ZYGMUNT STĘPLEWSKI

Zatrucie ołowiem dzieci w regionie przemysłowym Górnego Śląska w Polsce

Children's lead poisoning in the industrial upper Silesian Region of Poland

Streszczenie

Praca jest prezentacją wyników polsko-amerykańskiego programu współpracy między polskim zespołem badawczym, a dr Robertem W. Rider'em z Uniwersytetu Yale, który jest przedstawicielem Physicians for Social Responsibility (amerykańska organizacja pozarządowa – Lekarze dla Odpowiedzialności Społecznej). Zaprezentowano także istniejący problem występowania ołowicy u dzieci. Kontrolne badanie przypadków pozwoliło określić główne czynniki zagrożenia ołowicą w regionie Górnego Śląska w Polsce. Główne czynniki mające wpływ na wystąpienie ołowicy u dzieci przedstawiono według ich siły oddziaływania. Czynniki w kolejności od najbardziej zagrażających, do najsłabszych to: poziom wykształcenia matki; wiek budynku, w którym mieszka rodzina dziecka; spożywanie wody z kranu; usytuowanie okna (teren brudny, czy czysty); średni poziom koncentracji ołowiu w kurzu domowym oraz poziom wykształcenia ojca. Główne czynniki zagrożenia ołowicą są związane ze stylem życia rodziny – czynnikami łatwo podlegającymi działaniom prewencyjnym, takim jak: podniesienie poziomu wykształcenia, czy zmiana nawyków higienicznych.

Abstract

This review presents results of Polish – American collaborative program performed by us and Dr. Robert W. Rider of Yale University as a representative of Physicians for Social Responsibility. The present problems of lead poisoning in children are also presented. The main risk factors in lead poisoning in Upper Silesian region of Poland were established in a case control study. Main risk factors influencing lead poisoning in children are presented according to their strength of influence. From highest to the lowest, the risk factors were: mother's level of education; the age of the dwelling occupied by child's family; drinking of tap water; orientation of child's room window (dirty or clean area); mean home dust lead concentration and father's educational level. The main risk factors are related to the family life style, factors clearly susceptible to the preventive measures such as education and change of hygienic habits.

Słowa kluczowe: ołowica, dzieci, czynniki zagrożenia, środki prewencyjne

Key words: lead poisoning, children, risk factors, preventive measures

Department of Public Health, University of Information Technology and Management in Rzeszow, Poland

INTRODUCTION

Childhood lead poisoning continues to be of interest for environmental epidemiology and pediatrics. Up to now, no known biological function for lead was found. Therefore, the normal level lead in blood equals 0 [1]. Every increase of blood lead level results in negative health effects. This is especially true for children, since their fast developing organisms are more susceptible to harmful actions of lead [2-4]. Based on the definition of Center for Disease Control (CDC) we have defined a lead poisoned child, when it's blood lead concentration equals or excides 10 µg/dl. At this level, first symptoms of lead poisoning in cohorts of children can be observed. It was previously shown, that in children with higher than 10 µg/dl of blood lead level, statistically significant decrease of IQ is detectable [4].

The problem of childhood lead poisoning is not sufficiently recognized in Poland. The Upper Silesia Region (southern Poland) is the area with especially high risk of lead poisoning. Here, in the highly industrialized and polluted region, almost 100% of industrial lead is produced. Most of the zinc and lead smelters are localized in Upper Silesia. Natural layers of this heavy metal are present throughout this region. Another source of lead in Silesian environment was very dense traffic with thousands of cars and trucks using leaded gasoline. Although there is no more leaded gasoline in use since 1974, the previously deposited lead in the soil, water and deposited dust remain a significant source of lead. Due to the constant motions of air and soil, the lead continues to be released. This problem is ignored and remains to be remedied. The earlier studies revealed prevalence of significant lead poisoning of children in the neighborhood of lead smelters [5]. Up to now there is no information on children's lead poisoning in the cities of the region with no emission sources of lead.

The main problem of diagnosing lead poisoning clinically is a lack of specific symptoms. Such clinical symptoms can be detected when lead blood levels are over 40 µg/dl, a level much exciding highest acceptable concentration. This levels demands rapid detoxification of the patient [1,2,4].

