous 10 years were evaluated (*44*). The blood lead levels in a random sample of 694 healthy subjects in the age range 0–65 years were 4.06 µg/dl (umbilical cord), 8.9 µg/dl (children), and 7.8 µg/dl (adults). Over this 10-year period there had been a reduction of more than 50% in blood lead levels, reflecting a decrease in the lead concentration in the ambient air.

Developing countries

Lead continues to be a significant public health problem in developing countries (*25*), where there are considerable variations in the sources and pathways of exposure. For example, in many Latin American countries, leaded paint is not a significant source of recurrent exposure, whereas lead-glazed ceramics are such a source (*45*). Exposure attributable to miscellaneous sources may be even more significant than universal exposure associated with leaded petrol, especially for people living in poverty. Exposure to lead from lead mining, smelting, battery factories and cottage industries is a significant environmental hazard in developing countries.

In Jamaica a survey was conducted to determine the distribution and determinants of environmental and blood lead levels in populations living near conventional and cottage lead smelters (*46*). Geometric mean blood lead levels in exposed groups were nearly twice as high as those in unexposed groups; 44% of exposed under-6-year-olds had blood lead levels ⩾25 µg/dl. In Berat and Tirana, Albania, the mean observed blood lead levels in 84 preschool children living less than 2 km from a battery plant was 43.4 µg/dl, significantly higher than the value of 15.0 µg/dl in 45 preschool children living more than 2 km from the plant (*47*); 98% of preschool children and 82% of schoolchildren had blood lead levels >10 µg/dl.

In China, childhood lead poisoning may be widespread as a result of rapid industrialization and the use of leaded petrol (*48*). Children residing in industrial areas and in areas with heavy traffic had average blood lead levels of 21.8–67.9 µg/dl. The proportion of blood lead levels > 10 µg/dl ranged from 64.9% to 99.5%. Even about 50% of children living in non-industrialized areas had blood lead values >10 µg/dl (*48*). There is also evidence of an increase in blood lead levels among non-smoking women between 1983 and 1998, associated with a rapid increase in the number of motor vehicles. The problem of lead exposure in children is particularly significant in small towns with numerous small factories (*49*).

The situation is similar in other countries where industrialization is occurring. In Dhaka, lead concentrations in airborne particulate matter averaged 453 ng/m^3 during the low rainfall season of November to January (*50*). The mean blood lead concentration among 93 randomly selected rickshaw pullers in India was 53 µg/dl (*51*). Also in India, direct testing for blood lead was carried out randomly on 2031 children and adults in five cities with high population densities where leaded petrol had contributed to environmental lead levels. Approximately 51% had levels >10 µg/dl, and 13% had values >20 µg/dl. The proportion of children with levels ⩾10 µg/dl ranged from 40% in Bangalore to 62% in Mumbai (*52*).

A cross-sectional study was carried out on a random sample of 200 children aged under 5 years living in an area of Mexico City (*53*). Samples of floor, window and street dust, paint, soil, water and glazed ceramics were obtained from the participants' households, as well as blood samples and dirt from their hands. Blood lead levels ranged from 1 µg/dl to 31 µg/dl, the mean being 9.9 µg/dl. Among children aged ⩾18 months, 44% had blood lead levels exceeding 10 µg/dl. Except for glazed ceramic, the lead content of environmental samples was low. The major predictors of blood lead levels were the lead content of the glazed ceramics used in the preparation of children's food, exposure to airborne lead from vehicle emissions, and the lead content of dirt from the children's hands.

African children may be particularly predisposed to environmental lead exposure because of their lifestyle and socioecological factors. However, the true picture of childhood lead poisoning in Africa remains unclear. Petrol sold in most African countries contains 0.5–0.8 g/l lead, which may be among the highest levels in the world (*54*). In urban and rural areas and near mining centres, average atmospheric lead concentrations reach 0.5–3.0 mg/m^3 and exceed 1000 μg/g in dust and soils. In addition to automotive and industrial sources, the following are hazards in individual households: cottage industries and the burning of paper products, discarded rubber, battery casings, and painted wood for cooking and heating. Lead paint, lead solder and lead cosmetics are unregulated in some countries.

