Lead Poisoning Among Children in Katowice, Poland

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Environmental contamination caused by unconstrained industrial activity in Poland is of high concern to physicians and public health officials in Poland. Blood lead levels in children can be seen as a sensitive biological indicator of adverse exposure to the complex environment of Poland, which is characterized by chronic air, water, and soil pollution. A review of the available data suggests that, in certain areas, particularly Upper Silesia, blood lead levels among Polish children are unacceptably high. A project is described that will attempt to assess the prevalence of childhood lead poisoning in Upper Silesia and to provide appropriate intervention as required. It is hoped that this project will serve as a model to use in designing future programs to assess, control, and prevent childhood lead poisoning, as well as other health problems arising from the environmental contamination that many countries in Eastern Europe are experiencing.

[PSRQ 1992:2:77-84]

Lead serves as a good paradigm for assessing the magnitude of Poland's environmental problem while also allowing the adverse consequences on human health associated with environmental exposure to be objectively quantified. In this report, the magnitude of exposure to environmental lead in Poland will first be outlined. Available information on the adverse human health effects of these environmental sources will be reviewed. A brief summary of a visit that representatives of Physicians for Social Responsibility (PSR) made to Poland in November 1991 will be presented. Finally, a plan of action to ameliorate the environmental lead problem in Upper Silesia will be outlined. This program will involve cooperation between members of PSR and members of the Silesian Academy of Medicine.

0051-2438/1992/0202-0077$03 00/0

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ENVIRONMENTAL POLLUTION AND ITS EFFECTS ON HUMAN HEALTH IN UPPER SILESIA

Of all the regions in Poland, Upper Silesia has the most serious public health problem created by prolonged exposure to lead found in the environment. Intense industrial activity (the mining of coal and lead, the burning of coal, and the manufacturing of steel) (Fig 1), which has been this region's major source of employment for several decades, has produced high environmental lead levels throughout Upper Silesia [1]. Upper Silesia occupies 2.1% of Polish territory and is inhabited by 10.5% of the Polish population (total of 38 million people) [1]. The atmospheric emission of pollutants from Upper Silesia (Fig 2) in 1985 illustrates the primary role that Upper Silesia plays in polluting the Polish environment. In that year the pollutants amounted to 453,900,000 kg of dust and 1,450,800,000 kg of gaseous substances, accounting, respectively, for 25.4% and 31.2% of the total emission of dust and gases in Poland [1].

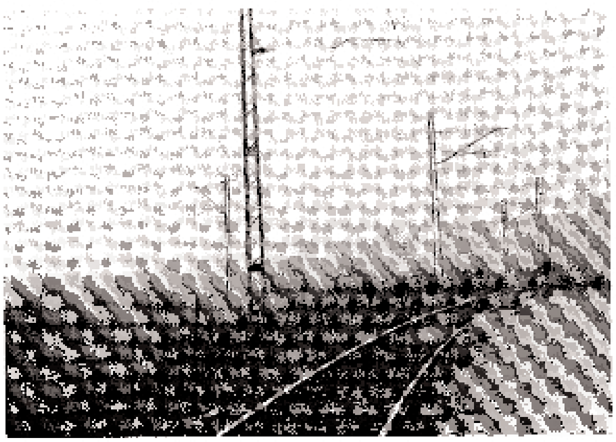

FIGURE 1. This is not a poorly taken photograph, but rather an illustration of the pollution in Katowice, Poland.

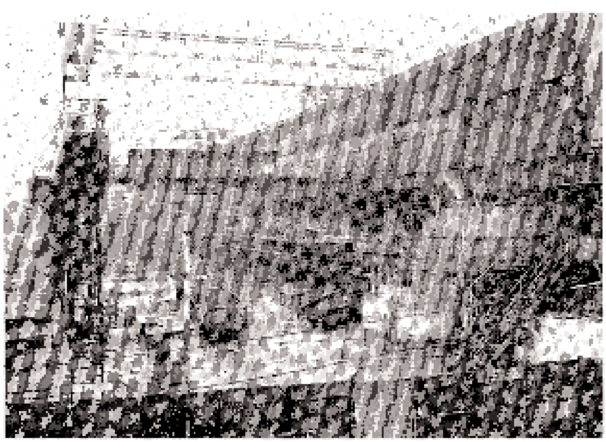

FIGURE 2. Steel works with open furnace in Katowice, Poland. This plant is located in a mixed industrial and residential area.

