Post-Remediation Blood Lead Level Study in Shoubra El Kheima, Qalyoubia

Livelihood and Income from the Environment Program Lead Pollution Clean-up in Qalyoubia

October 10, 2007

This publication was produced for review by the United States Agency for International Development. It was prepared by Millennium Science and Engineering Inc., in cooperation with Chemonics International.

Post-Remediation Blood Lead Level Study in Shoubra El Kheima, Qalyoubia

Livelihood and Income from the Environment Program Lead Pollution Clean-up in Qalyoubia

DISCLAIMER

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

.

CONTENTS

EXECUTIVE SUMMARY **V**

INTRODUCTION **1**

RATIONALE FOR THE STUDY **3**

HYPOTHESIS **4**

GOALS AND OBJECTIVES **4**

METHODOLOGY **5**

Type of the Study 5
Review of the 2004 BLL Study Database and Report 5
Study Site 9
Target Population 10
Data Collectors 11
Sampling Methods and Sample Size 11
Missing Data 12
Data Collection 13
Quality Control 13
Laboratory Quality Control 13
Data Quality Control 14
Study Period 14
Study Activities 14
Data Analysis 15
Ethical Considerations 16
Maintenance of Records 16
Institutional Responsibilities and Agreements 16

RESULTS **16**

Description of the Study Population 16
BLL for the Population in the Study Area 18
BLL for Children in the Study Area 20
BLL for Adult Females in the Study Area 24
BLL for Adult Males in the Study Area 27

DISCUSSION **30**

CONCLUSIONS **32**

Recommendations **34**

REFERENCES **35**

APPENDICES

APPENDIX A: Location of Sites Remediated In Shoubra El Kheima 37

APPENDIX B: Description of the Remediated Secondary Lead Smelters 38

APPENDIX C: Laboratory Techniques 40

APPENDIX D: Questionnaire Used for the Purpose of the Study 41

APPENDIX E: Consent form used for the Purpose of the Study 49

APPENDIX F: Lead and Its Impact on Human Health 51

Figures

Figure 1: Spatial Division of the Study Area into Operational Units (OU) According to the 2004 Study. 6

Figure 2: Operational Units Based on Lead Concentration in Soil and Dust that has been used in the Presentation of Results in this Report. 7

Figure 3: Soil Lead Contamination Levels and Location of Samples Collected in 2003 10

Figure 4: Percentage of Different Population Groups with BLLs Exceeding 10 µg/dL comparing the 2004 and 2007 Studies 30

Tables

Table (1) Estimated BLL (µg/dL) Results by OU Presented in the 2004 BLL Study Report and by OU based on lead Concentration in soil and dust 8

Table (2) Revised Estimation of Mean BLL (µg/dL) by Subject Type by OU Presented in the 2004 BLL Study and the Revised Estimation Based on Lead Concentration in Soil and Dust 8

Table (3) Revised Estimation of the Percentage of Population with BLL > 10 µg/dL, by OU Presented in the 2004 Study and the Revised Estimation Based on Lead Concentration in Soil and Dust 9

Table (4) Study Groups Recruited in this Study 12

Table (5) Status of the 2004 Study Subjects Regarding Participation in the 2007 Study 13

Table (6) Characteristics of the Study Families 17

Table (7) Estimated BLL (µg/dL) by OU Comparing the 2004 Study and the Current 2007 Study 18

Table (8) Estimated Percentage of the Population with BLL > 10 µg/dL by OU comparing the 2004 Study and the current 2007 Study 19

Table (9) Percent change in BLL Between 2007 and 2004 Studies by OU 20

Table (10) Estimated BLL by OU for Children Comparing the 2004 Study and the 2007 Study 21

Table (11) Estimated Percentage of Children with BLL > 10 µg/dL, Comparing the 2004 Study to the 2007 Study by OU 22

Table (12) Percent Change in BLL (µg/dL) among Children Between 2004 and 2007 Studies by OU 23

Table (13) Risk factors for Exposure to Lead among Children Comparing the 2004 and 2007 Studies 24

Table (14) Estimated BLL (µg/dL) for Adult Females Comparing the 2004 Study and the t 2007 Study by OU 25

Table (15) Estimated Percentage of Adult Females with BLL > 10 µg/dL, by OU Comparing the 2004 Study and the 2007 Study by OU 26

Table (16) Percent Change in BLL among Adult Females between the 2004 and 2007 Studies by OU 26

Table (17) Estimated BLLs (µg/dL) for Adult Males Comparing the 2004 Study and the 2007 Study by OU 27

Table (18) Estimated Percent of Adult Males with BLL > 10 µg/dL Comparing the 2004 Study to the 2007 Study by OU 28

Table (19) Percent Change in BLLs among Adult Males Between the 2004 and 2007 Studies by OU 29

Table (20) Medical Management of Confirmed Lead Toxicity in Children 56

ACRONYMS

Chemonics	Chemonics International
BLL	Blood Lead Level
EEAA	Egyptian Environmental Affairs Agency
EEPP	Egyptian Environmental Policy Program
GOE	Government of Egypt
LIFE	Livelihood and Income from the Environment Program
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency

UNITS OF MEASUREMENT

mg/kg	milligram per kilogram
m^2	square meter
µg/dL	microgram per deciliter

EXECUTIVE SUMMARY

Lead contamination is a common problem in developing countries such as Egypt. It is frequently associated with the use of leaded gasoline and industrial smelting operations. Lead is considered a toxin that has no biological function, but causes adverse health effects through inhalation, ingestion, and dermal absorption.

Children under seven years of age and fetuses are particularly susceptible to lead toxicity because of their developing nervous system, small body mass, and they have less ability to excrete lead from their bodies (Amira et al, 2000). In general, if adults and children swallow the same amount of lead, a higher percentage of the lead will enter the blood stream of children.

The World Health Organization (WHO) and the U.S. Center for Disease Control (CDC) have set a blood lead concentration of 10 micro grams per deciliter (µg/dL) as the level of concern. The overall percentage of children with a blood lead level (BLL) exceeding 10 µg/dL in any population should be less than 5% (ATSDR, 1999).

Elevated lead effects on children include neurobehavioral manifestations such as decreased intelligence, developmental delay, and coma. A fetus could suffer decreased gestational age and weight, and miscarriage. Among adults, manifestations range from hypertension to encephalopathy at high BLLs (USEPA, 2003). The biokinetics and toxic effects of lead differ according to gender. For example, during pregnancy and breast feeding, lead stored in the bones of females may re-enter their blood and contribute to adverse health effects on both the mother and her baby (ATSDR, 1999).

The United States Agency for International Development (USAID) has funded several projects in Egypt to help understand the lead pollution problem and to develop methods to reduce its impact on the population. The activities of USAID-funded projects are described in the following:

- The threat of multimedia lead exposure was estimated through the use of a Comparative Risk Analysis Study in 1994. The study concluded that lead contamination was one of Egypt's most serious environmental problems. This study resulted in the development of a Lead Exposure Abatement Plan (LEAP) and Lead Smelter Action Plan (LSAP). The LEAP further documented sources of human exposure to lead and potential mitigation measures. The LSAP defined activities to reduce the threat of secondary lead smelters.

- The Cairo Air Improvement Project (CAIP) began implementation of the LSAP in 1997. The activities conducted by the CAIP supported dialogue between the Government of Egypt (GOE) and the smelter owners to relocated and upgrade smelters, and to reduce the demand for lead-based products. In addition, the CAIP investigated contaminated smelter sites following relocation in Shoubra El Kheima, Qalyoubia.

- The Egyptian Environmental Policy Program (EEPP) was initiated in 2003 to further the studies completed by the CAIP. The EEPP was responsible for working with the GOE (i.e., the Egyptian Environmental Affairs Agency and the Governorate of Qalyoubia) to develop a program that would prohibit smelter operations in populated areas and to relocate those smelters using cleaner production technologies. In addition, EEPP developed procedures for the remediation of lead smelter sites in Shoubra El Kheima.

- In 2004, the Lead Pollution Clean-up in Qalyoubia Project (LIFE-Lead) was initiated as a component of the Livelihood and Income from the Environment Program. LIFE-Lead's focus was to remediate seven secondary lead smelters in the Eastern District of Shoubra El Kheima to remove the sources of lead contamination. During the course of the investigative work, two schools and a medical center were identified as having been impacted by lead smelter operations in the area and were subsequently remediated by the project. In addition to the remediation activities, the project has implemented a Community Awareness and Participation Program to educate the population on the hazards of industrial pollution, with emphasis on lead, and to communicate methods of preventing exposure to industrial pollutants.

In addition to the activities listed above, the EEPP conducted a Baseline Human Health Risk Assessment for receptors within a 1-kilometer radius of the former Awadallah Secondary Smelter No. 1 exhaust stack. The purpose of the risk assessment was to assess the health effects on the population due to the operation of the smelter. The assessment was specific to the Awadallah Secondary Lead Smelter No. 1 and excluded the six additional smelters in the area that were remediated by LIFE-Lead. This assessment concluded that a significant number of children and adults living in the area were at risk from lead exposure and that the exposure approximated poisoning. The level of exposure and risk was stated as requiring immediate actions including medical intervention.

In early 2004, the EEPP completed an Epidemiological Study in collaboration with the Egyptian Ministry of Health and Population to establish a baseline to establish BLLs in the population of Shoubra El Kheima living within 1-kilometer of the former Awadallah Secondary Lead Smelter No. 1 exhaust stack. Blood samples were collected from 284 subjects in 86 residences within the study area. The results of the study showed that 66.7% of men, 63.4% of women, and 48.9% of children less than seven years of age in the study area had BLLs higher than 10 µg/dL. The maximum BLL in the study area was 41 µg/dL and the mean was 13.7 µg/dL.

The EEPP Study indicated that the elevated BLLs were associated with lead contamination in soil and dust in the study area (EEPP, 2004) The Epidemiological Study concluded that there was a substantial risk to those living near secondary lead smelters in Shoubra El Kheima and recommended that the sites should be immediately remediated to protect residents from lead hazards.

LIFE-Lead conducted a BLL Study during the late spring of 2007 within the 2004 Study area. The purpose of the 2007 Study was to compare the current BLLs to those determined in the 2004 Study. In order to perform a statistically viable comparison, the 2007 Study contacted those individuals that participated in the 2007 Study. Approximately 75% of the 2004 participants were successfully recruited for the 2007 Study. The total participants included 133 children, 82 adult females, and 69 adult males. The 25% of participants that were not available from the original survey were replaced by another family or an age/sex matched subject from the nearest residence who has resided in the study area for at least 12 months.

The results presented in this study are reflective of the remediation and community activity efforts of LIFE-Lead. Between the time of the 2004 Study and the 2007 Study, the BLLs higher than 10 µg/dL for men dropped from 66.7% to 15.9%, from 63.4% to 8.5% for women, and from 48.9% to 20.3% for children under the age of seven. The maximum BLL in the study area dropped from 41.0 µg/dL to 33.6 µg/dL and the mean BLL dropped from 13.7 µg/dL to 6.5 µg/dL when comparing the 2004 and 2007 Studies.

The results of the 2007 Study demonstrate significant improvement to the health and quality of life of the population living near the smelters due to the remediation of the secondary lead smelters and the community activities. However, the lead levels in dust and soil on streets and in common public areas is still high and needs to be remediated to further protect the residents.

INTRODUCTION

Lead is a widespread environmental contaminant found in air, drinking water, soil, canned food, beverages, and paint. Lead is considered a toxin that has no biological function but causes adverse health effects (US-EPA, 2003). It can enter the body through inhalation, ingestion, and dermal contact. Children below seven years of age and fetuses are particularly susceptible to lead toxicity because of their developing nervous system, small body mass, and they have less ability to excrete lead from their bodies (Amira et al, 2000). In general, if adults and children swallow the same amount of lead, a higher percentage of the amount swallowed will enter the blood in children than in adults. The World Health Organization (WHO) and the U.S. Center for Disease Control (CDC) have set a blood lead concentration of 10 micro grams per deciliter (µg/dL) as the level of concern. The overall percentage of children with a blood lead level (BLL) exceeding 10 µg/dL in any population should be less than 5% (ATSDR, 1999).

Effects of lead on children include neurobehavioral manifestations such as decreased intelligence, developmental delay, and coma. A fetus could suffer decreased gestational age, weight, and miscarriage. Among adults, manifestations range from hypertension to encephalopathy at high BLLs (US-EPA, 2003). The biokinetics and toxic effect of lead differ according to gender. For example, during pregnancy and breast feeding, lead stored in the bones of females may re-enter their blood and contribute to adverse health effects on both the mother and her baby (ATSDR, 1999).

In Egypt, studies were conducted to estimate the BLL among children and some occupational groups in Shoubra El Kheima. The blood level for children living in Shoubra El Kheima was between 7.8 and 39 µg/dL compared to blood lead levels between 4.5 and 12.1 µg/dL for children living in the Dokki area of Cairo which was used as a control area (Amira et al, 2001 and Salem et al, 2000).

The private sector lead smelting industry in the Cairo metropolitan area has traditionally been located in the northern Cairo suburb of Shoubra El Kheima, Qalyoubia which is a well known industrial-residential area in Greater Cairo. Most of the environmental lead contamination (71.4%) coming from stationary sources (i.e., non-mobile sources) in 2001 was attributed to the secondary lead smelting industry in this area (EEPP, 2003).

Several United States Agency for International Development (USAID)-funded analyses have helped understand lead pollution in Egypt and the potential for reducing it. The threat of multimedia lead exposure was first estimated through a comparative risk analysis effort in 1994. This study ranked lead contamination as one of the country's most serious environmental problems. The Lead Exposure Abatement Plan (LEAP) further documented sources of human exposure to lead in Egypt and potential mitigation measures. A separate Lead Smelter Action Plan (LSAP) defined activities to reduce the threat of secondary lead smelters.

Beginning in 1997, the USAID-funded Cairo Air Improvement Project (CAIP) implemented the LSAP; which supported policy dialogue to relocate and upgrade smelters and to reduce demand for lead-based products, and investigated contamination at smelter sites following relocation and closure.

An early CAIP Study of secondary lead smelters in the Governorates of Cairo, Giza, and Qalyoubia indicated that there were 22 secondary lead smelters in the three targeted governorates. These 22 facilities represent the majority of secondary lead smelting operations in Egypt as the area was a major source for batteries used in secondary lead

smelting and most battery manufacturing operations were located within the three governorates.

The CAIP focused efforts in the area of Shoubra El Kheima, Qalyoubia, which has a population of approximately three million, and five major secondary lead smelters and two small secondary lead smelters as well as approximately 150 other ferrous and non-ferrous foundries. The Awadallah family owned three secondary lead smelters in Shoubra El Kheima and was responsible for an estimated 75 percent of the national lead smelting production (EEPP, 2003).

Lead smelter properties in Shoubra El Kheima were heavily contaminated with lead and other heavy metals. Lead concentrations of more than 60 percent by weight were found in soil samples during the CAIP investigations at one of the Awadallah sites.

Activities supporting the air objective of the USAID-funded Egyptian Environmental Policy Program (EEPP) further addressed contaminated smelter sites. The activities included methods to prohibit smelting activities in populated areas and requirements for remediation of contaminated sites in Shoubra El Kheima. Analyses under EEPP followed and deepened the knowledge of work previously completed by the CAIP.

The Awadallah Secondary Lead Smelters ceased operations in 2001 as the Government of Egypt (GOE) encouraged smelters to relocate to new industrial zones and install up-to-date technology to reduce emissions from the smelting process. Nevertheless, other smelters in the area continued to operate until late 2004. Since 2005, most of the smelter facilities in the area have been used for storage of lead products although fugitive dust continued to be dispersed through site operations resulting in further contamination of the area surrounding the smelters.

In 2002, the CAIP prepared a Preliminary Assessment of the Awadallah Secondary Lead Smelter No. 1 (CAIP, 2002). In 2003, the CAIP completed a more detailed soil and dust investigation of the Awadallah Secondary Lead Smelter No. 1 and provided the results in a Contaminant Assessment Report (CAIP, 2003). In addition to the Contaminant Assessment Report, a systematic soil and dust sampling program was also designed and completed within a 1-kilometer radius of the Awadallah Secondary Lead Smelter No. 1 exhaust stack by EEPP in 2003. The results of this sampling event are presented in a Site Investigation Report (EEPP, 2003a).

The results from both the Preliminary Assessment and Site Investigation studies were used by EEPP to prepare a Baseline Human Health Risk Assessment for receptors within the 1-kilometer radius of the Awadallah Secondary Lead Smelter No. 1 exhaust stack to assess the health effects of the operation of that smelter and excluded other smelters (EEPP, 2003b). The results of the EEPP Baseline Human Health Risk Assessment indicated that the Awadallah Secondary Lead Smelter No. 1 presented a multitude of health hazards to workers, nearby residents, and the environment. Human health risks were presented for receptors within a 1-kilometer radius of the Awadallah Secondary Lead Smelter No. 1 exhaust stack without differentiating between the various land uses. The risk assessment based on the IEUBK Model concluded that a large number of children are at risk from lead exposures and that it approximates poisoning and on that basis alone risk management actions should be undertaken including medical intervention.

Following the Baseline Human Health Risk Assessment; an Epidemiological Study was completed in collaboration with the Ministry of Health and Population that documented the BLLs of residents living within a 1-kilometer radius of the Awadallah Secondary Lead

Smelter No. 1 exhaust stack (EEPP, 2004). Blood samples were collected from 284 subjects in 86 homes within the study area. The results of the study showed that 66.7 percent of men, 63.4 of women, and 48.9 percent of children less than 7 years of age who live near that smelter have blood lead levels higher than 10 μg/dL. The maximum measured BLL was 41 μg/dL and the mean was 13.7 μg/dL in the study area.

