

**BLOOD LEAD LEVEL AND DECREASED INTELLIGENCE QUOTIENT IN FOUR  
YEARS OLD CHILDREN IN ALAVERDI CITY AND SHENGAVIT DISTRICT OF  
YEREVAN, ARMENIA**

Master of Public Health Thesis Project Utilizing Research Grant Proposal

Emma Anakhasyan, MD

MPH candidate

College of Health Sciences

American University of Armenia

Primary Advisor: Varduhi Petrosyan, PhD

Secondary Advisor: George J. Jakab, PhD

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## Executive Summary

**Background Information.** Public Health specialists consider lead (Pb) exposure as an issue of great importance because of the absence of harmless level of lead concentration and ability of this element to accumulate and remain in the human body for a long period of time. Children are the most vulnerable part of population because of their immature blood brain barrier, hand-to mouth behavior and other various reasons.

Effects of lead exposure differ by the time and level of exposure. Short-term (acute) exposure to high concentrations of lead in humans damages the brain; it also injures kidney and gastrointestinal system. Long-term (chronic) exposure in human affects blood, kidneys, central nervous, reproductive and immune systems and the metabolism of Vitamin D. There is an inverse relationship between blood lead levels (BLL) and children's intelligence measured by "Intelligence Quotient".

In 2001 the yard soil mean lead concentrations in Shengavit district of Yerevan (600-1000 mg/kg) and Alaverdi (493 and =mg/kg) exceeded the standard established by the USA Environmental Protection Agency (400 mg/kg). There are no studies about lead exposure and children's decreased IQ, sources and pathways of exposure in Armenia.

**Specific Aims.** The research question of the proposed study is:

- Does lead contamination in the environment, particularly yard soil, lead to lead exposure in children measured by BLL?

The objectives of this study are:

- To determine blood lead levels and IQ scores in 4 years old children
- To determine the association between the children's decreased intelligence and environmental lead exposure
- To explore differences in mean BLL and IQ between children who lives in Shengavit and Kentron districts of Yerevan, Alaverdi and Aghtala-Shamlugh.

**Methods/Study Design.** To explore blood lead levels and IQ score in 4 years old children in cities Alaverdi, Aghtala-Shamlugh and Yerevan (Shengavit and Kentron districts) an analytical cross-sectional study will be conducted. This study design will allow to determine and compare differences between lead exposure and mental development of 4 years old children in these cities. The study will be conducted in city Alaverdi where yard soil is contaminated by the polymetallic smelter activities and will be controlled by Aghtala - Shamlugh where yard soil contamination is within accepted standards. The study will be conducted also in Shengavit district of Yerevan, where soil is contaminated by lead-acid car batteries and controlled by Kentron district which is not contaminated by lead

**Study Population.** The study population will include children aged 4 years old, born and living in Alaverdi, Aghtala-Samlugh and Shengavit and Kentron districts of Yerevan. The rationale for choosing this particular age group is that decreased IQ score in children caused by lead exposure is reliably detected in children at = 4 years of age. Children's intelligence will be determined by conducting Wechsler Preschool and Primary scale of Intelligence. Children's blood will be taken from their fingers and analyzed by atomic absorption spectrometry.

**Sample Size.** About 228 study participants will be recruited from the policlinics from the chosen cities and districts.

**Data Analysis.** The statistical analysis will be carried out by STATA statistical package.

Based on the findings, the study team will prepare and send primary and secondary prevention recommendations to the Ministry of Nature Protection and the Ministry of Health of Armenia.

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## **Background Information/Literature Review**

### *Sources of lead and measurements of the exposure*

Lead (Pb) is a heavy and naturally occurring *grayish* metal. The atomic weight is 207.2 g/mol (1). It is toxic at all concentrations (2). Lead, due to its ubiquity, persistence and cumulative ability, contaminates food chain, wildlife and human beings making disruptive impact on the environment and human health. This heavy metal cannot be eliminated or changed into a less toxic form (3).

The main sources of lead are air, water, food and soil (1, 2, 4, 5, 6).

There are various sources of air contamination, such as waste combustion, coal, oils, steel and iron production, stationary sources, tobacco smoke, and lead-based paints (1, 2, 4, 5, 6). But the largest source of air contamination is combustion of leaded gasoline. Removal of lead from gasoline led to considerable decrease of air contamination and, as a consequence, decreased blood lead levels in the United States of America (USA) and European countries (4, 6, 7, 8).

Water born lead is an issue in areas of acidic soft water (4). And the main reason for that are solders and fixtures of the pipes. Particulate lead is possible to find in pipes during the transportation from reservoirs to the users (2). According to the USA Environmental Protection Agency (EPA) the maximum allowable level of lead in drinking water is 0.05 mg/liter (3).

Soil, house dust or contaminated dirt are also sources of lead (4). These sources are summarized in Figure 1.