In Cape Province, South Africa, over 90% of the children in some urban and rural communities have blood lead levels ⩾10 μg/dl. The mean blood lead level in inner-city, first-grade schoolchildren in the country was 18 μg/dl; 13% of mixed race children, but not white children, had blood lead levels ⩾25 μg/dl. Over 90% of children had blood lead levels >10 μg/dl (*55*). The levels of lead in blood, air and dust samples taken from schools close to roads carrying heavy traffic were higher than in those from schools further away (*55*, *56*). Raised blood lead values were also associated with dusty houses, houses in a poor state of repair, overcrowding, low parental educational and income levels, and other factors related to family structure and socioeconomic status (*57*). Social factors were thought to be important in predisposing children to poisoning by lead in the environment. Childhood lead poisoning appeared to be a widespread urban health problem throughout Africa (*54*).

The level of exposure to lead is, however, falling in some developing countries because of the reduced use of lead in petrol and elsewhere. In Thailand, for example, leaded petrol was phased out during the period 1984–96 (*58*) and was associated with a marked decline in atmospheric lead levels in Bangkok (*59*). A recent survey of 1000 children aged 6–72 months in Chiang Mai, Thailand, revealed that their average blood lead level was 4.2 μg/dl; only 4.6% of the children had blood lead levels ⩾10 μg/dl (*60*). Between February and September 1994 the blood lead levels in maternal and cord blood of 37 pregnant women from urban areas, 53 from periurban areas and 28 from rural areas of Chiang Mai were rather low and did not differ significantly: the geometric mean levels were 4.16 μg/dl and 3.32 μg/dl; 4.12 μg/dl and 3.11μg/dl; and 4.50 μg/dl and 4.12 μg/dl respectively. A total of 4.2% of maternal blood samples and 1.7% of cord blood samples had lead levels >10 μg/dl (*61*). In Bangkok, where air pollution levels were higher than in Chiang Mai, 5.2% and 2.4% of 500 pregnant women and their newborn babies, respectively, had blood lead levels >10 μg/dl. These values compared favourably with those determined in a previous study in Bangkok before the introduction of unleaded petrol (*62*).

Conclusions

Exposure to environmental lead is clearly a major public health hazard of global dimensions. As measures to control the transfer of lead to the environment are implemented in most developed countries through, for example, the phasing out of lead in fuel, paints and other consumer products, and tighter control of industrial emissions, environmental exposure to lead can, in general, be expected to continue to decline. However, because of rapid industrialization and the persistence of lead in the environment, exposure is likely to remain a significant public health problem in most developing countries for many years. Much work needs to be done to identify and treat children with elevated blood lead levels and reduce lead exposure in the community. Screening, monitoring, intervention and evaluation are critical for the development of rational, cost-effective and science-based public health policies aimed at achieving these goals.

Among the many international conventions that have acknowledged the importance of exposure to lead as a key public health issue are the following:

1) The 1989 Convention on the Rights of the Child.
2) Agenda 21 adopted by the United Nations Conference on Environment and Development in 1992.
3) The 1997 Declaration on the Environment by the Leaders of the Eight (on Children's Environmental Health).
4) The OECD Declaration on Lead Risk Reduction (*36*).

Public health measures should continue to be directed to the reduction and prevention of exposure to lead by reducing the use of the metal and its compounds and by minimizing lead-containing emissions that result in human exposures. This can be achieved by:

1) Phasing out lead additives in fuels and removing lead from petrol as soon as is practicable.
2) Reducing and phasing out the use of lead-based paints.
3) Eliminating the use of lead in food containers.
4) Identifying, reducing and eliminating lead used in traditional medicines and cosmetics.
5) Minimizing the dissolving of lead in water treatment and water distribution systems.
6) Improving control over exposure to lead in workplaces.
7) Improving identification of populations at high risk of exposure on the basis of monitoring systems.
8) Improving procedures of health risk assessment.
9) Improving promotion of understanding and awareness of exposure to lead.
10) Increasing emphasis on adequate nutrition, health care and attention to socioeconomic conditions that may exacerbate the effects of lead.

11) Developing international monitoring and analytical quality control programmes (*36*).

Specific recommendations on national policy and implementation measures to reduce the impact of lead on human health in developing countries have been drawn up by the Executive Committee of the International Conference on Lead Poisoning (*63*).

