Special Review Article

Blood Lead Levels in Japanese Children -Effects of Passive Smoking-

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Abstract

Lead is highly toxic to human body especially to children and pediatric lead poisoning has been a public health problem not only in the developing countries, but also in the developed countries. Many studies have been conducted to investigate blood lead levels (BLL) of children of those countries. The mean BLL of Japanese children was among the lowest levels in the industrialized world in the early 1990's and also in the early 2000's according to our study. Fortunately the BLL of children and adults have been decreasing steadily in many countries during these two decades.

Recent studies have revealed that even low-level lead exposure (BLL less than 10μg/dl) might adversely affect growth and intellectual development of children, and it is considered now that there does not exist the safe level of blood lead.

Several studies have suggested that passive smoking causes increase of BLL of children, therefore, children should be protected from cigarette smoke for the purpose of avoiding the risk of lead exposure.

Keywords : lead, passive smoking, growth, intellectual development, children

Introduction

Lead (Pb) is one of major environmental pollutants, and is highly toxic to human body. Since children are much more vulnerable to lead toxicity than adults, pediatric lead poisoning has been a public health problem not only in the developing countries, but also in the developed countries. Therefore, many studies have been conducted to investigate blood lead levels (BLL) of children of those countries.

In recent years many studies revealed that low-level lead exposure could adversely affects human health, especially to childhood growth and intellectual development. On the other hand, it has been reported that children of smoking parents have a higher BLL than those of non-smoking parents[1)2)].

In this paper, blood lead levels of children of several countries including Japan will be presented partly in relation to passive smoking, and the effects of lead mainly on growth and development of children will be discussed.

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Received : 1 May 2007
Accepted : 8 May 2007

Blood lead levels of Japanese children

Study in 1993[3)] :

There had been few data on the BLL of Japanese children until we studied in 1993. Then we measured the BLL of 188 children (106 boys, 82 girls) aged 1 to 15 years, who visited the pediatric outpatient clinic of Shizuoka General Hospital. We also asked their parents about their smoking style in the home. The subjects were divided into three groups according to the parent's smoking style as follows ;

Group A : Children of smoking parents who usually smoke in the same room with their children.

Group B : Children of smoking parents who usually take care not to smoke in the same room with their children.

Group C : Children of non-smoking parents.

They were classified further into preschool children and school children.

As a result, there were 6 subgroups in all.

The BLL (mean±standard deviation) of all the subjects was 3.16±1.50μg/dl, and ranged between 0.80 and 9.51μg/dl. The BLL of boys was 3.17±1.34μg/dl and that of girls was 3.14±1.69μg/dl. There was no significant difference between them.

The BLL of groups A, B and C in preschool children were 4.15±1.56μg/dl (n=28), 3.22±1.46μg/dl (n=32) and 3.06±1.31μg/dl (n=31), respectively. The BLL of groups A, B and C in school children were 2.97±1.50μg/dl (n=34), 3.24±1.66μg/dl (n=26) and 2.56±1.19μg/dl (n=37), respectively (Fig.1).

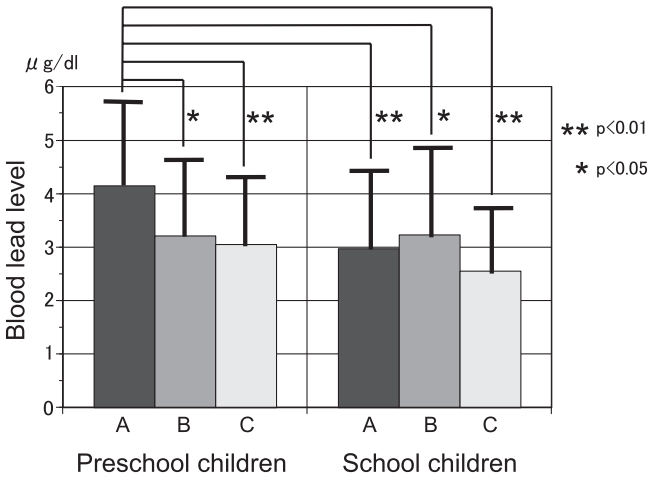

Fig. 1 Blood lead levels in Japanese children in relation to their parents' smoking style in 1993.
A : Children of smoking parents who usually smoke in the same room with their children.
B : Children of smoking parents who usually take care not to smoke in the same room with their children.
C : Children of non-smoking parents.