There are different indicators of lead exposure. The amount of lead in blood is the main indicator of lead exposure (1, 4, 8). Lead exposure can also be evaluated by measuring the erythrocyte protoporphyrin (EP) (1). A decrease of enzyme activity results in an increase

of EP in the red blood cells. However, recent data indicate that the EP level is not sufficiently sensitive at lower levels of BLL and is not useful as a screening test (9). Other methods of assessment of lead exposure could be measurement of the lead amount in teeth or bones by X-ray fluorescence techniques (1).

### *Lead Toxicity*

Lead is harmful for human body even in very small amounts (3). The ingested, inhaled or absorbed lead can damage every system of human body because it disrupts enzyme systems (4). On a molecular level, lead is able to inhibit or mimic the actions of calcium and interact with proteins. Lead is also responsible for disruption of enzymes that participate in hemo-synthesis (9).

The absorption and biologic outcome of lead in the human body depends on a variety of factors such as the physiological characteristics of the exposed person, nutritional status, general health status and age (9). Children and pregnant women can absorb up to 70% of ingested lead, while the adults generally absorb up to 20% (9).

The absorbed lead is placed in blood, soft tissues (liver, kidneys, lungs, brain, spleen, muscles, and heart) and mineralizing tissues (bones and teeth). The half-life of lead in adult blood is estimated to be from 28 days to 36 days (9). The half-life of lead in bones is estimated to be 20 years (2). During pregnancy and lactation and in case of some chronic diseases (e.g., osteoporosis) and other conditions lead can move from the bones to blood and soft tissues (9).

Effects of lead exposure differ by the time and the level of exposure. Short-term (acute) exposure to high concentrations of lead in humans damages the brain; it also injures kidney and gastrointestinal system. Long-term (chronic) exposure in human affects blood,

kidneys, nervous , reproductive and immune systems and the metabolism of Vitamin D (1, 4, 10, 11) (see Tables 1).

Lead affects the peripheral and central nervous systems. Lead encephalopathy, brain damage, neurological symptoms in workers, and slowed nerve transference in adults are registered (9, 13). Lead workers have 3-4 more times Alzheimer disease (13). Anemia is reported in adults and children (1). Lead can cause reproductive impairments in men (impotence and sterility, depression on sperm count ) and women (decreased fertility, abnormal menstrual cycles) ( 1, 3, 9). Human studies are uncertain regarding the correlation between lead exposure and increased cancer risk (1, 9).

#### *Children's susceptibility*

Children are more vulnerable and sensitive to lead exposure due to various reasons. Children's breathing zone corresponds to the height of car emissions which increases the risk of being exposed. The same lead concentration is much more harmful in children because of their less weight (6). Moreover, children are the most vulnerable population because they put their hands, toys and other things into their mouths (4). In addition, children's blood brain barrier is not mature because of "the lack of the high-affinity lead-binding protein in the astrocytes of the brain" (12).

Gastrointestinal absorption of lead in children is increased in case of dietary deficiency of iron, calcium, zinc, and ascorbate (4, 9, 12).

Furthermore, lead exposure may begin prenatally due to lead transportation through placenta (1, 2, 4, 7). Harmful effects include increased frequency of miscarriage, stillbirth, premature births and low birth weight (1, 3, 4, 6, 7). Human studies are uncertain regarding the correlation between lead exposure and birth defects (1, 4).

After the absorption lead is much more mobile in children's body than in adults. Moreover, after accumulating in the skeleton, the excretion of the lead is much slower in children (6). Lead interferes with a hormonal form of vitamin D responsible for multiple processes, including cell maturation and skeletal growth. Studies of children indicate opposite correlation between blood lead level (BLL) and vitamin D levels (9).

Chronic exposure to lead can slow children's cognitive development, growth and elevate hearing thresholds (1, 4, 10, 11, 12). Harmful effects also include a decreased mental ability of the infant, learning and behavioral problems (1, 4, 6, 7).

#### *IQ and its relation to lead exposure*

Lead affects the peripheral and central nervous systems of children (9, 13). "By substituting for calcium or zinc, lead interferes with the synaptic mechanisms of neurotransmitter release and mitochondrial energy metabolism. Lead activates Ca-dependant protein kinase C in brain micro-vessels, which can result in breakdown of the blood-brain barrier. In cases of high lead poisoning (>80 µg/dL), this breakdown can lead to abnormal barrier properties, increasing the permeability of brain vessels, which allows a large amount of plasma proteins, ions, and water to enter into the brain causing swelling" (12).

There is an inverse relationship between BLL and children's intelligence (16, 17). Children's intelligence can be measured through Intelligence Quotient (IQ) score. The stable ratio of mental age (MA) alienated by chronological age (CA) is the "Intelligence Quotient" (19). "IQ = (MA/CA) \* 100. The IQ is equal to 100 times the Mental Age divided by the Chronological Age" (14). There are several classifications of IQ (15) (see Appendix 1).

