Biological monitoring of lead exposure in high risk groups in Berat, Albania

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Abstract

Study objective—To determine blood lead concentrations in children living in an area with a battery plant in Berat, Albania. Another aim was to determine blood lead concentrations in mothers and cord blood levels in neonates from Berat and compare them with values found in Tirana.

Design—Cross sectional survey with a 10% random sample of children, and a 10% sample of mothers and newborn.

Setting—Hospitals, schools, and kindergartens in Berat and Tirana, Albania

Participants—129 preschool children, 373 school children, 151 mothers and their newborn.

Main results—The mean observed blood lead concentrations in 84 preschool children living less than 2 km from the battery plant was 43.4 µg/dl (SD 23.0) and significantly higher than in 45 preschool children (mean 15.0 µg/dl, SD 3.5) living more than 2 km from the plant. Mean lead concentrations in 145 school children living close to the plant were 26.6 µg/dl (SD 14.4) compared with 16.0 µg/dl in 228 school children living at a greater distance. In 67% of the preschool children and 41% of the school children lead levels exceeded the WHO borderline level of 20 µg/dl, and 98% of preschool children, and 82% of school children had values greater than 10 µg/dl. Mean lead concentrations in cord blood of 151 newborn was 8.9 µg/dl (median 8.8, range 4.9–20.0 µg/dl), and

10.6 µg/dl in blood of their mothers (median 10.0, range 5.0–25.4 µg/dl). Mean lead concentrations in Tirana were 8.9 (newborn), and 7.0 µg/dl (mothers).

Conclusions—Blood lead concentrations in children from Berat are comparatively high and abatement measures are needed.

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Table 1 Distributions of blood lead concentrations (µg/dl) in children living in the vicinity of a battery plant in Berat, Albania, 1988–1993

Group	Distance*	Number	Lead concentrations			% above†	
			mean	SD	median	10	20
preschool children	<2 km	84	43.4	23.0	35.0	100	98
	>2 km	45	15.0	3.5	15.0	96	11
school children	<2 km	145	26.6	14.4	24.6	98	58
	>2 km	228	16.0	9.5	13.5	73	29
all	<2 km	229	32.7	19.0	29.1	99	73
	>2 km	272	15.8	8.8	13.5	76	26
total		502	23.5	17.0	17.9	86	48

*Distance of residence from the battery plant. †Percentage of children with lead concentrations above the WHO recommendations.

Table 2 Distribution of blood and cord blood lead concentrations (µg/dl) in mothers and their newborn in Berat and Tirana, Albania, 1988–1992

Group	City	Number	Lead concentration			% above	
			mean	SD	median	10	20
mothers	Berat	151	10.6	3.4	10.0	48	2
mothers	Tirana	155	7.0	4.4	5.8	19	2
newborns	Berat	151	8.9	2.6	8.8	17	1
newborns	Tirana	155	5.2	3.6	4.5	9	0

Lead is an environmental contaminant that is ubiquitously found and as such is of worldwide public health concern.^{1,2} The adverse chronic health effects of low doses of lead include disruptions of haematological and both peripheral and central neurological functions. For several reasons, children and particularly preschool children represent the population at highest risk.^{3–9} Results of surveys on biological monitoring of blood concentrations in children in various countries have been published.^{10–14} Additionally, relevant investigations in children living around point sources have been carried out.^{15–18} Fetuses constitute another high risk group for lead exposure and intoxications, and have been often studied.^{9,19–23}

Little is known about lead exposure and its associated health risks in Albania. This is of particular concern in areas adjacent to known point sources of lead emissions. Therefore, a study was conducted of blood lead concentrations in children, neonates, and their mothers living around a battery plant in Berat, Albania.

Methods

The city of Berat is situated in central Albania and has a population of 43 000 inhabitants. It is located about 90 km south of Albania's capital, Tirana, and comprises residential as well as industrial areas. The major environmental source of lead is a battery plant in the south eastern part of the city. The residential areas are situated around the perimeter of the industrial zone. Prevailing wind direction is from the south east. The plant consists of four buildings that have been in operation since 1985.

This survey was conducted from 1988 to 1993. A total of 129 preschool children aged 2 to 5 years, and 374 school children aged 6 to 15 years were examined. The group of children comprised a 10% random sample of all children enrolled in the schools and kindergartens of Berat. Children whose fathers or mothers, or both, worked in the factory were excluded from the study. Additionally, 151 newborns and their mothers were included. Pregnant women were identified from Berat Obstetric Hospital, which is located about 1.5 km west of the battery plant. Each year all

Figure 1 Distribution of blood lead concentrations (µg/dl) in 129 preschool children living in the vicinity of a battery plant in Berat, Albania 1988–1993.

Figure 2 Distribution of blood lead concentrations (µg/dl) in 373 school children in Berat, Albania 1988–1993.

babies (and their mothers) delivered during one specific month at the hospital between 1988 and 1992 were included. A control group comprised 155 mothers and their newborn from Tirana.

