ENVIRONMENTAL LEAD EXPOSURE : ARE WE AT RISK?

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ABSTRACT
This paper discusses the new evidence linking lead at low levels of environmental exposure to adverse effects on aspects of children's neurobehavioural development. Risk factors for environmental exposure are discussed, with particular reference to the role of atmospheric lead. Epidemiological aspects of childhood lead exposure in South Africa are outlined, with consideration given to the need for appropriate intervention strategies.

Lead has received an inordinate amount of attention in the scientific and medical literature worldwide over recent years. Part of the reason for this is that lead, as an environmental pollutant, is somewhat unique. It has been used over thousands of years in hundreds of products and as a result is one of the most widely dispersed pollutants in the environment. It also has a particularly long residence time in the environment and has accumulated in significant amounts which have given rise to concern regarding the health impact on human populations.

HEALTH EFFECTS

There is no known biological function for lead and a continuum of harmful or potentially harmful effects exists over a wide range of exposure. Many different organ systems and biochemical/physiological processes may be affected. Whilst the clinical manifestations of lead poisoning have been well known for centuries, more recently there has been much concern about the effects on children at relatively low levels of environmental exposure. Biochemical and haematological effects have been documented and impairment of central nervous system function may be caused, as well as adverse effects on aspects of children's neurobehavioural development.

Over the past few years, sophisticated longitudinal prospective studies on the effects of lead on prenatal and postnatal development have been designed which are currently being conducted in countries throughout the world. These studies differ in design from the earlier cross-sectional studies and take into account several methodological pitfalls which beset such studies. They also use common and more sensitive measures of exposure and developmental outcomes than previously, consider numerous covariates and confounding variables and utilize meticulous quality control.

Bellinger *et al* (1984) were the first to report on the relationship between low level prenatal exposure and developmental outcomes; other studies have subsequently been published. In most of these studies, foetal exposure levels (as indicated by maternal or umbilical cord blood lead concentrations) have averaged around 10 ug/dl, and results have shown a relationship between lead exposure during foetal development and neurobehavioural performance (as measured by the Bayley Mental Development Index). At blood lead levels as low as 10 to 15 ug/dl, effects such as impaired neurobehavioural development, reduced gestational age and lowered birth weight may occur (Davis and Svendsgaard, 1987). The degree to which the effects of prenatal exposure persist in children remain to be seen. It has been estimated however that a deficit of even a few IQ points may result in a three-fold increase in the rate of severe deficit in the population as a whole (Needleman *et al*, 1982).

Due to the increased evidence of significant effects of lead on the nervous system and other important physiological processes at decreased levels, the action level for lead in blood of children has recently been lowered to 25 ug/dl in tthe United States of America (CDC, 1985). What has also emerged is that no socio-economic or ethnic group is exempt from risk, although poor inner city children are at greatest risk of exposure. Adults too, however, may not be spared, and lead at low levels of exposure has been found to contribute independently to the prediction of raised systolic and diastolic blood pressure in middle-aged men (Harlan *et al*, 1985; Pirkle *et al*, 1985).

RISK FACTORS

In terms of preventing childhood lead exposure the question that arises is: Where does the lead come from? What are the risk factors for environmental lead exposure?

It basically depends on what level of exposure one is talking about, as the risk factors may differ accordingly. For instance at moderate to high blood lead levels (above 25-30 ug/dl), it is usually children with pica who are at highest risk, particularly those who ingest leaded paint chips. At levels averaging around 15 ug/dl, atmospheric lead normally plays a more significant role in those countries which still have leaded fuels. In countries where there has been stringent control of sources of lead (and where dramatic falls in blood lead levels have occurred, such as in the USA, parts of Europe and Scandinavia) attention is now focussing on the role of drinking water. Of course, the relative importance of the various sources is likely to differ from one community to another and it is therefore difficult to make broad generalisations.

