Blood lead levels of maternal-cord pairs, children and adults who live in a central urban area in Turkey

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Lead levels were measured in blood samples of 99 adults, 180 children and 143 pregnant women living in Eskişehir, an urban area in Turkey. One hundred and twenty 120 cord blood and 93 breast-milk samples were also obtained. Mean lead level in blood of adults, children, pregnants, cord blood and in breast-milk samples were 3.13±1.4 μg/dl, 3.56±1.7 μg/dl, 2.8±1.5 μg/dl, 1.65±1.4 μg/dl and 2.34±1 μg/L, respectively. It was higher in men than in women in adults ($p<0.05$) and in iron-deficient children than in those not deficient ($p<0.01$), and was negatively correlated with body weight (BW) and hemoglobin (Hb) in children ($p<0.05$ for both). Maternal lead level was strongly related with cord blood and breast-milk lead contents ($p<0.001$, $p<0.0001$, respectively). The lead exposure in this region is much lower than the critical level defined for lead poisoning as ≥10 μg/dl by the Centers for Disease Control and Prevention iron deficiency poor nutrition are the risk factors to lead exposure in children.

Key words: lead, pregnant women, breast-milk, cord blood, adults, children.

Lead is not necessary for any physiologic function in the body, and thus is a poisonous element for living organisms. It is taken up via contaminated air, dust and food and accumulates in the body, primarily in the bones. The biologic half-life of lead is quite long in the body[1-2]. The critical value for lead poisoning was identified as ≥10 μg/dl of blood lead level in children by the Centers for Disease Control and Prevention (CDC) in 1991[2,3]. Adverse effects involve mainly hematopoietic, renal and neurologic systems. Acute encephalopathy, coma and death are also encountered[1-4]. These severe manifestations are usually observed at high blood levels. During the developing period of the nervous system, children are more vulnerable to lead's neurotoxic effects[2-4]. Medical intervention is recommended for a child with a level higher than 25-45 μg/dl, even if asymptomatic.

Leaded gasoline and dust from the lead-based house paints are major sources of lead causing ambient air pollution and soil contamination. The other sources are occupational exposure in automotive and aircraft paint manufacturing, battery recycling plants, lead smelters, lead pipes, fuels used for heating, lead-glazed ceramics, some Asian cosmetics like kohl or sürme and some Mexican medicine[1-3,5]. Elevated blood lead levels have been reported in cigarette smoking (active and passive) and wine consumption[5]. Because maternal lead is transferred to the fetus via the placenta, the fetus is not safe during the intrauterine period. Intrauterine lead exposure can be predicted by measuring cord blood lead level[3-10]. Breast-milk is another source of lead in neonates[11-13].

The sources of lead contamination change regionally. Every region must evaluate their risk factors for lead poisoning in order to control the environment. The aim of this study was to determine the level of lead exposure in children and adults in a Central Anatolia city in Turkey, Eskişehir, in and to identify risk factors of lead exposure in this region. Maternal-cord blood and breast-milk samples were also taken to determine the level of lead exposure during the prenatal and neonatal periods.

Material and Methods

This study was conducted in autumn and winter during 2001-2002 in Eskişehir, an urban area with a population of 600,000. The study group

consisted of 99 adults and 180 children. One hundred and forty-three pregnant women admitted for delivery to the Maternity Hospital were also included. One hundred and twenty cord blood and 93 breast-milk samples were obtained from these women. All adult subjects were included in the study if they had lived in this city for more than three years. Some of the adults were medical students or staff of the Medical Faculty Hospital of Osmangazi University. The other adults and children were selected from the patients who admitted to this hospital with acute health problems, except for those with renal, neurologic and another chronic diseases. Complicated pregnancies like imminent abortion, gestational diabetes, preeclampsia, multiple fetuses and premature deliveries with a gestational age less than 37 weeks were also excluded.

All adults and parents of the children were asked to participate in the study and were interviewed via questionnaire about their socio-demographic characteristics and the risk factors of lead exposure and poisoning [e.g., traffic density at their residence, heating system of the residence, smoking exposure (active-passive), education and occupations of the adult participants, the parents of the children, and husbands of the pregnants, history of PICA, alcohol consumption and use of kohl].

Physical examinations of all children and newborns were done. Growth parameters [body weight (BW), height and head circumference] were compared with standard physical development tables for sex and age.

Venous blood samples were taken from all study subjects. The samples were obtained from the pregnant women just before delivery. Cord blood samples were taken immediately after birth. Breast-milk samples were collected in metal-free special tubes within 2-3 days after the delivery. All collected blood samples were stored in metal-free vacutainers® that contained EDTA. All samples were kept cold until analysis.