Inverse relationship between BLL and intelligence was described by Lamphear et al. (16) and Canfield et al. (17). They report about 2.0-5.5 point reduction in IQ for every 10-20 µg/dL increase in blood lead level in children. Changes in IQ are simultaneously shifting a



large number of children from the highest category intelligence into the mental retardation category (18) (see Figure 2). Chen et al (19), Calderon et al(20) and Fienberg et al (21) used Wechsler Intelligence Scale in their studies to measure children's IQ.

It is estimated that 3 points of decreased IQ in population is related to 28% increase of prevalence in high school dropouts, 25% increase of prevalence of poverty and 25% increase of prevalence of jailed men (17). Grosse et al mentioned that one unit increase in IQ was associated with 1.76% -2.38% increase in workers productivity in the USA during late 1970s (22). A small shift in average IQ in individuals has huge implications for the society; it can bring to an increased need for special education and services and significantly diminished intellectual capacity within population as a whole.

Thus, Public Health specialists consider lead exposure as an issue of great importance because of the absence of harmless level of lead concentration and ability of this element to accumulate and remain in the human body for a long period of time contributing to the problems of child's development (2).

#### *Lead Pollution and Exposure in Armenia*

Armenia is a mountainous country and due to the geographic position air pollutants do not disperse and maintain high levels in residential areas (23). There are three main sources responsible for lead pollution in Armenia : mining, means of transportation and industry (13).

In 1980-1990 the largest source of air contamination was the usage of the leaded gasoline (24, 25). In 1987 the traffic related emissions were equal to 66.7%. This figure decreased by 69% because of decreased traffic density and introduction of the unleaded gasoline in 1998 (30% of total sales) (23). Nowadays, in Armenia the use of leaded gasoline is not banned, and since 2003 the permissible norm is equal to 0.013 g/l (26).

Other sources of air contamination with lead in Armenia are waste combustion, smelters, stationary sources, industrial usage and tobacco smoke (24, 25).

The Armenian Law on Atmospheric Air Protection prescribes maximum permissible concentrations (MPCs) for anthropogenic lead related emissions which are inherited from the former Soviet Union. Armenian air quality standard is  $0.3 \mu\text{g}/\text{m}^3$  which is stricter than WHO standard of  $0.5 \mu\text{g}/\text{m}^3$ . Lead in the environment is not monitored on a regular basis, and current methods do not assure reliability of data (23). Indoor air is monitored very rarely and information about indoor lead concentration is very limited (23). Moreover, there is no special legislation for monitoring lead concentrations in the air.

According to National Environmental Health Action Plan (2002), “the highest total emissions of lead into the atmosphere are clearly in Yerevan” (24, 25, 27). “In the other regions of the country total lead emissions are many times less and are almost of the same level as in all regions” (24). Yerevan soil is contaminated by lead, copper, silver, zinc, chromium, nickel, molybdenum, cobalt. The main source of soil lead pollution is the transportation means (25, 27). According to the Center for Ecological Noosphere’s report (2003), there is an obvious correlation between lead pollution and intensive transport motion in Yerevan (28).

Lead concentrations of air in Yerevan exceed the national MPCs and WHO guidelines. In 1995, the air lead concentration in Yerevan was  $1.0\text{-}3.5 \mu\text{g}/\text{m}^3$  (22).

The study conducted by the Environmental Conversation and Research Center of the American University of Armenia (AUA) aimed to assess the lead pollution level of yard soils in Yerevan (29). About 1131 samples of yard soil were analyzed. Study has revealed that high concentrations of lead were everywhere in Yerevan. They exceeded the natural level of  $10\text{-}20 \text{ mg}/\text{kg}$  by 10-20 times. In some yards lead concentrations were approximately 10000-

55000 mg/kg. The most polluted district was Shengavit, the industrial part of the city and the less exposed region was Kentron (29).

A study conducted in Alaverdi reported that in Alaverdi the environment (soil) with three kilometers in diameter around the polymetallic smelter is polluted by heavy metals 20-40 times exceeding national MPCs for soil. The main factors of pollution are copper (32.5 times) and lead (16 times) (23, 30). Within a pilot study conducted by Petrosyan et al. in 2001 samples of soil, exterior and interior dust were collected and analyzed from Alaverdi and two mining towns Aghtala and Shamlugh (30). About 34% of soil samples and 77% of exterior dust samples in Alaverdi exceeded the USA EPA standard of 400 mg/kg (30). According to the results of that study, the main source of lead was the smelter located in the middle of Alaverdi; the lead concentrations in mining towns of Aghtala and Shamlugh were much lower (30).

According to some studies, the surface water of Armenia is also polluted by lead (12). About 100 tons of heavy metals enter the Lake Sevan every year. The River Hrazdan is also contaminated by heavy metals. Fish and crops irrigated from these water reservoirs are also sources of lead exposure (12).

