Biological Monitoring of Child Lead Exposure in the Czech Republic

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The area around the Pribram lead smelter has been recognized to be heavily contaminated by lead (Pb). In the early 1970s, several episodes of livestock lead intoxication were reported in this area; thereafter, several epidemiological and ecological studies focused on exposure of children. In contrast to earlier studies, the recent investigation (1992–1994) revealed significantly lower exposure to lead. From 1986–1990, recorded average blood lead levels were about 37.2 µg lead (Pb)/100 ml in an elementary school population living in a neighborhood close to the smelter (within 3 km of the plant). The present study, however, has found mean blood lead levels of 11.35 µg/100 ml (95% CI = 9.32; 13.82) among a comparable group of children. In addition to blood lead, tooth lead was used to assess exposure among children. Statistically significant differences (p <0.05) were observed between the geometric mean tooth lead level of 6.44 µg Pb/g (n = 13; 95% CI = 3.95; 10.50) in the most contaminated zone and 1.43 µg Pb/g (n = 35; 95% CI = 1.11; 1.84) in zones farther away from the point source. Both biomarkers, blood and tooth lead levels, reflect a similar pattern of lead exposure in children. This study has attempted a quantitative assessment of risk factors associated with elevated lead exposure in the Czech Republic. Content of lead in soil, residential distance from the smelter, consumption of locally grown vegetables or fruits, drinking water from local wells, the mother's educational level, cigarette consumption among family members, and the number of children in the family were factors positively related (p<0.05) to blood lead levels. The resulting blood lead level was found to be inversely proportional to the child's age. *Key words:* blood lead, children, lead, risk factors of exposure, tooth lead. *Environ Health Perspect* 105:406–411 (1997)

Since the late 1960s the area around the lead smelter in Pribram has been recognized to be heavily contaminated by lead. In the early 1970s several episodes of livestock lead intoxication were reported in this area; afterwards, a network of measuring stations was established to monitor the quality of ambient air. In addition, several epidemiological and ecological studies investigated the exposure of children to lead, describing the contamination of environmental components such as soil, air, and food chains in different localities (*1,2*).

In the early 1990s, available data were critically reevaluated based on the current knowledge of lead in the environment and its effect on human health. The reevaluation concluded that children living near the smelter have been at high risk of chronic intoxication by environmental lead. The World Health Organization/European Center for Environment and Health, Bilthoven Division, supported the program to reduce environmental lead exposure in children living in contaminated areas, which was implemented through the national integrated program on environment and health in the Czech Republic (*3*). The following are the principal objectives of the program:

- To define the extent and geographic limits of the area in which the level of environmental contamination caused by the smelter poses the actual human health hazard;
- To evaluate the level of lead exposure in children living in such defined area;
- To evaluate the level of lead exposure in children living in other parts of the Czech Republic not burdened by the smelter;
- To identify risk factors of exposure both in areas burdened by the smelter and in other parts of the Czech Republic; and
- To estimate contribution of identified sources/pathways of exposure with respect to current level of exposure in children.

Because of the enormous scope of collected data, only part of this project—concerning exposure level of children and sources of exposure plus risk factors associated with exposure—are discussed in this paper.

Materials and Methods

Blood Sampling

The blood sampling was organized parallel to the October/November 1992 Czech national serological survey whose purpose was to determine a national vaccination policy. Blood sampling followed the selection criteria of this program. The serological survey required the selection of a random sample of Pribram District inhabitants and the same participation rates from different parts of the district. Participant selection was by personnel responsible for the serological survey; they had no knowledge of the specific hypothesis tested in the lead project nor of the soil contamination pattern, made available after blood samples were taken. The survey covered approximately 108,000 inhabitants of the Pribram District, including those near the smelter. Approximately 1.7% (n = 374) of all children from age 1 to 14 (n = 21,882) were sampled. Among these, 9.6% (n = 36) of these childrens' parents refused to provide additional information about family background. Therefore, these children were excluded from this study, leaving 1.5% (n = 338) of the district children aged 1–14 in this study.