The impact on the health of the Upper Silesian population of this long-lasting ecologic catastrophe is difficult to assess because of a paucity of population-based data. Several studies of high-risk populations (workers in coal mines, children living near lead smelters, etc.) have demonstrated a high prevalence of occupationally or environmentally induced problems [2]. However, no population-based studies have yet been conducted to assess the adverse health effects that arise simply from living in Upper Silesia. Indirect evidence suggests a deterioration of health owing to environmental causes. For example, the rate of cancer-related deaths in 1985 was 193/100,000 in Upper Silesia and 189/100,000 in Poland [1]. This rate contrasts sharply with the rate in the United States during this same period of 45/100,000 [3]. The percentage of congenital defects as a cause of infant mortality increased from 9.2% to 23.6% between the years 1961 and 1985 [1]. The universal perception of Upper Silesian health professionals is that the available data highly underestimate the magnitude of the problem and that the issue of ecologic disaster in Upper Silesia should be a priority for public health initiatives in Poland (conversation with Professor Andrzej Lange, Institute of Immunology and Experimental Therapy of the Polish Academy of Sciences, Wroclaw, Poland, 1991).

Part of the difficulty in quantifying the adverse effects that derive from Poland's polluted environment is the lack of good "indicator" diseases whose etiology can be exclusively attributed to environmental pollution. For example, childhood asthma may be a sensitive indicator of air pollution [4]. However, with the extremely high prevalence of tobacco smoking in the adult Polish population [1], the incidence of childhood asthma attributable to air pollution is clearly confounded by the passive exposure to tobacco smoke that a child encounters in a poorly ventilated house occupied by smokers.

LEAD POISONING IN POLAND

In Poland lead is now ubiquitous in the environment because of its historically wide range of uses. There are many sources and pathways of exposure: air; soil and dust; tobacco and other manufactured products; automobile emissions; direct and indirect exposure in the workplace (in industries such as primary and secondary lead smelting, iron and steel production, coal combustion, battery manufacture, and radiator repair); waste incineration; some traditional medicines; food and liquid stored in improperly glazed ceramic containers; drinking water passed through soil or pipes containing lead; and food grown in soil contaminated with lead.

Lead is similarly ubiquitous in its effects, many serious and irreversible, on virtually all human biochemical processes and organ systems. Of special concern is its impact on children, whose hematopoietic and nervous systems are particularly sensitive [5]. Among the most deleterious neuropsychological effects on the very young are learning and reading disabilities [6], reduced performance as measured on standard tests of intelligence [7], and childhood behavioral disorders [8], all of which have been recognized at progressively lower levels of exposure; all of these may be related to serious behavioral and other disorders later in life [6].

Because childhood lead poisoning adversely affects so many different biological systems, because there is an extensive science base concerning its effects [6–8], and because there are proved cost-effective interventions for control and remediation [9], lead serves well as a paradigm for scrutinizing the implications of environmental hazards for public policy, technology transfer, human resource development, sectorial needs, and public education in Poland. Furthermore, in Poland the level and variety of pollution from environmental lead are so egregious [1] that even simple interventions will return large benefits to the public health.

Limited data on environmental sources of lead in Poland are available. Studies have demonstrated that a large proportion of the garden plots in Katowice are located adjacent to industrial areas that have been contaminated with lead by both airborne deposition and the practice of liming the soil with inorganic industrial waste [1]. In a study involving an evaluation of the amount of lead in the soil in farm and garden allotments in the most heavily polluted areas of Katowice, Drs. Marchwiniska and Kucharski of the Polish Environmental Pollution Abatement Center found that fewer than 40% of the allotments were suitable for unrestricted cultivation of edible plants because of heavy metal soil contamination. They found that a full 50% of plots should be restricted to the growth of selected edible plants that tend not to concentrate heavy metals. At least 10% of the farms and gardens were found to be fit for cultivation of only decorative plants. The recent decline of the Polish economy, its associated need to become more self-reliant, and the long-standing Polish tradition of growing vegetables in "backyard allotments" illustrate the difficulties of controlling or decreasing environmental pollution in a country simultaneously changing from a communist to a free market economy [1]. Table 1 shows the average concentrations of lead in potatoes from various places within Upper Silesia.