Regarding the role of atmospheric lead (to which attention was first drawn in the late 1960's), much confusion has resulted from the fact that in the majority of studies, exposure has been inadequately measured. Very few studies have addressed the issue of microvariations in pollutant levels, and usually, no environmental sampling is carried out whatsoever. If it is, it is often at one site only, over a short period, normally at a place entirely unrepresentative of human exposure. In our studies in the inner city areas of Cape Town, where we set up an extensive environmental monitoring scheme, we found very significant variations in air quality (both spatially and temporally) within a relatively small area. Most studies have failed to take account of such variations, and have often also failed to measure other sources and pathways of exposure, or to consider behavioural patterns of individuals which put them in a different relationship to sources of lead in the environment. We now know for example, that the ingestion of lead-rich dust, rather than the direct inhalation of aerosols, is probably of greater significance in terms of young children's exposure (Duggan, 1983). For the population at large, food and water are probably the most important pathways of exposure.

The US Environmental Protection Agency, in weighing up all of the experimental and epidemiological evidence relating to the lead in blood : air lead relationship, concluded that in industrialized countries, atmospheric lead, via direct and indirect routes of exposure (e.g. through ingestion of dust, via the food chain) accounts for between 25% to 50% of the body burden (EPA, 1986). Important evidence derived from the Second US National Health and Nutrition Examination Survey (NHANES II), which detected a significant downward trend in blood lead levels over time (37%) which correlated closely with decreases in lead in petrol and air over the period (Annest *et al*, 1983). This association held after controlling for the effects of race, sex, age, region of country, season, income and degree of urbanisation.

SOUTH AFRICA

What is the situation in South Africa regarding environmental lead exposure?

Whilst numerous studies on the impact of lead in the environment on human popultions have been carried out in various parts of the world, in southern Africa little is known about the extent of lead absorption in the population at large. Although lead poisoning is a notifiable disease in this country, there have been surprisingly few cases of poisoning detected. This led the Department of Health to conclude in 1979 that ...

"It is possible that we are now in the same position as New York prior to 1950, when cases of lead poisoning were simply not diagnosed by uninformed doctors and ailments were ascribed to more familiar causes" (Department of Health, 1979).

An epidemiological study designed to determine the extent of increased lead absorption among children in different parts of Cape Town was carried out by von Schirnding in 1982 (von Schirnding, 1982, von Schirnding and Fuggle, 1986). In a lead screening study of 1 234 coloured first and second grade children attending schools in the Cape Peninsula, it was found that, among children from urban-industrial areas, there was an approximate two-fold increase in the prevalence of raised zinc-protoporphyrin (ZPP) and blood lead levels compared to children from suburban areas. This suggested that children from urban-industrial areas are at increased risk of exposure to lead. There was also evidence that aspects of childrens' school performance were being adversely affected (von Schirnding and Fuggle, 1984).

Other studies, such as one of blood and tooth lead levels among clinic- and hospital-based Cape children (White *et al*, 1982) confirmed that children had accumulated lead to an extent comparable to that in large Western cities.

Subsequent studies of specifically urban children in Cape Town (Deveaux *et al*, 1986; von Schirnding, 1987) have shown that blood lead levels average around 15 ug/dl and that about 13% of coloured pre-schoolers and first-grade children (but no white children) (von Schirnding, 1987) have blood lead levels > 25 ug/dl. In countries such as the UK and Scandinavia, it is relatively rare to detect children with blood lead levels in this range, and levels tend to average around 10 ug/dl and below.

In the first major study to systematically address the risk factors for lead exposure in these inner city communities (von Schirnding, 1989), it was shown that significant intra-urban variations in blood lead levels occur, with children exposed at school to heavy traffic densities having significantly higher blood lead levels (averaging around 20-21 ug/dl) than other inner-city children, after controlling for various factors such as socio-economic status and residential area. This study considered in detail the role of environmental, social, cultural and behavioural factors in influencing the course of childhood lead exposure, and a separate investigation was conducted into the risk factors for children with markedly elevated lead levels, in which it was revealed that amongst other things, aspects of children's behaviour, and the accessibility of lead in and around the home were important influencing factors.

