

Blood Lead Level of Children and its Trend in Mitrovica, Kosovo

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Abstract

Environmental exposure to lead is considered to be one of the most important hazards to the health of children. Most commonly exposed are those who are poor and live in developing countries. The environmental lead pollution problem in the Roma Mahala neighborhood of Mitrovica was discovered through the appearance of high blood lead levels (BLLs) in children living there. The aim of our study was to investigate the BLLs in children according to gender, age, and area of residence. This study describes the results from a 7-year retrospective study (January 2010–April 2017) based on BLLs conducted on children aged 0 to 13 years living in all three districts of Mitrovica. The survey included 331 children. Blood lead analysis was performed in the laboratory using capillary and venipuncture samples tested by anodic stripping voltammetry using LeadCare II machines. Mean BLLs were the highest in the Roma Mahala with 23.6 mg/dL (standard deviation \pm 15.9 μ g/dL). We obtained a statistical significance ($p < 0.0001$) between BLLs according to the settlements. The mean BLLs was higher in the 3 to 4 years aged children group in comparison with other age groups ($p = 0.009$). In none of the age groups with the Mann–Whitney test we obtained a significant gender difference on BLL ($p > 0.05$). Lead poisoning levels continue to be a serious problem among children living in Mitrovica over the past several years due to heavy lead pollution. All children from this region should receive environmental evaluations and medical examinations.

Keywords

- ▶ blood lead levels
- ▶ children
- ▶ lead mining and smelting

Introduction

Lead poisoning is an old and significant public health problem throughout the world.^{1,2} Toxicity correlates with lead concentration in blood and progresses from biochemical and subclinical abnormalities, at levels around 10 μ g/dL, to coma and death at levels of more than 100 μ g/dL.^{3–5} Elevated blood

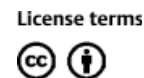
lead is also associated with neurodevelopment abnormalities including attention-deficit disorders, behavioral disturbances, learning disabilities, and deficits in fine and gross development.^{6–9} Impairment of intelligence quotient occur at even lower levels of exposure (1 μ g/dL).^{2,10,11}

Due to local lead mining and processing, environmental exposure to lead is considered one of the most important

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hazards to the health of children.¹² Most susceptible are the children, and most commonly exposed are those who are poor and live in developing countries.¹³ In many developing countries where leaded gasoline is no longer used, many children and workers are exposed to fugitive emissions and mining wastes.¹⁴ Nutritional deficiencies faced by children living in poverty, enhance lead's absorption and/or effects. Low calcium, iron, zinc, and vitamin C intake are examples of nutrients that influence the availability and toxicity of lead.¹⁵

Health concerns related to lead in Kosovo come from lead emissions in the air and water from lead and zinc mines and lead processing plants, in particular lead smelters.^{16,17} The emissions are spread over miles of latitude, which are known as hot spots. Kosovo has some lead and zinc mines, mainly in northern Mitrovica.¹⁸ A lead smelter has been working for decades in Zvečan (several kilometers north from Mitrovica) until the end of 2000 when it was closed. So Zvečan and Mitrovica are hot spots as regards the presence of lead.¹⁹ Lead emissions in the air have dropped significantly since the Zvečan crusher closure, but lead and sterile mines still contaminate the air (breathable dust), water, and soil (rain-fall precipitation and dust deposits).^{20,21} Similarly, the land around Zvečan, which is still contaminated by lead deposits, is a major source of exposition risk.

The city of Mitrovica is one of the most polluted cities in the region due to the mining and metallurgical activities of the "Trepça" industrial complex.¹⁶ The following industrial plants of the "Trepça" complex contributed to the pollution and poisoning of the environment in Mitrovica and its surroundings: the smelter, the refinery, the flotation, the factory of chemical products, the fryer, the lead and zinc refinery, the power plant, the zinc electrolysis, the battery factory, and the equipment plant for disposal of medical material and medicines.