The Institute of General Hygiene and Occupational Medicine of Yerevan conducted a case-control study on BLL in 1992 and in 1996 (12, 23). The cases were 54 children from Byureghavan, which is a lead crystal industry center. The results were compared with the results of 218 children from different areas of Yerevan. The mean lead concentrations were 10 µg/dL for the children from Byureghavan and 65 µg/dL for the children from Yerevan. BLL of children from Byureghavan matched the lowest-observed-effect levels which could bring changes in the central nervous system. This Institute also conducted study of lead concentration in indoor air in schools 300 meter far from the crystal factory. The

concentration range was 0.3-1.0  $\mu\text{g}/\text{m}^2$ . The lead concentration in settled dust samples from indoor environment indicated a range 115-1700  $\mu\text{g}/\text{m}^2$  (12, 23).

There is very limited information about studies conducted in Armenia regarding effects of lead exposure on human health and especially on children who are more susceptible. Even more, there are no studies exploring relationships between environmental lead contamination, children exposure and their intelligence level

### **Specific Aims**

The main aim of this study is to measure BLL and IQ levels in children to see if yard soil lead contamination leads to increased BLL, therefore low IQ and explore the sources and pathways of lead exposure among Armenian children. After study is conducted recommendations will be developed on the prevention strategies for children's protection from lead exposure.

The main research question of the proposed study is :

- Does lead contamination in the environment, particularly yard soil, lead to lead exposure in children measured by BLL?

The specific objectives of this study are:

- To determine blood lead levels and IQ scores in 4 years old children
- To determine the association between environmental lead exposure and children's decreased intelligence
- To explore differences in mean BLL and IQ scores between children who live in Shengavit and Kentron districts of Yerevan, Alaverdi and Aghtala-Shamlugh.

## Methodology

### *Study design*

The analytical cross-sectional study design is proposed for this study.

1. X<sub>1</sub> O Shengavit
2. O Kentron (control)
3. X<sub>2</sub> O Alaverdi
4. O Aghtala -Shamlugh (control)

In X<sub>1</sub> and X<sub>2</sub> soil is contaminated by lead: in Shengavit yard soil is contaminated because of lead-acid car batteries and in Alaverdi because of the polymetallic smelter (24, 25, 30). Results from Shengavit will be controlled by Kentron district of Yerevan, where contamination by lead is low. Results from Alaverdi will be controlled by Aghtala-Shamlugh mining cities where yard soil lead levels are within accepted standards. The data from Shengavit will be compared with data from Alaverdi to check whether there are any differences in mean BLL or IQ scores. This could help to understand if the sources and pathways of lead exposure are similar in two cities where lead contamination is a result of different activities. The assumption is that the only source of lead exposure is lead in the yard soil as children are exposed to yard soil rather than general soil (30).

### *Study population*

The study population will include children aged 4 years old, born and living in Alaverdi, Aghtala-Shamlugh and Shengavit and Kentron districts of Yerevan. Children are the most vulnerable to lead exposure, that is why this study will focus on them. Rationale for choosing this particular age group is that decreased IQ score in children caused by lead exposure is reliably detected in children at = 4 years of age (19, 22).

The names of children will be obtained from the polyclinics of four study areas. According to the preliminary research, about 512 children were born in Alaverdi, 45 children in Aghtala-Shamlugh, 845 children in Kentron district and approximately 1021 children in Shengavit district of Yerevan in 2002 (32). Children's names will be listed and numbered. Later through systematic random sampling participants will be chosen from each city. The starting point and sampling interval will be determined after obtaining the lists of 4 years old children

Inclusion criteria are:

- Children born and residing in Alaverdi, Aghtala-Shamlugh and Shengavit and Kentron districts of Yerevan
- Children of 4 years old

Exclusion criteria are:

- Refusal to participate in the study
- Children born in other districts but residing in Alaverdi, Aghtala-Shamlugh and Shengavit and Kentron districts of Yerevan

### *Sample size*

Every time, the two of the population groups will be compared.

To determine sample size for two equal independent samples the following formula is used (33):

$$n = 2s^2 \frac{[Z_{1-\alpha/2} + Z_{1-\beta}]^2}{(\mu_1 - \mu_2)^2}$$

Where,  $s$  is the estimated standard deviation (assumed to be equal for each group) and equal to 1.6 (34) (see Table 2).

The WHO upper estimate for Armenia is 4.4  $\mu\text{g/dL}$  ( $\mu_1$ -estimated mean), the WHO lower estimate for Armenia is 3.1  $\mu\text{g/dL}$  ( $\mu_2$ -estimated mean) (34). For the 95% confidence interval  $Z_{1-\alpha/2}=1.96$  and for 80% power  $Z_{1-\beta}=0.842$ .

The calculated sample size is equal to 24 in each group. The literature suggests a response rate of 39% (35). Therefore, each group will include 61 participants. The appropriate number of 4 years old children in Aghtala and Shamlugh is 45, therefore all of them will be asked to participate. Thus, the estimated sample size is equal 228.

This number of children in each group is required to detect a difference of 1.3  $\mu\text{g/dL}$  blood lead between the control and exposed groups.

### *Variables*

Dependent variables or outcome variables of the proposed research are the BLL and IQ score. The BLL will be used for measuring the lead exposure in children and IQ will be used for measuring children's intelligence. BLL and IQ are continues variables.

