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INCREASED LEAD ABSORPTION IN CHILDREN IN THE VICINITY OF A LEAD SMELTING PLANT

D. PRPIĆ-MAJIĆ, J. PONGRAČIĆ, A. KERŠANC, S. TELIŠMAN and V. KARAČIĆ

Institute for Medical Research and Occupational Health, Zagreb, Yugoslavia

ABSTRACT

The intensity of lead absorption in 60 children (32 boys and 28 girls) living in several settlements in a river valley close to a lead smeltery was examined by means of the characteristic indicators showing lead effect on the haemoglobin synthesis. In comparison with the values of the control group, in most children the activity of δ-aminolevulinic acid dehydratase was decreased, the concentration of erythrocyte protoporphyrin and lead in blood was increased, while the concentration of haemoglobin and urinary δ-aminolevulinic acid and coproporphyrin were within a normal range. The difference between preschool (11 months to 4 years) and school (5 to 16 years) children was not significant. The children whose fathers were occupationally exposed to lead had a slight additional lead exposure, which was probably due to industrial dust brought home by the fathers in their clothes and hair.

In the vicinity of a lead smelting plant the environment is polluted by lead and the population living in such an area is subjected to a higher lead exposure than under normal conditions. Increased lead absorption by children living near a lead smelting plant has been documented in several papers[10,11,13,14,16,19].

Children are more susceptible to lead than adults. The intensity of lead absorption in children cannot be predicted on the basis of information in adults. Children absorb much more dietary lead than adults, an approximate relationship being 50 per cent in children[1,20] and 10 per cent in adults[9]. Comparative data on airborne lead absorption in children and adults are not available.

The haematopoietic system is currently considered to be the site where the first measurable adverse effect ("critical effect") occurs[4,12,21]. The quantitative determinations of characteristic indicators showing lead effect on the haemoglobin synthesis are the most common parameters in the assessment of elevated lead exposure. On this basis, using objective biochemical indicators we determined the intensity of lead absorption in children living near a lead smelting plant. Furthermore, we attempted to find out the role, if any, of supplemental lead absorption in children whose fathers are highly occupationally exposed to lead.

SUBJECTS AND METHODS

Altogether 60 children (32 boys and 28 girls) living in several settlements (A, B_1, B_2, C_1, C_2, C_3 and D) in a river valley close to a lead smeltery were examined (Figure 1). The valley is approximately 500 m above sea level. Winds blow either from the south-west, bringing humid air and rain, or from the north--east, bringing dry, cold air and fair weather. The average concentration of