In Upper Silesia, the standards for lead established by the World Health Organization (WHO) are grossly exceeded. However, information on samples taken at the point of exposure do not necessarily reflect the dietary experience of the population. In Table 2, the soil lead levels in residential hot spots in Upper Silesia are compared with the residential soil standards in Europe and North America. Hot spots are defined areas that have been declared

Table 1. Lead in Potatoes

Region	Average Lead Concentration (ppm)
WHO standard	0.4
Katowice Province	0.91
Selected towns in Katowice Province	
Zvglin	2.17
Zabkowice Bedzinskie	1.47
Chorzow	0.17
Walbrzyskie	0.19
Kieleckie	0.38
Byogoskie	0.28

Sources: Polish Ministry of Health [1] and internal document from The World Bank.
ppm = parts per million

Table 2. Soil Lead Levels in Selected "Hot Spots" in Upper Silesia*

	Mean Soil Lead Level (ppm)	Range (ppm)
Katowice		
Hot spot 1	6,449	753–19,750
Hot spot 2	2,124	82–6,775
Hot spot 3	1,025	447–1,550

* Acceptable residential levels in Europe and North America are <500 ppm.
Source: Polish Ministry of Health [1]
ppm = parts per million

environmental disaster zones by the Polish government.

The worst areas in Upper Silesia operate virtually outside the experience of much of the Western world. Soil lead levels are not an esoteric parameter. In North America, lead in soil is the principal determinant of high blood lead in children who are not exposed to lead-based paints [6]. This is because young children (under the age of five years) tend to passively ingest approximately 100 mg of soil per day through direct contact or through contact with house dust, which has equilibrated with the outside soil levels through people bringing soil into the house on their shoes, clothing, etc. Thus, children in Katowice are potentially exposed from both food and soil.

A study carried out in the 1980s by the Academy of Medicine in Zabrze, Poland involved children living near the Miasteczko lead and zinc smelter. Table 3 demonstrates the age-specific blood lead levels among children in that area and compares these values with those found in the South Riverdale district of Toronto, an area near a lead smelter where children have traditionally been found to have elevated blood lead levels [1].

The distribution of blood lead is higher for the Upper Silesian hot spot, but, among children under the age of six years, the differences are not large. However, it is important to point out that several children with acute symptoms were excluded from the Upper Silesian sample. These children had blood lead levels between 35 and 87 μg/dl, and thus the sample data from Upper Silesia were conservatively biased. Another important characteristic is that the blood lead levels appear to peak in the ages of seven to 10 years in Upper Silesia. In North America, blood lead levels tend to peak at the age of three or four years. This would suggest, indirectly, that passive ingestion of soil as a source of exposure may be relatively more important in North America than in Poland, where both food and soil may play a major role. The difference also suggests that the epidemiology of childhood lead poisoning in Poland may be different from the well-studied epidemiology of childhood lead poisoning in North America. Studies have shown that ingestion of lead-based paint is the most important cause of elevated blood lead levels in children in North America.

The effect of the widespread environmental contamination of lead in Upper Silesia is shown in Table 4. There are very high distributions of lead in mothers and children in all regions of the province except for the remote regions of Lubowice and Bojszow. By way of general comparison, 15 μg/dl of blood lead in children is given as the "lowest adverse effect level" by the Centers for Disease Control (CDC) in Atlanta, Georgia [9]. Levels above 25 μg/dl call for medical investigation, according to the CDC [9]. Thus, in five of the 10 locations listed in Table 4, the mean lead level among the children was at or near the investigation level, and all but two of the means were above the lowest adverse effect level.

Since the principal effect in children of blood lead is on the developing nervous system [8], this phenomenon of sustained high blood lead levels throughout childhood may be disproportionately important in terms of long-term biological effects.