The environmental lead pollution problem in the Roma Mahala neighborhood of Mitrovica was presented through the appearance of high blood lead levels (BLLs) in children living there. Lead analyses on environmental samples were performed at the same time to identify the possible sources of lead (e.g., drinking water, soil, and air).^{12,17} It is essential for children suffering from *lead poisoning* to have regular follow-up examinations, and specifically need their BLLs to be monitored.¹⁷

The aim of our study is to investigate the BLL in children according to gender, age, area of residence, and its trend within the years.

Materials and Methods

Study Design

This study describes the results from a 7-year retrospective study (January 2010–April 2017) based on BLLs in children aged 0 to 13 years living in all three districts of Mitrovica. We evaluated BLLs according to ages, sex, and geographical regions.

Laboratory Analysis

We assessed the lead exposure of the children by measuring lead concentration in blood. Since 2010, these samples are

sent to a laboratory in Mitrovica Family Medicine Center (MFMC-AMF), Health and Heavy Metals Unit in Mitrovica, which systematically records data on lead levels in blood tests conducted for screening and follow-up in the Roma community. For BLL greater or equal to 45 µg/dL, a further blood lead test was made within 3 weeks, after chelation therapy. For levels of < 45 µg/dL, a second test was made within 6 months. "ESA" Lead Analyzer type I and II donated by the European Union (EU), USAID Mercy, was used.

Blood lead analysis was performed in the laboratory in MFMC-AMF using capillary and venipuncture samples tested by anodic stripping voltammetry (ASV) using LeadCare II machines. The highest reported level of lead quantified by this analyzer is 65 mg/dL. Higher levels register as "HIGH." Inclusion criteria were residence in Mitrovica and children younger than 18 years of age.

Ethical Clearance

The study was approved by the Research Ethics Committee, University of Pristina, Pristina, Kosova.

Statistical Analysis

All statistical analyses were performed using the Statistical Package for Social Science, SPSS 22.0. Continuous variables are summarized with arithmetic or geometric mean, standard deviation (SD), minimum, and maximum value. Categorical variables are summarized as frequency (*n*) and percentage (%). In the statistical analysis, differences between normally distributed continuous variables were tested with the Student's *t*-test and differences between groups with not normally distributed variables were tested with Mann–Whitney test or Kruskal–Wallis test. The Spearman's correlation is calculated with the correlation between BLLs and age. Level of statistical significance was set to *p*-value of < 0.05.

Results

The survey included 331 children who at the time of the first measurement were aged 0 to 13 years. ► **Table 1** shows the general characteristics of the study's subjects. The mean age of the children included in the research was 5.0 years (SD ± 3.1 years). Based on the age group, most of the children were 5 to 9 years old, namely 139 or 42.0%, whereas the smaller group was the age group of < 1 years old, represented with 14 or 4.2%. In terms of gender, 151 children or 45.6% were females and 180 or 54.4% were males.

The children involved in the research came from three settlements. The largest number of them, 236 or 71.3%, were from the Roma Mahala and 40 or 12.1% from the neighborhood 2 Korriku in Mitrovica. From Leposavic, there were 55 or 16.6%. Geometric mean of BLLs was 16.10 µg/dL (SD ± 2.13 µg/dL). Blood lead values at first measurement were 45 µg/dL in 28 or 8.5% children, of which 8 or 2.4% had lead values of 45 to 54 µg/dL and 20 or 6.0% had lead values of 55 to 69 µg/dL (► **Table 1**).

With Spearman's correlation, we did not obtain any significant correlation between age and BLL (*r* = -0.07, *p* = 0.193). However, at 3 to 4 years the mean BLLs was

Table 1 General characteristics of the children involved in the research

	N	Percentage
Total	331	100.0
Gender		
F	151	45.6
M	180	54.4
Age group (y)		
< 1 year	14	4.2
1–2	72	21.8
3–4	70	21.1
5–9	139	42.0
10–13	36	10.9
Age (mean \pm SD)	5.0 \pm 3.1	
2 Korriku	40	12.1
Roma Mahala	236	71.3
Leposavic	55	16.6
First BLL ($\mu\text{g}/\text{dL}$)		
< 45	303	91.5
\geq 45	28	8.5
45–54	8	2.4
55–69	20	6.0

Abbreviations: BLL, blood lead level; F, female; M, male; SD, standard deviation.

higher in comparison with other age groups ($p = 0.009$) (\rightarrow Fig. 1). In none of the age groups with the Mann–Whitney test did we obtain a significant gender difference ($p > 0.05$) (\rightarrow Fig. 2).