The mean BLL of group A preschool children was significantly higher than those of the other five subgroups, and there were no significant differences among the other five subgroups.

Study in 2004-2005 :

We measured the BLL of 282 children (140 boys, 142 girls) aged 3 months to 15 years, who visited the pediatric outpatient clinic of Shizuoka Children's Hospital in 2004-2005.

The BLL of all the subjects was 1.55±0.85μg/dl, and ranged between 0.19 and 7.68μg/dl. The BLL of boys was 1.60±0.81μg/dl and that of girls was 1.49±0.88μg/dl. There was no significant difference between them.

The BLL of groups A, B and C in preschool children were 1.90±0.92μg/dl (n=20), 1.82±1.27μg/dl (n=61) and 1.41±0.60μg/dl (n=60), respectively. The BLL of groups A, B and C in school children were 1.53±0.65μg/dl (n=36), 1.55±0.75μg/dl (n=44) and 1.30±0.52μg/dl (n=61), respectively (Fig.2).

The mean BLL of group A and B preschool children were significantly higher than those of group C preschool children and group C school children. There were no significant differences among the others.

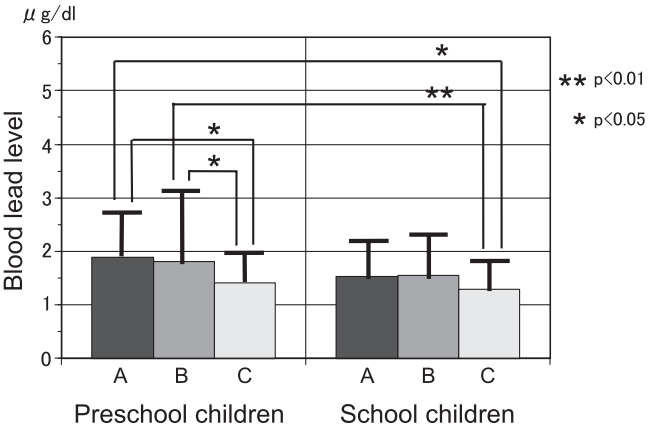

Fig. 2 Blood lead levels in Japanese children in relation to their parents' smoking style in 2003-2004.

Blood lead levels of children of foreign countries

Reviewing several data on the children's BLL from various regions of the world around 1990, Hayes et al. reported that the mean BLL of children aged 6 months to 5 years (mean : 2.7 years) was 12μg/dl in Chicago in 1988[4]. Sherlock et al. measured the BLL of Caucasian and Asian children (age range 2.5 to 5 years, age and sex-matched) living in London, and reported that the mean value was 9.7μg/dl in Caucasian children and 8.1μg/dl in Asian children in 1985[5]. Jin et al. reported that the mean BLL was 6.0μg/dl (range : 1.24 to 17.6μg/dl) in children aged 24 to 36 months in Vancouver in 1995[6]. Cambra et al. reported that the mean BLL of children aged 2 to 3 years in Basque county in Spain was 5.7μg/dl and that 14% of the children had levels exceeding 10μg/dl in 1995[7]. Andren et al. reported that the mean BLL of Swedish children (8 to 13 years of age) of non-smoking parents was 2.95μg/dl in 1988[1].

Comparing to these reported values, the mean BLL of Japanese children, according to our study in 1993, was among the lowest levels in the industrialized world in the early 1990's. Fortunately the BLL of children and adults have been decreasing steadily in many countries during these two decades, of which the primary reason is prohibition of leaded gasoline use and subsequent reduction of

air pollution with lead. In Switzerland, for example, leaded gasoline was predominantly used formerly, but unleaded gasoline use was encouraged since the late 1980's. Then the mean BLL of adults in Switzerland decreased remarkably in only nine years ; from 12.2 to 6.8 μg/dl in men and from 8.5 to 5.2μg/dl in women[8].