Lead analysis was done with a Perkin-Elmer SIMAA 6000 atomic absorption spectrophotometer (AAS) equipped with a graphite furnace and Zeeman background correction certified by the Düzen Clinical Chemistiry Laboratory in Ankara. Lead analysis of breast-milk samples was determined by AAS after centrifugation with trichoroacetic acid (TCA).

Calcium, phosphorus and alkaline phosphatase levels and complete blood count were determined by an automatic analyzer with commercially excilable kits (Roche Diagnostic, Switzerland) and hematology analyzer (Coulter Gen-S), respectively. Ferritin level was measured by automated chemiluminescence system (ACS: 180 Plus CIBA-CORNING).

Anemia was diagnosed by comparing the hemoglobin (Hb) levels to the reference Hb levels for each age and sex group. Iron deficiency was defined regarding red cell distribution width (RDW), mean corpuscular volume (MCV) value and ferritin level.

Independent samples t test was used for the comparisons. The correlation analysis was performed by the Pearson Product Moment Coefficient.

Results

Clinical characteristics and blood lead levels are shown in Table I. The mean blood lead levels were 3.13±14 μg/dl, 3.56±1.7 μg/dl and 2.8±1.5 μg/dl in adults, children and in pregnant women, respectively. Lead levels were higher than 10 μg/dl only in two adults and in three children. Mean cord blood lead levels was 1.65±1.4 μg/dl, and it was 61% of the maternal lead levels. Mean breast-milk lead content was 2.34±1 (range: 0.28-7) μg/L.

The general comparisons of the lead levels in groups were as follows: In the adult group (men and non-pregnant women), men had higher lead levels than women ($p<0.05$). When the pregnant women were included in this adult group, the difference between the two sexes was more significant ($p<0.001$). Pregnant women had lower blood levels than non-pregnant women, but it was not statistically different ($p>0.05$). Children had higher blood lead levels than this combined adult group (men and all women) ($p<0.001$). Blood lead levels were not different between the two sexes in children ($p>0.05$).

There was no history of occupational exposure to lead, alcohol consumption or use of kohl in any study participants or members of their families. One hundred and twenty-two women were housewives. Mean education duration was 9±4 (range: 5-17) years in the adults. Twelve pregnant women and one man never attended school. History of PICA was present only in one

Table I. Results of the Entire Study

	n	Age (yr)	Blood lead levels (μg/dl)	Range
Entire Study Group	422		3.2±1.6	(0.7-13)
Adults	99	30±7 (20-51)	3.13±1.4	(1.3-10.3)
Men (32)		31±7 (22-51)	3.6±0.9*	(2.2-5.1)
Non-pregnant women (67)		29±7 (20-50)	2.9±1.5	(0.7-10)
Pregnant women	143	25±5 (16-41)	2.8±1.5	(0.7-10)
Cord blood (120)			1.65±1.4	(0.12-8.2)
Children	180	10±4 (1-17)	3.56±1.7**	(1.2-13)
Boys (78)		10±4 (2-17)	3.42±1.6	(1.3-11.9)
Girls (120)		10±4 (1-17)	3.65±1.8	(1.2-13)

Data are presented as mean±standard deviation.

*p<0.05, men versus women.

**p<0.001 children versus the combined group of adults with pregnant women.

non-pregnant woman, in 21 pregnant women and in 10 children. Lead levels were not different between the pregnant women with and without PICA history (p>0.05). Anemia was found in 24 children, 24 adults and 71 pregnant women. Ninety-six adults and two children were smokers. The lead levels did not differ between groups regarding the presence of anemia, traffic load of the residence, smoking habits (passive-active), or type of heating system (p>0.05). In children, lead levels of the iron-deficient (4.6±2 μg/dl) were higher than in non iron-deficient children (3.4±1.5 μg/dl) (p<0.01).

Blood lead levels were correlated negatively with age (r=-0.2, p=0.01) and positively with alkaline phosphatase and calcium levels (r=0.13, r=0.2 and p<0.05, p<0.01, respectively) in all groups.

There were no low birth weights, intrauterine growth retardation nor congenital anomalies among the neonates. Maternal and cord blood lead levels were not correlated with gestational age, BW or length of the newborns (p>0.05). Maternal blood lead level was strongly correlated with cord blood and breast-milk lead contents (r=0.5, r=0.6 and p<0.001, p<0.0001, respectively), and it was correlated with head circumference of the newborns (r=0.3, p<0.05). Breast-milk lead content was correlated only with maternal alkaline phosphatase (r=0.2, p<0.05).