The independent variable is the place of residency, it is a categorical variable.

The literature suggest that child's sex, mother's level of education, parent's employment, mother's age at birth, father's age at birth, number of live births previous to the sampled child could be confounders (19, 21). These variables will be assessed:

1. child's sex will be measured a binary variable (female/male);
2. mother's level of education, will be measured as an ordinal variable;
3. parent's employment, will be measured as a nominal variable;
4. mother's age at birth is continues variables;
5. father's age at birth is continues variables;
6. number of live births previous to the sampled child is continues variables.

### *Study instrument*

The Wechsler Preschool and Primary scale of Intelligence (WPPSI) (31) IQ testing form will be used for assessing children's IQ\*. A psychiatrist will administer the WPPSI and interpret it. The WPPSI includes six Verbal and five Performance subtests. The eleven subtests are information, animal house and animal house retest, vocabulary, picture completion, arithmetic, mazes, geometric design, similarities, block design, comprehension, and sentences (31). Verbal and Performance IQs will be scored based on the results of the testing, and then a composite Full scale will be computed (31).

The WPPSI test will be translated into Armenian and pre-tested.

### *Data collection*

Investigation of BLL and determination of 4 years old children's IQ will be conducted in polyclinics by trained examiners.

A laboratory assistant from the National Institute of Standards Testing Laboratory will take blood samples from these children in the polyclinics. Minimum of 200 uL and maximum of 500 uL blood will be taken from fingers of 4 years old children and collected in lead-free containers (35). For Fingerstick Collection Protocol see the Appendix 2.

Blood samples will be sent to the laboratory of the National Institute of Standards Testing Laboratory. Blood will be analyzed by atomic absorption spectrometry (37). It is important to ensure that all materials used are free of lead contamination; laboratory work must be done in a clean environment avoiding contamination by lead in the air or dust during the analysis; the laboratory must run regular quality-control samples for properly functioning equipment and operators' use of the correct techniques (34).

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\* WPPSI will be obtained when the proposal gets funding.



A psychiatrist will test the children's IQ through WPPSI. Test administration will last 60-90 minutes (31).

In addition, during the meeting with mothers, the project assistant will collect information on place of residency, mother's level of education, parent's employment, mother's age at birth, father's age at birth, number of live birth births previous to the sampled child (19, 21). The instrument for collecting demographic information is presented in the Appendix 3.

Collected data will be double entered into SPSS statistical software (version 11.0) and cleaned for the analysis. The cleaned data set will be transformed into STATA statistical package (version 7.0) for further analysis.

### *Data Analysis*

In order to identify associations between dependent and independent variables the following methods will be used:

- Descriptive statistics to describe the basic features of the data
- Independent t-test to compare means between 2 groups at a time
- Multiple Linear Regression Model which will allow to determine the associations between the dependent and independent variables statistically controlling for possible confounding factors.

### **Limitations of the study**

There are several possible limitations that have to be considered.

Selection bias - Selection of study participants from the polyclinics could introduce a selection bias in case if some children are not registered in the polyclinics. Possible high

nonresponse rate because of blood testing in children also could be a reason for selection bias.

Information bias – Some information bias could be in case if assistant of laboratory or psychiatrist will incorrectly perform IQ test or determination of BLL. These will bring to misclassification of results.

Instrumentation bias – Instrumentation bias could be because of absence of validated IQ testing instrument in Armenian and trained specialists in Armenia.

### **Time Frame**

The duration of the study is expected to be 15 months (see Appendix 4). During the first 2 months a preparatory work will be done that includes hiring the necessary personnel.

Then (from the 3<sup>rd</sup> month till the 14<sup>th</sup> month), the project assistant will arrange meetings with parents. Later laboratory assistant will take the children's blood samples and the same day will refer to laboratory for investigation (from the 3<sup>rd</sup> month till the 14<sup>th</sup> month). Each meeting, sample taking, sending of samples to laboratory and transportation will take an hour and a half. Psychiatrist will examine 4 years old children and assess their development (from the 3<sup>rd</sup> month till the 14<sup>th</sup> month).

The project assistant will obtain results of analysis (from the 3<sup>rd</sup> month till the 14<sup>th</sup> month); will do data entry from 13<sup>th</sup> month till 15<sup>th</sup> month of the project implementation. After all, the project coordinator will perform data analysis (from 13<sup>th</sup> month till 15<sup>th</sup> month). The project coordinator will prepare and present the Final report and Recommendations by the end of the 15<sup>th</sup> month.

### **Personnel responsibilities**

The program personnel include a program coordinator, an assistant, 2 psychiatrists, 2 laboratory assistants, 2 nurses from polyclinics, accounting consultant and a driver.

The program coordinator is responsible for overseeing the study, management and administrative duties. The program coordinator will perform data analysis and will be responsible for preparation of the final report and recommendations.

The project assistant will be responsible for data collection and data entry. S/he will also assist in ongoing daily activities.

