Original Article

Effect of Living in Lead Mining Area on Growth

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ABSTRACT

Objective. Blood lead level BLL and growth parameters including weight and height, in children, living in lead mining area was surveyed.

Methods. Two groups of 7-11 yr old children, including 45 from a lead mining area (Angooran-Zanjan Province-Iran) and 36 from control area (similar area to the study area, but not lead mining: Ijrood- the same province), were selected to assess BLL (by atomic absorption spectrometry) and growth parameters.

Results. In the children of the study and control areas, mean BLLs were 36.97±24.67 (µg/dL; mean ± SD) and 15.57 ± 13.35 (µg/dL; mean±SD), respectively (P=0.0005). No significant correlation was found between BLL in children and their fathers' occupation. In addition, there was no significant difference in growth parameters, including weight and height, in the children of two groups.

Conclusion. Regarding the results of this study, environmental exposure due to living in lead mining area can lead to increased BLL in children. In addition, our results suggest there is no significant effect of BLL on growth parameters in children in lead mining area. Since some clinical and sub clinical problems are strongly probable when BLL is increased, special attention of the relevant organizations, and more research about the problem and its outcome, is recommended. **[Indian J Pediatr 2007; 74 (6) : 555-559]**

Key words : *Blood; Children; Environmental exposure; Growth; Lead; Mining*

Lead is a non-essential metal that its presence in body at any level could be considered as contamination. According to the definitions of the Centers for Disease Control (CDC) and The American Academy of Pediatrics, a blood lead level (BLL), up to 10µg / dL is acceptable, and greater than this level for children runs the risk of lead poisoning.[1]

Intake of lead to the body is through respiratory system (with more absorption in children than in adults), digestive system and skin.[2]

Several mechanisms for lead toxicity are explained, such as binding to erythrocytes, irreversible binding to intracellular enzymes(especially those having sulfhydryl groups, which diminish the function of the enzymes), competition of lead with calcium through which many calcium-binding proteins, may have altered function, although reversible, resulting in intra- and intercellular communications breakdown. Another serious problem that lead may cause, is preventing the development of the normal tertiary structure in the brain during the first few years of life, result in permanent abnormality.[1]

There are some reports that indicate a direct relation between the blood lead level and clinical manifestations.[3] Nevertheless, other reports do not confirm this relation.[1] On the other hand, more severe symptoms and signs related to lead poisoning are observed much more in greater blood levels.[4]

Symptoms and signs due to high BLL in children can be observed in many systems of the body. Disorders in central and peripheral nervous system, include "encephalopathy, seizures, cranial nerve palsies, cerebral

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edema and increased cranial pressure, ataxia, diminished deep tendon reflexes, peripheral neuropathy, muscle weakness, etc.". Gastrointestinal symptoms include "persistent vomiting, intermittent abdominal pain, anorexia, chronic constipation and so on". Growth retardation (weight loss and short stature), anemia, impaired hearing, renal involvement(nephropathy, almost in adults with chronic exposure), arthralgia, impaired vitamin D metabolism, developmental delay, decreased IQ, behavior and cognition disorders, intermittent lethargy are all manifestations due to high BLL.[1,4]

Different environmental sources for lead are considered, such as dust, soil, water, air, food, leaded paint and other exotic material present around.[4] Also animal products can be an important source for lead entrance.[5]

Based on CDC classification, recommendations for management in different levels of BLL are suggested.[6]

Some part of Zanjan Province named Angooran, (Northwest of Iran), in the west in the capital, Tehran, is rich in lead mines, and because of low knowledge about the effects of living around lead mines on health, especially in children, this study was carried out to assess the effect of environmental exposure due to living around these mines on growth and blood lead level in children, in both sexes.

MATERIAL AND METHODS

In this historical cohort study, after exact study of two areas of study and control, two groups of 7-11 yr-old children were selected as the samples. The study group included children, living in an area having lead mines (some rural areas in Angooran township, Zanjan province, Iran, at 47.5 degrees longitude and 36.5 degrees latitude). The control group was selected from an area with a very similar situation to the study area, in all aspects of habits, culture, food, the level of poverty, ethnicity and so on, and about 95-100 km far from the study area (space distance), but without lead mines (some rural areas in Ijrood township, in the same province, at 48.5 degrees longitude and 36.5 degrees latitude. In addition, the rural areas of the control region were not on the way of streams, passing the area having lead mines or lead smelting industries. All the selected children in two groups had been living continuously in the related area.