Mean BLLs were the highest in the Roma Mahala with 23.6 $\mu\text{g}/\text{dL}$ (SD \pm 15.9 $\mu\text{g}/\text{dL}$), then in the neighborhood of 2 Korriku with 15.6 $\mu\text{g}/\text{dL}$ (SD \pm 10.3 $\mu\text{g}/\text{dL}$), and the lowest in children of Leposavic, 12.4 $\mu\text{g}/\text{dL}$ (SD \pm 6.2 $\mu\text{g}/\text{dL}$). With the Kruskal–Wallis test, we obtained a statistical significance

($p < 0.0001$) between blood lead values according to settlement (\rightarrow Fig. 3).

Discussion

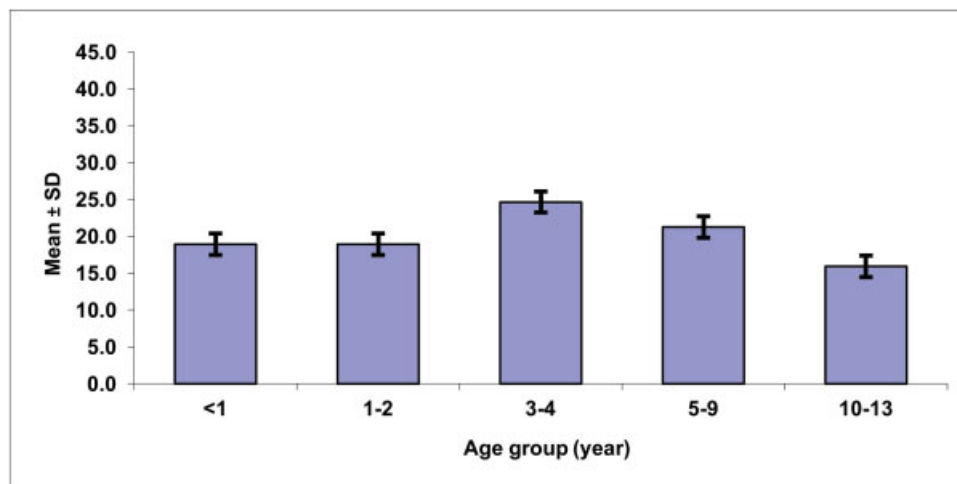
Overall, our study revealed that the BLLs of most of the children in Mitrovica registered a poisoning level and need further monitoring.

Although the impact of landfills and the ongoing activities of the Trepça mine and flotation is present not only in the city of Mitrovica but also in the surrounding areas, the most affected by heavy metal poisoning are the residents living in their vicinity, such as the residents of the Roma Mahala, followed by the 2 Korriku neighborhood and Leposavic. Roma Mahala has the largest number of lead-poisoned children and the highest BLLs compared with other neighborhoods, and this is due to the fact that the neighborhood is much closer to the mining sites, and the Roma, Ashkali, and Egyptian (RAE) community lives in the worst economic-social situation, with 95% of the members of this community unemployed,²² and the level of parental education is very low. Blood lead concentrations, average levels 23.6 \pm 15.9 $\mu\text{g}/\text{dL}$, in the children in our study were 3 to 12 times higher than the current average (1.9 $\mu\text{g}/\text{dL}$) of children (ages 1–5 years) in the United States.²³ In contrary, various scientific research,^{13,24–26} that calculated BLL in children in developing countries, also had similar results to ours.