The poor sensitivity of clinical examination in detection of lead poisoning demanded better methods of diagnosis. Therefore, a blood lead level measurement was established as a gold standard for diagnosing the lead poisoning [1]. In the ideal world this method would be applied to all children. It is however impossible at present due to technical and budgetary reasons. The recent approach to diagnosing lead poisoning involves assessment of risk factors for lead poisoning first, and measurement of blood lead concentration in high risk children next. For surveying population for lead poisoning, the risk factors analysis must be performed before further studies are conducted.

The main goal of the presented program was to establish approaches for preventive program against chronic lead poisoning for children living in the industrial area of Upper Silesia. The aims consisted of: evaluation of children lead poisoning in selected Silesian cities (phase I), and studies of children lead poisoning risk factors influencing the surveyed population as a base for establishing the preventive approaches (phase II).

CROSS SECTIONAL STUDIES OF LEAD POISONING IN SILESIAN CHILDREN

The first stage of the studies was designed to establish the level of lead poisoning in children inhabiting selected cities of Upper Silesia with different environmental conditions [6-8]. The cities selected for the studies were: Miasteczko Slaskie – city with active industrial sources of lead – zinc and lead smelters; Piekary Slaskie – highly industrialized city with industrial sources of lead, and no smelters; Zywiec – city with low industrialization, and high transportation traffic (use of leaded gasoline at the time of first analysis); Lubliniec – with low level of industrialization, outside of ecologically degraded region, rural surroundings; and Zabrze – highly industrialized, large city with no industrial sources of lead, with high automobile traffic. Randomly selected children for this study were 1 to 10 years old. In every city every 24th randomly selected child was included in the study. Children were divided into two groups: 1 to 6 years and 7 to 10 years old. Collected blood samples were analyzed for the level of lead using atomic absorption spectroscopy (AAS).

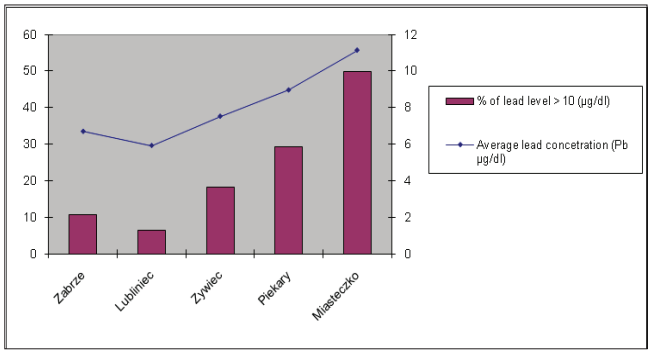

FIGURE 1. Frequency of childhood lead intoxication in selected cities of Upper Silesia.

As shown in Figure 1, the highest percentage of children with elevated level of lead in their blood was found, as expected, in the town of Miasteczko Slaskie, where the smelters were located. Almost 50% (48.8%) children had elevated levels of lead, and they had the highest average concentration of lead – 11.13 µg/dl. Also, as expected, the next highest percentage of children with elevated blood level of lead (29.3%) was found in the town of Piekary Slaskie. The lowest percentage of children with elevated lead level was found in the town of Lubliniec (6.3%) a rural region, again, as expected. It is clear that the closer to the industrial sources of lead, the higher levels of lead in children's blood was detected [6].

CASE CONTROL STUDY OF LEAD POISONING IN SILESIAN CHILDREN

Children previously found to be lead poisoned, with blood concentration greater or equal to 10 µg/dl were selected for further studies. A group of children with lowest blood lead levels were selected from the same population as a control. Both groups were matched for gender, age and the living conditions. The environmental in field studies were performed by research teams consisting of a physician and laboratory technician. Research teams visited children

at home and interviewed both, parents and children, using a questionnaire. During the visit teams collected samples of indoors and outdoors dust, and samples of drinking water. Detected levels of lead in those environmental samples were correlated with individual children blood lead concentrations. The collected data were submitted to the statistical analysis using Epi-Info 6.0 software. In the case of non-homogenous variances a Kruskal-Wallis test was applied. Differences were considered to be statistically significant at p level ≤ 0.05. The detailed analysis of the collected data have been published before [5-16]. Here I am summarizing the most important aspects of lead poisoning risk factors among over 800 processed during the data analysis.