The number of samples, 36 for each area was calculated considering: α=0.05, β=20% d=10 and σ=15. The process of sample selection was completely random, including both sexes and different age groups. After talking to the children's parents and obtaining their satisfaction for participation of their children in the study and blood sampling, a questionnaire that included demographic data and characteristics of the children was completed for each one of participants.

Measurement of weight (Wt) was performed barefoot and with the least clothing and by means of standardized Seca scales in Kg, and height (Ht) by means of a wall mounted " height measuring tape", in cm, as the child stood barefoot and completely upright, heels, back and head touching the wall, and a straight plate on the head.

Because of different range of age among the children in both the areas, the quantities of Wt and Ht were not at equal value and comparable, therefore, we changed these quantities to the ratio of Wt or Ht to standard Wt or Ht for age, whereas the nominator of these fractions were calculated based on formulae as below:

Standard Wt (Kg) for age $_{7\text{-}12\text{yr-old}}$ =age (yr).7 -5 / 2

Standard Ht (Cm) for age$_{2\text{-}12\text{yr-old}}$ = age (yr).6 + 77. [7]

Five ml required venous blood, taken with disposable syringes, was promptly transmitted to a lidded glass centrifuge tube with 15 ml capacity. Before clotting, the reagent of APCD (3-5% solution of ammonium pyrrolidine ditio-carbamate, which binds to lead in blood and facilitates its separation at next stage) was added in equal volume to the blood and the mixture was shaken for two minutes. Thereafter, 5 ml of another substance, named solution B (Normal solution of butyl acetate), was added to the tube and all the mixture was shaken. This solution helps to bring out the lead from the previous combination. Finally, the tube was centrifuged in high speed for 10 minutes, to separate two distinct layers.

Upper clear layer in the tube was transmitted to a special lidded container, containing some amount of solution B and the whole mixture was transmitted under the appropriate condition to the laboratory. All the samples were measured simultaneously by one experienced expert, blindly in the chemistry laboratory of Iran Atomic Energy Organization in Tehran and by means of atomic absorption spectrometry, model A5 equipped with graphite crematory, calibrated based on Merck standards, made by Varian Company in USA.

The last assessed variable was relationship between children's BLL and their paternal occupational contact to lead. Working in lead mine or related industrial units were considered as occupations in contact to lead. The results were statistically analyzed, using the Statistical Package for Social Sciences (SPSS). The variety of statistical analyses included frequency distributions, t test, for comparison of means, and chi-square test of proportions. $P<0.05$ was considered significant.

RESULTS

Out of 81 children studied, 45 were from study area (23 female and 22 male) and 36 from control area (16 female and 20 male). The mean Blood Lead Level (BLL) of children living in study area (n=45), was 36.97 ± 24.67 (µg / dL; mean±SD) with median of 35, whereas, the mean in children of control area (n=36) was 15.57±13.35 (µg / dL; mean±SD) with median of 10 (P=0.0005).

Because of wide variation of BLL between two groups, comparison was performed through "Mann-Withney U test", by which, once again, the same previous result (P=0.0005) was obtained. The comparison of BLL in the children of two areas, regarding sex, is shown in Table 1.

Table 1. Comparison of Mean BLL in Two Studies and Control Areas in two Sexes, Separately

Group	Girls			Boys		
	Number	Mean	SD	Number	Mean	SD
Control	16	13.96	11.58	20	16.85	14.78
Study	23	39.89	27.46	22	33.90	21.59
P value		0.0001			0.005	

Comparison of children in two areas based on being normal or abnormal in BLL (BLL<10µg / dL: Normal and BLL of 10 µg / dL or more: abnormal, according to CDC classification[6]), showed abnormal quantities of BLL as 91.1% and 58.3% in children of study and control areas, respectively (Table 2), with significant difference (P=0.001) and RR=1.56 (95% CI =1.17, 2.09) and AR=0.359. In addition, no correlations between BLL in children and their father's job (regarding being in contact to lead or not) were found in both groups (Table 3).

Table 2. Comparison of Children of Study and Control Areas Based on Being Normal or Abnormal in BLL (BLL<!0µg/ dL : Normal and BLL of 10 µg/dL or more: Abnormal, According to CDC Classification)

Abnormal	Normal	Total	P value	
Control group	21 (58.3)	15 (41.7)	36 (100)	
Study group	41 (91.1)	4 (8.9)	45 (100)	0.001
Total	62 (76.5)	19 (23.5)	81 (100)	

Comparing two other important variables, *i.e.* the situations of weight (as the ratio of weight to standard weight for age) and height (as the ratio of height to standard height for age), between two groups, showed no significant differences (Tables 4 and 5).