Various studies^{20,21,27,28} were continuously performed related to BLLs among children in Mitrovica region. The World Health Organization (WHO) has conducted BLL tests from 2004 to 2007, of which the vast majority have resulted with a high BLL.²⁰

These results are due to the fact that very little was done by the government to take measures to cleanse the country, exterior soil remediation (overcast removal, covering with clean soil), and closure of factories. Also, people with high BLLs who were removed from certain areas move and do not stay in a clean place.²⁷

Another study by WHO was performed in 2004 on 296 children under the age of 4 living in Mitrovica (North and South), several nearby towns (Zvečan, Zubin Potok, and

**Fig. 1** Blood lead levels ($\mu\text{g}/\text{dL}$) according to age groups.

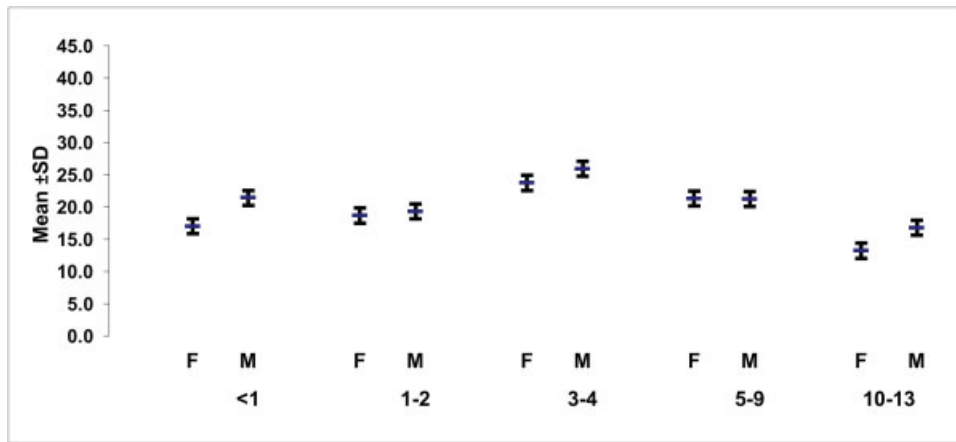


Fig. 2 Blood lead levels ($\mu\text{g}/\text{dL}$) according to age groups and gender.

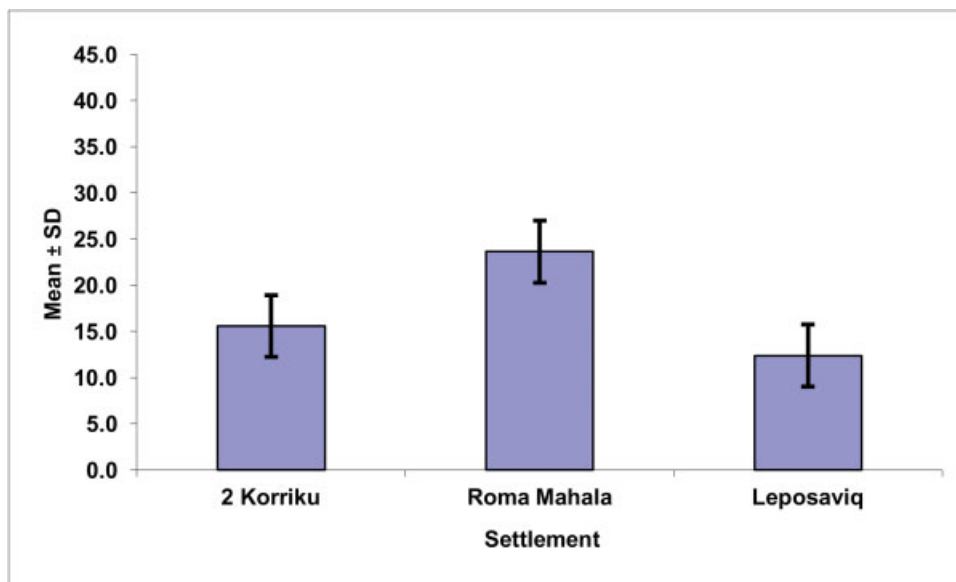


Fig. 3 Blood lead levels ($\mu\text{g}/\text{dL}$) according to settlement.

Leposavic), and in Pristina.²⁷ Blood samples from children were analyzed for lead and the following results were obtained: Zvečan (22 children): average BLL = 32.59 $\mu\text{g}/\text{dL}$, SD = 28.67, and Northern Mitrovica (44 children): average BLL = 14.32 $\mu\text{g}/\text{dL}$, had the highest BLL compared with other cities in Kosova.

