Spatial variation in lead levels in blood among children of Mumbai: Evidence from NFHS II

Introduction

The WHO estimates that 15-18 million children in developing countries are suffering from permanent brain damage due to lead poisoning, and several millions of children and pregnant women in practically all the countries are exposed to elevated levels of lead (Bandyopadhyay, 1999). Earlier studies showing the high concentration of blood lead in the Indian population in various cities. (Raghunath et al, 1999, Annapurna et al 1985, Parikh, 1990) and in preganant women (Awasthi et al, 1996 and Saxena et al, 1994). A survey conducted in seven major Indian cities revealed that more than half the children below the age of 12 have levels of lead in their blood far above the acceptable limit of 10 micrograms per decilitre. Fourteen per cent or more have "seriously elevated levels" of 20 micrograms. The study also explored that Mumbai had the highest incidence of lead poisoning with a percentage of 61.86 children affected, followed by Chennai (60.54), Calcutta (55.78), Delhi (54.10) and Bangalore (39.94).Lead has been implicated in a number of health effects, ranging from severe enciphalopathy to and death to subtle effects on IQ (Needleman, 1996).

Lead enters humans most frequently through ingestion and inhalation, skin absorption and in utero exposures. Most individuals ingest lead via food almost daily. Contamination of plants from atmospheric lead is the most important pathway for lead to enter the human food chain. It is also ingested through milk and meat. The amount of lead inhaled depends on the lead levels in air and the amount of air being inhaled by the individual. Generally adults inhale 15 m3 of air daily while children of 2 years inhale roughly 6 m3 of air daily. The ability of the skin to absorb certain organic lead compounds, such as tetraethyl lead found in petrol has been recognized since the 1940s. Inorganic lead compounds (e.g. lead nitrate, lead acetate and lead oxide) can also be absorbed through the skin but in very small quantities. Lead poisoning is caused by acute or chronic environmental exposure through air, drinking water (lead soldered pipes), food (cans), paints, soil, dust. The varied and heterogenous nature of environmental exposure is a constraint to the control, reduction, prevention, and intervention strategies implementation. Vehicular emissions and effluents from battery industries had been major contributors to the excessive amounts of lead in the Indian environment. The total estimated release of lead from vehicular traffic emissions is 640 TPY (Khandekar et al, 1987). About 50%-70% of this is expected to be released as emissions into the environment, and the rest gets deposited in the exhaust system. These annual mean values have come down to 350 ng/m3 in 1996 and 220 ng/m3 in 1997 as reported in CPCB annual report of 1997-98. This report also indicates highest emissions of Pb in Delhi followed by Calcutta, Mumbai and Chennai among the 4 mega cities.

Congested traffic on main roads of cities and old vehicles serve as distributed source of Pb pollution (Ramanathan, 1999; Samanta et al, 1995). Significant difference of ambient air lead levels have been reported from high and low exposure areas which ranges from

131-864 ng Pb/m3 147-476 ng Pb/m3 (daily average range) respectively (Parikh et al, 1999). In a study carried out on school children in Ahmedabad city, 61.6% children had Pb levels higher than the 10 mg/dL (NIOH, 1999). In a survey by the Indian Council of Medical Research, a total of 198 samples of 20 brands of infant formula milk were collected from retail shops in and around Pune, Mumbai, Mysore, Lucknow and Ludhiana, and analysed for pesticides and metals. The study indicated high levels of metal contamination (As, Cd, Pb, Cu and Zn (ICMR, 1993). Pb levels in most of the water sample collected from various sources and sites in India (Kaphalia et al, 1981) interestingly showed lead levels within permissible limits, from roadside urban water supply in Lucknow and Kanpur (Seth et al, 1975) to water samples from various sites of Yamuna (Israili and Khurshed, 1991) and Ganga rivers (Israili, 1991). Lead may accumulate in the body over decades and is stored in the bones and teeth. Young children absorb it more than adults (42-48% and 8-10% respectively). Particles between 10-70 mm diameter are commonly generated by mechanical or hand sanding and particles <40 mm are invisible to the naked eye. Fine lead dust particles smaller than 100 mm are of particular hazard to children because: they adhere more strongly to the skin they are more soluble in the gastrointestinal tract than coarser particles. Those <10 mm diameter can be readily absorbed through the respiratory tract. Once absorbed, Pb is not homogeneously distributed throughout the body there is rapid uptake by blood and soft tissues, followed by slower redistribution to the bones. Blood Pb levels are used as a measure of body burden and absorbed doses of Pb. The half-life for Pb in blood is 25-36 days but much longer in the bones.

The literature above indicates that there are few remote incidents of lead poisoning were detected in India, and population based studies to institute blood lead levels are rarely done. Though the continual implementation of preventive measures are being implemented by Indian government for the last few years, even today, no reliable statistics are available on the prevalence of lead poisoning and its impact on the population, and hence, the problem remains poorly understood. Moreover, the studies on factors that are associated to the spatial disparity in the distribution of blood lead levels are scarce. This paper is an attempt in this direction.

