MINISTRY OF HEALTH

DIGESA

BLOOD LEAD STUDY ON A SELECTED GROUP OF THE POPULATION OF LA OROYA

(November 23 – 30, 1999)

Lima – Peru

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EXECUTIVE SUMMARY

INTRODUCTION

Lead constitutes a health hazard and jeopardizes the intellectual development of children. The long-term effects, in terms of future productivity, signify that the income for these people and the quality of life shall be devastating. The consequences for society include an increase in the cost of healthcare, a reduction of national productivity and the loss of national competitiveness, consequently affecting sustainable development. On an international level, the concern first came to light during the Summit of the Americas, where the Heads of State established agreements to promote the Removal of Lead from Gasoline. In our country, Supreme Resolution No. 057-97 MTC created the Multi-sector Commission for the Management and Coordination of the Air Quality Improvement and Removal of Lead from Gasoline Program. The Ministry of Transportation, Housing and Construction, through the Vice-minister of Housing and Construction, was charged with coordinating the Organization of the Commission, with the assistance of the Technical Organizations for the Transportation, Mining and Health Sectors, to support the development of the Activities included in said Program, linked to the areas of Regulation, Fuel Specifications, Air Quality and Environmental Monitoring—the latter two were coordinated by the Health sector through DIGESA.

In accordance with the aforementioned, the General Directorate for Environmental Health (DIGESA) proposed conducting blood lead studies in areas of major urban development and based on the number of circulating vehicles. The studies began in the cities of Lima and Callao. With the results obtained from an area in Callao, it was evident that the sources were mineral concentrate deposits originating from the center of country, located close to the homes and educational centers.

Peru is a mining country par excellence and La Oroya is the largest and oldest metallurgical center for smelting and refining. More than 505 of the mineral concentrates arriving at Callao originate from La Oroya. In light of this, DIGESA conducted the Blood Lead Study on a Selected Group of the Population of La Oroya, between November 24th and 30th, 1999. The main purpose of the study was to determine the baseline levels of lead exposure to later assess the changes in blood lead levels associated to the implemented industrial control and safety measures, as well as the environmental control measures.

It was expected for the population who lives in La Oroya to present values equal to or greater than those presented in Callao as they are also exposed to particles emitted during the permanent smelting and refining processes.

The city of La Oroya has a surface area of 388,420 Km^2, located at the southern latitude of 11°31'03" and western longitude of 75°17'15, at a height of 3,745 MASL. It is located 125 kilometers from Huancayo, and its climate ranges between <5°C and 17°C, with an average temperature of 14°C.

La Oroya's total population is 33,043 inhabitants, of which 4,000 are workers of the Smelter. The number of inhabitants under the age of 10 years make up 24.35% of the population (8,045 inhabitants), and population density is 68.95. With respect to primary and initial educational centers, the city has 22 primary educational centers and 21 initial educational centers, with a student population of 21.8%. The percentage of the population that is illiterate is 6.81% (2,732 inhabitants) of which 18.3% are men and 81.7% are women.

In La Oroya there are two companies that supply water to the population, one of which is the Municipal Company EMSAPA that supplies water to part of the population, and the other the company DOE RUN. The first extracts water from the stream and spring called Shincamachay, while the second extracts water from the Thisgo river. The Municipal Company has 1,390 domestic connections, 16 public fountains, 292 commercial connections and 42 state connections (education and health). The company DOE RUN has 6,536 connections supplying 30% of the Population (workers of the company DOE RUN company). 36.2% of the population has access to water and sewage services (12,626 inhabitants), and 15.7% (5,166 inhabitants) have access to only water services. The majority of the population is dedicated to mining activities—the remainder to commerce and transportation.

32% of the urban hub has access corridors and roads, and 22% sidewalks. With respect to the number of vehicles circulating, 60% of these are comprised of minibuses, 10% automobiles and the remaining 10% omnibuses. DIGESA conducted an evaluation of the air quality between August 31st and September 6th, 1999, registering a maximum concentration at 11:00 a.m. of 27.5 ug/m^3, a value that exceeds by 17.5 times the quarterly standard of 1.5 ug/ m^3 for lead according to the Environmental Protection Agency of the United States (EPA). These levels of atmospheric contamination were registered at La Oroya Antigua where the company DOE RUN's smelter is located. As such, the atmospheric contamination problem of the city of La Oroya is mainly linked to the Metallurgical Industry.