Nearly 100 countries, mostly developing, still use leaded petrol (*64*). Evidence from Europe, Japan, Mexico, and the USA suggests that phasing out leaded petrol is the most effective way of reducing the general population's exposure to lead, although other sources are also important (*65*). Many developing countries have been actively engaged in lead reduction programmes, particularly in respect of leaded petrol, "the mistake of the twentieth century" (*66*). Bangladesh, China, Egypt, Haiti, Honduras, Hungary, India, Kuwait, Nicaragua, Malaysia, and Thailand have, for example, made dramatic efforts to phase out leaded petrol in recent years. Success in this endeavour requires government commitment, incentive policies, a broad consensus among stakeholders and public understanding, acceptance and support (*67*, *68*).

Because of their experience, many international bodies are well equipped to provide assistance with tackling the various dimensions of exposure to lead in the environment. Concerted efforts on a worldwide basis can overcome this menace. ■

Résumé

Exposition au plomb dans l'environnement : un problème de santé publique d'importance mondiale

Le présent article analyse les caractéristiques de l'exposition environnementale au plomb dans le monde et ses conséquences en santé publique dans les pays développés et en développement. On y attire l'attention sur les mesures qui ont été prises pour résoudre ce problème et on y évoque les politiques et interventions nécessaires à l'avenir.

Le fait que le plomb soit utilisé depuis la préhistoire et qu'il soit largement répandu et libéré dans l'environnement a accru l'exposition de l'homme à cet élément non essentiel, qu'il a fixé toujours plus. Dans le monde, on estime que le traitement extensif des minerais de plomb a libéré près de 300 millions de tonnes de plomb dans l'environnement au cours des cinq derniers millénaires, principalement au cours des cinq cents dernières années. Au XX^{e} siècle, l'apparition des véhicules à moteur a conduit à une augmentation importante de la contamination de l'environnement du fait de l'utilisation de l'essence au plomb. La consommation mondiale de plomb a régulièrement augmenté entre 1965 et 1990 pour atteindre 5,6 millions de tonnes. Si elle a peu augmenté entre 1980 et 1990 dans les pays développés, dans les pays en développement elle a été multipliée par 2,7 – passant de 315 000 tonnes en 1979 à 844 000 tonnes en 1990.

On estime que chez l'homme la concentration naturelle, c'est-à-dire préindustrielle, de plomb dans le sang était d'environ 0,016 µg/dl, c'est-à-dire 50 à 200 fois moins que les concentrations les plus faibles rapportées aujourd'hui dans des populations vivant dans des régions reculées des hémisphères Sud ou Nord (0,78 µg/dl et 3,20 µg/dl, respectivement) et environ 625 fois moins que la concentration qui nous préoccupe aujourd'hui et qui est de 10 µg/dl chez les enfants, selon les Centers for Disease Control and Prevention des Etats-Unis d'Amérique.

Dans beaucoup de pays en développement et qui s'industrialisent ainsi que dans certains pays développés, l'exposition professionnelle et environnementale reste un problème grave. L'exposition professionnelle au plomb est souvent mal réglementée dans les pays en développement, où il y a peu de surveillance dans ce domaine. Le saturnisme dû à des expositions professionnelles et environnementales est encore fréquent dans bon nombre de pays en développement. Les enfants sont en général particulièrement vulnérables aux effets indésirables du plomb, auquel ils sont davantage exposés dans l'environnement général. La plombémie élevée continue d'être un problème propre aux populations socialement et économiquement défavorisées. Les pauvres plus que les autres vivent dans des logements de catégorie inférieure, à proximité d'entreprises industrielles ou de zones où la circulation est dense, et ils sont exposés à des poussières de plomb ramenées à leur domicile par les ouvriers ; ce sont également eux qui présentent des carences nutritionnelles qui les rendent plus sensibles.

Grâce aux campagnes de santé publique, la libération de plomb dans le milieu ambiant a diminué ces dernières années dans les pays développés, du fait de la réduction des utilisations commerciales de ce dernier, en particulier dans l'essence. Si les problèmes de saturnisme aigu ont reculé dans ces pays, l'exposition chronique à de faibles concentrations de plomb est toujours importante, en particulier dans certaines minorités et groupes socio-économiquement défavorisés.

Les pays en développement ont pris de plus en plus conscience de l'importance de l'exposition au plomb, mais relativement peu d'entre eux ont introduit des politiques et des réglementations visant à la réduire sensiblement. Du fait d'une industrialisation rapide et de la persistance du plomb dans l'environnement, on peut s'attendre à ce que l'exposition environnementale continue à poser des problèmes de santé publique importants dans la plupart des pays en développement durant encore bien des années. Il y a beaucoup à faire pour identifier et traiter les enfants présentant une plombémie élevée et réduire l'exposition au plomb dans la communauté. Dépistage, surveillance, intervention et évaluation sont indispensables pour élaborer des politiques de santé publique rationnelles, scientifiquement fondées et ayant un bon rapport coût/efficacité, qui visent à atteindre ces objectifs.