Table 4. Comparison of the Ratio of Weight (W) to Standard Weight for Age (SW for age) in two Study and Control Areas

	Number	W / SW for age	SD	P-value
Control	36	0.94	0.16	0.8
Study	45	0.93	0.18	

Table 5. Comparison of the Ratio of Height (H) to Standard Height for Age (SH for age) in two Study and Control Areas

	Number	H / SH for age	SD	P-value
Control	36	1.018	0.052	0.52
Study	45	1.011	0.050	

DISCUSSION

Regarding the results of this study, there is a significant difference between blood level of lead in children living in lead mining area, and the children of control area (P=0.0005) without any relationship to children's paternal occupation, whether in contact to lead or not. On the other hand, living in lead mining area, as this study showed, did not have any effect on weight or height of the children.

As the results show, relative risk is 1.56 that indicates living in mining area increases BLL in children. On the other hand, although mean BLL in children of control area was less than study group, this was greater than acceptable level. A number of similar studies were found in which some showed similar findings as ours.

Margueytio *et al.* studied 6-92 mth-old children in Missouri (USA) and compared BLL in 226 and 69 children of study (lead mining area) and control groups, respectively. In the study group: mean BLL=6.52±3.92 and 17% of children had BLL, greater than normal (>10 µg / dL). On the other hand in control group, mean BLL=3.43±1.98, with only 3% having abnormal BLL, showing significant difference (P=0.000). The other finding of their study was the lead level of soil and dust in study area, up to 10 times more than control area, which they postulated this as an important reason of increased BLL in children of that area.[8]

The same researcher in another study on 6-71 mth-old children, living in lead-mining and control areas, whose

Table 3. Comparison of Mean BLL in Children of Each Area with Their Paternal Occupational Contact to Lead

	No paternal occupational relationship to lead			with paternal occupational relationship to lead			P value
	No.	Mean BLL	SD	No.	Mean BLL	SD	
Control	3	12.83	7.18	33	15.82	13.82	0.7
Study	26	39.98	28.27	19	32.84	18.61	0.34

BLLs and the lead levels of soil and dust in their homes were compared. They found that, homes in the lead mining area had significantly increased soil and dust lead levels and children of that area had significantly higher BLLs, and the primary source of dust lead was soil lead. They found a strong relationship between BLLs and dust and soil lead.[9]

In another study Kafourou *et al.* in Greece, 522 children of 6-9 yr old, from two lead mining and industrial cities (as study groups) and another city (as control) were compared for BLL and height. Mean BLLs in two study groups were 19.0±7.9 and 7.4±3.1, and in control group was 5.5±3.3. In addition, they found an inverse association between BLL in height in children (P=0.02)[10].

Although the results of all three above-mentioned studies are relatively similar to ours, our results show mean BLLs, higher than normal in both areas and on the other hand the difference is so much higher in the case group than in control one. The results of researches on relationship between BLL and growth parameters in children were found to be varied.

Schwartz *et al.* in USA, through NHANES II (The second National Health and Nutritional Examination Survey), studied 2695 children aged between 6 mth and 7 yr for BLL and growth parameters. In individuals with BLL of 4-35 μg / dL, they did not find any relationship or threshold between height and BLL (P<0.001), but there was an inverse relationship between weight and BLL (P=0.001).[11]

Study of Ballew *et al.* in USA through NHANES III, on 4391 children aged 1-7 yr showed their mean BLL 3.7μg / dL±0.17. They found an inverse association between BLL and height (P<0.001), but not any relationship between BLL and weight (P>0.05).[12]

Vivoli *et al.* in Italy studied 11-13 yr-old children for BLL and height. Out of 418 cases, the mean BLL in boys and girls was 8.5 and 7.0 μg / dL, respectively, with an inversely relationship between BLL and height in individuals with BLL of 10.8 μg / dL or greater (P=0.03).[13] Selevan *et al.* studied 2186 girls aged 8-18 years of different ethnicities, living in USA for BLL and height. Although the mean BLL in their cases was low (BLL<3 μg / dL), they found an inverse association between BLL and height in individuals with BLL>3μg / dL compared to those with BLL<1μg / dL (P<0.001). They did not find any relationship between BLL and weight.[14]

In a longitudinal study in Boston-USA Rokho kim *et al.* surveyed relationship between chronic exposure to lead and physical growth. Firstly during 1975-78, they measured lead level in teeth and tibia bones, weight and height of 270 children, and once again during 1989-90 the same assessments were performed on 79 children of the same group. They found out a relationship between bone and teeth lead levels, and BMI (body mass index: W / H^2) which was mostly due to higher weight, and they postulated that chronic exposure to lead can lead to obesity in children.[15]

The most important limitation in our study was a high BLL of children in control group compared to normal range. In this study, we did not find any significant difference in growth parameters of both groups, that may be result of a high BLL in the control group. Therefore, further research is needed to investigate possible sources of contamination in the control area which was far from mining area.