Main risk factors: The most powerful factors influencing the risk of lead poisoning in children of surveyed population are presented in Figure 2.

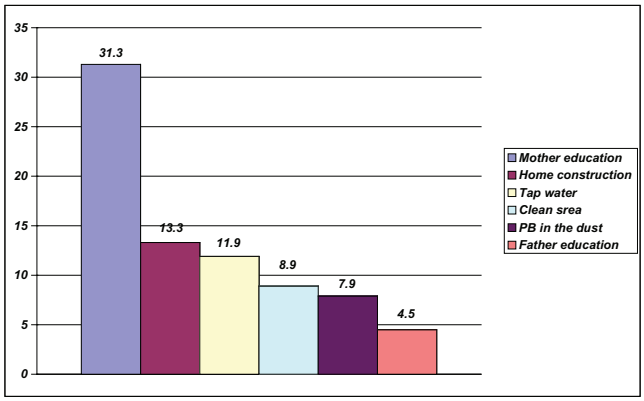

FIGURE 2. Most important risk factors of children lead poisoning.

Mothers level of education – strength of influence = 31.3. In the survey we found that mother educational level strongly influences the risk of lead poisoning. The influence was positive when mother was highly educated and negative when the mother was poorly educated. The relationship between mothers education level and mean blood lead concentration is presented in Table 1.

TABLE 1. Mother educational level and children mean blood lead concentration.

Mother educational level	Primary	Technical	Secondary	University
Mean blood lead level ± SD	13,384 ± 7,311	10,5 ± 4,6	8,946 ± 3,6	7,05 ± 4,4

When mother had university education, the children blood lead level was significantly lower and their children were placed in the control group. In comparison, children whose mothers had only primary education had much higher levels of blood lead ($p<0.0001$). Obviously, mother's educational level was not a variable acting alone. This variable was strongly connected with other variables, directly influencing levels of children lead blood levels. One of such variables was the number of children in the family. Up to 10 children in families with only primary education (mean 2.3) and 3 children in families with higher education (mean 1.2) were found. The difference was statistically significant ($p<0.02$).

The per capita income was about twice as high in families with higher education than those with primary education. Furthermore, the amount of time the child spent away from living environment during holidays was two times longer in families where mothers had higher education (5.1 weeks/yr versus 2.5 weeks/yr).

Another important factor influencing the risk of lead poisoning was the possession of room of child's own. Such children had mean blood level concentration of 9.6 µg/dl, while the children sharing living space with adults had blood lead concentration 12.4 µg/dl. While in the families where mothers had higher education only one of 45 children had no room of his own, in the families where mothers had only primary education, out of 130 children, only 79 had their own rooms.

The age of the child's living quarters (buildings) – strengths of influence = 13.3. In the surveyed population the age of living quarters was divided into 3 groups. Structures built before year 1945, built in the years 1945-1975 and those built after 1975. It was expected that at homes built before 1945 the lead sources to be water supply (lead pipe) and leaded paint. At homes built after 1945, but before 1975 only leaded paint was expected. In homes built after 1975 were expected to be lead free. The actual data presenting mean blood lead concentration in children inhabiting those three types of dwellings are presented in Table 2.

TABLE 2. Mean blood lead concentration in children inhabiting building constructed in different time periods, mean lead concentration in the indoor dust.

Year of construction	Number of children inhabiting	Mean blood lead level ± SD (mg/dl.)	Mean concentration of lead in the dust ± SD (mg/m^2)
Before 1945	237	11,59 ± 6,15	101,99 ± 202,36
1945 - 1975	252	9,87 ± 4,51	89,2 ± 223,72
After 1975	249	9,34 ± 4,56	53.6 ± 83,85

Both, mean lead blood concentration and mean concentration of lead in the dust were significantly higher in the old buildings than in newer ones, $p=0.00003$ and $p=0.01$, respectively. Replacement of pipes during general renovations and replacement of old paints from the buildings decreased only insignificantly mean blood lead concentrations in surveyed children. One of the possible causes of higher risks of lead poisoning of surveyed children inhabiting old buildings is the heating system. Old homes were more likely heated by separate, coal burning stoves. Newer homes are centrally heated. Home heating stoves produce dust contaminated with heavy metals, including lead. This will increase mean concentration of this metal in indoor dust.