Children considered eligible for the study and for biological monitoring of lead had no known chronic diseases associated with deprived response to vaccination (chronic infectious diseases, hereditary diseases with an immunological component, e.g., disglobulinemia), and no apparent acute hectic diseases. Other eligibility criteria were not applied (*3*).

According to selection criteria of the Czech national serological survey, this group represents the sample of children aged 1–14 (median = 7 years old) living in the Pribram District in 1992, with an approximately equal number of both genders (female 50.9%, male 49.1%). Fifty-eight percent of participants were recruited from urban areas and 42% from rural areas. Study participants from one-child families totaled 16.6%. Children in the study from larger families included two-children families, 60.6%; three-children families, 17.6%; four-children families, 3.8%; and five-children families, 0.9%. The mean per capita income of less than 1,000 Czech crowns per month was reported by 3.6% of families. In 58.2%, per capita income ranged from 1,001 to 2,000 crowns and in 30.6%, from 2,001 to 3,000 crowns. Income of more than 3,000 crowns per capita was reported by 7.6% of families. Sixteen percent of mothers had 8–9 years of

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elementary-school education, whereas 28.1% had apprenticeships. Mothers who completed high school accounted for 41.1%; 8.8% finished college.

All parents of children included in the serological survey provided informed consent to participate in the lead study.

Tooth Sampling

During the period 1993–1994, the deciduous teeth extracted or lost by children in the Pribram District were collected. A large proportion of the teeth were collected in cooperation with the school dental service. Individual dental offices were also selected to cover all district areas. In some cases, parents were asked to supply extracted teeth kept at home. Because of the limited number of children living in the relatively small area near the smelter, this was the only possible way to collect at least some teeth during a short period. As a result of the time shortage and the difficulties connected with collection of a sufficient number of teeth, no other specific selection or eligibility criteria was applied. In this way, 162 deciduous teeth, representing about 1.15% of children of Pribram District aged 6–14 (n = 14,067), were collected and analyzed. Each child contributed only one tooth (*3*).

Exposure Assessment

Blood lead levels. Blood samples (1 ml) were taken via venipuncture by trained nurses, placed into polypropylene micro test tubes (1.5 ml with lid Eppendorf; Koh-I-Noor-Hardmuth Inc., Ceske Budejovice, Czech Republic). Capped tubes that contained 0.025 ml of heparin (Leciva Inc., Prague, Czech Republic) were then gently mixed. These samples were kept in a freezer at -20°C.

All analyses were carried out in the Atomic Absorption Spectrometry (AAS) laboratory of the National Institute of Public Health (NIPH), Prague, which has been involved in an international quality assurance/quality control (QA/QC) system since 1985. The QA/QC system operates within the framework of the U.K. National External Quality Assurance Scheme (UK NEQAS) and uses the criteria of the Wolfson Research Laboratory in Birmingham.

A Varian SpectrAA-30 atomic absorption spectrometer (Varian Australia Ptv Ltd., Victoria, Australia), equipped with a graphite furnace atomizer (GTA-96) and Zeeman background correction system, was used in conjunction with a programmable Varian autosampler and data station (DS-15). All of these accessories are also from Varian.

The hollow cathode lead lamps (no. 56-101029-00) were purchased from Varian Australia Ptv Ltd. The pyrolytically coated plateau graphite tubes and pyrolytic platforms were purchased from SGL Carbon, Ringsdorff-Werke GmbH, Bonn, Germany.

A 1.000-g Pb/l certified reference solution—$Pb(NO_3)_2$ in 0.5 mol/l HNO_3 (Merck KGaA, Darmstadt, Germany) was used to prepare all standards. Fresh working standard used for the analyses (prepared daily) contained 25 ng Pb/ml in 1% HNO_3 (Suprapur Merck). A solution of 2% $NH_4H_2PO_4$ (Suprapur, Merck) was used as a modifier. The samples of blood were diluted with 0.1% Triton X-100 (weight/vol). The water used to prepare all reagents was purified by the Milli-Q Plus system (Millipore, Milford, MA.)