The study indicated that the elevated BLLs were associated with lead contamination in soil and dust in the study area (EEPP, 2004). The Epidemiological Study concluded that there is substantial risk to those living near lead smelters in Shoubra El Kheima and that remediation activities should commence immediately to protect residents from the hazards of lead in the environment.

In January 2004, the Governor of Qalyoubia issued a decree that prohibited lead smelting in Shoubra El Kheima, followed by another decree that prohibited the use of the closed lead smelter sites in Shoubra El Kheima unless they were remediated.

To help solve this problem, the USAID and the GOE designed a lead clean-up component under the Livelihood and Income from the Environment Program (LIFE). The clean-up component is called LIFE-Lead Pollution Clean-up in Qalyoubia (LIFE-Lead). The overall goal of LIFE-Lead is to empower local residents in the polluted communities to improve their living conditions. The focus of the project was remediation of seven secondary lead smelter sites in Shoubra El Kheima including Awadallah Nos. 1, 2, and 3, Seoudi, El Mahy, Khaled Saad, and Osama Zakaria Secondary Lead Smelters in addition to two public schools, and a medical center (see Appendices A and B) . In addition to site remediation, the project includes activities in community involvement and public participation, communications, capacity building, and policy/legal support.

The remediation activities conducted by the project did not include off-site remediation of streets and public use areas. Secondary lead smelters which were the main source for the off-site lead contamination were properly remediated to stop the dispersion of lead contaminated dust and soil from the smelter sites. The remediation activities concluded in early 2007.

RATIONALE FOR THE STUDY

The previous uncontrolled operation of the secondary lead smelters in Shoubra El Kheima has contaminated soil, dust, and air in the area. Activities supporting the air objective of the EEPP further addressed contaminated smelter sites, as well as methods for prohibiting smelting activities and forcing proper smelter site clean-ups in Shoubra El Kheima. Lead smelter sites in this neighborhood were heavily contaminated with lead and other metals. Lead concentrations of more than 60 percent by weight were found in some of the soil samples taken during the CAIP investigations at the Awadallah Secondary Lead Smelters (EEPP, 2003a).

In 2005, LIFE-Lead initiated remediation activities for seven secondary lead smelters. Due to remediation of the contamination sources (i.e., the secondary lead smelters), it was anticipated that the lead levels in soil outside the smelters will decrease overtime. This decrease was expected to have a positive impact on the health of the population in the study area. Such health gains of the remediation activities were undetermined.

In this study, we will attempt to determine the health effect of the remediation activities of LIFE-Lead by estimating the reduction in BLLs of the population living in the vicinity of the smelters by comparing them to the previous BLLs estimated in the 2004 Epidemiologic Study.

It was estimated that the economic benefits of universal screening exceeds the cost when more than 14% of children have a BLL above 10 µg/dL blood (AAP, 1998). As long as more than 60% of adults and 48.9% of children living closest to the smelters have BLLs above the same limits as estimated in the 2004 Epidemiologic Study, there would appear to be an economic benefit to the general population. This benefit can only be confirmed through the conduct of a second BLL Study and a comparison to the Study 2004.

It is crucial to reach a conclusion regarding the health effects of these remediation activities based on complete data and proper design as this is the first time lead remediation activities have been conducted in Egypt using an approved remediation methodology.

HYPOTHESIS

Remediation activities that took place in the secondary lead smelters during the period 2005 through 2006 have improved the environmental conditions in terms of lower lead concentrations in soil and within the facility boundaries. After elimination of the sources of continuous lead dispersion to the surrounding environment, the off-site soil lead content is expected to decline over time. Consequently, it is anticipated that high BLLs of the population living in this vicinity of the smelters, as estimated in the 2004 Epidemiologic Study, have been reduced.

The remediation activities for the secondary lead smelters started in 2005 (Appendix B) and was concluded by the end of 2006. Considering the fact that the half life of lead in blood is approximately 28 ± 4 days, it is expected that the collected blood in the procedures of this study would measure the steady BLL of the residents over time. It was anticipated that a comparison of the 2004 BLLs to the 2007 BLLs in the original sample population will show a decline in the BLL due to the activities conducted by LIFE-Lead including remediation and community awareness and participation.

Determining the BLL of the population living in the vicinity of the remediated sites will allow for an estimate of the direct health effect of remediation and community awareness and participation activities on the population of the study area.

GOALS AND OBJECTIVES

The goal of the study was to estimate the health effects of the remediation activities conducted by the LIFE-Lead project on the population living in the vicinity of the secondary lead smelters.

There were two objectives for this BLL Study, which includes the following:

- To estimate the BLL in children below 7 years of age, females of reproductive age, and adult males living in the vicinity of the lead smelters following the completion of remediation and community awareness and participation activities.

- To compare the BLL of the population subgroups with that obtained in the 2004 Epidemiologic Study to estimate possible reduction in blood lead that may be attributed to remediation and community awareness and participation activities conducted by LIFE-Lead.

METHODOLOGY

Type of the Study

This study relies on applied standard epidemiologic methods using a quantitative approach to estimate the potential positive effect of remediation activities that took place at the seven smelter sites on the health of the population living in the study area.

A repeated cross sectional study in which the BLLs of the population living in the vicinity of the smelters estimated before the remediation activities in the 2004 Epidemiologic Study were repeated and compared to the same individuals after the remediation was completed in early 2007. The BLLs of the study population in the new study were compared to the previous BLLs estimated in the 2004 Study to detect changes that may indicate positive health effects from the remediation activities.

Review of the 2004 BLL Study Database and Report

As part of the current study, the principal investigator was assigned the task to review the database and report for the 2004 Study. The database and the report were provided by the LIFE-LEAD Project.

The report of the 2004 Study did not use the lead concentration in soil and dust as a basis for breaking the study area into Operational Units (OU). Instead, it used a sole spatial method where each group of recruited participants in close geographic area were included in an OU regardless of the lead concentration of soil and dust. The OUs used in the 2004 Study are shown in Figure 1. The method for division of the study area into OUs that was used in the 2004 study follows:

- OU 1 was the most polluted area and was located within a 50 meter radius from the Awadallah Secondary Lead Smelter No. 1 and has both the greatest soil and dust contamination, and the highest mean value of BLLs.

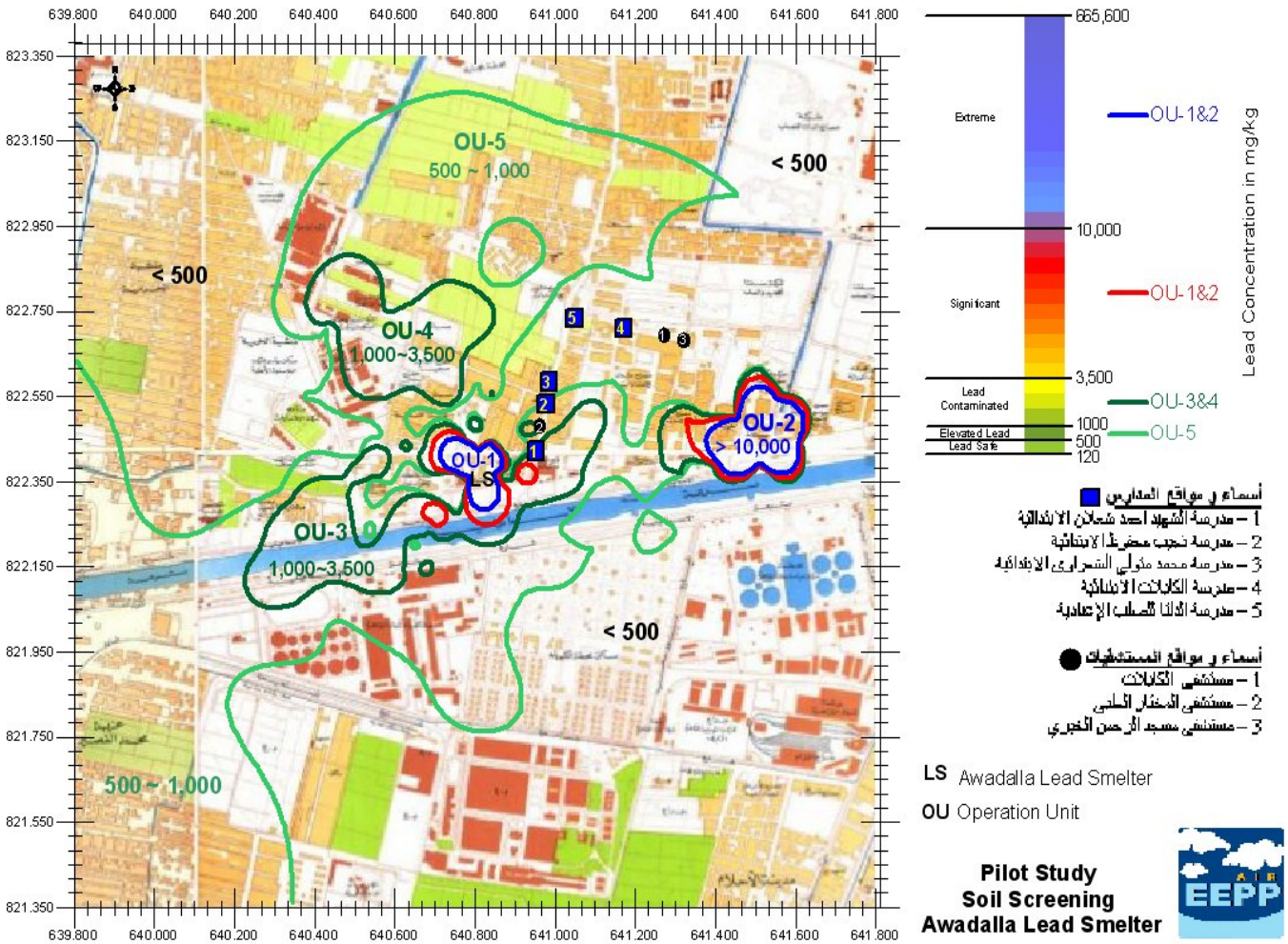
- OU 2 was as highly contaminated as OU1 and located to the east around the El Mahy Secondary Lead Smelter.

- OU 3 is an area south of the Awadallah Secondary Lead Smelter No. 1 and north to the Ismailia Canal.

- OU 4 is northwest of the Awadallah Secondary Lead Smelter No. 1.

- OU 5 is a larger, surrounding area within 500 meters of the Awadallah Secondary Lead Smelter with the lowest estimated level of lead in soil and dust.

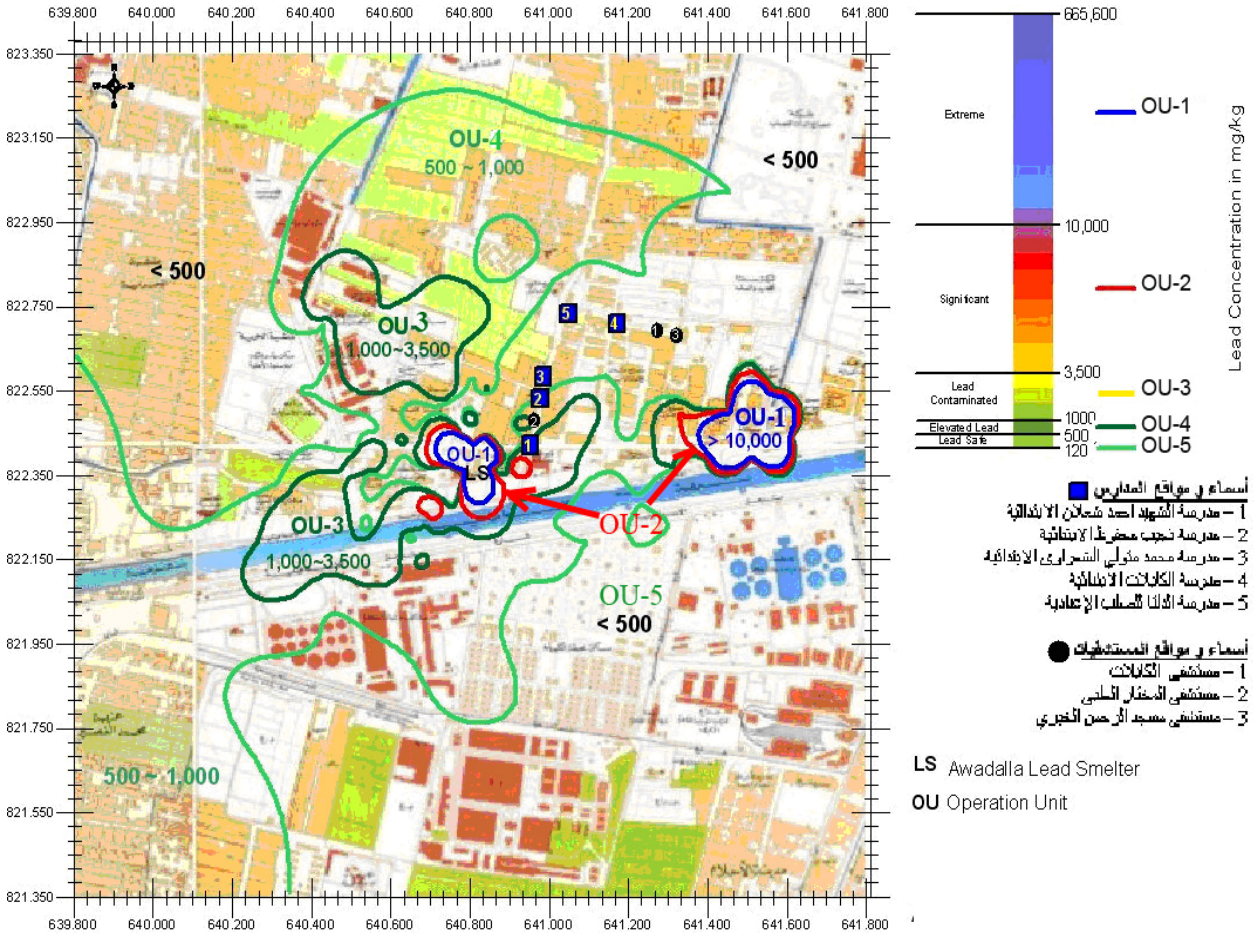
Figure 1: Spatial Division of the Study Area into OUs According to the 2004 Study



For the purpose of this study, the results of the sampling event that were presented in the Site Investigation Report (EEPP, 2003a) were used to divide the study area into OUs based on lead concentrations in soil and dust. Accordingly, the area was divided into five zones or OUs of lead concentration in soil and dust as indicated in Figure 2. The OUs are defined by the following:

- OU 1 (blue) is the area within the study area where the lead concentration in soil and dust was >10,000 mg/kg (average = 15,000).
- OU 2 (red) is the area within the study area where the lead concentration in soil and dust ranged between 3,500 and 10,000 mg/kg (average = 7,500).
- OU 3 is the area within the study area where the lead concentration in soil and dust ranged between 1,000 and 3,500 mg/kg (average = 2,500).
- OU 4 (dark green) is the area within the study area where the lead concentration in soil and dust ranged between 500 and 1,000 mg/kg (average = 750).
- OU 5 (faint green) is the area within the study area where the lead concentration in soil and dust was < 500 mg/kg (average = 250).

Figure 2: Operational Units Based on Lead Concentrations in Soil and Dust that has been used in the Presentation of Results in this Report



A revision of the database was undertaken together with re-analysis of the data after revising and correcting inconsistencies in the database. Re-analysis of the data was performed based on the above mentioned division of the study area into OUs based on lead concentrations in soil and dust. Results are presented hereunder and the following figures and tables were used as a basis for comparing the 2004 Study to the current 2007 Study.

The general results pertaining to the study group from the new statistical analysis was compared to that presented in the final report of the 2004 Study. This comparison revealed differences between what could be concluded from the dataset and the results presented in the final report of the 2004 Study.

The 2004 Study indicated that the total number of families interviewed in this study was 82, although the review of the database revealed that 86 families were interviewed. In addition, the data presented in the 2004 Study stated that “a total of 299 blood samples were taken from 134 children younger than 7 years of age, from 88 females of childbearing age, and from 77 males between the ages of 18 and 49. The review of the 2004 database and final report revealed that 306 blood samples were obtained from study participants of which 29 samples were duplicates for the purpose of laboratory quality assurance. The review of the database also revealed that the total number of study participants who donated blood was 284 of which the laboratory was able to process and report the results of 277 blood samples within the context of the study after

exclusion of duplicate samples. The corrected estimate of the distribution of the study participants as determined after exclusion of duplicate samples showed that the actual number sampled included 133 children, 82 adult females, and 69 adult males.

According to the Table 1, the mean BLL declined as we moved to lower soil concentrations of lead after the exclusion of OU1. This trend is very obvious and is explained by the fact that soil and dust could be the major source of lead exposure.

Table 1: Estimated BLL (µg/dL) Results by OU Presented in the 2004 Study and Revised Estimation Based on Lead Concentrations in Soil and Dust

Operational Unit	Estimated BLL by OU as Presented in the 2004 Study			Revised Estimation of BLL by OU Based on Lead Concentrations in Soil and Dust		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
OU 1	4.1	35.3	22.51	1.7	35.0	14.1
OU 2	1.98	18.79	8.88	3.9	35.2	19.0
OU 3	5.69	25.75	14.23	2.9	40.8	15.2
OU 4	2.63	40.75	18.89	2.4	20.7	11.0
OU 5	2.1	23.5	10.76	2.1	27.1	10.1

As shown in Table 2, the highest BLL is for males followed by females and lastly the children. The mean BLL in the revised data is above 10 µg/dL for all study subjects in every OU except for the females in the OU5. At the same time, the BLL in all OUs except OU1 declined as the soil lead concentrations declined.