Tap water drinking – strength of influence = 11.9. In children drinking tap water the mean blood lead concentration was 12.32 µg/dl while in children without this habit, the level was 9.58 µg/dl and the observed difference was statistically significant, $p<0.0001$. Factors such as frequent hand washing, especially before the meals significantly lowered the risk of lead poisoning [12].

The quality of land next to the child's room window – strength of influence = 8.9. Parents were asked to assess the status of the area situated directly under the window of child's room. Was it a clean area (garden, grass, forest, park, playground) or dirty, wasted area (factory, junk yard, garages, parking, street).Children with clean area had the mean blood lead level of 9.67 μg/dl while the other group had 10.95 μg/dl and the difference was statistically significant, p=0.0003. Subjective assessment of the parents was confirmed by 2 environmental measures: lead concentration in the outdoor dust and lead concentration in windowsill dust. In the outdoor dust in the "dirty" areas the lead level was measured at 131.7 μg/kg, while in the clean areas was 85.5 μg/kg. The difference is statistically not significant, p = 0.2. It is clear that orientation of the child room window plays a significant role in contamination of indoor dust with lead. Also, lead in the indoor dust is a main environmental risk factor for both groups [9].

Indoor dust lead contamination - strength of influence = 7.9. The level of lead contamination was measured in dust collected from windowsills and from the floor or furniture. The sampling procedure has been described before [11]. The mean lead contamination was calculated from data obtained during both sites of sample collection. Mean dust lead levels in high risk regions of Silesia reached 109.3 μg/m2, while in the low risk areas was only 54.07 μg/m2 and the difference was statistically significant, p=0.00015. The mean positively correlated with blood lead concentrations in surveyed children (r=+0.26; 95% confidence interval [0.19 – 0.32, r=0.07]). To our surprise, it was found that also this environmental factor was dependent on mother's educational level. At homes where mothers had only primary education, the mean dust lead concentration equaled 108.9 μg/m2, while at homes where mothers had higher education was 64μg/m2, although the observed difference was statistically not significant, p= 0.07.

Father's level of education – strength of influence = 4.5. Father's educational level influence on the child's risk of lead poisoning was seven times weaker than that of mother's. It seems to show that in Silesian family fathers have weak influence on child rearing [13].

ANALYSIS AND CONCLUSIONS

From the very beginning of our studies, it was expected that among the risk factors of children lead poisoning, the most important will be the environmental ones, associated with water, soil and indoor dust. The presented above studies revealed that these are important, but not to the degree expected [17,18]. Main risk factors established during this research are attributed to widely understood life style, in which education plays the most important role. These findings are not consistent with previously reported studies, which emphasize only environmental factors as main sources of child lead poisoning [15,17]. It was probably due to the way the children were recruited for the studies, since they were living close to the sources of industrial lead. In the vicinity of lead smelters the environmental lead excides all limits. Under such conditions of industrial calamity, the environmental factors seem to be overwhelming the life style factors.