Resumen

Exposición al plomo ambiental: un problema de salud pública de dimensiones mundiales

En este artículo se analizan las características de la exposición al plomo ambiental a nivel mundial y su trascendencia para la salud pública en los países en desarrollo y desarrollados. Se resaltan las medidas adoptadas para abordar el problema y se examinan las respuestas normativas y las intervenciones necesarias en ese terreno.

El uso que se ha hecho del plomo desde tiempos prehistóricos y su extendida distribución y movilización en el medio han dado lugar a un aumento de la exposición a ese elemento no esencial y de su captación por el hombre. A nivel mundial, se estima que la intensa explotación de las menas de plomo ha liberado unos 300 millones de toneladas del elemento al ambiente a lo largo de los últimos cinco milenios, sobre todo durante los pasados 500 años. La aparición de los vehículos de motor en el siglo XX, y el consiguiente uso de gasolinas con plomo, ha conllevado un aumento sustancial de la contaminación del ambiente. El consumo mundial de plomo aumentó sin cesar hasta aproximadamente 5,6 millones de toneladas a lo largo del periodo 1965–1990. Aunque el consumo en los países desarrollados aumentó sólo ligeramente entre 1980 y 1990, el consumo en los países en desarrollo se multiplicó por 2,7, de 315 000 a 844 000 toneladas, entre 1979 y 1990.

Se estima que la concentración natural – esto es, preindustrial – de plomo en la sangre del ser humano ha sido de aproximadamente 0,016 μg/dl, lo que representa un nivel 50–200 veces inferior a los más bajos registrados hasta ahora, concretamente en habitantes de regiones remotas de los hemisferios austral y boreal (0,78 μg/dl y 3,20 μg/dl, respectivamente), y unas 625 veces inferior al límite actual de alarma, 10 μg/dl, propuesto para los niños por los Centros de Control y Prevención de Enfermedades de los Estados Unidos.

Tanto la exposición ocupacional como la ambiental siguen constituyendo serios problemas en muchos países en desarrollo o en vías de industrialización, así como en algunos países desarrollados. En los países en desarrollo la regulación de la exposición ocupacional al plomo es con frecuencia inadecuada y apenas existen mecanismos de vigilancia de la exposición. El saturnismo por exposición ocupacional o ambiental es aún un fenómeno frecuente en muchos países en desarrollo. Los niños en general son especialmente vulnerables a los efectos nocivos del plomo, y están más expuestos a este elemento en el medio en general. Los niveles elevados de plomo siguen representando un problema especial entre las personas social y económicamente desfavorecidas. Los pobres habitan con más frecuencia en viviendas precarias o próximas a empresas industriales o a arterias de intenso tráfico, corren un mayor riesgo de exposición al polvo de plomo que introducen en el hogar los trabajadores que están en contacto con el metal, y son más susceptibles a éste como consecuencia de la frecuente malnutrición asociada.

Gracias a las campañas de salud pública emprendidas, la liberación de plomo en el medio ha disminuido en los últimos años en los países desarrollados; a ello ha contribuido el menor uso comercial del metal, sobre todo en la gasolina. Aunque los casos de saturnismo agudo han disminuido en esos países, la exposición crónica a concentraciones bajas de plomo es aún relevante, sobre todo entre algunas minorías y entre grupos socioeconómicamente desfavorecidos.

El reconocimiento de la importancia de la exposición al plomo es cada vez mayor en los países en desarrollo, pero son relativamente pocos los que han introducido políticas y normas para reducirla de forma significativa. Debido a la rápida industrialización y a la persistencia del metal en el medio, es de prever que la exposición al plomo ambiental seguirá constituyendo un importante problema de salud pública en la mayoría de los países en desarrollo durante muchos años. Se requiere aún mucho trabajo para identificar y tratar a los niños con altos niveles sanguíneos de plomo y para reducir la exposición a éste en la comunidad. Las actividades de cribado, vigilancia, intervención y evaluación son fundamentales para formular políticas de salud pública racionales, eficientes y científicas que permitan alcanzar esos objetivos.

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