Table 2: Revised Estimation of Mean BLL (µg/dL) by Subject Type and OU Presented in the 2004 Study and the Revised Estimation Based on Lead Concentrations in Soil and Dust

Operational Unit	Male		Female		Children	
	Presented in 2004 Study	Revised	Presented in 2004 Study	Revised	Presented in 2004 Study	Revised
OU 1	27.88	15.2	22.71	16.7	20.35	11.8
OU 2	9.55	22.3	7.81	19.8	9.13	17.4
OU 3	17.35	20.6	15.24	17.5	11.07	11.0
OU 4	25.96	10.7	16.61	11.5	16.75	10.8
OU 5	10.81	10.5	9.36	9.5	11.68	10.3

Table 3 shows that the values for the percentage of people with BLL above 10 µg/dL is different from what has been reported in the 2004 Study. While it was reported in the 2004 Study report that the highest percentage of people with BLL above 10 µg/dL were in OU1 followed by OU4, the revised estimates showed that the highest percentages were in OU2. The percentages for the different population groups with BLL above 10 µg/dL dropped continuously from OU3 to OU5.

Table 3: Revised Estimation of the Percentage of Population with BLLs >10 µg/dL by OU Presented in the 2004 Study and the Revised Estimation Based on Lead Concentrations in Soil and Dust

	Male		Female		Children	
Operational Unit	Presented in 2004 Study (%)	Revised (%)	Presented in 2004 Study (%)	Revised (%)	Presented in 2004 Study (%)	Revised (%)
OU 1	100.0	60.0	100.0	62.5	84.0	45.8
OU 2	45.0	100.0	27.3	93.3	29.4	72.7
OU 3	82.4	88.2	46.6	73.7	45.5	43.8
OU 4	100.0	50.0	100.0	57.1	69.2	50.0
OU 5	38.0	56.3	26.4	33.3	48.0	44.0

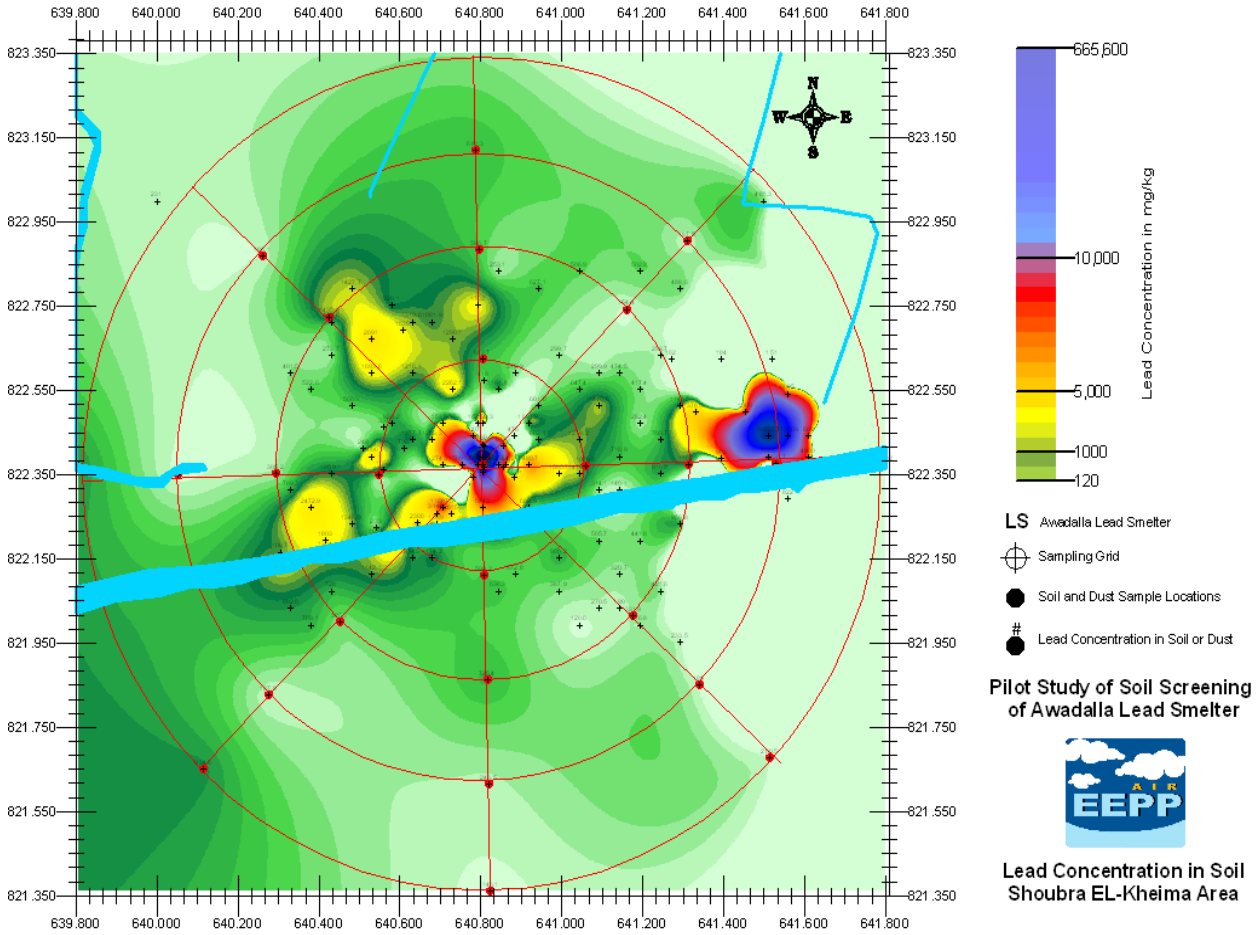
Study Site

The study was conducted in Shoubra El Kheima, Qalyoubia. The study area was defined as the area within a 1-kilometer radius centered on the former Awadallah Secondary Lead Smelter No. 1 exhaust stack. This circle contains the seven remediated secondary lead smelter sites and the El Shahid Ahmed Shaalan School. According to the extensive soil study (160 soil samples) done by the CAIP in 2003 and 2004, this circle was considered to contain the contaminated area by air dispersed lead from the smelters. Accordingly, it was considered and examined thoroughly prior to the conduct of the 2004 Epidemiologic Study.

Figure 3 shows lead contamination levels from the soil screening conducted within the 1-kilometer radius of the Awadallah Secondary Lead Smelter No. 1 exhaust stack in 2003. The study area included the following four administrative districts in East Shoubra El Kheima:

- Mostorod
- Bahteem
- Masaken El-Amiria
- El-Zawya El-Hamra

Figure 3: Soil Lead Contamination Levels and Location of Samples Collected in 2003



Source: EEPP, 2003

Target Population

Using the database for the 2004 Epidemiological Study, LIFE-Lead attempted to contact all individuals who participated in the 2004 Study (284 participants). LIFE-Lead asked those whom we were able to find to participate in this study by giving a new blood sample. All data necessary to contact those individuals who participated in the 2004 Study including their full names, home addresses, and GPS information to locate their residence were available from the 2004 database. These participants included residents in 86 households of the following categories:

- 133 with children below 7 years of age at the time of the 2004 Study.
- 82 females in the childbearing age of between 15 and 49 years of age at the time of the 2004 Study.
- 69 adult males (above 18 years of age) at the time of the 2004 Study.

Each family was contacted; the objective of the study was explained and they were asked to participate in the current study as a continuation of the 2004 Study. When they agreed, the head of recruited family was asked to sign the informed consent, and a

simple questionnaire was completed by an interviewer which included the same or similar questions from the previous study. At the end of the interview, samples of venous blood were collected by trained personnel from the same family members who were included in the 2004 Study. These families may include 1 to 2 children, the father, and the mother. Blood was analyzed to determine its lead level.

Data Collectors

The same study team that conducted the 2004 data collection from the Ministry of Health and Population and the LIFE-Lead technical study group conducted this study. The study personnel were divided into three teams to work simultaneously at different houses to conduct the interviews and collect blood for analysis of the BLL. Each team was comprised of one lab worker, a LIFE-Lead social worker, one female nurse from the local health office, and a field supervisor.

One-day training for the entire study team was conducted by the principal investigators at the Life-Lead office. The study was explained, the group was divided into three teams, and questions of the study teams were answered.

Laboratory workers were responsible for collecting the blood samples from the Study participants. Social workers with experience in community work and household studies were responsible for interviewing the family and completing the questionnaire. Nurses who were known and trusted by community members identified the family based on the information provided to them by the principal investigator. According to the Study schedule, they contacted the families one day prior to the interview, explained the study to participants and requested their participation with the study team scheduled for the following day. The social workers were responsible for the overall conduct of the field work of each team, solving problems, and obtaining subjects' approval to participate in the study.

No separate piloting of the study was deemed necessary as the team, the tools, procedures, and team members were almost the same as that for the 2004 Study. However, after the first day of field work, the study team met to solve any encountered problems. The principal investigator was responsible for training data collection teams and the overall supervision of the field work.

Sampling Methods and Sample Size

Participants in this study were identified by their previous participation in the 2004 Study and all of them, unless they had moved from the area, were asked to participate in this follow up study. All needed personal information such as names, home addresses, and GPS locations of their residences were available from the 2004 Study. Maps for study houses were plotted using GPS readings by the Life-Lead GIS expert to help the study team reach targeted families if their written home address was not clear enough to determine their location. Each family was contacted and asked to participate again in this study. Table 4 shows the number of residents recruited for this study.

Table 4: Study Groups Recruited in this Study

Population Group	Blood Samples
Children below 7 years of age	133
Females aged 15 to 49 years of age	82
Adult males	69
Total	284

At the laboratory, two samples were not analyzed due to an insufficient quantity of blood collected to conduct the required analysis. Results in this report are therefore presented for 282 blood samples.

Missing Data

The study team was able to successfully reach all houses of families included in the 2004 Study. Unfortunately, not all families/individuals recruited in the 2004 Study were available.

A family or a family member who was temporarily unavailable at time of interview was paid another visit at his/her convenience as indicated by neighbors or the family. If possible, this subsequent visit was conducted on the same day or rescheduled for another day during the field work. The missing subjects were unavailable due to the following:

- Unwillingness of the family to participate in the 2007 Study.
- The entire family had moved permanently to another area.
- A family member had moved from the family house due to various reasons such as getting married, traveling for work, etc.
- Other unforeseen reasons in which a family or a person could not be reached for the entire period of the study.

In cases of inability to find subjects at their home addresses identified from the 2004 Study, attempts were made to reach them by inquiring with their neighbors regarding whether they moved from their residences or if they were just unavailable at the time of the visit. A second visit was paid if they were unavailable at the time of the first visit.

Once determined that a previous study family or subject was unavailable, a matched neighbor of similar age and sex from the nearest residence that had lived in the area for a minimum of 12 months was asked to replace the missing subject. The missing subjects who were replaced by matched subjects represented 25% of the total study participants and only 3.5% were replaced due to refusal to participate. The other subjects were

replaced by matched subjects because they permanently moved from the study area as shown in Table 5.

Table 5: Status of the 2004 Study Subjects Regarding Participation in the 2007 Study

	Study Subjects
Accepted participation	213 (75.0%)
Refused to participate	10 (3.5%)
Could not be reached	61 (21.5%)
Total	284 (100.0%)

Sensitivity analyses were conducted to estimate the weight of missing data. The first analysis conducted did not include the matched participants. The second analysis included the matched participants to evaluate the difference in the results. The difference between the two analyses was minor so the results presented in this report include all 284 subjects recruited for the study.

Data Collection

Venous blood samples were collected using sterile single-use syringes and blood was evacuated in a test tube with lithium heparin as an anticoagulant. Laboratory analysis for the BLL was performed by the Chemical Laboratory of the Environmental Monitoring and Occupational Health Studies Center (EMOHSC) at the Ministry of Health and Population.

Blood was analyzed to determine its lead level using an Atomic Absorption Spectrophotometer according to the standardized method approved and recommended by the U.S. Environmental Protection Agency (USEPA) (Appendix C). The EMOHSC is well equipped and the staff is trained on blood withdrawal and performing the chemical analysis for lead in blood using the Atomic Absorption Spectrophotometer according to the standard technique.

A brief questionnaire was completed by a trained social worker for each family with separate sections for the children, mothers, and fathers. This questionnaire asked participants about the possible risks of exposure to lead from the environment. The questionnaire included the same questions as the 2004 Epidemiologic Study excluding questions that were expected to remain unchanged (Appendix D).

Quality Control

Laboratory Quality Control--

The blood sample withdrawn is anticipated to between 2 and 3 cubic centimeters (cc). For every tenth sample, a larger amount of blood (approximately 5 cc) was withdrawn, divided between 2 test tubes and given different code numbers to be treated at the laboratory as different samples. The estimated differences in BLL in every pair of samples were less than 10% which is within the accepted quality control standards.

Data Quality Control--

Data was entered twice on Microsoft Access 2003 software using the same database that was used for the 2004 Epidemiologic Study. The two databases were merged into one database, a method that enables detecting errors due to data entry, and then the errors were corrected by the principal investigator. The revised database was converted to a Software Package for Social Sciences (SPSS) file using SPSS 13.0 software package for statistical analysis.

Study Period

Between 45 and 50 blood samples were collected per day by the three teams working simultaneously in the field. Nurses identified and approached the families the day prior to the visit by the field sampling team. The data collection process took 12 working days and was comprised of 102 person working days during March 2007.

Study Activities

Preliminary activities included a familiarization meeting in which researchers and LIFE-Lead staff met with officials at the Ministry of Health and Population, the GOQ, and the local health office staff to discuss the objectives of the study and obtain their support. In addition, a meeting was conducted with the laboratory directors at the EMOHSC where the blood analysis for lead was going to take place to develop an agreement and make the necessary arrangements for the analyses. Preliminary activities included the following:

- Secure the final approval of the study sampling and analysis methodology from the Ministry of Health and Population.
- Identify the nurses working at the local health office that served in the 2004 study and obtain official approval to recruit these nurses to work for this study.
- Identify laboratory workers from EMOHSC who collected blood samples for the 2004 Study and request their assistance.
- Contact the same social workers from the 2004 Study and request their assistance for this study.
- Develop a contractual agreement between LIFE-LEAD and the EMOHSC for the laboratory analysis of the blood samples.
- Train the team of nurses and/or technicians responsible for sample collection on the proper approach to residents, common questions, responses to questions that they might face, and proper sampling procedures.

The same data collection team who conducted the 2004 Epidemiologic Study was recruited for this study. Two out of the four nurses who took part in the 2004 Study joined the team. The principal investigator provided orientation and training to the two nurses who previously worked in the 2004 Study and the two new nurses that took part in the sampling.

Data Analysis

Data entry and revision was done using an Access database and then converted to the SPSS software version 13.0. The BLLs of the study participants were compared with their previous BLLs from the 2004 Study and the change in BLL was calculated. The difference in BLL between the two sampling events was used to determine the effect of the LIFE-Lead remediation and community awareness and participation activities on the health of the population living in the vicinity of the smelters.

To manage possible missing values, a sensitivity analysis was conducted to estimate the weight of missing values. Statistical analyses were conducted twice. The first analysis did not use the matched participants. The second analysis included the matched participants as replacements for missing persons to determine if there was a difference in results. Sensitivity analysis showed similar results after including the matched study subjects and accordingly, all the results represented in this report include the matched subjects.

In OU 1, the study population (n=56) was recruited from two areas around the Awadallah No. 1 and the El Mahy Secondary Lead Smelters inside the study site with 40 (n=40) of the subjects recruited from around the El Mahy Secondary Lead Smelter. This group of people had recently moved to their residences near the El Mahy Smelter within a two month period prior to the 2004 Study. Their BLLs were found to be significantly lower when compared to the other study population in OU1 as they were not exposed to the sources of lead contamination for as long as the other population.

The results of BLLs for the study population in OU1 including the comparisons are presented using three different approaches. First, the results are presented which include the entire population in the OU1 group (n=56). The second approach presents the results from the population surrounding the Awadallah No. 1 Secondary Lead Smelter (n=16). The third approach for presenting the results including the study population surrounding the El Mahy Secondary Lead Smelter (n=40).

The mean BLL was reported for the study group and subgroups (i.e., children, adult women, and adult males) by OU. The BLL in OU1 was reported three times. It was reported once for the total population in OU1 (n=56). Then it was separately reported for those who were living in close proximity to the Awadallah No.1 Secondary Lead Smelter and the El Mahy Secondary Lead Smelter. The 2004 and 2007 BLL results of the population living in the vicinity of the smelters were compared. The difference was estimated using Paired t-test and the percent change in the BLL was calculated. For comparing the subgroups in OU1, where the population number was less than thirty, the Mc Nemar (non-parametric) Test was used.