PREVENTING CHILDHOOD LEAD EXPOSURE

What can be done to minimize the risk of exposure? Both primary and secondary preventive measures are urgently needed, considering that childhood lead exposure is an entirely preventable disease. In other parts of the world, better control of sources such as lead in petrol, paint, canned foods, drinking water, has led to significant decreases in blood lead levels in the population. We in South Africa would be wise to introduce similar controls, in order to provide a larger margin of safety for those sections of the population unduly exposed to lead. Regarding the control of petrol-derived lead, the most widely dispersed source, South Africa should move further towards the introduction of lead-free fuels. Recent steps taken to lower the lead content of our petrol (previously one of the highest in the Western world) are welcomed, and should be accompanied by a timetable for further reductions to bring us into line with other developed countries. Certainly, every attempt should be made to site institutions such as schools and creches away from major roads with heavy traffic densities.

Secondary prevention strategies are also needed and children living in high risk inner-city areas should be screened for lead and efforts made to reduce their subsequent risk of exposure.

Ultimately, vigilant control of lead from all sources is needed, especially in light of the new evidence in favour of significant adverse effects in young children at increasingly lower blood lead levels.

REFERENCES

CENTRES FOR DISEASE CONTROL. Preventing Lead Poisoning in Young Children: A Statement by the Centers for Disease Control. Washington, C. US Department of Health and Human Services, 1985.

DAVIS J, SVENDGAARD D. Lead and child development. Nature 1987; 329 : 297-300.

BELLINGER DC, NEEDLEMAN H, LEVITON A, WATERNAUX C, RABINOWITZ M, NICHLS M. Early sensory-motor development and prenatal exposure to lead. Neurobehav Toxicol Teratol 1984; 6 : 387-402.

NEEDLEMAN H, LEVITON A, BELLINGER D. Lead-associated intellectual deficit. N Engl J Med 1982; 306 : 367.

ENVIRONMENTAL PROTECTION AGENCY. Air Quality Criteria for Lead Vol I of IV. (EPA-600/8-83/028dF 1986) Research Triangle Park, NC: Environmental Criteria and Assessment Office, 1986.

HARLAN W, LANDIS J, SCHMOUDER R, GOLDSTEIN N, HARLAN L. Blood lead and blood pressure. JAMA 1985; 253 : 530-534.

PIRKLE JL, SCHWARTZ J, LANDIS J, HARLAN W. The relationship between blood lead levels and blood pressure and its cardiovascular risk implications. Am J Epidemiol 1985; 121 : 246-258.

DUGGAN M. Contribution of lead in dust to children's blood lead. Environ Health Perspect 1983; 50 : 371-381.

ANNEST J, PIRKLE J, MAKUC D, NEESE J, BAYSE D, KOVAR G. Chronological trend in blood lead levels between 1976 abd 1980. N Engl J Med 1983; 308 : 1373-1377.

VON SCHIRNDING Y. A study of the impact of lead in the environment on school children in the Cape Town area. MSc thesis, University of Cape Town, 1982.

WHITE N, DEMPSTER W, POCOCK, F, KIBEL M. Lead absorption in Cape children : a preliminary report. S Afr Med J 1982; 62 : 799-802.

VON SCHIRNDING Y, FUGGLE R. A study of the relationship between low level lead exposure and classroom performance in South African children. Int J Biosoc Res 1984; 6 : 97-106.

VON SCHIRNDING Y, FUGGLE R. Zinc protoporphyrin levels and lead absorption in children attending schools in the Cape Peninsula, South Africa. S Afr J Epidemiol Infect 1986; I : 11-15.

DEVEAUX P, KIBEL M, DEMPSTER W, POCOCK F, FORMENTI K. Blood lead levels in preschool children in Cape Town. S Afr Med J 1986; 69 : 421-424.

VON SCHIRNDING Y. A cross-sectional study of the distribution and determinants of lead levels in Cape Town school children, South Africa. Paper presented at the 11th Scientific Meeting of the International Epidemiological Association, Helsinki, Finland, 1987.

VON SCHIRNDING Y. Environmental lead exposure among inner city Cape Town children : a study of associated risk factors., PhD thesis, University Cape Town, 1989.

DEPARTMENT OF HEALTH. Lead poisoning in Children Pretoria : Government Printer, 1979.