Decreases of BLL of children have been also observed in many industrialized countries. In Swedish children, for example, dramatic decrease of BLL was found during the period 1978-2001, from about 6 to 2μg/dl, which was considered to reflect a beneficial effect of gradual banning of leaded gasoline[9].

Reviewing the latest data on the children's BLL, Zhang et al. reported that the mean BLL of Chinese children aged 0 to 6 years was 5.95μg/dl in 2005[10]. Kirel et al. reported that the mean BLL of Turkish children was 3.56μg/dl in 2005[11]. Friedman et al. reported that the mean BLL of 3-year-old Ukrainian children was 3.15μg/dl in 2005[12]. Gulson et al. reported that the mean BLL of Australian children aged 0.29 to 3.9 years was 2.6μg/dl in 2006[13]. Comparing to these values, the mean BLL of Japanese children according to our latest study is very low, as it was in the 1990's. The reasons proposed are that leaded gasoline use was prohibited in Japan more than three decades ago, among the earliest in the world, and Japanese people generally do not often do house-painting which has been considered to be a major cause of lead poisoning in children in the United States and European countries.

Effects of lead on growth of children

It had long been considered that blood lead of less than 20μg/dl was almost harmless to human body, because no clinical or biochemical effects had been recognized in such condition until about two decades ago. Since then, however, many studies have revealed that much lower levels of blood lead might adversely affect human health, especially childhood growth and development. There have been several studies investigating the relationship between BLL and growth of children. Schwartz et al. examined about 2,700 children aged 7 years and younger in the Second National Health and Nutrition Examination Survey (NHANES II) in the United States, and found the inverse correlation between BLL in the range of 5 to 35 μg/dl and body height. They concluded that low-level lead exposure could impair the somatic growth of children[14]. Kafourou et al. also revealed negative relationships between BLL and growth parameters in Greek children aged 6-9 years, an increase in BLL of 10μg/dl being associated with a decrease of 0.86cm in height, 0.33cm in head circumference and 0.40cm in chest circumference[15].

In recent years several studies indicated the adverse effects of low-level lead exposure on the sexual maturation in adolescents. Wu et al. assessed measures of puberty in girls in relation to BLL to determine whether sexual maturation might be affected by current environmental lead exposure, using data from the Third National Health and Nutrition Examination Survey (NHANES III) in the United States. They showed negative relationship between BLL and attainment of menarche or stage 2 pubic hair, which remained significant in logistic regression even after adjustment for race, age, family size, residence in metropolitan area, poverty income ratio, and body mass index. They concluded that higher BLL was significantly associated with delayed attainment of menarche and pubic hair among U.S. girls[16]. Selevan et al. analyzed the relations between BLL and pubertal development among girls aged 8-18 years, including three ethnic groups ; non-Hispanic white, non-Hispanic African-American and Mexican American, also using data from NHANES III. They reported that BLL of 3μg/dl was associated with significant delays in breast and pubic hair development in African-American and Mexican American girls. They suggested that environmental exposure to lead might delay growth and pubertal development in girls, although confirmation should be warranted in prospective studies[17].

Effects of lead on intellectual development of children

The adverse effects of low-level lead exposure on children's intellectual and academic performance at school are more serious problems. Bellinger et al. evaluated the relationship between BLL and neuropsychological test score in middle-class and upper-middle-class children, and found that over the range of approximately 0 to 25 μg/dl, a 10μg/dl increase of BLL at 24 months was associated with a 5.8-point decline in WISC-R (Wechsler Intelligence Scale for Children-Revised) Full Scale IQ and an 8.9-point decline in K-TEA (Kaufman Test of Educational Achievement) Battery Composite score at age 10 years. These data indicated that slightly elevated BLL around the age of 2 years is associated with intellectual and academic performance deficits at age 10 years[18].