The BLLs were then converted into a binary variable and the frequency and percentages of the departure from the standard level for blood lead below 10 µg/dL of blood was presented by group. A comparison between the baseline data (2004 data) and the new data for each group was done twice using Chi square test for the BLL presented as a binary variable (above/below 10 µg/dL) and Paired t-test for the exact estimates for the BLL. Non parametric tests were used to compare the subgroups in OU1 who were living around Awadallah No.1 and the El Mahy Secondary Lead Smelters separately as the number of study subjects was limited. These tests of significance were done to estimate the health effect of the remediation and community awareness and participation activities conducted by LIFE-Lead on the health of the population living in the vicinity of the lead smelters. The results of these tests were presented together with the P value. The P value indicated the probability of significant difference between the estimated BLLs in

2004 versus 2007. There was a significant statistical difference between the two estimates if the P value is less than 0.05.

Ethical Considerations

This was a minimal risk study. There was minimal risk encountered in the study originating from withdrawing 2 to 5 cc of blood from each participant. The risk included pain during needle insertion, the possibility of inflammation at the site of insertion, and the possibility of bleeding for those who have bleeding disorders. There was no risk encountered with data collection as confidentiality was maintained and consent was obtained in writing from each adult participants and the guardian of participating children. All study staff were well trained and monitored by the principal investigator and field supervisors.

The ethical approval of the Research Ethics Committee at the Ministry of Health and Population was obtained prior to the commencement of work by the collaborating partner at the Ministry of Health and Population. A copy of the ethical clearance was provided to every participant and their consent was explained.

The guardian of the child was interviewed and the objectives of the study were explained. An informed consent was signed by each adult individual prior to collecting data or samples. Under some circumstances, a witness signed on behalf of the person if he/she could not read and/or write (Appendix E).

Maintenance of Records

Copies of all notes, codes, and data were maintained in a locked filing cabinet and a password protected computer belonging to the office of LIFE-Lead and the principal investigator. Access to the hard copies or the database was restricted to the two principal and co-principal investigators.

A copy of the protocol was maintained in the LIFE-Lead office. The original copies of the questionnaire and consent forms were kept by LIFE-Lead. After completion of the study, all copies were returned to LIFE-Lead where they are kept in a secure place for archival purposes. All information that could be used to identify the study subjects was removed.

A copy of the results of the BLL was provided to the EMOHSC. It was agreed that it is the responsibility of EMOHSC and other Ministry of Health and Population bodies such as the local Health Office to provide each individual with his/her BLL results.

Institutional Responsibilities and Agreements

All publications will be submitted to the Ministry of Health and Population, Ministry of State for the Environment, and USAID for review and clearance before submission to any outside agency or scientific journal.

RESULTS

Description of the Study Population

In this study, 284 subjects were recruited representing 86 families living within a one-kilometer radius of the former Awadallah Secondary Lead Smelter No. 1 exhaust stack. These subjects included a significant majority of the subjects recruited for the 2004 Study.

A majority of the parents within the study families were illiterate, especially mothers. Fathers were mostly manual workers (52.3%) and most of the mothers were housewives (87.2%). The level of income was less than 400 LE/month for most families and only 5 families were earning more than 1,000 LE/month. In 2007, the level of income slightly improved and it was between 200 and 700 LE/month for most families (Table 6).

Table 6: Characteristics of the Study Families

	Father		Mother	
	Frequency	Percent	Frequency	Percent
Education (n=86)				
Illiterate	31	36.0	43	50.0
Primary	8	9.3	5	5.8
Preparatory	11	12.8	12	14.0
Secondary	21	24.4	18	20.9
High	15	17.4	8	9.3
Occupation (n=86)				
Unemployed	6	7.0	75	87.2
Manual worker	45	52.3	4	4.7
Skilled worker	13	15.1	1	1.2
Semi-professional	14	16.3	1	1.2
Professional	8	9.3	5	5.8
	2004 Study		Current 2007 Study	
Income (LE/month) (n=82‡)				
<199	12	14.6	3	3.5
200-399	35	42.7	27	31.4
400-699	19	23.2	36	41.9
700-999	11	13.4	8	9.3
>1000	5	6.1	12	14.0

‡ *Four families refused to answer this question*

The majority of the residential buildings were constructed prior to 1980 (41 families) and almost 75% of the interviewed families were living in flats within the lower 3 floors of the building. In the 2004 Study, most of the interior of the flats were painted (90.7%) and the painting appeared to be in good condition in 60.5% of cases. Only 15.1% of families indicated that they use vacuum cleaning and by observation, interviewers noticed that the flat inside looked clean in only 47.7% of the residences and windows were opened in 64% of the residences.

The status slightly improved in 2007 as a higher percentage of flats were painted (97.7%), 31.4% were using vacuum cleaning, 65.1% of flats looked clean which may indicate less exposure to lead contaminated soil and dust. On the other hand, there was

higher percentage (75.6%) of windows opened as evaluated by the interviewers noticing that the 2007 Study was conducted at the same month of the year as that in 2004..

The remediation activities conducted by the project did not include off-site streets and public use areas. The main source for the off-site lead contamination, which are the secondary lead smelters, are properly controlled which minimizes further dispersion of lead contaminated soil and dust. Still, the risk of exposure to soil and dust contaminated with lead during the operation of the smelter was high. The higher percentage of families keeping windows opened in 2007 could be considered at risk for exposure to lead contaminated soil and dust from streets and public areas.

BLL for the Population in the Study Area

There was a significant drop in the BLL in the study area. The BLL dropped from an average of 13.7 µg/dL in 2004 to an average of 6.5 µg/dL in 2007. The estimates for the BLL dropped from >10 µg/dL in all OUs during the 2004 Study to < 10 µg/dL except in OU1 where the average BLL was almost 10 µg/dL. Likewise, the maximum and minimum BLL in OUs has dropped when comparing the 2004 Study to the 2007 Study as shown in Table 7. In OU1, the main drop in BLL was estimated for the population who were living around the Awadallah No.1 Secondary Lead Smelter as the BLL dropped from 28.6 to 11.8 µg/dL. The drop in BLL of the population around the Awadallah No.1 Secondary Lead Smelter is compatible with the drop of BLL of the population in other OUs. There was no drop in the BLL for the population living around the El Mahy Secondary Lead Smelter. As previously stated, the population surrounding the El Mahy Secondary Lead Smelter moved to these residences within the two months prior to the 2004 study. Their exposure time was limited and there was not sufficient time for them to build BLLs similar to the population already living in the study area. There was a relationship between BLL and soil and dust concentrations of lead in the 2007 Study. The mean BLL dropped as lead contaminated soil and dust levels[1] dropped as indicated by OU.

Table 7: Estimated BLL (µg/dL) by OU Comparing the 2004 Study and the Current 2007 Study

Operational Unit	BLL (µg/dL) 2004 Study			BLL (µg/dL) 2007 Study			Significance
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	
OU 1 (n=56)	1.7	35.0	14.1	2.5	30.3	10.1	0.009*
OU1§ (n=16)	20.4	35.0	28.6	2.8	22.6	11.8	<0.001*
OU1‡ (n=40)	1.7	21.1	8.7	2.5	30.3	9.4	0.55
OU 2 (n=48)	3.9	35.2	19.0	1.0	22.6	7.3	<0.001*

[1] *Always refers to soil and dust concentrations as measured in the Site Investigation Study (EEPP, 2003a)*

OU 3 (n=69)	2.9	40.8	15.2	1.2	18.0	5.6	<0.001*
OU 4 (n=52)	2.4	20.7	11.0	1.9	11.9	5.2	<0.001*
OU 5 (n=59)	2.1	27.1	10.1	1.0	33.6	4.9	<0.001*
Overall (n=284)	1.7	40.8	13.7	1.0	33.6	6.5	<0.001*

*N.B. * indicates significant statistical difference comparing 2004 to 2007*
§ OU1 for Study population who has been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

The percentage of population in the study area with BLL exceeding the threshold of 10 µg/dL has dropped significantly from approximately 60% of population in 2004 to only 16% in 2007 as shown in Table 8. In general, OU1 was the only OU that did not show a significant drop in the percent of population with BLL >10 µg/dL. Although, a significant drop in the percent of population with BLL >10 µg/dL was estimated for the population living around the Awadallah No.1 Secondary Lead Smelter in OU1, it was not evident in the population surrounding the El Mahy Secondary Lead Smelter. The population surrounding the El Mahy Secondary Lead Smelter had moved to their residences within a two month period prior to the 2004 Study and their exposure time was not enough to elevate their BLL comparable to the levels of the lead contamination in 2004. The other OUs show significant decreases in the percentage of population with a BLL >10 µg/dL.

Table 8: Estimated Percentage of the Population with a BLL >10 µg/dL by OU Comparing the 2004 Study to the Current 2007 Study

Operational Unit	2004 Study (%)		2007 Study (%)		
	Frequency	Percent	Frequency	Percent	Significance
OU 1 (n=56)	30	54.5	25	44.6	0.35
OU1§ (n=16)	16	100.0	10	62.5	0.018*
OU1‡ (n=40)	15	37.5	15	37.5	0.5
OU 2 (n=48)	38	84.4	11	23.4	<0.001*
OU 3 (n=69)	43	63.2	5	7.2	<0.001*
OU 4 (n=52)	26	52.0	2	3.9	<0.001*
OU 5 (n=59)	26	44.1	2	3.4	<0.001*
Overall (n=284)	163	58.8	45	16.0	<0.001*

*N.B. * means significant statistical difference comparing 2004 to 2007*
§ OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

In the 2007 Study, the percentage of participants with BLL exceeding 10 µg/dL was increasing with increasing concentrations of lead in soil and dust represented by OU. In other words, the percentage of participants with BLL exceeding 10 µg/dL was as low as 3.4% in OU5 and kept escalating upwards to reach 44.6% in OU1. This trend was not evident in the 2004 Study.

There was a marked reduction in the BLL in all OUs in this study, except for OU1. In OUs other than OU1, the reduction in BLL ranged from 51% up to 66% with an average reduction for the whole study area of 52%. There was slight change in BLL in OU1 (-18%). After excluding the group of population living around the El Mahy Secondary Lead Smelter in OU1, there is a clear reduction in BLL (57%) that is similar to the reduction in other OUs. As shown in the following tables, children continued to have high BLLs in OU1 so; this kept the reduction in BLL in OU1 to a minimum as shown in Table 9.

Table 9: Percent Change in BLL between 2007 and 2004 Studies by OU

Operational Unit	Percent Change in BLL (µg/dL)		
	Minimum	Maximum	Median
OU 1 (n=56)	-89	1,169	-18
OU1§ (n=16)	-89	-23	-57
OU1‡ (n=40)	-78	1,169	11
OU 2 (n=48)	-97	410	-65
OU 3 (n=69)	-91	93	-66
OU 4 (n=52)	-90	142	-51
OU 5 (n=59)	-94	265	-54
Overall (n=284)	-97	1,169	-52

N.B. § OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

BLLs for Children in the Study Area

For this study, 133 children were recruited from 86 families. There were 28 (21.1%) children recruited to replace the children that could not be located from the 2004 Study. These replacement children were age and sex matched to those recruited in the 2004 Study. The sex ratio was nearly one with 71 males to 62 female children. The mean age for the children in this study was 6.7 years, while the mean age during the 2004 Study

was 3.9 years. The same questionnaire used for the 2004 Study was completed for each recruited child. The study included questions regarding risk factors for lead exposure together with the possible manifestation of lead toxicity.

Table 10 provides a comparison of the changes in BLL between 2004 and 2007. There were significant reductions in BLLs in all OUs including OU1 after exclusion of the population living around the El Mahy Secondary Lead Smelter. From OU2 to OU5, the mean BLL dropped to below 10 µg/dL in 2007 from levels that were all above the critical level of 10 µg/dL in 2004. In OU1, the BLL of children living around the Awadallah No.1 Secondary Lead Smelter dropped from 27.9 to 12.0 µg/dL. Children who moved to live in the area surrounding the El Mahy Secondary Lead Smelter in the two month period prior to the 2004 Study had their BLL increased from 6.5 to 11.2 µg/dL. This increase in BLL indicates the presence of a source of lead exposure. The small number of children in each subgroup limited the validity of the statistical significance of a difference comparing 2004 to 2007 Studies.

A positive trend was shown for the BLL in 2007 where the BLL dropped from the OU with highest soil and dust lead concentrations (OU1) to the OU with lowest soil and dust lead (OU5).

Table 10: Estimated BLL for Children Comparing the 2004 Study to the 2007 Study by OU

Operational Unit	BLL (µg/dL) 2004 Study			BLL (µg/dL) 2007 Study			Significance
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	
OU 1 (n=24)	1.7	35.0	11.8	5.2	30.3	11.5	0.9
OU1§ (n=6)	20.4	35.0	27.9	8.6	15.7	12.0	0.05
OU1‡ (n=18)	1.7	14.1	6.5	5.2	30.3	11.2	0.02*
OU 2 (n=24)	3.9	35.2	17.4	1.0	19.7	8.4	0.004*
OU 3 (n=33)	2.9	25.7	11.0	1.9	13.0	6.3	<0.001*
OU 4 (n=27)	2.4	20.7	10.8	2.0	11.9	6.1	<0.001*
OU 5 (n=25)	2.1	27.1	10.3	1.2	12.9	4.7	<0.001*
Overall (n=133)	1.7	35.2	12.1	1.0	30.3	7.3	<0.001*

*N.B. * means significant statistical difference comparing 2004 to 2007*
§ OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.

‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

Children in all OUs showed improvement as the percentage of children with BLLs exceeding 10 µg/dL dropped significantly as indicated in Table 11. In OU1, all children (100%) living in the area surrounding the Awadallah No.1 Secondary Lead Smelter had their BLL above 10 µg/dL in 2004. In 2007, there was an approximate one-third reduction in this percentage. Consistent with estimates presented in Table 10, the percentage of children in OU1 living in the area surrounding the El Mahy Secondary Lead Smelter with BLL above 10 µg/dL has increased from 27.8% to 50% which again indicates the presence of a source of lead exposure to these children. The small number of children in each subgroup limited the validity of the statistical significance of a difference comparing 2004 to 2007 Studies

In OU2, OU4, and OU5 there was a drop of approximately 40% in the percentage of children with BLL exceeding 10 µg/dL. There was a positive trend in the percentage of children with BLL exceeding 10 µg/dL, where the percentage was increasing with higher lead in soil and dust represented by OU classification in the study area. The percentage of children with BLL exceeding 10 µg/dL was as low as 4% in OU5 and increased to 54.2% in OU1. This trend was not that obvious in the 2004 Study. However, there was slight increase in the percentage of children with BLL exceeding 10 µg/dL in OU1.

Table 11: Estimated Percentage of Children with BLL >10 µg/dL Comparing the 2004 Study to the 2007 Study by OU

Operational Unit	2004 Study (%)		2007 Study (%)		Significance
	Frequency	Percent	Frequency	Percent	
OU 1 (n=24)	11	45.8	13	54.2	0.77
OU1§ (n=6)	6	100.0	4	66.7	0.46
OU1‡ (n=18)	5	27.8	9	50.0	1.0
OU 2 (n=24)	16	72.7	8	33.3	0.017*
OU 3 (n=33)	14	43.8	3	9.1	0.002*
OU 4 (n=27)	13	50.0	2	7.4	0.001*
OU 5 (n=25)	11	44.0	1	4.0	0.001*
Overall (n=133)	65	48.9	27	20.3	<0.001*

*N.B. * means significant statistical difference comparing 2004 to 2007*
§ OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

There was nearly a one third (32%) reduction in BLLs in 2007 compared to 2004 among children in the study area as indicated in Table 12. This reduction was highest for OU2 (57%) and OU5 (53%). The average BLL for children in OU1 showed mild elevation (12%) although after excluding children living around the El Mahy Secondary Lead

Smelter, the reduction is consistent (55%) with other OUs. Again, there was an increase in the percent change in the BLL of children living around the El Mahy Secondary Lead Smelter. This finding indicates that they were exposed to more lead after moving to their new residence near the El Mahy Secondary Lead Smelter. The small number of children in each subgroup limited the validity of the statistical significance of a difference comparing 2004 to 2007 Studies.

Analysis of risk factors for lead exposure could not explain why children in OU1 surrounding the El Mahy Secondary Lead Smelter had higher BLLs. From available data, this elevation could be explained by the higher soil and dust contents of lead on the streets in OU1 compared to streets outside the study area. Streets were not included in the remediation activities of the Life-Lead project and fugitive soil and dust could be contributing to the elevation of BLLs among children in OU1 and possibly children in other OUs compared to the population of Shoubra El Kheima outside the study area.

Table 12: Percent Change in BLL Among Children between 2004 and 2007 by OU.

Operational Unit	Percent Change in BLL (µg/dL)		
	Minimum	Maximum	Median
OU 1 (n=24)	-75	1,169	12
OU1§ (n=6)	-75	-30	-55
OU1‡ (n=18)	-63	1,169	56
OU 2 (n=24)	-97	410	-57
OU 3 (n=33)	-87	93	-28
OU 4 (n=27)	-84	142	-39
OU 5 (n=25)	-89	137	-53
Overall (n=133)	-97	1,169	-32

N.B. § OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

Table 13 provides an indication of the practices of children that could affect an increase in lead exposure. Most of the children (72.2%) were reported to play in the streets on a regular basis. Many of them (55.6%) spent more than an hour a day playing in the streets in 2007 compared to 45.1% in the 2004 Study.

All other risk factors showed a slight reduction in 2007 compared to 2004. This could be caused by the fact that the age of the children sampled has increased approximately 3 years. More than half of the children were reported to put their hands into their mouth in 2004 and still one third of them do so in 2007, a practice that can increase their risk of exposure to dust contaminated with lead.