Whole blood was diluted 10-fold by 0.1% Triton and Pb was determined by the standard additions method. Analyses were carried out at wavelength of 283.3 nm, and ash and atomization temperatures were 900 and 2,400°C, respectively.

Tooth lead levels. A Varian SpectrAA-30 atomic absorption spectrometer, equipped with a graphite furnace atomizer (GTA-96) and Zeeman background correction system, was used in conjunction with a programmable Varian autosampler and data station (DS-15).

The hollow cathode lead lamps were purchased from Varian Australia (no. 56-101029-00). The pyrolytically coated plateau graphite tubes and pyrolytic platforms were purchased from SGL Carbon.

A 1.000-g Pb/l certified reference solution—$Pb(NO_3)_2$ in 0.5 mol/l HNO_3 (Merck) was employed to prepare all standards. The working standard used for obtaining a calibration curve contained 20 ng Pb/ml in 1% HNO_3 (Suprapur Merck) and was prepared fresh daily. The HNO_3 used was prepared by dilution of 65% HNO_3 (Suprepur Merck). A solution of 2% $NH_4H_2PO_4$ (Suprapur Merck) was used as modifier. The water used to prepare all reagents was purified by Milli-Q Plus system (Millipore).

Each tooth was washed in 5% H_2O_2 (Chemapol, Prague, Czechoslovakia), dried, weighed, and mineralized with 2 ml HNO_3 (65%; Merck). Lead was then determined by the method of a calibration curve. Analyses were carried out at a wavelength of 283.3 nm, and ash and atomization temperatures were 550 and 2,400°C, respectively.

Risk Factors and Assessment of Confounders

Questioning—blood lead. For each child sampled, a trained nurse used a questionnaire to obtain information on potential risk factors, family characteristics, and other factors. The parents were then interviewed immediately after venipuncture.

The questionnaire used was adopted from earlier studies (*2*) and slightly modified. The questions focused on place and character of residence (length of stay, type of building, type of residence), socioeconomic status and family structure (number of children, number of family members, average per capita income, education of parents, occupation of family members), smoking habits of family members, food habits (including questions dealing with home production of foodstuffs—e.g., fruit, vegetable, domestic animals, eggs), sources of drinking water (local well or water pipeline system), recreational habits (number of days spent away from residence), and risk behavior of children (placing objects or fingers into the mouth, nail biting, soil consumption).

Questioning—tooth lead. A simple questionnaire was used to gather information on child age at the moment of tooth extraction or loss, the reason for extraction, the living status of the tooth, the kind of tooth, and the child's length of residence at current address. However, neither parents nor dentists filled out these questionnaires completely; therefore, only data on age, gender, and place of residence were used for analyses. No other information on potential confounders was available (*3*).

Soil contamination. In the course of this study, soil contamination was recognized to be a crucial source of exposure. In an attempt to broaden the knowledge on lead concentration in soil within the district, two main sources of data were utilized.

First, the study performed by the District Hygienic Station in Pribram [supported by Czech Ministry of Environment Grant no. GA/62/93 (*4*)] focused on detailed mapping of soil contamination. Results revealed that irregularities occur within individual distance zones. These local hot spots do not necessarily originate from the smelter operation; rather, they are the remnants of mining and ore processing conducted in Pribram since the Middle Ages. Figure 1 shows the levels of contamination in the zones of interest. The distant parts of Pribram District where the soil was not analyzed for lead content were considered to be areas with lead levels less than 100 mg/kg.

Second, the conclusion about the magnitude of contamination in the vicinity of the lead smelter has been supported by an independent investigation of the Imperial College of Science, Technology and Medicine, London (*5*).