Our data indicate the influence of parental education, especially education of mothers on the strength of children lead poisoning risk factors. The educational level of the parents was strongly associated with other variables influencing the risk of lead poisoning. These included the number of siblings in the family, per capita income, level of hygiene, nutritional habits and child's possession of room of its own. Another unexpected result was relation of mean level of lead in dust and mother level of education. In the dwellings where mothers had only primary education the dust lead contamination was twice as high, as in those where mothers had higher education. Furthermore, mothers with higher education were mostly working mothers and reported less frequent house cleaning, than the non working mothers possessing only primary education. Living in old dwellings results in the increased exposure to lead contaminating paints, dust and the coal burning stove dust. The paint containing lead is the main risk factor of lead poisoning in the USA [2,3]. In our studies the housing conditions played an important role, but much weaker than the educational level of mothers. Among other housing conditions an important role played the orientation of child's room windows. Windows oriented to the outdoor dirty areas, the lead-rich dust found the window as a gate to infiltrate the child's room. It increased the pool of contamination and the mean indoor lead in dust was the fourth risk factor by the criteria of the strength of influence. This is the only variable dependent on the child's place of living. The mean indoor dust lead contaminations were highest in lead polluted cities such as Miasteczko Slaskie and Piekary Slaskie and much lower in cities without industrial source of lead. However, the potency of this factor was much weaker than that of life style factors. These studies also revealed the power of everyday hygiene on the dangers of lead poisoning. Some of the poor hygienic habits significantly increased the risk of lead poisoning in children of Silesia. It seems that "dirty hands" are not only o source of infectious diseases but also of lead poisoning. Some of the discrepancies in mother's responses to the questionnaire, regarding the hygienic home-rules may be due to their embarrassing quality. Some of the responses were clearly better than the reality. The sequence of power of influence of the most powerful lead poisoning risk factors clearly indicate that the lead poisoning of Silesian children is preventable. This is already a national policy of the United States. In the States, since 1970 the average lead blood level in children fell from 15 μg/dl to 2 μg/dl. Still the lead in paint, lead pipes and lead in imported toys paint are considered to be of great risk to American children [19, 20]. In the CDC plan to eliminate lead poisoning in children by the year 2010 it is stated that at present in US about 250,000 children aged 1 to 5 years still have more than 10 μg/dl of lead in blood. By the year 2010 CDC plans to identify and control lead paint hazards, identify and treat children with elevated lead levels. CDC will monitor progress in lead poisoning prevention and continue research in the field of lead poisoning prevention [21]. To the best of my knowledge such comprehensive national program of lead poisoning prevention in polish children is not pursued. In this review I am presenting the main risk factors of children lead poisoning in Upper Silesia. Among the most important risk factors is the role of parent's education. At present,

the simple solutions would decrease, at least in part the dangers of lead poisoning in children. The educational program for parents, children, pediatricians and teachers will increase their knowledge about preventive measures of lead poisoning. The simple hygienic measures at homes and surroundings in the high risk region may also be of some help.

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REFERENCES:

1. Roper VL, Houk VN, Falk H, Binder S. Preventing lead poisoning in young children-a statement by the Centers for Disease Control. www.cdc.gov, October 1991.
2. Needleman H, Schell M, Bellinger D, Leviton A, Allred E. The long-term effects of exposure to low doses of lead in childhood. New Eng J Med. 1990; 322(2): 83-8.
3. Hager-Malecka B, Sroczynska M, Sychłowy A, Sonta-Jakimczak D, Dzioba P, Krol J. Chronic lead poisoning in twins with Sanfilipo mucopolysaccharidosis. Ped Pol. 1977;52:659-64.
4. Rabinowitz M, Leviton A, Needleman H, Bellinger D, Waternaux C. Environmental correlates of infant blood levels in Boston. Environ Res. 1985;38:96-107.
5. Schwartz J. Low-level environmental lead exposure and children's IQ: a meta-analysis and search for a threshold. Environ Res. 1994;65:42-55.
6. Strugala-Stawik H, Dembicka D, Pastuszek B, Pietraszkiewicz T. The investigation of blood lead concentration in children from the copper smelting area of Legnica. Pol J Env Studies 1997;6,Suppl:180-3.
7. Lukas. W, Sliwa F, Steplewski Z, Tendera M, Kozak M, Ryder RW, Frydrych J, Janikowski E. Towards individual prophylaxis of lead poisoning in children. I. Cross sectional studies of increased blood level of lead in selected cities of Upper Silesia. Pam. Kraj. Symp. „Być zdrowym i szczęśliwym w szkole i rodzinie." Łódź;1995:359-64.
8. Steplewski Z, Jaskolecki H, Tendera M, Kozak M, Mercik M, Miarczynska-Jonczyk H, Steplewska-Mazur K, Ryder RW, Lukas W, Sliwa F. Towards individual prophylaxis of lead poisoning in children. II. Identification of lead intoxication sources. Pam. Kraj. Symp. "Być zdrowym i szczęśliwym w szkole i rodzinie." Łódź;1995:365-71.
9. Steplewski Z, Tendera M, Ryder RW. The system of indywidual lead poisoning prevention In children. Pol J Env Studies, 1997; 6 Suppl:146-9.
10. Steplewski Z, Jaskolecki H, Kozak M, Malecka H, Mercik D, Miarczynska-Jonczyk H, Steplewska-Mazur K, Tyrpien M, Stawiany W, Sajdak G, Paszek M, Tendera M, Ryder RW. Lead concentration in water, indoor dust, and outer layer of soil (outdoor dust) and the risk of lead poisoning in Silesia. Pol J Env Studies, 1997;6 Suppl: 150-2.
11. Steplewski Z, Jaskolecki H, Kozak M, Malecka H, Mercik D, Miarczynska-Joczyk H, Steplewska-Mazur K, Tyrpien M, Tendera M, Ryder RW. The influence of car exhaust and conditions of play on lead poisoning in Silesian children Pol J Env Studies; 1997;6 Suppl, 156-8.
12. Steplewski Z, Jaskolecki H, Kozak M, Malecka H, Mercik D, Miarczynska-Jonczyk H, Steplewska-Mazur K, Tyrpien M, Tendera M, Ryder RW. The hygienic status of the house and the risk of chronic lead poisoning in Silesian children. Pol J Env Studies; 1997;6 Suppl: 159-62.
13. Steplewski Z, Jaskolecki H, Kozak M, Malecka H, Mercik D, Miarczynska-Jonczyk H, Steplewska-Mazur K, Tyrpien M, Gwozdz A, Tendera M, Ryder RW. The influence of hygienic habits on chronic lead poisoning in Silesian children. Pol J Env Studies; 1997;6 Supl: 163-6.
14. Steplewski Z, Jaskolecki H, Kozak M, Malecka H, Mercik D, Miarczynska-Jonczyk H, Steplewska-Mazur K, Tyrpien M, Kasperczyk J, Tendera M, Ryder RW. The educational level of the mother and the blood lead level in Silesian children. Pol J Env Studies;1997, 6 Suppl: 167-9.
15. Steplewski Z, Jaskolecki H, Kozak M, Malecka H, Mercik D, Miarczynska-Jonczyk H, Steplewska-Mazur K, Tyrpien M, Kasperczyk J, Tendera M, Ryder RW. Low birthweight (LBW) and the risk of children lead poisoning in Upper-Silesia. Pol J Env Studies;1997, 6 Suppl: 170-2.
16. Steplewski Z, Jaskolecki H, Kozak M, Malecka H, Mercik D, Miarczynska-Jonczyk H, Steplewska-Mazur K, Tyrpien M, Kasperczyk J, Tendera M, Ryder RW. The influence of lead poisoning In Silesiak children on their psychophysical development by the opinion of their parents. Pol J Env Studies 1997;6 Suppl:173-5.
17. Steplewski Z, Jaskolecki H, Kozak M, Malecka H, Mercik D, Miarczynska-Jonczyk H, Steplewska-Mazur K, Tyrpien M, Tendera M, Ryder RW. Social conscience of risk of lead poisoning in children in ecologically endangered regions. Pol J Env Studies 1997; 6 Supl:176-9.
18. Hager-Małecka B, Sroczyńska M, Sychłowy A, Sonta-Jakimczak D, Dzioba P, Król J. Chronic lead poisoning in tweens with Sanfilipo mucopolysaccharidosis. Ped Pol. 1977;52:659-64.
19. Heinze I, Gross R, Stehle P, Dillon D. Assessment of lead exposure in schoolchildren from Jakarta. Environ Health Perspect 1998; 106(8):499-501.
20. Manahan J, Bockman C, Woodss E. Lead poisoning in childrenn still a serious risk. Ann Resident Staff Physician 2006;52:1-5.
21. Silbergeld EK. Preventing lead poisoning in children. Rev Publ Health 1997;18:187-210.

Informacje o Autorze
Prof. dr hab. Zygmunt Stęplewski – Katedra Zdrowia Publicznego,
Wyższa Szkoła Informatyki i Zarządzania z siedzibą w Rzeszowie

Adres do korespondencji
Katedra Zdrowia Publicznego
Wyższa Szkoła Informatyki i Zarządzania z siedzibą w Rzeszowie
ul. Sucharskiego 2, 35-225 Rzeszów