Methodology:

The data was obtained from National Family Health Survey (NFHS) survey undertaken in 1998-99 covered a representative sample of more than 99 percent of the population in Mumbai (IIPS and ORC Macro, 2000). The primary objective of the survey was to provide national and state-level data on different demographic and socio-economic determinants with respect to family planning, maternal and child health indicators. A two-stage, stratified PPS (Probability Proportion to Size) sampling procedure is used to select the households in each state. This survey is similar to the Demographic and Health Surveys (DHS) in other countries.

In the National Family Health Survey II, the blood test for the lead in the blood administered to children, below three years of age. The test was done in the field, using approximately 2-3 drops capillary blood (50 µl) taken just after a single drop of blood was taken to for anaemia test, using the same finger prick or heel prick. Before any blood was taken, an expanded informed consent statement was read to the child's mother requesting her consent for the child to receive both anaemia test and the lead test. If she agreed to the lead test, the child hands were first washed thoroughly with soap and water before the blood was taken. The blood for the test was mixed with treatment reagent. In this test, the blood and the reagent mixture is then transferred to sensor using a pippette and the sensor is introduced into a lead care analyzer. In three minutes, the test results are displayed digitally by the analyzer. The analysis carried out on different spatial aspects such as water bound areas, slum area and slum households in different areas of Mumbai. Mapping of concentrated areas of higher elevated lead levels was done. The mean average lead levels were computed for different major areas within Mumbai city. The mapping also done for the city area and suburban areas.

Findings

Around 50 percent of the children under the age 3 in Mumbai have elevate lead levels in blood (≥ 10.0 µg/dl), including 8 percent who have lead levels of 20-44.9 µg/dl. The proportion of children with elevated lead levels (≥ 10.0 µg/dl) varies by background characteristics. This may reflect the cumulative effects of exposure to lead overtime, as well as fact that younger children are less likely to be exposed lead outside home. Currently breast-feeding children are also likely to have elevated lead levels (45 percent) than children who were breast fed only in the past (59 percent), perhaps at least in part because currently breast feeding children are also less likely to be younger. There are no much differentials by sex of the child. However girl children are having slightly higher elevated levels of lead (52 percent) than the male children (50 percent). The noticeable finding is that the children of birth order four and above relatively having higher levels of lead in blood than the children of birth order three and below. With this regards, the proportion of children with elevated lead levels in blood is considerably high among the children of low standard of living (66 percent) than the medium (53 percent) and higher standard of living (42 percent). The proportion of children is slightly higher among the households of the slum areas (54 percent) where as 40 percent in slum households. Similarly the higher elevated blood lead levels are higher (53 percent) among slum areas than the non-slum area (46 percent).

The noticeable finding is 54 percent of the children who are living in water bound area of Mumbai are having higher elevated lead levels (54 percent including 8 percent of 20-44.9 µg/dl). Where as 46 percent of the children in non-water bound areas of Mumbai are also higher elevated lead levels in blood (10-44.9 µg/dl including 7 percent of 20-44.9 µg/dl). The interesting observation from this study is longer the duration, i.e, as the duration of place of residence increases the higher elevated lead levels is also increasing. 75 percent of permanent residents are having higher lead levels in blood including 25 percent of 20-44.9µg/dl. It also exploring, among the children of the households which are residing more than three years having elevated lead levels (50 percent) than the children of households, which are residing less than one year. This may be due to the exposure for various environmental risk factors such as air pollution, industrial and vehicular emission of poisonous gasses in to the air. And also may be due to the housing dust, exposure to the open space drainage, sewage waste and soil contamination. The lead levels also vary among children coming from different household conditions in terms of the type of kitchenware and cooking fuel used. Use of aluminium kitchenware and use of kerosene as main type of cooking fuel are both associated with higher proportions of children with elevated lead levels in the blood (61 percent and 54 percent respectively) than are found in children from households using stainless steel kitchenware and liquid petroleum gas as the main cooking fuel (49 percent and 48 percent respectively).

The proportion of children with elevated lead levels in blood is lowest among the children who are not anemic (38 percent) and it increases with severity of anemia, from 49 percent among mildly anaemic children to 60 percent among moderately anaemic children. More than half of the children born to illiterate mothers or to mothers with less than a high school education are found to have elevated blood levels in the blood. The proportion of children with high lead levels in the blood is lower (45 percent) among the children of mothers who have competed at least a high school education. Muslim children and children not belonging to scheduled castes, scheduled tribes, or other back ward classes are somewhat less likely than other children to have elevated blood levels. Even with these differentials, the high prevalence of elevated lead levels in almost all subgroups of young children clearly indicates that lead in the environment, especially in the poorer areas of Mumbai, is serious public health problem.

Conclusion

The results of this study, with its particular attention to spatial variations in blood lead levels in young children, lends support to a belief that the areas lead poisoning is severe among the children belonging to slum areas, living in water bound or industrial areas. It further demonstrates that increased levels of blood levels are closely linked to the life style and socio economic status of the households. Findings of this paper suggest many policy issues in the efforts to reduce the lead poisoning among children for better health.