Whole blood samples were taken from mothers by venipuncture and umbilical cord blood from the newborn; for both heparinised Vacutainer tubes were used. Blood samples from children were collected by the finger prick method using Eppendorf tubes. Samples were stored at -20°C , and lead measurements carried out within one week. Lead concentrations were determined by electrothermal atomic absorption spectrophotometry at 283.3 nm using the Pye Unicam instrument, model SP 6. Dilutions of lead were used as reference standard (Merck, Darmstadt, Germany). Double measurements of 50 samples were carried

KEY POINTS

- Children living within 2 km of a lead emitter (Berat, Albania) had higher blood lead concentrations than those living further away.
- Preschool children were found to constitute the group at special risk from lead exposure.
- Maternal blood lead and cord blood lead in newborns were significantly related.
- Cord blood lead concentrations were on average higher in newborn from Berat than in those from a control area (Tirana).

out by the Trace Laboratory, Bristol, UK. The coefficient of variation was 3.1%.

Mean lead concentrations between groups were compared using *F* tests. Data were analysed with the Statistical Analysis System, version 6.05, SAS, Cary, NC.

Results

Tables 1 and 2 and figures 1 and 2 show the lead concentrations in the subgroups investigated. The mean blood concentrations were lowest in the newborns, followed by their mothers. School aged children had higher mean and median values, and highest values were obtained from the group of preschool children. There was no significant difference between lead concentrations of boys and girls, nor was there any significant difference in lead concentrations obtained during the different years. Blood lead concentrations were significantly higher in children residing in close vicinity (<2 km) of the battery plant than in those residing at greater distance (>2 km).

Mothers had lead concentrations approximately 20% higher than newborns (table 1). The relation between maternal (PbB) and newborn (PbC) lead concentrations is highly significant, and the correlation coefficient is characterised by the following equation: $\text{PbC} = 3.280 + 0.538 \text{ PbB}$ ($r=0.54$, $p < 0.001$). Women residing in Berat had about 50% higher concentrations than women living in Tirana (10.6 v 7.0 µg/dl; $p < 0.0001$). Cord blood lead concentrations in neonates from Berat were also significantly higher than those from newborn in Tirana (PbC 8.9 v 5.2 µg/dl; $p < 0.0001$).

Discussion

Numerous questions have been raised in recent years as to the extent of environmental pollution in Eastern European countries. In this study an evaluation was conducted of lead concentration in adult women, neonates, and children in a small Albanian community with a single point source emitter of lead.

The baseline value of blood lead concentration has been reported as being between 4 and 6 µg/dl,² and the WHO recommended that 98% of a population should have values below 20 µg/dl and 50% below 10 µg/dl. According to the US Centers for Disease Control corrective action should be taken if the mean of the blood

lead concentrations in children in a community exceeds 10 µg/dl.²⁴ Approximately 48% of the children in Berat had values above 20 µg/dl and 86% above 10 µg/dl. Therefore, the blood lead concentrations in children from Berat are not low. However, recent reports from other East European countries found concentrations in the same range. Verberk, for example, reported a mean of 44 µg/dl in preschool children residing less than 1.5 km from a smelter in Baia Mare, Romania, compared with mean blood lead concentrations of 16 µg/dl in other children.¹⁶ Bernard reported mean concentrations between 9 and 15 µg/dl in children (aged 12–15 years) living in the vicinity of a Czech smelter compared with 8.5 µg/dl in children residing in Prague.¹⁷ Carvalho determined that the mean level among children aged 2–9 years, who lived less than 900 m from a smelter in Brasilia, was 58 µg/dl.¹⁸

The cord blood lead concentrations are also higher than those reported from other countries, where mean concentrations between 1 and 6 µg/dl have been found.^{19–21, 23} However our PbC concentration are lower than those reported from Lucknow, India, where mean concentrations of 16.5 µg/dl in neonates and 21.0 µg/dl in their mothers were found.²² Cord blood lead concentrations above 10 µg/dl in neonates are cited as the level of exposure at which a child's risk of adverse outcomes begins to rise.^{5, 7, 9} Fortunately, only 1% of the newborn had lead concentrations above this value.

As a result of this study families of the children were advised on appropriate hygienic and sanitary measures to reduce lead exposure such as hand cleaning and cleaning of houses. Also avoidance of consumption of crops from the area was recommended to the public.

In conclusion, the study confirmed differences in lead exposure in the various subgroups residing near or attending schools around a point source, or both. Children were more affected than adults, particularly in the age group 2–5 years; ingestion of dust from playgrounds may be suggested as a source for the increased intake. Recent evidence has linked lead concentration in children above 10 µg/dl to deficits in neuropsychological developments.^{5, 7, 9} Our findings that 17% of newborns and 98% of preschool children had lead concentrations above 10 µg/dl show that further follow up and preventive measures are needed in Berat city.

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