Air pollution. The content of Pb in the ambient air has been systematically moni-

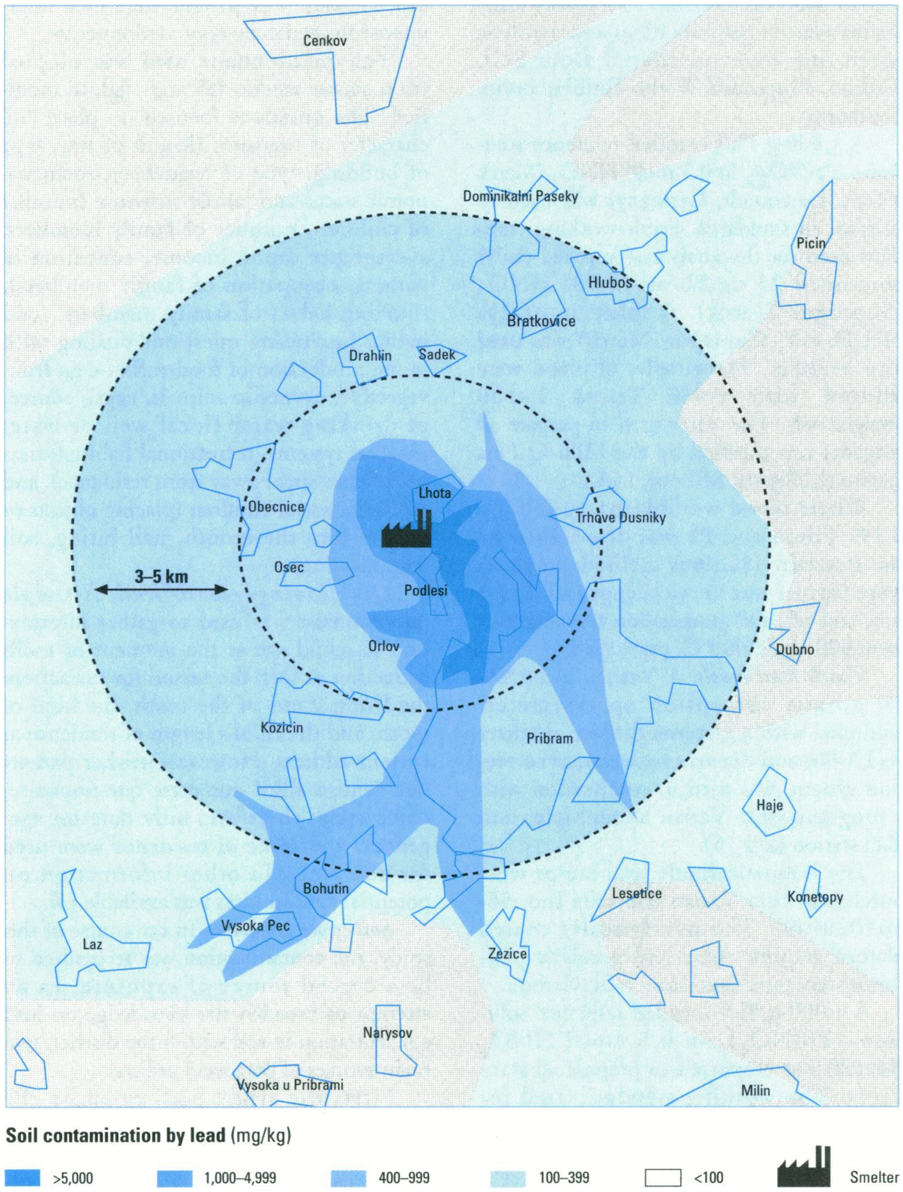

Figure 1. Soil contamination by lead and settlement near the smelter.

tored in the last 20 years. In 1991, sampling was conducted continuously at eight measuring points within 6 km around the smelter for most of the year. Values of 24-hr mean concentrations ranged from 0.2 to 0.3 µg Pb/m^3 within 2.5–3.3 km of the smelter. The 24-hr mean concentration of 1.5 µg Pb/m^3 was recorded in an adjacent village (the measuring point was 0.5 km from the factory chimney). In 1992, the values of 24-hr mean concentrations ranged from 0.14 to 0.72 µg Pb/m^3 within 2.5–3.3 km. [A comparable measurement at points closer to smelter were not available in 1992 (*6*)].

There are no other localities in Pribram District where air quality has been regularly measured. Therefore, the distance from the plant was used as a surrogate measure of air pollution.

Statistical Analysis

Measured blood and tooth lead levels were log-transformed to normalize the right-sided distribution.