Nurses that will be hired for the project from polyclinics will assist for the selection of the study population. Laboratory assistants will take blood samples from children. Two psychiatrists will conduct IQ testing.

The accounting consultant will be in charge of accounts and financial statements preparation. The driver assistant will be responsible for transportation.

### **Budget**

The estimated expenses for implementation of the proposed study amount to **\$35,889**. Out of this amount about 74% are for personnel salaries. The operational costs are covered by 21% of the total expenses and 5% of the total budget covers unexpected expenditures (see Appendix 5).

### **Ethical considerations**

The student investigator will implement this study only after getting the approval of the Institutional Review Board/Committee on Human Research of the American University of Armenia .

The unique identifiers given to each participant will assure the confidentiality of the subjects. Only study team will have an access to the identification numbers of participants.

The program assistant will present a written consent form (see Appendix 6) to each parent. The consent form includes information about the aim of the study, the conductors of the study, procedures, risks, benefits, confidentiality and anonymity assurance, voluntariness and whom they can contact in case of questions or non-respectful attitude.

### **Conclusion**

After the project implementation, the final report and primary and secondary prevention recommendations will be shared with the Ministry of Health, Ministry of Nature Protection and other interested stakeholders.

Based on the findings of the proposed study further investigation in this field may be necessary.

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**Table 1. Lowest Observed Effect Levels for Lead-Related Health Effects (Klaasen, 1996; Sullivan and Kriger, 1992)**

<b>Blood Lead Concentrations (<math>\mu\text{g/dL}</math>)</b>		
Effect	Children	Adults
<i>Gastrointestinal</i>	50	50
<i>Nerurological</i>		
Encephalopathy	80-100	100-120
Hearing deficit	20	30
IQ deficit	10-15	---
In-utero effects	10-15	---
Peripheral	40	40
<i>Neuropathy</i>		
<i>Hematological</i>		
Anemia	80-100	80-100
<i>Renal</i>		
Nephropathy	40	40
Vit.D metabol.	<30	---
<i>Reproduction</i>	---	40

Source: Petrosyan V. Lead contamination and exposure issues in the US and Armenia, University of Idaho MS Thesis, Moscow, Idaho (2000).



**Table 2. Blood lead levels in children 4 years old, by subregion.**

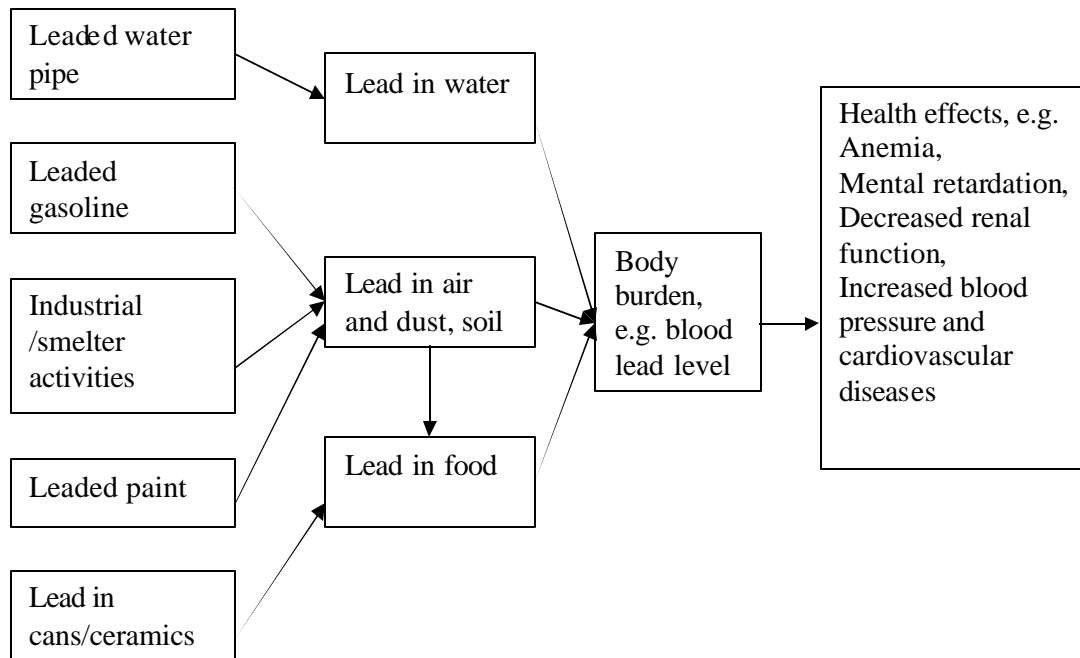
<b>Blood lead measurements</b>	<b>Subregion</b>		
	<b>EUR A</b>	<b>EUR B</b>	<b>EUR C</b>
Subregional mean	1.9a	<b>3.1</b>	4.3
BLL	2.9b	3.9	4.3
(µg/dl)	3.8c	<b>4.4</b>	6.4
Standard Deviation	1.5	<b>1.6</b>	2.4
(µg/dl)			
Children with >5	3.3	11.5	48.6
µg/dl blood lead (%)	9.4	28.2	42.8
	24.9	38.7	61.0
Children with >10	0	0.1	21.5
µg/dl blood lead (%)	0.1	1.6	16.9
	0.9	3.2	31.7
Children with >20	0	0	6.2
µg/dl blood lead (%)	0	0	4.1
	0	0	11.0
Countries for which recent data are available	Croatia1 Czech Republic2 Finland3 France4 Germany5 Greece6 Italy7 Portugal8 Spain9 Sweden10 UK11	Armenia12 Bulgaria13 Poland14 Turkey15 Yugoslavia16	Hungary17 Russian Federation18