In children, blood lead levels were correlated negatively with age and Hb levels (r=-0.2, r=-0.2 and p<0.01, p<0.05, respectively). Anthropometric data could be obtained from 117 children. Blood lead levels were correlated negatively with BW (r=-0.2, p<0.05). Height of 21 children was below 10% of the growth standards, but their blood lead levels were not different from those in the children whose growth was above 10% (p>0.05).

There was no another correlation between the lead levels and the other parameters investigated in the study.

Discussion

Our results revealed that the mean blood lead levels were much lower in all study groups than the critical intoxication level defined by the CDC. According to our knowledge, blood lead level is not routinely measured in any hospital; before, there are limited data about the level of lead contamination and its morbidity in our country. A few studies with small sample size have reported regional lead exposure in the country. Results of the recent studies are summarized in Table II[7-11,14-17]. Furman and Laleli[16] performed a study in 365 people aged between 8-36 years from 17 different cities of the country in 1999 and they found much lower blood lead levels. Fifteen people from Eskişehir were included in this study. Their mean lead level was 4.2±2.5 μg/dl, which is higher than our results. All these studies have shown that blood lead levels have declined over time, and that lead exposure is much lower in Turkey than in previous years.

We did not find any history of risk factors for lead contamination such as occupational exposure, alcohol consumption or use of sürme. In our study, blood lead levels did not differ regarding the presence of the other risk factors for lead exposure. It was higher only in the iron-deficient children.

Table II. Results of the other Studies from Turkey

Date	Author	Location	n	Materials	Mean lead level (μg/dl)
1994	Bostancı	Ankara	100	Cord blood	16.9
		The village of Ankara	54	Cord blood	9.4
1994	Özek	İstanbul	145	Cord blood	8.8
1994	Ermiş	İstanbul	77	Cord blood	8.15
		İstanbul	77	Breast-milk	2.17*
1995	Göker	İstanbul	201	Children	5.55
1998	Özmert	Ankara	118	Children	3.8
1998	Furman	İstanbul	65	Pregnant women	1.69
		İstanbul	104	Cord blood	2.37
1999	Furman	17 cities	365	Children and adults	3.6
			139	Children	3.54
		İstanbul	67	Children and adults	3.64
		Ankara	26	Children and adults	3.75
		Eskişehir	15	Children and adults	4.24

* also μg/dl.

No house paints containing lead nor lead pipelines are used in Turkey. The only source of lead is the leaded gasoline. Thus, while blood lead levels were lower in people living in rural areas, higher blood lead levels were found in drivers, traffic police, vendors and people living in regions with high traffic density[9,14,16,18]. Unfortunately, in this study we did not ask participants whether or not they were drivers.

In this study, the lead levels did not differ according to traffic density of the residential areas. Eskişehir is not a large city and there are only slight differences among traffic densities in the districts. People generally walk around the same central areas for shopping and social events. Thus, it can be assumed that the exposure to lead is rather homogenous among the people living in this city.

In our country, the number of automobiles increases yearly. However, the lead level in blood was found to be rather low not only in our region but also around the country. The decrease in the percentage of lead content of gasoline since 1989 and the increasing consumption of unleaded gasoline are the likely reasons for this finding[16,17].

While men had higher blood lead levels, it was not associated with any of the parameters investigated in men in our study. This finding may be related with Turkish lifestyle. Compared to women, the prevalences of smoking and driving are higher in men. Men are more frequently involved in outside activities, and they spend significantly more time in streets with higher traffic density and in cafes crowded with people who have been exposed to lead occupationally and/or in traffic and carry leaded dust on their clothes, skin and hair, and who are heavy smokers. On the other hand, the majority of the female participants were house wives who spend a majority of the daytime in the house, furthermore, in Turkey, as a tradition, shoes are taken off outside the home and this behavior reduces the amount of lead-contaminated dust entering the house. These factors may explain the lower lead exposure in women compared to the higher exposure in men.

Asymptomatic morbidity is reported especially in childhood in chronic lead exposure even at blood levels lower than 10 μg/dl. Thus, it has been recently concluded that there is no safe level for lead poisoning as defined by the CDC[4]. Nonspecific clinical symptoms of low exposure in children are stomach pain; loss of appetite; anemia; and some physical growth retardation and neurobehavioral abnormalities such as impaired attention, changes in sensory functions, learning, reading and spelling difficulties, decrement in intelligence score (IQ) and poor school performance and academic skills, and impairment in some motor and sensory functions[3,4,18-24]. Some of these abnormalities may persist during adulthood[4,28]. The subjects in our study were not evaluated in detail for asymptomatic neurologic and cognitive impairment, and we did not observe growth retardation in any children. However,

the lead levels in our study were much lower than the levels associated with the asymptomatic morbidity described above.