Examinations of lead presence in blood in the city of Mitrovica have also been reported by the nongovernmental organization (NGO) "Society for People Under Threat,"²⁸ where most of the examined resulted with high levels of lead in their bloodstream. According to this report, from 2004 to 2008, a total of 602 persons of different ages were examined, of whom 575 had lead in their blood and only 27 were not affected.

Another study shows that 139 out of 240 or around 58% of examined patients during 2007 in Mitrovica resulted with over 10 $\mu\text{g}/\text{dL}$ of BLL. Most of the affected people were aged between 0 and 6 years, and most of them were from "2 Korriku," the neighborhood of the Trepça battery factory, which used to work until 1999.²¹

Examination of persons potentially affected by lead poisoning continued even after 2010 by the MFMC-AMF, a project sponsored by the NGO "Mercy Corps." According to data provided by MFMC-AMF from 2010 to June 2014, a total of 899 persons aged between 1 month and 12 years have been examined, of which 19 resulted in over 45 $\mu\text{g}/\text{dL}$ BLL and are still under treatment, whereas the majority resulted in over 10 $\mu\text{g}/\text{dL}$ BLL.

It has been a long time since these researches have been conducted, and even these days (current study) comes with the same results that the BLLs of the RAE community are high. However, to bring a small decrease in BLLs, there is a need to support financially the relocation and medical treatment of the residents, including by ensuring that adequate funds are available to relevant Kosovo ministries, and also by ensuring that returnees to the Roma Mahalla have access to welfare, health and education services, security, and access to employment as a matter of priority.

This has been proven by McWeeney.²⁹ Lower mean BLLs were found in children born following implementation of the

interventions as compared with the children born before the interventions. However, this decrease in mean BLLs was attenuated in children born into families suspected of informal lead smelting. Despite lower BLLs following interventions, children living in these camps have BLLs that remain unacceptably high.

Few studies^{24,30} revealed that the BLLs of children showed a decreasing trend after gasoline with lead was banned, or after children received medical intervention, including iron supplementation and improved nutrition, and their mothers received hygienic dietary instructions on how to reduce lead absorption,^{5,25,31,32} something that we did not achieve in our study.

From various works it was proved^{12,30,32} that the soil was apparently the principal source to which the children were exposed, because the area where they lived was widely contaminated with lead scrap in the previous decades. It was found that in Mitrovica the average content of lead in the surface soil is 450 mg/kg (with a range of 35–35,000 mg/kg). This lead average exceeded the optimum value specified in the New Dutch list by five times, while it exceeded the EU average value by up to 20 times.¹⁷

The reason why their BLLs are still high is that a continuous resuspension of dust and dirt particles from the highly contaminated soil around the lead smelter may maintain a very high airborne lead concentration at the breathing height of the children. To mitigate the health problems of those affected, priority criteria were developed to achieve reductions in BLL.³³ These criteria emphasized education, hygiene, and nutrition.

Study Limitations

The major strength of this study is its large size. This study also had its limitations. We did not register if children under study received medical intervention, including iron supplementation and improved nutrition, and if their mothers received hygienic dietary instruction on how to reduce lead absorption.

Further research studies including soil, air, and water analysis and their correlation with BLL level among children living in those areas should be conducted. Future health and environmental actions are necessary to investigate other lead contaminated regions.

Conclusion

The data presented in this study on the increased BLL among children of the Mitrovica region speak best of the emergent need to take concrete steps to remedy the current situation, eliminate pollution sources, and rehabilitate the contaminated sites. Landfills created in the past as well as the current Trepça activities are a major source of pollution and represent a permanent health risk for the city of Mitrovica, in particular the residents living near the landfills. In addition, we recommend three primary prevention strategies for lead poisoning: identify sources, eliminate or control sources, and monitor environmental exposures and hazards.

Authors' Contributions

The author(s) contributed equally in the preparation of the manuscript.

Conflict of Interest

None declared.

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