More than 50% of children in 2004 were reported to eat unwashed vegetables and fruits and 38.3% do the same in 2007. Eating with dirty hands and the use of medicines that could contain lead (Kohl) were reported in 45.9% and 35.3% in 2004 and 42.1% and 12% in 2007 of the children, respectively. Regular or occasional eating of non-food material such as mud and wall paints which is known as pica, could be an important source of lead exposure among children, was reported in 25% and 11% in 2004 and 2007, respectively.

Table 13: Risk Factors for Exposure to Lead Among Children Comparing the 2004 and 2007 Studies

Risk factors (n=133)	2004 Study		Current 2007 Study	
	Frequency	Percent	Frequency	Percent
Play in the street	96	72.2	96	72.2
Spend > 1hour/day on the street	60	45.1	74	55.6
Put hands into mouth	72	54.1	43	32.3
Put objects into mouth	33	24.8	14	10.5
Regularly wash hands before eating	61	45.9	56	42.1
Eat unwashed vegetable and fruits	69	51.9	51	38.3
Put Kohl into eyes	47	35.3	16	12.0

BLLs for Adult Females in the Study Area

For this study, 82 females of childbearing age (15 to 49 years) were recruited of which only 4 women were not married. The mean age was 32.5 years. Only two women declared that they had previously given birth to a child with birth defects. The obstetric history was quite similar comparing the 2004 to the 2007 Study. The average number of pregnancies was 3.6 ± 2.0, the average number of deliveries was 3.3 ± 1.7, the average number of abortions was 0.6 ± 0.9, and the average number of living children was 3.2 ± 1.5 for each woman during the 2007. The average time a female spends outside the residence was 2.3 hours per day in both the 2004 and 2007 Studies. Most of the women declared that they wash their hands before eating, and 17 women were suffering from chronic diseases like hypertension, diabetes, and heart diseases.

During the 2007 Study, there were 6 women pregnant and 23 women lactating at the time of interview while there was four women pregnant and 25 women lactating during the 2004 Study. Almost half of the women (46.3%) have aborted at least once.

There were marked reductions in average BLLs in all OUs. BLL averages in all OUs dropped to below 10 µg/dL. The greatest reduction in the average BLL was in OU2 followed by OU3. In OU1, the average BLL of adult females in 2007 was nearly half that in 2004. BLL showed reduction for adult females both living in the areas surrounding the

Awadallah No.1 and the El Mahy Secondary Lead Smelters. Contrary to what was observed for children living near the El Mahy Secondary Lead Smelter, the BLL for females dropped from 11.4 to 7.2 µg/dL This indicated that the source of exposure of children to lead could be the street contaminated dust and soil. Adult females indicated that they stay at home for almost the entire day and only go out for short periods of time, if any. All the reductions in the average BLL were statistically significant except for females in OU1 living around the El Mahy Secondary Lead Smelter as indicated in Table 14. The small number of females in each subgroup limited the validity of the statistical significance of a difference comparing 2004 to 2007 Studies.

Table 14: Estimated BLLs (µg/dL) for Adult Females Comparing the 2004 Study to the 2007 Study by OU

Operational Unit	BLL (µg/dL) 2004 Study			BLL (µg/dL) 2007 Study			Significance
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	
OU 1 (n=16)	4.1	30.7	16.7	2.8	18.4	8.4	0.002*
OU1§ (n=5)	25.8	30.7	28.2	2.8	18.4	11.0	0.004*
OU1‡ (n=11)	4.1	19.5	11.4	3.9	13.1	7.2	0.08
OU 2 (n=15)	9.0	32.9	19.8	1.2	11.1	5.3	<0.001*
OU 3 (n=19)	5.7	29.6	17.5	1.2	13.5	4.1	<0.001*
OU 4 (n=14)	6.8	19.5	11.5	1.9	5.2	3.5	<0.001*
OU 5 (n=18)	2.6	22.2	9.5	1.0	8.3	3.7	0.001*
Overall (n=82)	2.6	32.9	15.0	1.0	18.4	5.0	<0.001*

*N.B. * means significant statistical difference comparing 2004 to 2007*
§ OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

The percent of adult females that have BLLs exceeding 10 µg/dL has shown marked reduction in all OUs. In OU4 and OU5, there were no adult females whose BLL exceeded this limit. A very small percentage of adult females in OU2 and OU3 exceeded the limit of 10 µg/dL (6.7% and 5.3%, respectively). In OU1, the percentage of females with a BLL >10 µg/dL in 2007 is half the 2004 percentage. As shown in Table 14 and Table 15, the BLL of participants was increasing as the soil and dust lead contents increased as represented by OU.

Table 15: Estimated Percentage of Adult Females with BLLs >10 µg/dL Comparing the 2004 Study to the 2007 Study by OU

	2004 Study (%)		2007 Study (%)		Significance
Operational Unit	Frequency	Percent	Frequency	Percent	
OU 1 (n=16)	10	62.5	5	31.3	0.16
OU1§ (n=5)	5	100.0	3	60.0	0.44
OU1‡ (n=11)	5	45.5	2	18.2	1.0
OU 2 (n=15)	14	93.3	1	6.7	<0.001*
OU 3 (n=19)	14	73.7	1	5.3	<0.001*
OU 4 (n=14)	8	57.1	0	0.0	0.001*
OU 5 (n=18)	6	33.3	0	0.0	0.01
Overall (n=82)	52	63.4	7	8.5	<0.001*

*N.B. * means significant statistical difference comparing 2004 to 2007*
§ OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

There were marked reductions in average BLL in 2007 as indicated in Table 16. As a whole, the average BLL has dropped by two thirds in 2007 when compared to 2004. The smallest reduction was 44% in OU1, while the largest reduction was 80% in OU3. Adult females living in the area surrounding the Awadallah No.1 Secondary Lead Smelter showed a larger reduction in their BLL (65%) compared to those living in the vicinity of the El Mahy Secondary Lead Smelter (38%).

Table 16: Percent Change in BLLs Among Adult Females between 2004 and 2007 by OU

Operational Unit	Percent Change in BLL (µg/dL)		
	Minimum	Maximum	Median
OU 1 (n=16)	-89	69	-44
OU1§ (n=5)	-89	-29	-65
OU1‡ (n=11)	-78	69	-38
OU 2 (n=15)	-94	-19	-79

OU 3 (n=19)	-91	-42	-80
OU 4 (n=14)	-90	-23	-64
OU 5 (n=18)	-94	85	-55
Overall (n=82)	-94	85	-64

N.B. § OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

BLLs for Adult Males in the Study Area

Among the 69 adult males (>18 years of age) recruited for this study, 51 males were fathers. The mean age of adult males recruited in 2007 was 36.3 years compared to 33.1 years in 2004. During both studies, adult males declared that they spend more than 11 hours per day outside their residences (mean = 11.3 and 11.4 hours in 2004 and 2007, respectively). Seven men in 2004 and nine men in 2007 indicated that they do not wash their hands before eating. Fifteen of the interviewed adult males were suffering from chronic diseases including hypertension, diabetes, and heart diseases.

For adult males, there were marked reductions in the average BLL in the study area and in each OU separately. As a whole, BLLs dropped by more than 50%, from 15.5 µg/dL for adult males in 2004 to 7.1 µg/dL in 2007. This should be considered as a significant reduction.

The average BLL in all OUs dropped to below 10 µg/dL except for adult males in OU1 living in the area surrounding the Awadallah No.1 Secondary Lead Smelter. However, the group of adult males living around the Awadallah No.1 Secondary Lead Smelter showed a significant reduction in their BLL from 30.8 to 12.0 µg/dL. Moreover, the BLL of adult males was increasing as the soil and dust lead increased as represented by OU in Table 17.

Table 17: Estimated BLLs (µg/dL) for Adult Males Comparing the 2004 Study to the 2007 Study by OU

Operational Unit	BLL (µg/dL) 2004 Study			BLL (µg/dL) 2007 Study			Significance
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	
OU 1 (n=16)	3.1	34.8	15.2	2.5	22.6	9.8	0.05
OU1§ (n=4)	25.8	34.8	30.8	5.2	22.6	12.0	0.036*
OU1‡ (n=12)	3.1	20.1	9.5	2.5	17.9	8.8	0.95
OU 2 (n=9)	13.4	35.2	21.2	1.7	22.6	7.8	0.009*
OU 3 (n=17)	7.7	40.8	20.6	1.4	18.0	6.0	<0.001*

OU 4 (n=11)	6.7	20.0	10.9	2.3	9.1	5.3	0.006*
OU 5 (n=16)	2.3	23.5	10.5	1.9	33.6	6.5	0.099
Overall (n=69)	2.3	40.8	15.5	1.4	33.6	7.1	<0.001*

*N.B. * means significant statistical difference comparing 2004 to 2007*
§ OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

The estimated percent of adult males with a BLL >10 µg/dL has shown a reduction in the study area and in each OU separately. The maximum reduction seen was in OU 4 where all adult males have their BLL below the 10 µg/dL limit in 2007 while 45.5% had BLL above 10 µg/dL in 2004. OU 3 showed a significant drop from 88.9% in 2004 to 5.9% in 2007 of adult males with BLLs >10 µg/dL. In OU1, there was a 12.5% reduction in percentage of adult males with BLL > 10 µg/dL. Adult males in OU1 living in the area surrounding the Awadallah No.1 Secondary Lead Smelter showed a reduction of 25% compared to those living around the El Mahy Secondary Lead Smelter (8.4%). The small number of adult males in each subgroup limited the validity of the statistical significance of a difference comparing 2004 to 2007 Studies as shown in Table 18.

In general, the reduction in the percentage of males with a BLL above 10 µg/dL is the lowest in OU1. This could be attributed to the fact that these men spent more time outside their residences and were exposed to the polluted soil and dust on the streets. The soil and dust on the streets in OU1 contained the highest lead concentration; this may be the cause of the lowest BLL decrease in OU1.

Table 18: Estimated Percent of Adult Males with BLLs >10 µg/dL Comparing the 2004 Study to the 2007 Study by OU

Operational Unit	2004 Study (%)		2007 Study (%)		Significance
	Frequency	Percent	Frequency	Percent	
OU 1 (n=16)	9	56.3	7	43.8	0.29
OU1§ (n=4)	4	100	3	75.0	0.44
OU1‡ (n=12)	5	41.7	4	33.3	0.02*
OU 2 (n=9)	8	88.9	2	22.2	0.002*
OU 3 (n=17)	15	88.2	1	5.9	<0.001*
OU 4 (n=11)	5	45.5	0	0.0	0.016*
OU 5 (n=16)	9	56.3	1	6.3	0.003
Overall (n=69)	46	66.7	11	15.9	<0.001*

*N.B. * means significant statistical difference compared 2004 to 2007§ OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.*
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

There was marked reduction in the average BLL among adult males when comparing the results from 2007 to those of 2004 as indicated in Table 19. The BLL dropped in 2007 by 56% of its 2004 level in adult males in the study area. In OU2 and OU3, the reduction in BLL was above 70%. The average BLL in OU1 was only 18% less than the level in 2004.

The reduction in BLL was less in OU1 compared to other OUs. After examining the reductions for the adult males living in the area surrounding the Awadallah No.1 and the El Mahy Secondary Lead Smelters separately, the first group showed a reduction that is consistent with reductions in other OUs. The group of males living in the area surrounding the El Mahy Secondary Lead Smelter who moved to their residences in the two month period prior to the 2004 Study showed minor elevation in their BLL. Again, exposure to street contaminated soil and dust could be an explanation.

Table 19: Percent Change in BLLs Among Adult Males between 2004 and 2007 by OU

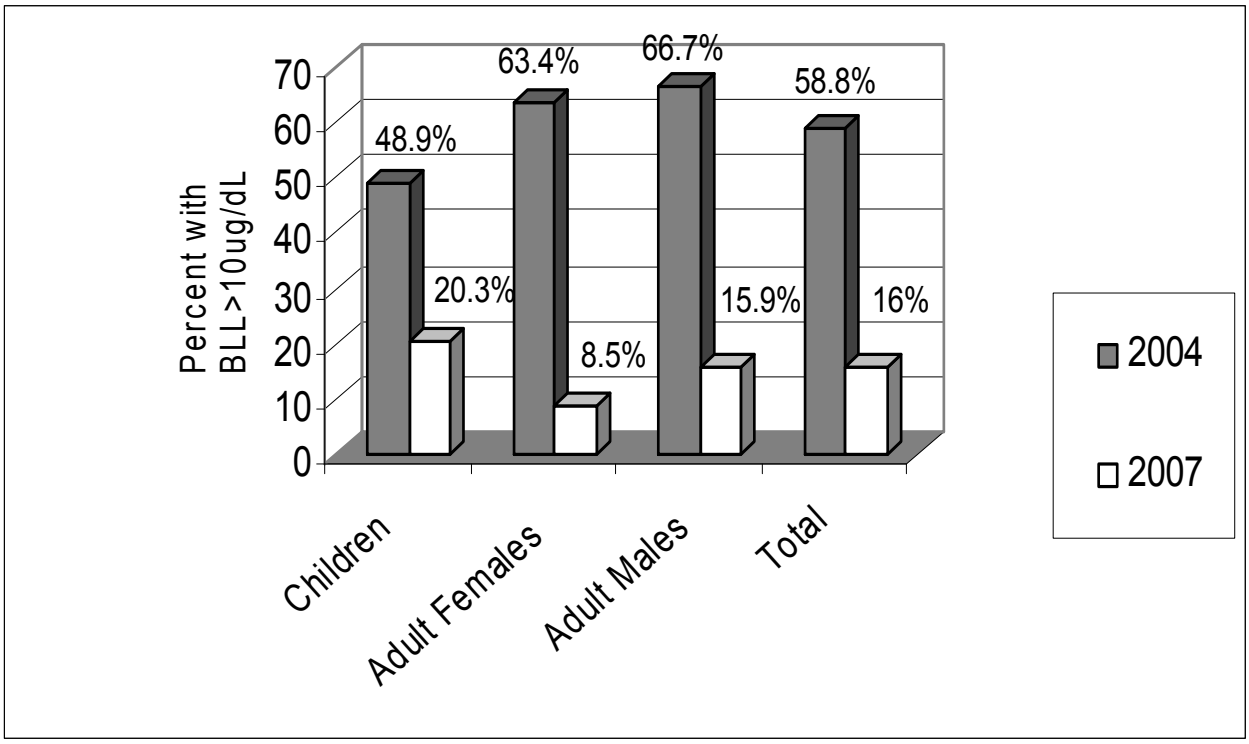
Operational Unit	Percent Change in BLL (µg/dL)		
	Minimum	Maximum	Median
OU 1 (n=16)	-84	67	-18
OU1§ (n=4)	-84	-23	-68
OU1‡ (n=12)	-71	67	4
OU 2 (n=9)	-95	-22	-72
OU 3 (n=17)	-88	-19	-71
OU 4 (n=11)	-88	0	-42
OU 5 (n=16)	-89	265	-55
Overall (n=69)	-95	265	-56

N.B. § OU1 for the study population who have been living for a longer period of time surrounding the Awadallah No.1 Secondary Lead Smelter.
‡ OU1 for the study population who moved-into the area surrounding the El Mahy Secondary Lead Smelter within the two month period prior to the study.

Summary of BLLs by Population Groups

Figure 4 provides a graphical summary of the changes in BLLs by population groups (i.e., children, adult females, and adult males. All population groups showed a significant decrease in BLLs when comparing the results from 2004 to 2007.

Figure 4: Percentage of Different Population Groups with BLLs Exceeding 10 µg/dL Comparing the 2004 and 2007 Studies



DISCUSSION

This is the first time that secondary lead smelter sites in Egypt have been remediated. The effect of the remediation activities for these sites on the health of the population in the surrounding area has not been previously estimated. To our knowledge, this is the first follow-up non-occupational study in Egypt to detect changes in BLLs of a population. The study team was able to collect blood in a household study which is a difficult task to achieve. All individuals and families included in the 2004 Study were successfully traced and their status regarding participation in the study was determined. Seventy five percent of the original participants were successfully recruited in 2007. Those who have moved or refused to participate were replaced with age and sex matched subjects.

Unfortunately, the concentration of lead in soil and dust in the study area outside the remediated sites was not determined within this study due to resource limitations. Accordingly, the direct effect of remediation on the lead content of soil and dust in the study area outside the smelter sites was not determined. Nevertheless, the concentrations of lead in soil and dust as estimated in 2003 were used to divide the study area into five OUs. The relative lead concentrations in soil and dust represented by the OUs were used in the statistical analysis and presentation of data. This was based on the assumption that the relative lead concentration in soil and dust between the OUs did not change since 2003.

In this study, we found an overall significant reduction in the BLLs in the study area comparing the situation in 2007 to that in 2004. The fallout of lead particulate from the ambient air precipitates and contaminates dust and soil. Lead contaminated fugitive dust and soil are generally considered to be the main source of lead exposure (ATSDR, 1999).

The primary routes of exposure to lead are inhalation and ingestion. Inhalation includes inhalation of air or fugitive soil and dust contaminated with lead. Ingestion includes ingestion of contaminated food items or ingestion of contaminated soil and dust especially by children (USEPA, 2003).

The air concentrations of lead were determined in Shoubra El Kheima by the CAIP. The average air concentrations of lead dropped significantly to 1 $\mu g/m^3$ in 2004 after the secondary lead smelters ceased smelting operations. The air concentration level of lead is considered constant because the main source of lead in air, leaded gasoline, has been controlled through the adoption of the use of unleaded gasoline. Accordingly, the remaining source of lead in the study area was exposure to lead contaminated soil and dust either through inhalation or ingestion.