Scientific understanding of the health effects of lead has flourished over the past two decades. Advances in this area of research have spawned a series of efforts by

governmental agencies to enhance the protection of public health from the adverse effects of lead. The United States Centers for Disease Control and Prevention and the World Health Organization defined a BLL of 10μg/dl as the threshold of concern in young children. Therefore, one of main goal of those efforts was to reduce numbers of children who had BLL exceeding 10μg/dl during these two decades. Blood lead of less than 10μg/dl was considered to be almost harmless, because any derangement of biochemical indices were not observed originated from lead of the lower level.

Most recently, however, it has been considered that there does not exist the safe level of blood lead, and lead exposure is still a serious health problem for children. Many studies have demonstrated that even very low-level lead exposure causes intellectual and behavioral impairment in children. Lanphear et al. reviewed recent international population-based longitudinal cohort studies investigating the relationship between low-level lead exposure and intellectual deficits in children, and found an inverse relationship between BLL and IQ score even in the range of low BLL. They reported that using a log-linear model, a 6.9 IQ point decrement was found associated with an increase in concurrent BLL from 2.4 to 30 μg/dl. The estimated IQ point decrements associated with an increase in blood lead from 2.4 to 10μg/dl, 10 to 20μg /dl, and 20 to 30μg/dl were 3.9, 1.9, and 1.1, respectively. For a given increase in blood lead, the lead-associated intellectual decrement for children with a maximal BLL less than 7.5μg/dl was significantly greater than that observed for those with a maximal BLL exceeding 7.5μg/dl. They concluded that environmental lead exposure in children who had maximal BLL less than 7.5μg/dl was associated with intellectual deficits[19].

Effects of passive smoking on the blood lead level of children

It has been suggested that children who are exposed to cigarette smoke have higher BLL than children who are not[1)2)].

We measured BLL of Japanese children and evaluated the effects of passive smoking on the BLL, and found that passive smoking increased the BLL of preschool children in the study in 1993. The mean BLL of preschool children who were exposed to cigarette smoke in their home was 4.15μg/dl, and those whose family never smoked was 3.06μg/dl, the difference significant. We also found that passive smoking did not increase the BLL of school children. About the reasons of the difference of the effects of passive smoking on the two groups of children, we speculate that preschool children might spend more time with their parents and might have more contact with cigarette smoke than school children, and additionally, young infants have limited ability to excrete lead from the body because of the immaturity of renal function.

Ballew et al. investigated the BLL of a total of 4,391 non-Hispanic white, non-Hispanic black, and Mexican-American children of the United States aged 1 to 7 years, using data from NHANES III. They reported that the mean BLL of the children who had smoking family was 4.36μg/dl and that of the children who had not was 3.29 μg/dl[20], very similar to the values reported in our study (Fig.3). Stromberg et al. also reported a significant effect of parental smoking habits on the BLL of Swedish children, 18% increase on average[9].

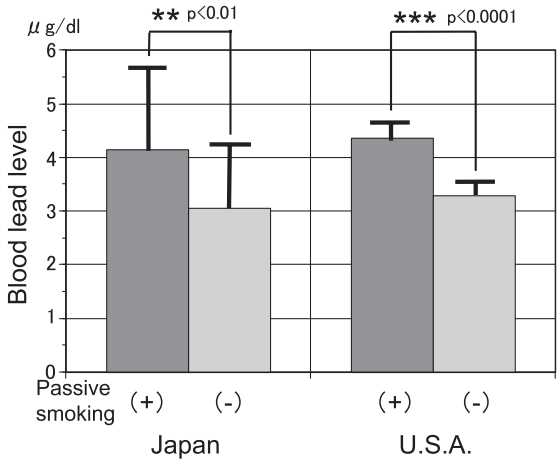

Fig. 3 Blood lead levels in Japanese and US children in relation to passive smoking.

We measured BLL of Japanese children and evaluated the effects of passive smoking on the BLL also in the study in 2004-2005, and found that the BLL of preschool children who had smoking parents (both Group A and B) were higher than that of preschool children who had non-smoking parents (Group C). In this study, the BLL of Group B preschool children was as high as that of Group A, for which reason we speculate insufficiency of protection of children against cigarette smoke in their home, in spite of the Group B parents' answer that they usually take care not to smoke in the same room with their children.