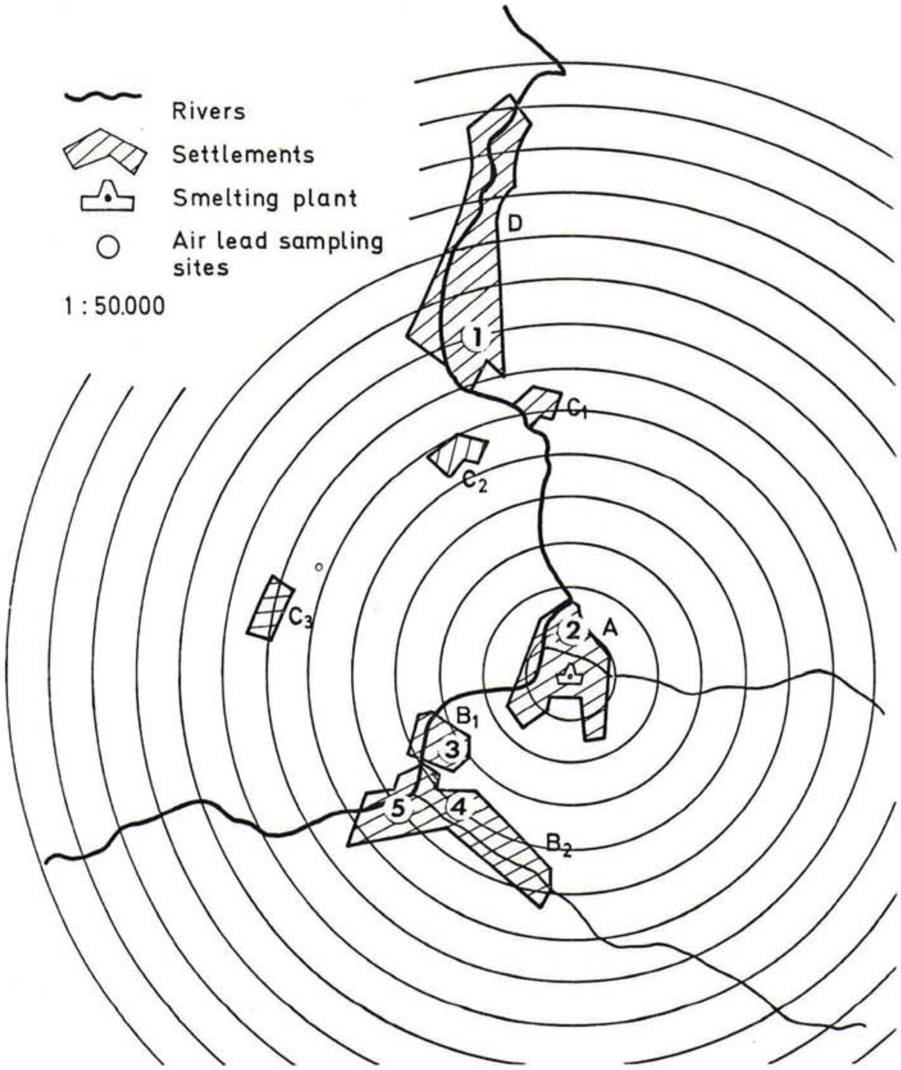

FIG. 1 – Scheme of the lead contaminated area.

airborne lead for three consecutive years was 10 μg/m³ (site 1), 18 μg/m³ (site 2), 22 μg/m³ (site 3), 17 μg/m³ (site 4) and 17 μg/m³ (site 5). The highest average concentration was found at site 3, which was 1.5 km SSW from the smeltery. The concentration at site 1, which was the most distant from the emitting source, was consistently the lowest and differed from that at sites 2, 3, 4 and 5. The differences between sites 2, 3, 4 and 5 were not significant.

Children were divided into two groups, one (N = 20) with fathers occupationally exposed to lead (11 preschool and 9 school children) and the other (N = 40) with fathers without occupational lead exposure (19 preschool and 21 school children). Habitation distribution by distance from the smeltery for both groups is presented in Table 1.

TABLE 1

Habitation distribution by distance from lead smeltery in lead exposed Groups 1 and 2.

Habitation	Distance from lead smeltery (m)	Group 1		Group 2	
		Preschool children	School children	Preschool children	School children
A	150 – 800	2	3	2	2
B_1, B_2	1 900	1	1	4	4
C_1, C_2, C_3	3 000 – 3 400	3	2	3	3
D	4 200 – 6 500	5	3	10	12

In each subject characteristic biological indicators of elevated lead exposure were measured. Haemoglobin (Hb) was determined spectrophotometrically by the cyanmethaemoglobin method[8]. The concentration of erythrocyte protoporhyrin (EP) was determined according to the method of Rimington as modified by Cripps and Peters[5]. The activity of δ-aminolevulinic acid dehydratase (ALAD) was determined according to the modified method of Bonsignore and co--workers[3]. A modification of the original method was applied in the lower pH value of δ-aminolevulinic substrate (pH = 6.8) with a sodium phosphate buffer instead of a carbonate buffer and in the volume of reagents which was increased to twice the original volume. Lead in blood (Pb-B) was analysed by flameless atomic absorption spectrophotometry with Perkin-Elmer HGA-72. The original method[7] was slightly modified[15] with regard to the volume of injected sample and the temperature programme. The concentration of δ-aminolevulinic acid (ALA) in urine was determined by the Davis-Andelman[6] modification of the Mauzeral-Granick method. Urinary coproporphyrin (CP) concentration was measured fluorometrically by the method of Schwartz and co-workers[18].

The results obtained were statistically evaluated and compared with the results of the control group, which was matched to the exposed groups with regard to the socio-economic status and nutritional conditions.

In fourteen homes household dust was analysed for lead content by means of atomic absorption spectrophotometry.