Univariate statistics were calculated for all variables of interest. Kruskal-Wallis one-way analysis of variance (ANOVA) and bivariate regression analyses were used to assess the relation of blood and tooth lead levels to individual covariates of interest. Correlations between independent variables were also tested.

For multivariate analyses, measured log-transformed blood and tooth lead concentrations were used as the outcome variables. Multivariate linear regression models were used to assess the outcome variables in terms of the risk factors and confounders. Stepwise procedures, both forward and backward, were included. An alpha of 0.05 was used for both inclusion and exclusion from the model.

All statistical approaches have drawn consistent results; therefore, only the outcomes of the analyses of variance and multivariate analyses are provided. All tests of hypothesis were two-sided. EPI-INFO 5.01b, a word processing, database, and statistics program for public health (Centers for Disease Control and Prevention, Atlanta, GA, World Health Organization, Geneva, Switzerland) or SPSS PC+ (Statistical Program for Social Sciences; SPSS Inc., Chicago, IL) statistical programs were used for all analyses.

Results

Blood Lead

The influences of residence distance from the smelter and level of soil contamination on blood lead level were investigated simultaneously to test the hypothesis that the soil contaminated by different industrial activities, together with atmospheric transport from the smelter, are the major sources of human exposure to lead. A distinct dependence of mean blood lead on distance and a visible relationship between blood lead level and soil contamination in areas more distant from the smelter are considered important. However, observed differences were not statistically significant, probably due to the small number of samples in individual categories. Table 1 exhibits the outcomes of seven different one-way ANOVAs. The differences in mean blood lead levels according to the soil contamination within the specified distance from smelter are displayed in rows. The differences in mean blood lead levels by specified distance from smelter within the level of soil contamination are displayed in columns. Table 1 shows that the mean blood lead in the epicenter of the hot spot reached the level of 15.42 µg Pb/100 ml (n = 6; 95% CI = 7.17; 33.17). In the parts of the Pribram District that are not burdened by this point source of lead, mean blood lead levels were 4.66 µg Pb/100 ml (n = 165; 95% CI = 4.30; 5.04). Due to the distribution of residences and contamination of the environment by lead, four cells in Table 1 represent the exposure levels that cannot occur.

Twenty-seven variables were used for the statistical model describing the correlation between blood lead levels, potential risk factors, and possible confounders.

Table 1. Geometric means of blood lead levels compared with soil contamination by lead and distance from smelter

	Distance from smelter (km)		
	<3	3–5	>5
<100 mg/kg			
n	–	–	165
GM	NA	NA	4.66
95% CLs (µg/dl)			
Lower	–	–	4.30
Upper	–	–	5.04
Statistical test[a]			
ANOVA			
Not available			
K-W			
Not available			
100–399 mg/kg			
n	14	76	2
GM	10.59	5.41	4.85
95% CLs (µg/dl)			
Lower	8.96	4.86	1.68
Upper	12.49	6.01	14.90
Statistical test[a]			
ANOVA			
p-value = 0.000041			
K-W			
p-value = 0.000007			
400–999 mg/kg			
n	3	66	6
GM	8.59	5.50	5.43
95% CLs (µg/dl)			
Lower	7.88	4.75	3.11
Upper	9.36	6.36	9.49
Statistical test[a]			
ANOVA			
p-value = 0.564			
K-W			
p-value = 0.278			
>5,000 mg/kg			
n	6	–	–
GM	15.42	NA	NA
95% CLs (µg/dl)			
Lower	7.17	–	–
Upper	33.1	–	–
Statistical test[a]			
ANOVA			
Not available			
K-W			
Not available			
Statistical test[b]			
ANOVA *p*-value	0.122	0.856	0.778
K-W *p*-value	0.162	0.917	0.894

Abbreviations: *n*, number; GM, geometric mean; CLs, confidence limits; ANOVA, analysis of variance; K-W, Kruskal-Wallis one-way analysis of variance; NA, not available.
[a]For differences within area.
[b]For differences between areas.