Table 3. Blood Lead Levels in an Upper Silesia Hot Spot Compared with an Area in Toronto, Canada near a Lead Smelter

Age (yr)	Mean Blood Lead (μg/dl)	% > 30 μg/dl
Upper Silesian hot spot*		
1–3	17.3	6.5
4–6	20.1	7.1
7–10	25.8	20.9
11–15	19.3	2.6
Toronto, South Riverdale (1984)		
>6	15.5	3.7

* Several children with acute symptoms (blood lead levels were 35–87 μg/dl in these children) were excluded from this survey
Source: Polish Academy of Medicine

Table 4. Blood Lead Levels in Children and Mothers in Various Places in Upper Silesia

Location in Upper Silesia	Children		Mothers	
	Mean (μg/dl)	% > 35 μg/dl	Mean (μg/dl)	% > 35 μg/dl
Szopienice	26.7	17.8	21.1	11.2
Miasteczko S1	24.7	16.6	21.6	14.7
Zyglin	26.1	21.8	20.1	9.7
Lubowice	12.7	0	10.6	0
Zabrze	18.9	3.2	15.9	3.5
Toszek	17.9	13.2	13.1	4.5
Bytom	15.2	10.0	15.5	5.1
Bojszow	12.3	0	11.5	0
Brzeziny S1	22.4	13.0	17.6	6.0
Brzozowice	23.4	7.8	16.8	4.3

Source: Polish Environmental Protection Agency

Table 5 dramatically illustrates this point with a 13-point IQ gradient between the children with the highest and lowest blood lead levels in a study carried out in Upper Silesia [1].

Were these results to apply population-wide, they would have a devastating effect on the prospects for the adult lives of children in Upper Silesia. However, no population-based surveys of blood lead levels in children have yet been carried out in this region or in any other region of Poland.

COLLABORATION BETWEEN PSR AND THE SILESIAN MEDICAL ACADEMY

In 1991 PSR opened up a dialogue with scientific colleagues at the Silesian Medical Academy in Katowice, Poland, since this region, not only in Poland but in all of Eastern Europe, was among those most severely affected by the environmental scars of the cold war. Several interested and capable physicians at the Silesian Medical Academy indicated an interest in working with PSR to rectify the adverse human health effects of environmental pollution caused by unchecked central planning. The collective hope of health professionals at the Silesian Medical Academy and PSR is that, if the program met with success, it would be emulated in other less severely affected regions in Poland and in other regions in Eastern Europe and the former Soviet Union.

As a preliminary step in forging this collaboration, PSR organized a team of American physicians with experience in environmental hazard assessment, lead, and epidemiology, which traveled to Poland from November 19 to 22, 1991. The PSR team first met with Polish Ministry of Health officials in Warsaw. The Ministry indicated very clearly that it would endorse an active collaboration between PSR and the Silesian Medical Academy. Meetings were also held in Warsaw with officials at the United States Embassy, including Ambassador Thomas J. Simons, Jr. The delegation then traveled the 400 km between Warsaw and Katowice by train. During the next three days, a series of meetings was held with several faculties at the Silesian Medical Academy, the Institute of Occupational Medicine in Sosnowiec, the local Environmental Protection Agency, and the local Epidemiologic Monitoring Station of Katowice. The delegation visited key sites in Upper Silesia where environmental damage was most severe as well as selected health facilities where both children and adults with environmentally induced illnesses were examined and interviewed.

On the basis of these meetings, the PSR delegation decided that the most fruitful area for initial collaboration would be lead poisoning in childhood—the environmental health problem of greatest concern to local medical and environmental officials.

PSR and its Katowice partners focused on a one-year program plan with three components: 1) a cross-sectional epidemiologic study of children in Upper Silesia to determine the prevalence and likely sources of lead poisoning in the region and to expose young Polish physicians to Western epidemiologic techniques and standards; 2) a training program conducted by U.S. physician experts on lead poisoning for Silesian pediatric health care providers and public health workers; and 3) institution-building assistance from PSR chapters and key U.S. medical institutions to help the Silesian Medical Academy establish an environmental medicine institute.