By 2007, the population in the study area has a lower overall BLL compared to the level in 2004. This indicates that the exposure to contaminated soil and dust has been controlled to a great extent.

Many factors may have contributed to the reduction in soil and dust contents of lead. Among which is the cessation of fallout of lead-contaminated dust from the secondary lead smelter sites after remediation in addition to the dispersion of the outer most contaminated layer of the soil and dust by the effect of air over time.

It could be claimed that this improvement would not be attained if the heavily contaminated secondary lead smelter sites remained as a source of fugitive dust and soil in the area and accordingly, this improvement is attributed primarily to the remediation activities in the study area.

Among the study population, children in OU1 showed little or no improvement as indicated by their BLLs. The percentage of children with their BLL exceeding 10 µg/dL has slightly increased for children in OU1. In addition, the percent change in their BLLs showed mild elevation. The children living within OU1 were then grouped into two different areas. The first group living in the area surrounding the Awadallah No.1 Secondary Lead Smelter has a longer history of exposure to lead in the study area. The second group lived in the vicinity of the El Mahy Secondary Lead Smelter and had moved to the area within a two month period prior to the 2004 Study. The first group showed reductions similar to children in other OUs. The second group showed an elevation in their BLL indicating their exposure to a source of lead inside the study area. After excluding other possible sources of lead exposure, it is concluded that the contaminated street soil and dust could be that source of their increased exposure and higher BLLs. However, this exposure was not apparent in the BLL for adult males and females.

Analysis of risk factors for lead exposure was not able to recognize a source of lead other than soil and dust in the streets, which was not subjected to remediation. As shown in the Site Investigation Report (EEPP, 2003a), the soil and dust content of lead was the greatest in OU1 and 72.2% of the children play in the streets where they are exposed to lead though inhalation and ingestion of soil and dust. The children in 2007 were 3 years older than those sampled in 2004. The percentage of children playing on the streets for more than one hour per day has slightly increased from 45.1% in 2004 to 55.6% in 2007 which could be responsible for the minor improvement in BLLs in OU1 in general and the elevation in BLL for the children living in the area surrounding the El Mahy Secondary Lead Smelter.

Another important point that has been raised in this study is that the drop in the BLL for the study population was the lowest in OU1. This was clear where the drop was from

nearly 55% of the population with BLLs >10 µg/dL in 2004 to nearly 45% in 2007. The population group recruited from the area surrounding the El Mahy Secondary Lead Smelter had moved to the study area during a two month period prior to the 2004 Study. The duration of their exposure during this two month period was not enough to build as high a BLL as other population in the study area. Accordingly, their lower BLL was a source of error in concluding what had happened to the BLL in OU1. The estimates for the BLL for the population group living around the Awadallah No.1 Secondary Lead Smelter who had lived there for a long period of time indicated that the improvement in the BLL is consistent with the improvement in other OUs. However, there was mild elevation in the BLL for the population living around the El Mahy Secondary Lead Smelter and was noticeable among the children. The main reason for the elevation in the BLL may be due to OU1 having the highest level of lead contamination of street soil and dust. Fugitive soil and dust can be inhaled and/or ingested especially by children. Furthermore, detailed statistical analysis indicated that the study participants living in OU1 were slightly different compared to other study participants. The residents in OU1 were of lower socio-economic standard indicated by the poorer painting of the interior of their residences, unclean and dusty residences, less education of the fathers, and a lower socio-economic score compared to other study participants. These differences may indicate less health awareness and more exposure to street soil and dust and hence the least response to remediation activities conducted by the project.

The significant reduction in the BLLs exceeding the limit of 10 µg/dL was most obvious for adult females compared to children and adult males. This could be explained by the fact that adult females do not go out frequently compared to adult males and children who were exposed to the lead contaminated soil and dust on the streets.

The acceptable BLL exceeding 10 µg/dL in any area is less than 5% of the children below 7 years of age with BLLs above 10 µg/dL. This target has not been attained for children in the study area in general and in any OU except for OU5. This indicates that further efforts are needed to eliminate potential sources of lead contamination in the area along with efforts to reduce exposure to lead contaminated sources.

In addition, 71 subjects (25%) of the 2004 Study could not be included in this study due to several reasons, primarily because they moved outside the study area. The process of choosing age and sex matched subjects to replace the unavailable individuals from the 2004 Study proved to be effective. Statistical analysis indicated that the results were not significantly different after including the age and sex matched subjects in the statistical analysis which means that they were representative of the unavailable subjects.

Further studies are needed to determine the lead concentrations in soil and dust in the study area after remediation of the secondary lead smelters.

CONCLUSIONS

The major conclusions obtained from the post remediation BLL Study in Shoubra El Kheima are summarized below:

- BLLs of the population in the study area have dropped significantly in 2007 compared to what was estimated in the 2004 Study. Among children in the study area, there was significant drop in their BLL to below the critical limit of 10 µg/dL.

- For children living in the area that were relatively away from the smelter sites (i.e., living in OU3, 4, and 5); the percentage of children with BLLs above 10 µg/dL is

above the safe limit of 5%, but low enough that it does not necessitate routine screening in the future.

- For children living in areas that are close to the smelter sites in OU1 and 2; there was a drop in the percentage of children with BLLs above 10 µg/dL. However, this percentage is above 14% which makes further follow up and screening important and feasible. Adult females showed the highest drop in BLLs with a significant drop in the average BLLs in all OUs.

- Adult males were second to females regarding the extent of improvement in BLLs. The improvement in the BLLs for adult males dropped significantly and the percentage of adult males with a BLL above 10 µg/dL was significantly reduced.

- The highest BLLs in the 2007 Study were reported among residents living in OU1, which is in close proximity to the secondary lead smelter sites. OU1 was identified as having the highest concentration of lead in street soil and dust. Adult males and females living in OU1 showed improvement in their BLL, but children did not. Children stay longer in the streets playing and are more exposed to contaminated soil and dust on the streets. In addition, females were the main target of the community awareness and participation activities conducted by the Life-Lead project. These two factors could explain why females had lower overall BLLs than children.

- Analysis of risk factors could not explain the reduction in the BLL of the population in the study area. Accordingly, the reduction could be attributed to elimination of the source of fugitive lead contaminated dust and soil after remediation of the seven heavily contaminated secondary lead smelter sites.

RECOMMENDATIONS

The following recommendations are proposed based on the findings of this study:

- Remediation of lead smelter sites have a positive effect on BLLs and all similar smelter sites should be subjected to remediation.

- Street soil and dust is still a source of lead exposure in the areas around the remediated secondary lead smelter sites. The roads that are located in close proximity to the smelter sites in OU1 and 2 should be included in future remediation activities and could be as simple as street sweeping and paving contaminated areas.

- Further follow up and screening is needed for children living in OU1 and 2. Their BLLs should be determined periodically until the percentage of children with a BLL >10 µg/dL drops below 5%.

- Epidemiologic studies to estimate the direct health effects of environmental intervention yield information that could guide policy formulation. Remediation of the sources of environmental hazards should be an integral part of future activities. Street soil and dust levels of contamination should be determined in future similar studies and contaminated areas should be remediated.

REFERENCES

AAP: American Academy of Pediatrics, 1998: Screening for Elevated Blood Lead Levels. PEDIATRICS Vol. 101 No. 6 June 1998, pp. 1072-1078.

Agency for Toxic Substances and Disease Registry (ATSDR), "Case studies in environmental medicine, lead toxicity: Environmental alert." US Department of Health and Human Services, Division of Health Education and Promotion. Course: SS3059; 29-33, 2000.

Agency for Toxic Substances and Disease Registry (ATSDR), "Toxicological Profile for Lead." US Department of Health and Human Services, Public Health Service. Cited on the web at URL: http://www.atsdr.cdc.gov/toxprofiles/tp13.pdf, 1999.

Amira M. Koura, Sohair I Salem, El-Sayed M. ElMahdy, Hisham A. Orban 2001 : Biochemical indicators of lead exposure in blood and urine of children. Kasr El-Aini Medical Journal; vol 7; no 2; May 2001; 55:69.

ATSDR: Agency for Toxic Substances and disease Registry, 1999: Toxicological Profile for Lead. US Department of Health and Human Services, Public Health Service. Cited on the web at URL**:** http://www.atsdr.cdc.gov/toxprofiles/tp13.pdf

CAIP, 2002. Cairo Air Improvement Project (CAIP). Preliminary Assessment: Awadallah Secondary Lead Smelter in Shoubra El Kheima. Chemonics International, Inc. USAID/Egypt, Office of Environment. USAID Contract No. 263-C-00-97-00090-00. February 2002. Improvement

CAIP, 2003. Cairo Air Improvement Project (CAIP). Contamination Assessment of the Awadallah Secondary Lead Smelter at Shoubra El Kheima. Chemonics International, Inc. USAID/Egypt, Office of Environment. USAID Contract No. 263-C-00-97-00090-00. May 2003.

Cairo Air Improvement Project (CAIP), "2000/2001 Lead Emissions Inventory for the Greater Cairo Area: Trend Report," pp 1-3:2-4, 2003.

Centers for Disease Control and Prevention (CDC), US Department of Health and Human Services, "Surveillance for elevated blood lead levels among children in the United States, 1997-2001." Morbidity and Mortality Weekly Report; September 12, 2003 / Vol. 52/No. SS-10.

EEAA, 1997. Egyptian Environmental Affair Agency (EEAA). Lead Smelter Action Plan. Technical Cooperation Office for the Environment, EEAA, Cairo. February 1997.

EEAA, 2002. Ministry State of Environmental Affairs and United Nations Development Program; 2002. The National Environmental Action Plan 2002/2017.

EEPP, 2003a. Egyptian Environmental Policy Project (EEPP). Site Investigation Report: Awadallah Lead Smelter. Chemonics International, Inc. USAID/Egypt, Office of Environment. USAID Contract No. 263-C-00-97-00090-00. December 2003.

EEPP, 2003b. Egyptian Environmental Policy Project (EEPP). Baseline Human Health Risk Assessment: Awadallah Secondary Lead Smelter. Chemonics International, Inc. USAID/Egypt, Office of Environment. USAID Contract No. 263-C-00-97-00090-00. December 2003.

EEPP, 2004. Egyptian Environmental Policy Project (EEPP). Screening Epidemiological Study: Blood Lead Levels in the Vicinity of the Awadallah Smelter. Chemonics International, Inc. USAID/Egypt, Office of Environment. USAID Contract No. 263-C-00-97-00090-00. June 2004.

Egyptian Environmental Affairs Agency and Environmental Health Project, Activity Report No. 37, Lead Exposure Abatement Plan, Cairo, 1997.

Hassanien, M. A. and A. Horvath, "Lead Risk Assessment for Children in Hungary by Predicting their Blood Lead Levels using US EPA Integrated Exposure Uptake Biokinetic Model," Centr. Eur. J. Publ. Hlth 7, No 3, pp 155–159, 1999.

Koura, A. M., S. I Salem, M. El-Sayed, H. El Mahdy, and A. Orban, "Biochemical indicators of lead exposure in blood and urine of children," Kasr el-Aini Medical Journal, vol 7, no 2, May 2001, 55:69.

Laws, Edward A., Aquatic Pollution, An Introductory Text, second edition, pp 396– 411, 1993.

Madan, R. D., Modern Inorganic Chemistry, S. Chand & Company LTD, Ram Nagar, New Delhi, 1994.

Okun, Daniel A., ed., Water Quality Management. Public Health & Preventive Medicine, twelfth edition, chapter 35, pp 619–647, 1992.

Salem S., Mosseilhy S., KhalifaAG., Al-Ashmawy E., Karam El Din M., Salah I. 2000 : Blood lead delta aminolevulinic acid dehydratase and neurobehavioral abilities among children exposed to environmental lead pollution. Journal of Arab child; Volume 11, Number 4, December 2000, 531:550.

Timbrell, John A., Principles of Biochemical Toxicology, second edition, Taylor and Francis, London, Washington D.C. 1991.

United States Agency for International Development and Egyptian environmental Affairs Agency; 2003: 2000/2001 Lead Emissions Inventory for the Greater Cairo Area Trend Report; page 1-3:2-4.

US Environmental Protection Agency (EPA), "Lead in paint, dust and soil: basic information." Cited at URL: http:/www.epa.gov/lead/leadinfo.htm, 2003.

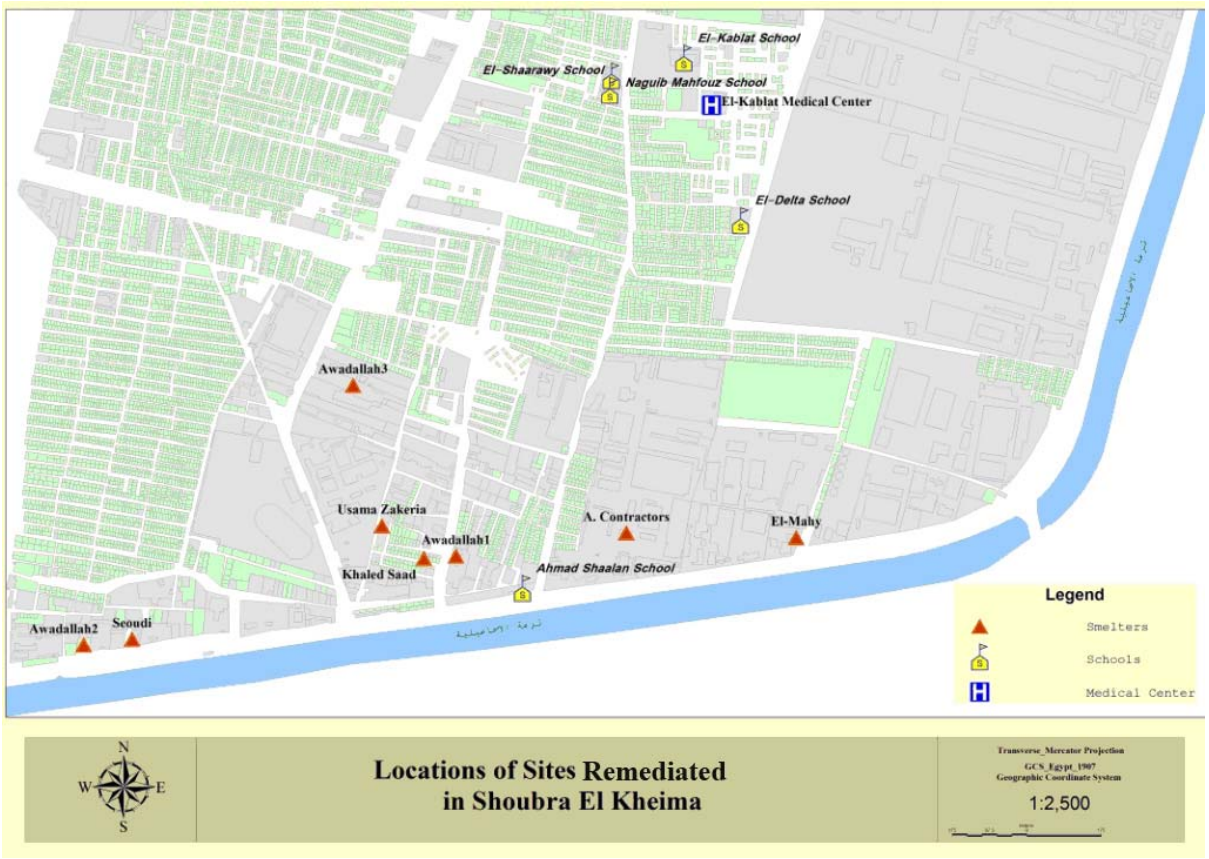
US Environmental Protection Agency (EPA), "Lead in paint, dust and soil: basic information." Cited at URL: http:/www.epa.gov/lead/leadinfo.htm, 2003.

Waldron, H. A. and D. Stofen, Sub-clinical Lead Poisoning, Academic Press, New York, p 224, 1974.

Zaki A, El-Shazly M, Abdel-Fattah M, El-Said K, Curtale F 1998: Lead toxicity among working children and adolescents in Alexandria, Egypt. Eastern Mediterranean Health Journal vol. 4 Issue 3, pages 520-529

APPENDIX A

Location of Sites Remediated by LIFE-Lead in Shoubra El Kheima



APPENDIX B

DESCRIPTION OF THE REMEDIATED SECONDARY LEAD SMELTERS

Awadallah Secondary Lead Smelters Nos. 1, 2, and 3

As part of Awadallah's commitment to the Governorate of Qalyoubia (GOQ), Awadallah ceased operation at his three smelters in Shoubra El Kheima in 2004. Awadallah completed preliminary remediation activities at his three secondary lead smelters in the study area. These remediation activities consisted of painting the walls, excavation and removal of soil from the floors, backfilling with sand, and pouring a concrete cap on the floor over the remaining contaminated soil. These preliminary remediation activities limited the amount of contaminated soil carried from the site by workers and operations into the residential areas surrounding the sites.

Although Awadallah can be complimented for his efforts, significant lead contamination was still present at the site in quantities that were dangerous to the workers. LIFE-Lead completed the remediation in late May 2006 and clearance samples indicated that lead levels were below the allowable level as defined by the Risk Based Remediation Goals developed by the project in conjunction with the EEAA for industrial facilities.

Seoudi Secondary Lead Smelter

The Seoudi Secondary Lead Smelter was located among an industrial area in close proximity to the Ismailia Canal Road. The Seoudi Smelter, which started operations as a leased facility in the late 1980's, was one of the main sources of lead pollution in the area. The 325 m^2 smelter included one rotary furnace and a filter that was not properly designed to regulate emissions from the smelter according to the Egyptian Environmental Law (Law 4/1994) requirements. The smelting process adopted in this smelter was lacking all measures of environmental controls; the rotary furnace was not designed according to standards, batteries were charged to the furnace without breaking, and proper pollution controls were not installed. Therefore, the Seoudi Smelter was closed by the GOQ in 2001.