Results of these analyses are given in Table 2. The content of lead in soil, distance of residence from the smelter, home production of vegetables or fruit, supply of drinking water from local wells, mother's educational level, family member smoking, and number of children in family were factors positively related ($p<0.05$) to blood lead level. The resulting blood lead level was inversely proportional to the child's age.

Table 2. Outcome of multiple linear regression analyses of risk factors and log-transformed blood lead levels

Dependent variable		Logarithm blood lead concentration (µg/dl)				
Source	*df*	Sum of squares	Mean square	F-statistic	R^2	Overall *p*-value
Regression	10	5.5574	0.5557	13.15	0.309	<0.001
Residuals	294	12.4272	0.0423			
Total	304	17.9847				

Independent variable	Beta coefficient	95% CL Lower	95% CL Upper	SEM	Partial F-test	*p*-value
Pb in soil >5,000 mg/kg	0.3359	0.1178	0.5541	0.1113	9.1086	<0.005
Distance from smelter <3 km	0.2578	0.1466	0.3690	0.0567	20.6323	<0.001
Pb in soil 100–399 mg/kg	0.1186	0.0571	0.1802	0.0314	14.2662	<0.001
Pb in soil 400–999 mg/kg	0.1062	0.0420	0.1704	0.0327	10.5235	<0.005
Home vegetable or fruits	0.0808	0.0287	0.1329	0.0266	9.2272	<0.005
Education of mother	0.0804	0.0326	0.1283	0.0244	10.8581	<0.005
Drinking water from well	0.0795	0.0171	0.1419	0.0318	6.2436	<0.025
Smoking of family members	0.0622	0.0123	0.1121	0.0255	5.9703	<0.025
Number of children in family	0.0375	0.0070	0.0678	0.0155	5.8303	<0.025
Age	-0.0097	-0.0164	-0.0029	0.0035	7.8494	<0.001
Y-intercept			0.4853			

Abbreviations: *df*, degrees of freedom; CL, confidence limit; SEM, standard error of the mean.

Tooth Lead

Table 3 shows the relation of tooth lead to the distance of residence from the smelter and the level of soil contamination. Similar to Table 1, of the 12 possible exposure categories, 4 are not present at all because those combinations of distances, soil contamination, and residences did not exist. The fifth cell (distance >5 km, soil contamination 400–999 mg/kg) is empty because no subject living in such area provided a tooth for study purposes. The next three cells have only 1 or 2 samples. Despite this, the data suggest statistically significant differences in mean tooth lead levels with soil contamination within a less than 3-km area. There also was a statistically significant difference ($p<0.05$) between the mean tooth lead level in the most contaminated zone (6.44 µg Pb/g; n = 13, 95% CI = 3.95; 10.50) and the nonburdened area (contamination of soil <100 mg Pb/kg, distance >5 km 1.45 µg Pb/g; n = 36, 95% CI = 1.14; 1.83).

Despite the obvious limitations of the dental data, attention was paid to developing an appropriate statistical model and investigating the relationship between tooth lead and risk factors under control of possible confounders. Because most of the questionnaires were incomplete, only gender and age of children could be controlled. In this model, residence in the area with heavily contaminated soil (>5000 mg/kg) and residence within 3 km of the smelter were the only factors influencing the content of lead in teeth significantly ($p<0.05$).

Discussion

The blood sampling parallelled a regular serological survey that was independent of the focus of interest—biological monitoring of child lead exposure. This serological survey was successfully carried out in selected districts of the Czech Republic every year for more than 20 years and brought both advantages and pitfalls.

The survey guaranteed the random selection of study subjects with the same participation rates from different parts of the district. From the lead study viewpoint, participant selection was conducted by personnel who were unaware of each child's exposure status. Therefore, we can conclude that the selection of participants was not related to the exposure status.

Applying the eligibility criteria was an unavoidable compromise between the needs of the lead study and those of the serological survey. However, it did not exclude any of the known clinical syndromes caused by chronic lead intoxication. In fact, all children invited for blood sampling who resided within 3 km of the smelter met the eligibility criteria and were included for blood sampling. Furthermore, no child in the survey was refused for a known history of immunological dysfunction. Consequently, the selection of participants was not related to the outcomes of the study.