The specific objectives of the epidemiologic study would be: 1) to assess blood lead levels in a randomly selected group of Polish children aged 0 to 10 years residing in selected cities of Upper Silesia, Poland; 2) to determine whether blood lead levels in children living in urban areas of Upper Silesia differ from blood lead levels in similarly aged children residing in rural areas of Upper Silesia; 3) to determine the major source(s) of lead poisoning in children in Upper Silesia and better understand the reasons why the epidemiology of childhood lead poisoning in this region appears to differ so markedly from the epidemiology of childhood lead poisoning in the United States; 4) to use the information collected in this study to stimulate Polish public health decision makers to initiate steps to reduce the adverse health effects of Poland's environmental pollution; and 5) to establish a research population

Table 5. Blood Lead Levels and IQ in Katowice Children from a Selected Hot Spot in Upper Silesia

Lead Level (μg/dl)	n	IQ
<20	94	111
20–25	59	105
26–30	53	105
>30	25	98

Source: Polish Ministry of Health [1]
n = number

for future studies on environmental, toxicologic, and clinical issues.

The delegation felt that as a first step it would be best to quantify the problem. Not only would the baseline data collected in this study provide a useful benchmark for assessing the effect of prevention and control programs, but it would also provide an opportunity to carry out vigorous quality control procedures on the blood lead level determinations that were being carried out in Upper Silesia.

PROGRAMMATIC ACTIVITIES TO INITIALLY BE PURSUED IN THE COLLABORATIVE EFFORT BETWEEN PSR AND THE SILESIAN MEDICAL ACADEMY

Phase I

Phase I will involve a cross-sectional study of approximately 5,000 children selected from five cities in Upper Silesia on the basis of a population-proportionate sample. The five towns included in this cross-sectional study were selected on the basis of their proximity to active lead smelting activities, proximity to major roads, proximity to other mining industries, volume of coal consumption, and socioeconomic status. Five towns were selected.

1. Bytom. A town with an old urban structure, moderate to high volume of traffic, and industrial pollution. It is located on the western edge of Upper Silesia and has a population of 240,000 persons.

2. Chorzow. A town in Upper Silesia with the worst air pollution that is located between Bytom and Katowice. It has a high volume of traffic, is very densely populated, and has a population of 138,000 persons.

3. Katowice. It is the capital city of the district. Its east-side subdivision, Katowice-Szopienice, has been a significant source of industrial lead emission. The subdivision of Szopienice has a moderate volume of traffic. The population of Katowice is 360,000 persons.

4. Chrzanow. A town chosen as a control. It is located 45 km east of Katowice and is separated from the heavy industrial areas of Upper Silesia. Because of the predominant wind direction, however, it is probably affected by the air pollution generated by Upper Silesia. Locally, there is little heavy industry and only a moderate amount of traffic. The population of Chrzanow is 40,000 persons.

5. Zywiec. A town chosen as a second control. It is located 90 km south of Katowice at the base of the Beskidy Mountains and is a resort town. There is a low to moderate amount of traffic. The population of Zywiec is 30,000 persons.

In Phase I, children aged zero to 10 years residing in the five selected towns of Upper Silesia will be the target population for the survey. In Poland all children zero to six years of age must be registered in the community health center located nearest their residence. We will use the registration lists at selected community health centers to identify children aged zero to six years in the target population. Children living in Upper Silesia and aged seven to 10 years are all enrolled in primary school. Therefore, lead surveys in children in this age group will be carried out in selected primary schools.

The number of primary schools in each of the five towns can be determined from the Upper Silesian Department of Education. In each town we will select the number of primary schools and community health center(s) located near each school on the basis of a proportionate population sampling frame (i.e., more heavily populated towns will have more primary schools and community health centers included in the sample).

The total population of the five towns in which we will carry out the cross-sectional survey is 808,000. We estimate that 25% of these individuals are in the target age group of zero to 10 years. This means that in the target areas there will be 202,000 (808,000 × 25% = 202,000) children aged zero to 10 years. For budgetary and sample-size reasons, we have decided to survey 5,000 children. Thus we will be sampling 2.5% of the target population (5,000/202,000). We will do a proportionate sampling as shown in the Table 6.

Table 6. Total Population of Selected Towns and Number of Children from Each Town Who Will Be Included in the Lead Survey

Town	Total Population	Population Aged 0–10 yr	2.5% of Population Aged 0–10 yr
Bytom	240,000	60,000	1,500
Chorzow	138,000	34,500	8,636
Katowice	360,000	90,000	2,250
Chrzanow	40,000	10,000	250
Zywiec	30,000	7,500	188
Total	808,000	202,000	5,051

We have arbitrarily assumed that each of the 10 age groups (zero to one year, one to two years, etc.) is equal in size among all five towns. This means that 500 children will be chosen from each of the 10 age groups (Table 7).