It is evident that passive smoking is now a major cause of lead exposure for children. Children should be protected from cigarette smoke for the purpose of avoiding the risk of increased BLL which might adversely affect

their intellectual development and physical growth.

Acknowledgments

I wish to express our appreciation to Dr. Norihiro Kobayashi, Dr. Kikuo Yoshida and Dr. Junko Nakanishi, Research Center for Chemical Risk Management, National Institute of Advanced Industrial Science and Technology, who measured BLL of children in our study in 2004-2005.

References

1) Andren P, et al : Environmental exposure to lead and arsenic among children living near a glassworks. Sci Total Environ 77 : 25-34, 1988.
2) Willers S, et al : Relation between lead and cadmium in blood and the involuntary smoking of children. Scand J Work Environ Health 14 : 385-389, 1988.
3) Kaji M, et al : Blood lead levels in Japanese children : effects of passive smoking. Jpn J Pediatr 101 : 1584-1587, 1997. [in Japanese with English abstract]
4) Hayes EB, et al : Long-term trends in blood lead levels among children in Chicago : Relationship to air lead levels. Pediatrics 93 : 195-200,1994.
5) Sherlock JC, et al : Blood lead concentrations and lead intake in children of different ethnic origin. Human Toxicol 4 : 513-519, 1985.
6) Jin A, et al : Blood lead levels in children aged 24 to 36 months in Vancouver. Can Med Assoc J 152 : 1077-1086, 1995.
7) Cambra K, et al : Blood lead levels in 2- to 3-year-old children in the Greater Bilbao Area (Basque County, Spain) : Relation to dust and water lead levels. Arc Environ Health 50 : 362-366, 1995.
8) Wietlisbach V, et al : Time trend and determinants of blood lead levels in a Swiss population over a transition period (1984-1993) from leaded to unleaded gasoline use. Environ Res 68 : 82-90, 1995.
9) Stromberg U, et al : Yearly measurements of blood lead in Swedish children since 1978 : an update focusing on the petrol lead free period 1995-2001. Occup Environ Med 60 : 370-372,2003.
10) Zhang SM, et al : Study on blood lead level and related risk factors among children aged 0 - 6 years in 15 cities in China. Zhonghua Liu Xing Bing Xue Za Zhi 26 : 651-654,2005. [in Chinese]
11) Kirel B, et al : Blood lead levels of maternal-cord pairs, children and adults who live in a central urban area in Turkey. Turk J Pediatr 47 : 125-131,2005.
12) Friedman LS, et al : Predictors of elevated blood lead levels among 3-year-old Ukrainian children : a nested case-control study. Environ Res 99 : 235-242,2005.
13) Gulson B, et al : Changes in manganese and lead in the environment and young children associated with the introduction of methylcyclopentadienyl manganese tricarbonyl in gasoline -preliminary results. Environ Res 100 : 100-114,2006.
14) Schwartz J, et al : Relationship between childhood blood lead levels and stature. Pediatrics 77 : 281-288, 1986.
15) Kafourou A, et al : Effects of lead on somatic growth of children. Arch Environ Health 52 : 377-383, 1997.
16) Wu T, et al : Blood lead levels and sexual maturation in U.S. girls : the Third National Health and Nutrition Examination Survey, 1988-1994. Environ Health Perspect 111 : 737-741,2003.
17) Selevan SG, et al : Blood lead concentration and delayed puberty in girls. N Engl J Med 348 : 1527-1536,2003.
18) Bellinger DC, et al : Low-level lead exposure, intelligence and academic achievement : a long-term follow-up study. Pediatrics 90 : 855-861, 1992.
19) Lanphear BP, et al : Low-level environmental lead exposure and children's intellectual function : An international pooled analysis. Environ Health Perspect 113 : 894-899,2005.
20) Ballew C, et al : Blood lead concentration and children's anthropometric dimensions in the Third National Health and Nutrition Examination Survey (NHANES III), 1988-1994. J Pediatr 134 : 623-630, 1999.