The questionnaire used in the study was adopted from earlier studies (*5*) and slightly modified; in particular, the portion investigating the smoking habits of parents and other family members was broadened. Because of time constraints, the questionnaire's validity and reliability could not be fully evaluated. In spite of this, the fact that the questions were simple and that the same health personnel (trained nurses) facilitated the completion of nearly all questionnaires, no adverse effects on the internal validity of the study are expected. It may be concluded that most relevant confounders were sufficiently controlled in the blood lead level part of study.

The section dealing with tooth lead suffers from confounding that is virtually impossible to control. The dentists collaborating in tooth collection were not properly encouraged to complete the data necessary for tooth characterization. Furthermore, no information on other known confounders was available. Seeking additional teeth lost by children living in the vicinity of the smelter might have introduced selection bias into this part of study.

Table 3. Geometric means of tooth lead levels compared with soil contamination by lead and distance from smelter

	Distance from smelter (km)		
	<3	3–5	>5
<100 mg/kg			
n	–	–	35
GM	NA	NA	1.44
95% CLs (µg/dl)			
Lower	–	–	1.14
Upper	–	–	1.83
Statistical test[a]			
ANOVA			
Not available			
K-W			
Not available			
100–399 mg/kg			
n	8	68	2
GM	2.30	1.48	1.42
95% CLs (µg/dl)			
Lower	1.84	1.27	0.63
Upper	2.86	1.72	3.18
Statistical test[a]			
ANOVA			
p-value = 0.161			
K-W			
p-value = 0.059			
400–999 mg/kg			
n	2	32	–
GM	2.25	1.42	NA
95% CLs (µg/dl)			
Lower	0.52	0.21	–
Upper	3.32	1.66	–
Statistical test[a]			
ANOVA			
p-value = 0.167			
K-W			
p-value = 0.117			
>5,000 mg/kg			
n	13	–	–
GM	6.44	NA	NA
95% CLs (µg/dl)			
Lower	4.15	–	–
Upper	10.00	–	–
Statistical test[a]			
ANOVA			
Not available			
K-W			
Not available			
Statistical test[b]			
ANOVA *p*-value	0.005	0.746	0.971
K-W *p*-value	0.005	0.767	0.948

Abbreviations: *n*, number; GM, geometric mean; CLs, confidence limits; ANOVA, analysis of variance; K-W, Kruskal-Wallis one-way analysis of variance; NA, not available.
[a]For differences within area.
[b]For differences between areas.

Two biomarkers with completely different characteristics were chosen for biological monitoring of the exposure of children in the Pribram District. In spite of the fact that there is no overlap between these samples (the case when one child provided both tooth and blood never occurred), both sets of data almost identically reflect the exposure levels of the children to lead and its severity. Moreover, the results confirmed the working hypothesis of two existing sources of exposure. In the closest area (less than 3 km from the smelter), the relative contribution of the air emissions from the smelter and the aged soil contamination could not be evaluated because of a strong relationship between soil contamination and the distance from the smelter. However, in the area within 3–5 km and the area more distant from the smelter, the prevailing contribution of soil contamination is evident.

The comparison of blood lead levels presented here with those published earlier (*5*) reveals considerable differences. Specifically, in the vicinity of the smelter (approximately identical with our area of <3 km), the mean value of 37.2 µg Pb /100 ml was reported in the period 1986–1990, more than three times higher than the value presented in this study [mean blood lead level in comparable population 11.35 µg/100 ml (95% CI = 9.32; 13.82) in 1992]. It is not likely that the exposure conditions in the time period 1986–1992 were so different as to explain the discrepancy. Furthermore, with mean blood lead levels so high, at least in some cases, one would also expect clinical signs of chronic lead intoxication. However, no such cases have been reported in the area. Besides the inadequate control of confounding, the earlier studies suffer from a lack of QA/QC systems in the analytical portion. This opinion is supported by parallel analyses performed in Belgium (*2,7*), which gave the mean values 12.1 µg Pb/100 ml, almost identical with levels presented here.