A blood lead level determination will be carried out on each child chosen for inclusion in the study. As part of the technology transfer, which is an integral part of this project, all blood lead samples will be split in two. One aliquot will be tested in a Polish government facility. The second aliquot will be sent to a reference laboratory in the United States to validate the Polish laboratory results. If wide discrepancies are found between the blood lead level determinations obtained in the Polish laboratory and those obtained in the laboratory in the United States, arrangements can then be made for a Polish laboratory technician(s) to come to the United States for short-term training.

In the survey, the sex, age, height, and weight of each survey child will be obtained. A short, self-administered questionnaire will be distributed to each subject's parents. Questions will be asked on duration of residence in the area, previous residence (place, dates), periods spent away from Upper Silesia within the last year (place, dates), family size, household characteristics (area, number of inhabitants), percentage of time spent playing outside, dietary habits (consumption of Baltic fish, canned food, vegetables), and relevant medical history.

Phase II

All children included in the first survey who are found to have blood lead levels greater than 25 μg/dl will be included in a "nested" case-control study as cases. Controls will be children of the same age and sex (±1 year) as the child with blood lead levels greater than than 25 μg/dl, who were tested immediately after the child with elevated blood lead levels, and who were found to have a blood lead level of less than 10 μg/dl. In the case-control study, each child's home will be visited by a trained Polish health worker. He or she will administer a standard questionnaire to the responsible guardian of the child. This questionnaire will seek to identify the source of the child's elevated blood lead level. In addition to the field worker, an industrial hygienist will visit the residence of each case and control child to determine lead levels in water, soil, and paint. We estimate that 10% of the surveyed population (i.e., 500 children) will be found to have blood lead levels in excess of 25 μg/dl.

To assess the environmental exposure to lead of each child in the case-control study, a series of environmental samples will be collected in each case and control household and analyzed for lead content. In each home, interior paint, particularly on surfaces accessible to children, will be checked for deterioration, flaking, or teeth marks. The lead content of representative interior painted surfaces in each home, especially of any damaged or flaking areas, will be assayed by X-ray fluorimetry (a technique for quantifying lead content). Also, the lead content of exterior paint will be examined. To assess children's exposure to lead in soil, two composite samples of surface soil will be collected from each child's play area (yard, playground, or vacant lot) and pooled for lead analysis. To assess the exposure to lead in household dust, three samples of household dust will be collected in each home and pooled for lead analysis. To assess possible exposure to lead in drinking water, two drinking water samples will be collected in each home and analyzed for lead content. One sample will be a first-draw morning sample to assess the worst case conditions in water that has stood overnight in contact with household plumbing. The second sample will be drawn during the interview. All samples will be collected in acid-washed, lead-free plastic containers by using methodologies developed by a suitably qualified agency in the United States.

Table 7. Number of Children to Be Included in the Blood Lead Survey from Each Age Group

Age Group (yr)	Number of Children to Be Included in Survey
0<1	500
1<2	500
2<3	500
3<4	500
4<5	500
5<6	500
6<7	500
7<8	500
8<9	500
9<10	500
Total	5,000

Phase III

Depending on which exposure sources of lead are found to be important in the Phase II survey, Phase

III will involve abatement procedures, behavioral change, or necessary dietary alterations. This activity is likely to involve school-based educational programs for children and their parents. Community action groups could also be organized. This educational activity will be run by appropriate local public health authorities who are already sensitized about a potential environmental lead problem in Upper Silesia.

It is anticipated that the conduct of these three phases will allow a technology transfer to occur between PSR members and the Silesian Medical Academy and enable additional areas of collaboration to be identified.

ACKNOWLEDGMENTS

The assistance of Ms. Alvara McBean in the preparation of this manuscript is gratefully acknowledged. I also thank Ms. Julia Moore, Dr. Richard Jackson, and Dr. Beth Bowen for their assistance in the preparation of the work plan.

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