In children, when compared to adults, the lead levels were higher and correlated negatively with age in our study. The lead content transferred from the mother in utero and/or through breast-milk contributed to the lead levels in infants. In addition, it has been reported that lead exposure in children is easier and much greater than in adults. The absorption of lead from the gastrointestinal system is much higher than in adults. Additionally, because of their short stature, children are closer to the floor, and hand to mouth habits may cause a higher ingestion of contaminated dust[2-4,13].

It has been reported that poor nutrition, with deficiency of calcium, phosphorus, zinc and especially iron, results in increased lead absorption from the gastrointestinal system and toxicity[5,4,25]. Elevated blood lead levels have been found in children with iron deficiency and growth retardation and in children from lower socioeconomic classes[4,15,25]. Dietary supplement of iron and calcium has been recommended in preventing lead poisoning[3,25]. In our study, blood lead level was higher in the iron-deficient group and was negatively correlated with Hb levels and BW in children. These findings indicate that lead exposure and absorption are related with nutritional status, especially in childhood, as reported previously.

More than 95% of body lead burden is stored in the bones. The absorption from the gastrointestinal system and accumulation in bones of lead are related with calcium. Because of the increased demand for calcium during the periods of increased bone turnover such as growth, pregnancy and lactation, lead is mobilized from the bones[1,5,11,12,26]. We found some relations between calcium metabolism and lead levels in blood and breast-milk samples. It has been reported that blood lead levels increase during the third trimester of pregnancy as a result of increased calcium transport to the fetus[5]. In our study, the lead levels in pregnant women were lower just before delivery. On the other hand, some studies reported unchanged or decreased blood lead levels during pregnancy, as in our study[5].

Lead crosses the placenta and accumulates in the fetus until birth[3-10]. Prenatal lead exposure has been found to be associated with intrauterine growth retardation, some congenital anomalies, adverse obstetrical outcomes and neurotoxicity related with blood lead level[3,4,6,21,22,27-30].

A relationship has been found between low levels of prenatal lead exposure and neuro-developmental deficits in early life. However, according to some studies, these deficits were not present at 3-5 years of age if postnatal exposure did not continue[3,4].

Controversial reports exist about the adverse effects of low level of prenatal lead exposure on fetal growth parameters such as BW and head circumference[3,7,21,30]. It has been concluded that prenatal lead exposure alone is not a significant factor on extrauterine growth retardation. It may be an important factor only if continued postnatal lead exposure is found, and its effects on growth seems to be reversible[3,29].

In our study no neonate experienced problems during the perinatal period that could be associated with prenatal lead exposure, since the complicated pregnancies were exluded from the study. Cord blood lead level was not related with any growth parameters of the neonates, and it was much lower than the levels associated with all the adverse effects described above. A detailed neurologic evaluation and continued follow-up are needed to draw any conclusions regarding the outcome of low pre-postnatal lead exposure in children.

Breast-milk has a stable amount of lead depending on the maternal blood lead levels and is an additional lead soruce[11-13]. The World Health Organization (WHO) has reported that lead is normally found in breast-milk, with a range of 2-5 µg/L. Colostrum samples have higher lead levels than mature milk. The contribution of dietary intake of lead to the blood lead level can be calculated by analyzing consumed milk lead content. It has been reported that this contribution cannot be disregarded, but it is less important than other pre-postnatal lead sources[12,13]. Mean breast-milk concentration of lead was 2.3 µg/L 2-3 days' postpartum in our study and this was much lower than reported in the other study from our country[11] (Table II).

In conclusion, exposure to lead in the Eskişehir region is much lower than the critical intoxication level accepted by the CDC. However, even at lower levels, the presence of lead in the body directly reflects environmental

contamination and poisoning, and is also found to be related with some asymptomatic morbidity. Thus, preventative strategies must be conducted to provide a lead-free environment in our country. These strategies should be based mainly on either decreasing the percentage of lead content in leaded gasoline or to completely prohibiting the usage of it, since it is the primary source of lead pollution in the environment. Iron deficiency and poor nutrition are the risk factors to lead exposure in children in our study, indicating that a routine follow-up program for growth and neurodevelopment is needed during childhood.

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