LIFE-Lead remediated the smelter in the spring of 2006. Clearance samples indicated that lead levels were below the allowable level as defined by the Risk Based Remediation Goals developed by the project in conjunction with the EEAA for industrial facilities.

El Mahy Secondary Lead Smelter

The El Mahy Smelter was one of the oldest smelting facilities in Shoubra El Kheima. It was located in a mixed residential/industrial area in Shoubra El Kheima on the Ismailia Canal Road. The plant footprint included an area of approximately 2,000 m^2.

Operations started more than 25 years ago using two smelting furnaces and two kettles for lead refining as well as a pipe extrusion facility. The two smelting furnaces were fired by heavy fuel (Mazot). The smelting process adopted in the smelter was lacking all measures of environmental standards; batteries were charged to the furnace without breaking, and proper pollution control systems were not installed. In 1999, the owner removed the furnaces and confined site activities to refining and pipe extrusion, and subsequently natural gas was used for firing kettles.

LIFE-Lead remediated the smelter in the spring and early summer of 2006. Clearance samples indicated that lead levels were below the allowable level as defined by the Risk

Based Remediation Goals developed by the project in conjunction with the EEAA for industrial facilities.

Khaled Saad Secondary Lead Smelter

The smelter was located in the southern portion of the Governorate of Qalyoubia in Shoubra El Kheima. The smelter is located in El Khalil Ibrahim Mousa Street within a street of mixed residential and industrial blocs. The smelter property encompassed an area of approximately 90 square meters (m^2) and consists of two wide empty rooms and an entrance occupying the second floor of a two story building. Life-Lead remediated the smelter in the fall of 2006.

Osama Zakaria Secondary Lead Smelter

The smelter was located in the southern portion of the Governorate of Qalyoubia in Shoubra El Kheima. The smelter is located on Ibrahim Lofty Street within a street of mixed residential and industrial blocs. The smelter property encompassed an area of approximately 120 square meters (m^2) and consists of three wide rooms occupying the first and second floors of a two story old building. Life-Lead remediated the smelter in the fall of 2006.

APPENDIX C
LABORATORY TECHNIQUES

For all the samples, standard methods for collection, preparation, and analysis of blood for lead were implemented. Blood samples were taken by venipuncture and not by the finger-stick method. Latex sterilized gloves were used to take each sample. The blood sample was put into a vacutainer containing lithium heparin as an anticoagulant.

Samples were analyzed at the Environmental Monitoring and Occupational Health Lab. The apparatus used as an atomic absorption spectrometer was the Perkins Elmer Analyst 100 with background correction deuterium arc lamp. The auto sampler was Perkins Elmer AS 800 and the graphite furnace brand was HGA 850.

The analytical techniques used for the preparation and analysis of the blood samples were those of US EPA and CDC respectively. Method EPA 7000A for atomic absorption spectroscopy of metals in solution is an applicable and rapid technique for the sample preparation. As for the analysis itself, CDC and NMS # 8020 methods were followed using 0.1 percent v/v Triton X-100 [octyl phenoxy polyethoxyethanol] and 0.8M 5 percent v/v analytical grade nitric acid and dibasic ammonium phosphate as the matrix modifier. The matrix modifier stabilizes the lead in blood and aids in the removal of the blood matrix. This method was chosen for many reasons, some of which are its high percentage recovery—between 97.7–105.6 percent—and its high sensitivity and precision.

All the other samples (excluding the blood) were analyzed at the Egyptian Geological Study Labs using a Perkins Elmer Analyst 800 atomic absorption spectrometer with Zeeman background effect. The auto sampler was a GBC 908 type.

Appendix D
The questionnaire that has been used in the 2007 Study

تقدير تأثير أنشطة معالجة تلوث البيئة بالرصاص على قياس مستوى الرصاص فى الدم لدى المقيمين فى منطقة حول مسبك للرصاص بشبرا الخيمة، محافظة القليوبية، 2007.

بيانات تعريفية: __تاريخ المقابلة(يوم/شهر/سنة اسم الباحث:.....

بيانات المنزل:

العنوان(رقم المنزل/اسم الشارع/الحي/أي علامة مميزة) ....
.....

الرقم	الأسئلة	الأجوبة
١.	إيه نوع الدهان اللى انتم مبيضين بيه الشقة؟	محارة.....صفر جير.....١ زيت.....٢ بلاستيك.....٣
٢.	إمتى كانت آخر مرة بيتضوا فيها الشقة؟	(عدد الشهور/السنين) ☐
٣.	عندكم مكنسة بالكهربا وبتستعملوها فى الكنس؟	نعم.....صفر لا.....١
٤.	حالة طلاء الحوائط داخل الشقة (بالملاحظة)	متماسك.....صفر متهالك.....١
٥.	نظافة المنزل من الداخل (بالملاحظة)	نظيف.....صفر مترب.....١
٦.	مكان خلع الأحذية (بالملاحظة)	عند باب المنزل.....صفر داخل المنزل.....١
٧.	حالة النوافذ في الغرف المطلة على الشارع (بالملاحظة)	مغلقة.....صفر مفتوحة.....١

بيانات الأسرة:

الرقم	الأسئلة	الأجوبة
٨.	رب الأسرة بيشتغل ايه؟ يذكر عمل رب الأسرة بالتفصيل (طبيعة العمل/الجهة التي يعمل بها):.....	لا يعمل.....١ عامل (صناعي/زراعي).....٢ حرفي (ميكانيكي).....٤ شبه محترف (كاتب).....٥ محترف (مدرس).....٧
٩.		**(تترك للباحث الرئيسى)** الأب لا يعمل في مجال مرتبط بالرصاص.....صفر الأب يعمل في مجال مرتبط بالرصاص.....١
١٠.	ربة الأسرة بتشتغل إيه؟	لا تعمل (ربة منزل).....١

	يذكر عمل ربة الأسرة بالتفصيل (طبيعة العمل/الجهة التي تعمل بها):	عاملة (صناعي/زراعي).....٢ حرفية (ميكانيكي).....٤ شبه محترفة (كاتبة).....٥ محترفة (مدرسة).....٧
١١.		**(تترك للباحث الرئيسي)** لا تعمل في مجال مرتبط بالرصاص.....صفر تعمل في مجال مرتبط بالرصاص.....١
١٢.	تقريبا مصاريفكم كام فى الشهر؟	أقل من ١٠٠ جنيه.....١ ١٠٠ – ١٩٩ جنيه.....٢ ٢٠٠ – ٣٩٩ جنيه.....٣ ٤٠٠ – ٦٩٩ جنيه ....٤ ٧٠٠ – ٩٩٩ جنيه....٥ ١٠٠٠ فأكثر.....٦ لا تعرف.....٩٩

الطفل الأول (أقل من ٧ سنوات):

اسم الطفل:.....

رقم المنزل في الدراسة:.....

رقم عينة الدم :.....

الرقم	الأسئلة	الأجوبة
١٣.	الطفل بيخرج يلعب في الشارع؟	لا.....صفر نعم.....١
١٤.	الطفل بيلعب بره البيت قد إيه كل يوم؟	(ساعة) ☐
١٥.	هو متعود يحط ايده جوه بقه؟	لا.....صفر نعم.....١
١٦.	هو متعود يأكل حاجات غريبة من الأرض زي التراب وتقشير دهان الحيطة؟	لا.....صفر نعم.....١
١٧.	هو متعود يحط أقلام رصاص أو ألوان في بقه؟	لا.....صفر نعم.....١
١٨.	الطفل متعود يغسل ايده قبل الأكل؟	لا.....صفر نعم.....١
١٩.	ساعات الطفل بياكل خضار أو فاكهة مش مغسولة؟	لا.....صفر نعم.....١
٢٠.	انتى بتحطى له كحل في عينه؟	لا.....صفر نعم.....١
٢١.	انتى ملاحظة إن الطفل حركته زايدة عن العادي؟	لا.....صفر نعم.....١
٢٢.	انتى ملاحظة إن الطفل عصبي زيادة عن العادي؟	لا.....صفر نعم.....١
٢٣.	انتى ملاحظة إن الطفل تركيزه ضعيف؟	لا.....صفر نعم.....١
٢٤.	هو تأخر في المشي؟	لا.....صفر نعم.....١
٢٥.	هو تأخر في الكلام؟	لا.....صفر نعم.....١
٢٦.	جاله أي تشنجات قبل كده؟	لا.....صفر نعم.....١
٢٧.	فى حالة نعم: كان سببها إيه؟	سخونة.....١ مرض بالمخ.....٢ لم يستطيع الطبيب تشخيصها.....٣ تسمم .....٤ أخرى: تذكر.....٥ لا تعرف.....٩٩
٢٨.	جاله إغماء قبل كده؟	لا.....صفر نعم.....١
٢٩.	فى حالة نعم: كان سببها إيه؟	خبطة فى رأسه.....١ مرض بالمخ.....٢ لم يستطيع الطبيب تشخيصها.....٣ تسمم ٤

		أخرى: تذكر.....٥ لا تعرف.....٩٩

الطفل الثاني (أقل من ٧ سنوات):

اسم الطفل:.....

رقم المنزل في الدراسة:.....

رقم عينة الدم :.....

الرقم	الأسئلة	الأجوبة
٣٠.	الطفل بيخرج يلعب في الشارع؟	لا.....صفر نعم.....١
٣١.	الطفل بيلعب بره البيت قد إيه كل يوم؟	(ساعة) ☐
٣٢.	هو متعود يحط ايده جوه بقه؟	لا.....صفر نعم.....١
٣٣.	هو متعود يأكل حاجات غريبة من الأرض زي التراب وتقشير دهان الحيطة؟	لا.....صفر نعم.....١
٣٤.	هو متعود يحط أقلام رصاص أو ألوان في بقه؟	لا.....صفر نعم.....١
٣٥.	الطفل متعود يغسل ايده قبل الأكل؟	لا.....صفر نعم.....١
٣٦.	ساعات الطفل بياكل خضار أو فاكهة مش مغسولة؟	لا.....صفر نعم.....١
٣٧.	انتى بتحطى له كحل في عينه؟	لا.....صفر نعم.....١
٣٨.	انتى ملاحظة إن الطفل حركته زايدة عن العادي؟	لا.....صفر نعم.....١
٣٩.	انتى ملاحظة إن الطفل عصبي زيادة عن العادي؟	لا.....صفر نعم.....١
٤٠.	انتى ملاحظة إن الطفل تركيزه ضعيف؟	لا.....صفر نعم.....١
٤١.	هو اتأخر في المشي؟	لا.....صفر نعم.....١
٤٢.	هو اتأخر في الكلام؟	لا.....صفر نعم.....١
٤٣.	جاله أي تشنجات قبل كده؟	لا.....صفر نعم.....١
٤٤.	فى حالة نعم: كان سببها إيه؟	سخونة.....١ مرض بالمخ.....٢ لم يستطيع الطبيب تشخيصها.....٣ أخرى: تذكر.....٤ لا تعرف.....٩٩
٤٥.	جاله إغماء قبل كده؟	لا.....صفر نعم.....١
٤٦.	فى حالة نعم: كان سببها إيه؟	خبطة فى رأسه.....١ مرض بالمخ.....٢

		لم يستطيع الطبيب تشخيصها.....٣ أخرى: تذكر.....٤ لا تعرف.....٩٩

الأم/ سيدة / فتاة سنها من ١٥ – ٤٩ سنة:

أسم السيدة , الفتاه:.....

رقم المنزل في الدراسة:.....

رقم عينة الدم :.....

الرقم	الأسئلة	الأجوبة
٤٧.	بتقضى وقت بره البيت قد إيه؟	(ساعة فى اليوم) ☐
٤٨.	يا ترى انتى متعوده تغسلى اديكى قبل الأكل؟	نعم..... ١ مش دايما.....٢ لا.....صفر
٤٩.	يا ترى عندك مرض بتتعالجى منه لمدة طويلة؟	لا.....صفر نعم.....١
٥٠.	في حالة نعم: يا ترى أيه هو المرض ده؟	مرض في القلب.....١ مرض في الكبد.....٢ مرض في الكلى.....٣ ضغط دم.....٤ أنيميا.....٥ أخرى:تذكر.....٦
٥١.	أنتى متزوجة؟	لا.....صفر نعم.....١
فى حالة نعم: أكمل الأسئلة التالية.		
٥٢.	هو أنتى حامل دلوفت؟	لا.....صفر نعم.....١
٥٣.	هو أنتى بترضعى دلوفت؟	لا.....صفر نعم.....١
٥٤.	أنتى حملتى كام مرة؟	(عدد مرات الحمل) ☐
٥٥.	أنتى خلفتى كام مرة؟	(عدد مرات الولادة) ☐
٥٦.	انتى عندك كام طفل دلوقتى؟	(عدد الأطفال الأحياء الآن) ☐
٥٧.	إنتى سَقطى كام مرة؟	(عدد مرات الإجهاض) ☐
٥٨.	حصل إنك جبتى طفل عنده عيوب خلقية أو تشوهات؟	لا.....صفر نعم.....١

الأب/ رجل عمره من ١٥ – ٤٩ سنة:

اسم الرجل:.....

رقم المنزل في الدراسة:.....

رقم عينة الدم :.....

الرقم	الأسئلة	الأجوبة
٥٩.	بتقضى وقت بره البيت قد إيه؟	(ساعة فى اليوم) ☐
٦٠.	يا ترى انت متعود تغسل اديك قبل الأكل؟	نعم..... ١ مش دايما.....٢ لا.....صفر
٦١.	يا ترى عندك مرض بتتعالج منه لمدة طويلة؟	لا.....صفر نعم.....١
٦٢.	في حالة نعم: يا ترى أيه هو المرض ده؟	مرض في القلب.....١ مرض في الكبد.....٢ مرض في الكلى.....٣ ضغط دم.....٤ أنيميا.....٥ أخرى:تذكر.....٦

Appendix E
Informed consent used for the purpose of this study

استمارة الموافقة علي المشاركة في البحث

عنوان مشروع البحث :

تقدير تأثير أنشطة معالجة تلوث البيئة بالرصاص على قياس مستوى الرصاص فى الدم لدى المقيمين فى منطقة حول مسبك للرصاص بشبرا الخيمة، محافظة القليوبية، ٢٠٠٦.

الباحثون الرئيسيون: دكتور: سهام حسين و دكتور:علاء أبوزيد

الغرض / التوصيف: استنشاق وبلع عنصر الرصاص من الممكن أن يؤدى إلى أخطار صحية داهمة للأطفال والكبار على حد سواء. والبيئة من الممكن أن تحتوى على الرصاص فى التربة والماء والهواء. وقد ظلت منطقة شبرا الخيمة تعانى لفترات طويلة من معدلات عالية للتلوث بالرصاص نتيجة تركز الصناعات الخاصة بالرصاص فى هذه المنطقة. ونحن نريد أن نعرف أكثر عن مستوى الرصاص فى أجسام الناس خصوصاً بعد توقف الأنشطة المرتبطة بالرصاص وإتمام إزالة بقايا ومخلفات مسابك الرصاص من المنطقة. والهدف من ذلك معرفة جدوى معالجة تلوث البيئة بالرصاص على صحة السكان. وهذه الدراسة تجرى بواسطة وتحت أشراف وزرة الصحة والسكان بمصر وقد تم اختيارك للمشاركة فى هذه الدراسة لأنك تعيش فى المنطقة التى تجرى بها الدراسة ولأن عمرك مناسب لمتطلبات الدراسة أيضاً.

الإجراءات / الأعمال المطلوبة : لك حرية المشاركة فى هذه الدراسة مع العلم أن المشاركة تشمل الحصول على معلومات عن صحتك وصحة أسرتك فى الماضي والعوامل التى مرت بكم وربما ساعدت على تعرضكم لعنصر الرصاص (تستغرق ١٥ دقيقة). وكذلك إعطاءك أنت وزوجتك وأطفالك تحت عمر ٧ سنوات كمية تعادل 5-٣ مللى من الدم (انظر إلى حجم الأنبوبة التى تحتوى على سائل بكمية مماثلة) . و سوف تفحص عينات الدم لتحديد مستوى الرصاص بها

المخاطر: يحدث أحيانا عند سحب عينة الدم بعض الألم أو التورم تحت الجلد ونادرا الالتهاب.

الفوائد : سوف تستفيد أنت مباشرة من هذه الدراسة بحصولك على نتيجة نسبة الرصاص فى الدم والتى قد تساعد الطبيب فى تشخيص و علاج الأمراض المختلفة. وكذلك نأمل أن تفيد المعلومات عن مستوى الرصاص ى الدم فى تقييم جهود الإزالة التى تمت وبالتالي العمل على تطبيقها فى أماكن أخرى.

بدائل المشاركة : مشاركتك فى هذه الدراسة تطوعية تماما ويمكنك رفض المشاركة فى الدراسة بدون تأثير على تقديم الرعاية الطبية لك في أي مركز طبي تابع لوزارة الصحة فى مصر.

السرية : سوف تعامل جميع المعلومات عنك بسرية تامة ولن يشار إليك شخصيا في التقرير وأثناء عرض النتائج . كل عينات الدم سوف تحفظ فى

مكان الدراسة بطريقة آمنة ولا يصل إليها إلا الأفراد المصرح لهم بذلك.