a lower estimate, assumes lead prevention programs had been in force in all countries since 1998;

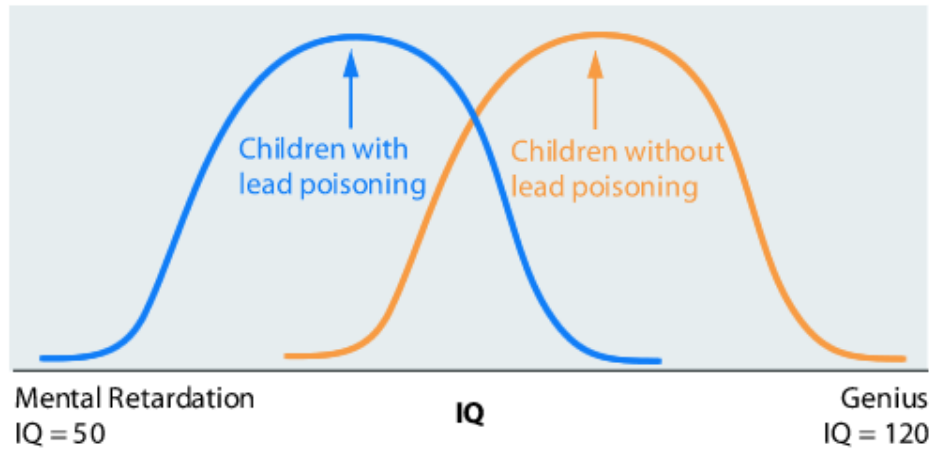
b best estimate, based on actual country data;

c upper estimate, assumes no lead prevention activity.

Source: Fewtrell L, et al. Lead assessing the environmental burden of disease at national and local levels. Environmental Burden of Disease Series, No. 2 Available from: URL: [www.who.int/quantifying\\_ehimpacts/publications/en/ebd8chap4.pdf](http://www.who.int/quantifying_ehimpacts/publications/en/ebd8chap4.pdf).

**Figure 1. Sources of lead and health effects**

**Figure 2. Lead-induced shift in population IQ.**



Source: Children's Environmental Health. Childhood Lead Poisoning. Available from:  
URL: [www.children'senvironmentalhealthinitiative.htm](http://www.children'senvironmentalhealthinitiative.htm)

## Appendix 1

### IQ classifications:

Terman's classification:

<b>IQ Range</b>	<b>Classification</b>
140 and over	Genius or near genius
120-140	Very superior intelligence
110-120	Superior intelligence
90-110	Normal or average intelligence
80-90	Dullness
70-80	Borderline deficiency
Below 70	Definite feeble-mindedness

Wechsler classification:

<b>Classification</b>	<b>IQ Limits</b>	<b>Percent Included</b>
Very Superior	128 and over	2.2
Superior	120-127	6.7
Bright Normal	111-119	16.1
Average	91-110	50
Dull Normal	80-90	16.1
Borderline	66-79	6.7
Defective	65 and below	2.2

Classification of mental retardation in the USA:

<b>IQ Range</b>	<b>Classification</b>
50-69	Mild
35-49	Moderate
20-34	Severe
below 20	Profound

Source: IQ Comparison Site. IQ basics. 2002-2004. Available from: URL:  
[www.IQBasics.htm](http://www.IQBasics.htm).

## Appendix 2

### Fingerstick Collection Protocol

1. Fill out the name of each child.
2. Open all equipment before holding the patient's hand. Open plug from top of microtainer.
3. Wash, rinse, and dry the patient's hand; wrap it.
4. Scrub the middle or ring finger with an alcohol pad.
5. Blot the sampling area once with a dry gauze pad and massage hand to increase blood flow.
6. Puncture the side of the finger with a sterile and disposable lancet. Immediately turn the child's hand over so that the blood drop forms toward the floor. Gently massaging the finger will promote better blood flow.
7. Absorb the first drop of blood with the corner of gauze pad.
8. Hold Microcontainer Tube vent hole in upward position.
9. Allow blood drops to fall into the tube and continue gently massage finger.
10. Fill tube desired level (minimum of 200 uL and maximum of 500 uL).
11. Treat collector as medical waste and discard in proper container. Place used lancets in puncture proof container.
12. Invert the tube several times to ensure adequate mixing of blood and the anticoagulant.
13. Write child's last name on the Tube.
14. Place tubes inside plastic bag with biohazard warning label.
15. Place inside the micromailer to reduce exposure to light.
16. Mail blood specimens as soon as possible to the Laboratory.