CONCLUSION

In conclusion, regarding the results of this study, environmental exposure due to living in lead mining area can lead to increased BLL in children, without any significant effect on their growth parameters or any relationship between BLL in children and their parents' occupation.

In this study, we did not assess the correlation between BLL and clinical or para-clinical changes, or the level of lead in different probable sources such as water, soil, atmosphere; food plants of the area, etc., all of which can be important objectives for the future researches.

Furthermore, since some clinical and sub clinical problems, and also some para-clinical changes are strongly probable when BLL is increased, special attention of responsible organizations, and more researches about the problem and its outcome, are recommended.

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REFERENCES

1. Markowitz M. Lead poisoning. In Behrman RE, Kleigman RM, Jenson HB, eds. *Nelson textbook of pediatrics.* 17th ed. Philadelphia: WB Saunders; 2004: 2358-2362.
2. Ahmadizadeh M. Industrial toxicology "Heavy Metals" [Persian]. 1st ed. Tehran: Hezaran; 1997.22,43,90-95.
3. Howard A, Schonfeld PJ, Schonfeld DJ. Lead; In Rudolph CD, Rudolph AM eds. Rudolph's pediatrics. 21st ed.,New York: McGraw-Hill; 2003: 368-371.
4. Henretig FM. Lead. In Goldfrank, Flomenbaum, Lewin, Howland, Hoffman, Nelson, ed. *Goldfrank's Toxicologic Emergencies.* 7th ed. New York: McGraw-Hill; 2002: 1200-1227.
5. Osweiler GD. *Toxicology: Metals and minerals.* 1st ed. Philadelphia: Williams and Wilkins; 1996: 196-197.

6. Centers for Disease Control: Preventing lead poisoning in young children. A statement by the Centers for Disease Control. *Atlanta: Centers for Disease Control, October,* 1991.
7. Needleman RD. Growth and development. In Behrman RE, Kleigman RM, Jenson HB, eds. *Nelson textbook of Pediatrics.* 17thed. Philadelphia: WB Saunders; 2004: 31.
8. Margueytio AM, Evans GR, Sterling DA, Clardy SA, Shadel BN, Clements BW. Relationship between lead mining and blood lead levels in children. *Arch of Environ Health* 1998; 53 : 414-423.
9. Margueytio AM, Evans GR, Roberts D. Relationship between soil and dust lead in a lead mining area and blood lead levels. *J Expos Analy Environ Epidem* 1998; 8 : 359-373.
10. Kafourou A, Touloumi G, Makropoulos V, Loutradi A, Papanagiotou A, Hatzakis A. Effect of lead on the somatic growth of the children. *Arch Environ Health* 1997; 52 : 377-383.
11. Schwartz J, Angle C, Pitcher H. Relationship between childhood blood lead level and stature. *Pediatrics* 1986; 77 : 281-288.
12. Ballew C, Khan LK, Kaufmann R, Mokdad A, Miller DT, Gunter EW. Blood lead concentration and children's anthropometric dimensions in the third National Health and Nutrition Examination Survey (NHANES III), 1988-94. *J Pediatr* 1999; 134 : 623-630.
13. Vivoli G, Fantuzzi G, Bergomi M, Tonelli E, Gatto MR, Zannetti F *et al.* Relationship between low lead exposure and somatic growth in adolescents. *J Expos Analy Environ Epidem* 1993; 3(supp 1) : 201-209.
14. Selevan SG, Rice DC, Hogan KA, Euling SY, Pfahles-Hutchens A, Bethel J. Blood lead concentration and delayed puberty in girls. *NEJM* 2003; 348 : 1527-1536.
15. Kim R, HU H, Rotnitzky A, Bellinger D, Needleman H. A longitudinal study of chronic lead exposure and physical growth in Boston. *Environ Health Perspect* 1995; 103 : 952-957.