التكاليف : المشاركة في هذا البحث مجانية والاختبارات والتحاليل مجانية.

الحق في الانسحاب : إن مشاركتك أنت في هذه الدراسة مسألة تطوعية تماما و من حقك سحب موافقتك علي المشاركة في هذه الدراسة في أي وقت بدون أي غرامة و بدون أي تأثير علي مستوي الرعاية الطبية المقدمة لك من وزارة الصحة. وإذا طلبت الانسحاب من الدراسة فيمكنك طلب التخلص من أي عينة محفوظة لك.

للحصول على معلومات إضافية عن البحث يمكنك الاتصال بالدكتور علاء أبوزيد, برنامج لايف – مشروع معالجة التلوث بالرصاص. تليفون رقم ٥٢٦٥٨٤٠ - ٠٢

ولأى سؤال عن حقوق المشاركين فى البحث وأي مشاكل تنجم عن المشاركة يمكنك الاتصال بمكتب رئيس لجنة مراجعة الأبحاث (مكونة من مجموعة من العلماء ، الأطباء ، وخبراء آخرين في تخصصات مختلفة) : مكتب اد عصام عزام بوزارة الصحة والسكان تليفون رقم ٧٩٤٨٥٤٤ - ٠٢

إذا كنت توافق علي المشاركة في هذه الدراسة ، من فضلك وقع على الاستمارة أو علم على المكان المناسب :

لا تعتمد إلا إذا كان خاتم IRB عليها .

سارية من : ٢٥ سبتمبر ٢٠٠٦ إلي ٢٤ سبتمبر ٢٠٠٧

اسم الفرد وتوقيعه

شهود علي إجراءات الموافقة : _____

توقيع المشارك : _____

التاريخ : _____

ملاحظة : نسخ هذا الاتفاق بالتوقيعات الأصلية يجب ان :

أ - تحفظ بالملف بواسطة الباحث الرئيسي .

ب - تعطي صورة الي الفرد المشارك .

APPENDIX F
LEAD AND ITS IMPACT ON HUMAN HEALTH

Lead contaminates the air, water, dust, and soil. It is probably the most persistent of all toxic metals in the environment. Knowledge of the toxic effects of lead (Pb) dates from as early as 1500 BC when the Egyptians used it. The Romans used lead extensively to line their aqueducts and water mains, and both the Greeks and Romans used it to line cooking vessels, since bronze pots tend to give food a bitter taste (Waldron and Stofen, 1974). Some historians have suggested that endemic lead poisoning caused by the consumption of contaminated food and drink contributed significantly to the fall of the Roman Empire because high lead levels have been detected in the skeletons of Romans dating from the period (Timbrell, 1991).

The use of lead or lead salts to sweeten wine was common in Europe after the 9th century, and associated outbreaks of lead poisoning were not infrequent. In colonial America, lead poisoning was also a problem, mainly due to the use of lead condensing tubes for distilling rum and to the use of earthenware with a high lead content (Waldron and Stofen, 1974). During Prohibition in the US in the 1930s, those drinking illicit moonshine whisky suffered renal damage as a result of lead poisoning that derived from the solder used to construct the stills. Lead poisoning has also resulted from the use of some medicinal agents (John, 1991).

CHEMISTRY OF LEAD

Physical Properties

Lead is a soft, bluish gray metal. Its fleshy surface shows a bright luster. It leaves mark on paper. The metal is malleable but not very ductile, the presence of other metal render it brittle. Lead is readily obtained in crystalline state through precipitation (Madan, 1994).

Chemical Properties

- Action of air: Lead is unaffected by dry air. Heating lead to a high temperature in the air will cause it to oxidize.

- Action of water: Lead is not affected by pure water in the absence of air but water containing dissolved air has a solvent action on it due to the formation of lead hydroxide. This phenomenon is called plumbo-solvency.

- Action of acids: Dilute acids have no action on lead, but hot concentrated acids form lead salts. Organic acids dissolve lead. A considerable danger is thus involved in using cooking vessels tinned with a compound containing lead (Madan, 1994).

USES OF LEAD

Lead is found in many compounds that have diverse industrial uses:

- Lead monoxide or litharge (PbO) is the atmospheric oxide of lead. It is used in the manufacture of paints, varnishes, ceramic cements, and red lead.

- Red lead (Pb3O4) is an oxide made by heating lead monoxide. Red lead is used as a red pigment, in the glass industry, and as a pipe joining cement.

- Lead dioxide (PbO_2) is used in grids for lead plate accumulators, as a rubbing surface for safety matches, and as an oxidizing agent.

- White lead is an amorphous powder insoluble in water and is used as a white paint, in preparation of red lead, and in pottery glazes. It is poisonous (Madan, 1994).

Lead is used in industry today, not in the kitchen. Major uses include:

- Metal products
- Batteries
- Power and communication cable coverings
- Sheet lead
- Solder
- Pipes, traps, and other extruded products
- Brass and bronze billets and ingots
- Building construction, especially for caulking lead
- Other oxides such as paints, pigments, and glass and ceramic products.

ROUTES OF EXPOSURE TO LEAD

Lead can enter the body through inhalation, ingestion, or contact with the skin. Although the amount of lead in food may be greater than that in the air, absorption from the lungs is greater. A significant cause of contamination is the fallout of lead particulate from the ambient air. In modern times, the chief source of lead in the air has been the burning of leaded gasoline, ore smelting, and coal burning (Timbrell, 1991).

Significant additional contamination of food with lead may occur during processing, particularly if the food is dried and ground. Other sources of lead contamination of foodstuffs include the use of lead arsenate as an insecticide and leaded ceramics and glazes in kitchenware. A significant additional source of lead contamination in the diet has been the use of lead-soldered cans for marketing food in areas that don't ban such cans.

Toddlers may ingest large quantities of lead through hand-to-mouth contact where their hands could be contaminated by soil and dust. Similarly, some children have a tendency to ingest non-food items (pica behaviors) that increase their exposure to lead (Hassanien and Horvath, 1999). Peeling, chipping, or chalking lead-based paints are a hazard to children, who chew paint flakes from window sashes and sills, doors, walls, and stairwells (EPA, 2003).

Lead may be found in drinking water due both to its presence in raw water supplies and to the corrosion of plumbing materials in water distribution network. The latter is usually the more important of the two sources.

The principal sources of lead in the distribution network are goosenecks or pigtails, lead service lines and interior household pipes, lead solders and fluxes used to connect copper pipes, and alloys containing lead, including some faucets made of brass or bronze. Lead solder and fluxes containing as much as 50 percent lead, for example, were commonly used to connect copper pipes (Laws, 1993).

All water is corrosive to metal plumbing materials to some extent, but lead is dissolved most readily by acidic water posing a danger to communities where tap water is soft and somewhat acidic. Waters remaining in contact with lead in the distribution system overnight, particularly soft waters, dissolve considerable lead. Meanwhile, customers with

lead service pipes should allow the first flush of water each day to be washed away (Okun, 1992).

The US Agency for Toxic Substances and Disease Registry (ATSDR, 1999) suggested that exposure to lead occurs in many ways. Exposure to dust and soil are generally considered to be the greatest danger. Lead in soil and dust can reach humans, especially children, through direct ingestion of the dust and soil on dirty hands or objects.

Inhalation of fugitive soil and dust blown by the wind could be another path of exposure to people living or working in areas with high lead levels in the soil and dust. Lead contaminated fugitive dust and soil could be picked up by the wind and deposited on uncovered food, deposited on food crops, or settle on any food during processing, as well as blowing onto the surface of water resources.

LEAD METABOLISM

The absorption and biologic fate of lead inside the human body depend on the physiologic characteristics of the exposed person, including nutritional status, health, and age. Children and pregnant women can absorb up to 70 percent of ingested lead, while adults typically absorb up to 20 percent (ATSDR, 2000).

Most of the retained lead is deposited in bones and teeth, which (in adults) contain about 94 percent of their total lead body burden. In children, bones and teeth contain about 73 percent of that burden. Lead may be stored in bones for a long time. Under certain conditions, lead will leave bones and re-enter the blood and soft tissue organs.

Those conditions include pregnancy, menopause, advanced age, and calcium deficiency (ATSDR, 2000). Inorganic lead is not metabolized, but absorbed, distributed, and excreted.

LEAD EXCRETION

Excretion of lead is accomplished primarily in the feces although some lead is also excreted in urine and sweat. Absorbed lead is transferred to the intestines primarily in the bile fluid, although a small amount of release also seems to occur directly through the intestinal wall (Waldron and Stofen, 1974). Because of the very slow rate of release of lead from bones and because of the continual exposure of humans to lead, the excretion rate of lead is generally exceeded by the rate of lead absorption throughout many people's life spans. Hence, the total body burden of lead tends to increase steadily with age. The body burden of lead during the first few years of life is minuscule compared to the body burden in later years, and since humans are not known to require lead in even very small amount, the accumulation can hardly be considered beneficial (Laws, 1993).

ADVERSE HEALTH EFFECTS

Lead is a toxin that has no biological function but one that causes adverse health effects (US EPA, 2003). The pathological effects vary, but in general reflect the tendency of lead to interact with proteins damaging tissue and interfering with the proper functioning of enzymes.

The precise molecular system of lead toxicity is not totally understood but its effects are clear and are exhibited primarily in the blood and nerves. This can create a specific risk for people living close to lead smelters from the smelter's emission of fine particles of reactive lead oxides. Lead produces anemia, growth impairments, and auditory pathway

and kidney function deterioration. Lead has an adverse effect in utero due to its ability to cross the walls of the placenta and restrict fetus development.

Children younger than seven years of age and fetuses are particularly susceptible to lead toxicity because of their developing nervous system, small body mass, and lesser ability to excrete lead from their bodies (Koura et al, 2001). In general, if adults and children swallow the same amount of lead, a bigger percentage of the amount swallowed will enter the blood of children than in adults (ATSDR, 1999).

Nervous System Toxicity

Fetuses and young children are more susceptible than adults to the neurological effects of lead. The incomplete development of the blood–brain barrier in fetuses and young children up to 36 months of age increases the risk of lead's entry into the developing nervous system, leading to permanent neurobehavioral disorders (ATSDR, 2000).

Adults may suffer increased incidence of depression, aggressive behavior, sleeping disorders, and antisocial behavior. Peripheral nerve palsies are rare, and the foot and wrist drop that were once characteristic of occupational lead poisoning only occurs after excessive exposure and are now rarely seen.

Blood Toxicity

Lead inhibits hemoglobin synthesis by inhibition of key enzymes in the heme pathway. Lead can induce two types of anemia: acute, high-level lead exposure induces hemolytic anemia, while chronic exposure interferes with heme biosynthesis by diminishing red blood cell survival (ATSDR, 2000).

Renal Toxicity

Acute exposure to inorganic lead can cause reversible damage to the kidneys; chronic exposure, however, may result in permanent damage. Gout caused by kidney damage has also been associated with lead poisoning.

Reproductive Dysfunction

Lead adversely affects reproductive function in both males and females, and recent studies in men occupationally exposed to lead have shown decreased sperm count totals and increased abnormal sperm frequencies. Although there is little information to indicate that lead is responsible for birth defects in humans, exposure of pregnant women can induce miscarriages and stillbirths (Laws, 1993)

Carcinogenic Effect

The US EPA classified elemental lead and inorganic lead compounds as Group 2B: probable human carcinogens (ATSDR, 1999).

Skeletal Effects

Lead prevents vitamin D conversion into its hormonal form, dihydroxyvitamin D, which is responsible for calcium homeostasis, thus impairing cell growth, tooth, and bone development.

Medical Management of Lead Toxicity

The medical care that should be given to a child with lead toxicity depends on the blood lead level (BLL) of that child. Lines of management other than medical include environmental and social interventions. Table 20 summarizes interventions to be taken in case of lead toxicity, depending on the BLL of the child.

Table 20: Medical Management of Confirmed Lead Toxicity in Children

Blood Lead Level µg/dL				
10-14	**15-19**	**20-44**	**45-69**	**≥70**
1. Lead education – Dietary – Environmental 2. Follow-up blood lead monitoring	1. Lead education – Dietary – Environmental 2. Follow-up blood lead monitoring 3. Proceed according to actions for 20-44 µg/dL if: – A follow up BLL is in this range at least 3 months after initial venous test or – BBL increase	1. Lead education – Dietary – Environmental 2. Follow-up blood lead monitoring 3. Complete history and physical examination 4. Lab work: – Hemoglobin of hematocrite – Iron status 5. Environmental investigation 6. Lead hazard reduction 7. Neurodevelopmental monitoring 8. Abdominal X-ray (if particulate lead ingestion is suspected) with bowel decontamination if indicated	1. Lead education – Dietary – Environmental 2. Follow-up blood lead monitoring 3. Complete history and physical examination 4. Complete neurological exam 5. Lab work: – Hemoglobin of hematocrite – Iron status 6. Environmental investigation 7. Lead hazard reduction 8. Neurodevelopmental monitoring 9. Abdominal X-ray with bowel decontamination if indicated 10. chelation therapy	1. Hospitalize and commence chelation therapy 2. Proceed according to actions in 45-69 µg/dL

Source: CDC, 2002

SCREENING CHILDREN FOR BLOOD LEAD LEVELS

Developed countries screen children for lead through screening programs that estimate the lead in blood of children on a routine basis to guide identification and case management of lead toxicity. The economic benefits of universal screening exceed the cost when more than half of children had elevated blood levels above 10 micrograms of lead per deciliter of blood (µg/dL). A sample of 3–5 milliliter (ml) of venous blood is drawn from the child and subjected to chemical analysis using a technique such as Graphite Furnace Atomic Absorption spectrophotometry.

The US started a national screening program for children between 12–72 months of age in 1991 (CDC, 2003). The Egyptian Ministry of Health and Population was planning to conduct an extensive survey to determine the distribution of actual blood lead levels in children in Cairo and to identify the environmental and behavioral factors determining exposure to lead (EEAA, 1997). Programs to manage lead toxicity include reducing or eliminating environmental hazards, improving nutrition, educating the family about managing lead hazards, and providing appropriate levels of medical care (CDC, 2003).

REDUCING OR ELIMINATING ENVIRONMENTAL HAZARDS

An environmental assessment of possible exposures, both interior and exterior, should be made. This should include:

- Inspection of the child's home and other sites where the child spends significant time.
- History of the child's exposure.
- Measurement of environmental lead levels in:
  - House dust
  - Paint that is not intact or is subject to friction
  - Drinking water

Once the assessment is complete, there are a number of specific actions that can be taken to reduce or eliminate the child's exposure to lead, including:

- Control house dust through frequent vacuum cleaning or by wet wiping, not by dry brushing, to control the dust.
- Replace or repair windows to reduce lead intrusion into the house.
- Keep windows closed as much as possible.
- Prevent the child from playing in sites containing contaminated soil such as play yards and streets.
- Wash hands frequently, especially before meals and after playing.
- Wash children's toys regularly.
- Seal or cover floors to make them smooth and cleanable.
- Wet wipe floors and wet wipe window components regularly.
- Vacuum clean carpets and floors before wet-mopping floors.
- Keep outdoor shoes for outdoor use only and leave them at the door: wear other shoes indoors.
- Move occupants out of housing that is being professional cleaned and/or remediated.
- If interior paint is known to contain lead:

  - Avoid disturbing intact lead paint
  - Replace or stabilize the leaded paints that are non-intact

- If drinking water is known to contain lead, run the tap water cold for 1–2 minutes in the morning, and then fill a container with water for drinking and cooking purposes.

IMPROVING NUTRITION

The following dietary suggestions may help decrease the hazardous effects of lead:

- An empty stomach may increase the chances of higher levels of lead due to increased absorption. Offer regular meals and snacks to your children. This can help reduce their chances of having high blood lead levels.

- High iron contents of food will reduce blood lead. Food high in iron include meats, chicken, dried beans, dark green leafy vegetables, molasses, and dried fruits.

- High calcium contents in diet will help reduce blood lead as it will help inhibit absorption. Foods high in calcium include milk, cheese, yogurt, tehina, halawa tehineia, and dark green leafy vegetables. Offer 2–3 servings of these foods each day.

- High zinc contents in food will lower blood lead. Foods high in zinc include meats, chicken, and whole-grain cereals and bread.

- High vitamin C will increase iron absorption. Foods rich in vitamin C include tomatoes, oranges, lemons, green peppers, watermelons, cantaloupes, strawberries, and green leafy vegetables.

- Do not encourage a low fat diet as a means of lowering high blood lead level. Generally speaking, raw fruits and vegetables are encouraged in the diet in accordance with reduction of fat contents. A balanced diet containing a variety of food especially raw vegetables and fruits provided at regularly scheduled meals and snacks will assure optimal nutritional status.

PUBLIC AWARENESS AND FAMILY EDUCATION

Residents of a neighborhood where lead contamination is high—and workers who have been employed in the area—should be informed about possible sources of lead identified during environmental investigations and the potential health effects of lead toxicity.

Family members should learn about the means of decreasing their exposure to lead in the environment through proper cleaning, window repair, and selection of food that is free from lead-bearing dust. They should be told of the special dangers of lead to children under 7 years of age, and warned to train their children to wash their hands frequently—especially after playing on the floor or outdoors. Children should be prevented from eating paint chips or other non-food items that might include lead bearing dust. Caregivers should receive instructions about proper nutrition and how a calcium and iron rich diet can directly impact lead-related health problems.

Finally, family members should understand the importance of medical screening and medical care, and where to obtain such care.