Source: Wadsworth Center. Blood Lead. Fingerstick Collection Protocol. Available from: URL: <http://www.wadsworth.org/testing/lead/fingerstick.htm>

### Appendix 3

#### Mother's Questionnaire

Data of interview (dd/mm/yy) \_\_\_\_\_

Interviewer \_\_\_\_\_

Data Entry # \_\_\_\_\_

START TIME: \_\_\_\_\_

1. Child's sex

1. Female
2. Male

2. Child's date of birth \_\_ \_\_ \_\_  
DD MM YY

3. Place of residency \_\_\_\_\_

5. What is your completed educational level?

1. School (8 years or less)
2. School (10 years)
3. College
4. Institute/University
5. Post-graduate
6. Other \_\_\_\_\_

6. Where did you work during the last 15 years?

JOB TITLE	DURATION	BRIEF DESCRIPTION OF WHAT YOU DO/DID

7. Where did the father of the child work during the last 15 years?

JOB TITLE	DURATION	BRIEF DESCRIPTION OF WHAT YOU DO/DID

8. What was your age at birth?  
Years old \_\_\_\_\_

9. What was the father's age at birth?  
Years old \_\_\_\_\_

10. How many live births did you have previous to this child?  
Record number \_\_\_\_\_  
88. Don't know   
99. Refused to Respond

Thank you for your time and effort!

END TIME: \_\_\_\_\_





## Appendix 5

### Budget

	\$	Duration	Subtotal
<b>Personnel</b>			
Program coordinator	\$400 per month	15 months	\$6000
Program assistant	\$300 per month	15 months	\$4500
Psychiatrist	\$200	12 months*2	\$4800
Assistant laboratory	\$150	12 months*2	\$3600
Nurse	\$150	12 months*2	\$3600
Accounting consultant	\$15 per day	60 days	\$900
Driver	\$200	15 months	\$3000
<b>Subtotal</b>			<b>\$26400</b>
<b>Operational costs</b>			
Blood analysis	\$10	228 blood samples	\$2280
IQ test buying	\$1000		\$1000
Communications	\$40	15 months	\$600
Office supplies	\$30	15 months	\$450
Car rental/maintenance	\$150	15 months	\$2250
Fuel	\$80	15 months	\$1200
<b>Subtotal</b>			<b>\$7780</b>
<b>Total</b>			<b>\$34180</b>
Unexpected expenses	5% of the total		\$1709
<b>Grand Total</b>			<b>\$35889</b>

## Appendix 6

### WRITTEN CONSENT FORM FOR PARENTS

#### **Introduction**

Hello, my name is Emma Anakhasyan and I am a graduate student of the Master of Public Health Program at the American University of Armenia.

I am performing a study with the purpose to explore if the environmental lead exposure causes a decrease of children's intelligence and a difference in 4 years old children's intelligence living in Alaverdi, Aghtala - Shamlugh, Shengavit and Kentron.

#### **Procedures**

You and your child have been selected to participate in the study, because your child's name was randomly selected among children from the selected cities.

In case you agree to participate in the study, minimum of 200 uL and maximum of 500 uL blood will be taken from your child's finger. Also, intelligence testing form will be used for assessing your child's intelligence. Blood and intelligence testing will take place only once. intelligence testing will last 60-90 minutes. We will also collect demographic data.

You are free to ask questions and stop the testing any time you want.

Your participation in this study is of great value. The information given by you will be very useful for this study.

#### **Risks/Discomforts**

There is a risk associated with the participation in this study. The child's finger will be pricked to take a blood sample which can be discomfort for child.

#### **Benefits**

You will learn whether your child is exposed to lead and whether the child has normal intelligence. Your participation will also help to explore the environmental lead exposure and relationship with child's intelligence. Moreover, the results of this study will contribute to the research in this field and to the development of appropriate prevention strategies in order to protect children.

#### **Confidentiality**

All information regarding you and your child will be kept confidential and will be used only by the research team in performing final analysis.

#### **Voluntariness**

Your participation in the study is voluntary. You can refuse to participate in the study at any time you want.

Your refusal to participate or your withdrawal from the study at any time will not have any negative consequences and will not affect medical care your child receives.

#### **Whom to contact**

You can ask the person in charge listed below any questions you may have about this research study. You can ask questions in the future if you do not understand something about the study. The person in charge of the study will answer all your questions.

Emma Anakhasyan (+37410) 52 36 04

If you want to talk to anyone about the research study because you feel you have not been treated fairly or think you have been hurt by joining the study you should contact the research team at (+374 10) 52 36 04.

If you agree to be in this study, please sign your name below.

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Subject's signature

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Witness to Consent Procedures\*

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Signature of Investigator

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Date

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