There is voluminous literature concerning lead exposure risk factors, and the risk factors reported in this study are fully in agreement with current knowledge. The overwhelming majority of information has been generated, however, in areas with a different cultural, economical, and political background than that of Central Europe. Therefore, the comparison of the present study with outcomes of epidemiological research conducted within this geographical realm is thought to be most important, and the observed similarities are not surprising. In Upper Silesia, Poland, Zejda (*8*) described a number of factors overlapping the risk factors reported in this study. Prpic-Majic et al. (*9*) drew almost the same conclusion on the significance of soil contamination from past exposure due to a lead smelter in Croatia and its long-term contribution to human exposure after the control of its emissions.

The higher contribution of soil with 100–399 mg/kg of lead to blood lead level than soil with a content of 400–999 mg/kg lead might appear surprising (Table 2). However, this is probably a result of differences in bioavailability of lead. The area itself has a rather complicated geological structure with a local maxima of different chemical species of lead in some spots. Moreover, due to complicated industrial development, lead pollution came from different sources operating at varied times covering a period of hundreds of years. In the Middle Ages and earlier, the major source of lead contamination was silver mining, especially silver refining. In the early Modern Age, there were several local lead smelters in the area and lead mining and processing became the most important industrial activity. After World War II uranium mining and mining of other metals also took place. In addition, lead from leaded gasoline may play a role, particularly in the district town of Pribram. In so complicated a terrain, when different technologies contributed to lead contamination by different lead compounds, the simple measure of lead content in soil does not provide adequate information about the bioavailability of lead, which depends on chemical species of lead, size of lead particles, age of particles in different environments, and many other factors. Therefore, it is possible that in this particular case, the less contaminated soil may contain more bioavailable forms of lead.

Conclusion

In summary, in the center of an environmental hot spot, where mean blood lead levels and tooth lead levels have reached 15.42 µg Pb/100 ml and 6.44 µg Pb/g, respectively, both air pollution and soil contamination have probably contributed to lead exposure. In a more distant area, soil polluted by other industrial activities is the major source of children's exposure. In parts of the district that have not been burdened by point sources, leaded gasoline is likely the major source of lead in the environment and the home production of fruits and vegetables, use of drinking water from local wells, and smoking by family members are other factors associated with elevated blood lead level. Mean blood lead levels of 4.66 µg Pb/100 ml and mean tooth lead levels of 1.43 µg Pb/g have been recorded elsewhere in the Pribram District. About 4.44% of children in this population have blood lead levels of more than 10 µg Pb/100 ml in this area, which is thought to be typical of rural Czech regions with developed agriculture.

The present study became the crucial source of information for developing intervention measures, taking into account conditions in the polluted area. The screening of blood lead focused on the children living in the contaminated part of the Pribram District was introduced in 1994. Its scientific objectives are the more precise demarcation of the area where blood lead screening on regular basis is necessary, the validation of the above-mentioned statistical model describing blood lead levels, and the confirmation of identified exposure risk factors. The main public health goal is evaluating the effectiveness of this intervention in the Czech Republic. The outcomes of this new project should be available in 1998.

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Department of Biology
The Center for Advanced Training in Cell and Molecular Biology

The Center for Advanced Training in Cell and Molecular Biology (CATCMB) will be conducting the following training programs:

May 1997

Basic Cell and Tissue Culture	May 5–9
Combinatorial Libraries	May 5–9
Recombinant DNA Methodology	May 12–16
PCR Techniques	May 17–19
DNA Sequencing	May 20–23
Immunocytochemistry	May 19–23
Site-directed Mutagenesis	May 29–31

June 1997

Plant Biotechnology, Gene Transfer and Expression	June 2–6
Expression of Recombinant DNA in Mammalian Cells	June 9–13
DNA-binding Proteins & Transcriptional Regulators	June 16–20
In situ Hybridization	June 23–27

July 1997

Recombinant DNA Methodology	July 7–11
Non-radioactive Labeling Technology	July 14–16
Capillary Electrophoresis Methods and Applications	July 18–19
Molecular Immunology and Immunochemistry	July 21–25

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