RESULTS AND DISCUSSION

The results obtained are summarised in subgroups of preschool and school children and presented separately as arithmetic means (X) with standard errors (SEX) for each group in Table 2. In both groups in comparison with the values of the control group the activity of ALAD was decreased, the concentrations of EP and Pb-B were increased, while Hb, ALA and CP were within the normal range. The difference between preschool and school children was not significant. According to biochemical findings both groups of children could be classified in a category of "slightly elevated" exposure.

TABLE 2

Statistical parameters of biological data in children of Group 1 (father occupationally exposed to lead) and Group 2 (father not occupationally exposed to lead).

Group	Subgroup	Statistical parameter	Blood				Urine	
			Hb (g/100 ml)	EP (μg/100ml E)	ALAD (units/ml E)	Pb (μg/100 ml)	ALA (mg/100 ml)	CP (μg/100 ml)
1	Preschool children	N	11	11	11	11	9	6
		$\overline{X}$	14.0	144.3	49.1	53.2	0.4	7.9
		$SE\overline{X}$	0.33	21.89	5.34	6.22	0.07	1.01
	School children	N	8	8	8	8	9	9
		$\overline{X}$	14.2	142.2	41.8	61.5	0.5	10.2
		$SE\overline{X}$	0.42	39.36	5.52	14.11	0.09	1.92
2	Preschool children	N	19	18	19	19	14	5
		$\overline{X}$	13.4	139.0	71.6	45.2	0.3	9.7
		$SE\overline{X}$	0.29	26.61	7.05	2.85	0.04	1.47
	School children	N	21	21	21	21	21	21
		$\overline{X}$	14.7	140.0	64.2	50.4	0.5	8.5
		$SE\overline{X}$	0.19	23.17	6.79	3.47	0.06	1.03
1–2	Preschool	t	1.232	0.155	2.549	1.173	1.382	0.997
		P	>0.10	>0.50	<0.05	>0.10	>0.10	>0.10
	School	t	1.084	0.050	2.551	0.765	0.349	0.789
		P	>0.10	>0.50	<0.02	>0.10	>0.50	>0.10

Comparison of the results in groups 1 and 2 shows a statistically significant difference in ALAD activity only for the two subgroups (Table 2). The children whose fathers were occupationally exposed to lead had a significantly lower ALAD activity than the children whose fathers were not occupationally exposed to lead. This is objective evidence that the children in Group 1 had a slight supplemental lead absorption in relation to the children in Group 2.

The average concentration of lead in household dust in Group 1 was higher than in Group 2 (Table 3) although this difference was not significant. A comparison between the lead content of household dust and biochemical indicators in children living in the same houses showed a significant negative correlation for ALAD (log) ($r = -0.438$; $P < 0.05$), a significant positive

TABLE 3
Statistical parameters of lead content in household dust (μg/g) in lead smeltery area.

Statistical parameter	Pb μg/g	
	Group 1	Group 2
$\overline{X}$	3 743.8	2 914.3
SE$\overline{X}$	728.62	1 000.10
N	7	7

correlation for EP (log) (r = 0.623; P < 0.01) and a fair but not significant correlation for Pb-B (r = 0.395; P < 0.10). A good correlation between ALAD and EP with lead in household dust indicates that the elevated lead absorption in children could be associated with lead contaminated household dust. Sayre and co-workers[17] found that if dirt or dust in the child's environment contained a high concentration of lead, more lead was present on the hands or on the objects that were handled and was available for ingestion through normal mouthing activities. It is logical to assume that the fathers engaged in the lead industry may have contaminated the home environment by bringing dust home from the work places in their clothes and hair. Home contamination with industrial dust from lead workers, as the source of greater lead absorption to children, has been described by Baker and co-workers[2] to whom the obtained results can be related.

It is possible that different residential distribution by distance from the lead smeltery in groups 1 and 2 (Table 1) could contribute to the observed difference. The fact that the children's mothers, who lived in the same houses, did not show such a difference, suggests that the habitation distance from the lead smeltery is less important. Therefore, it may be concluded that lead contamination in the home is due to fathers occupationally exposed to lead and that this is the principal source of supplemental lead absorption in their children.

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