The contamination produced by the mining activities not only involves air resources, but also water resources. Therefore, DIGESA conducted an evaluation of the quality of water from the Yauli river (classifying it as Class VI water) between March 22nd – 24th, the results of which showed a lead concentration in the water of up to 70 times over the maximum permissible limit (0.03 mg/L, according to the "General Law on Waters"), which, according to the report, explains the discernible deterioration of the natural ecosystem.

The contaminants from both the water bodies and air are deposited into the ground. The plants, through their roots, absorb the minerals, which are stored in the plant tissue and on consumption one part is eliminated and the other is stored in the tissue, and so forth successively until it reaches the final consumer. Bread products brought to La Oroya come from Tarma, Huancayo, Chancahamayo, Satipo and the Junín province. There is a custom of eating “dried meat”, prepared by placing the meat outdoors to dry—during this process the meat is contaminated with the particulate matter and, mainly, with particles originating from the metallurgical plant.

In view of the above, it was determined to measure the blood lead levels from sampling blood of children living in La Oroya. It was expected for the children of La Oroya to present higher blood lead levels than those children of Callao, who live and study close to the mineral concentrate deposits. For purposes of the study, the areas of La Oroya Antigua, La Oroya Nueva and Santa Rosa de Sacco were chosen. The study was conducted between November 23rd and 30th, 1999.

METHODS

346 children, aged between 6 months and 10 years, were studied. Eleven educational centers participated, located in the areas of La Oroya Antigua, La Oroya Nueva and Santa Rosa de Sacco, as well as 201 people over the age of 10 years selected from the same aforementioned areas.

The blood samples were analyzed with quick-reading Lead Care equipment, based on anodic voltammetry. The parents of the children who participated in the study responded to a brief questionnaire on aspects related to lead exposure.

Possible adverse effects from lead were also evaluated with respect to the behavior and performance of the children at school. All participants of the study received information on blood lead levels and educational material on how to decrease lead exposure.

RESULTS

The blood lead level average of the children analyzed in the study was 33.6 ug/dl—the permissible limit is 10 ug/dl set by the World Health Organization—where 99.1% (n=343) presented values greater than 10 ug/dl, 86 % (n=298) presented values greater than 20 ug/dl, and 18.9 % (n=65) presented values greater than 44 ug/dl.

In relation to the population studied over the age of 10 years, the blood lead level average was 36.5ug/dl, where 98% (n=197) presented blood lead levels greater than 10 ug/dl , 70.4% (n=140) presented blood lead levels greater than 20 ug/dl, and 15.1 % (n=30) presented blood lead levels greater than 44 ug/dl.

Differences in blood lead levels were observed between the samples by district, where the highest value was registered in the children of La Oroya Antigua, whose average was 43.5 ug/dl, followed by Santa Rosa de Sacco with 28.7 ug/dl, and La Oroya Nueva with 26.6 ug/dl. With respect to the population over the age of 10 years, the highest average of blood lead levels was registered at Santa Rosa de Sacco with 39.9 ug/dl, followed by La Oroya Antigua with 35.8 ug/dl, and in third place La Oroya Nueva with 33.8 ug/dl. These high results were mainly associated to the contamination produced by the Metallurgical Plant. Concerning behavior patterns and school performance, 6.9 % of the children evaluated did not pass the school year, and 2.3 % presented a low school performance.

ARGUMENT

In urban areas the main source of lead in the environment originates from gasoline. In La Oroya, the main source of atmospheric contamination is the Metallurgical Plant, confirmed by the study of air quality conducted by DIGESA, where lead exceeds by 17.5 times the permissible limit. Moreover, we must consider that the Yauli river is also contaminated with lead 70 times over the permissible limit due to discharges from the mining companies made along the course of the river.

Lead in drinking water slightly passes the permissible limit. The combination of these factors may possibly be decisively influencing the presence of lead in the blood of children from La Oroya. By imposing a strict control of industrial safety measures directed toward the metallurgical plant and the mining companies, who discharge waste into the water bodies, it may be possible to lower blood lead concentrations, with the consequential health benefits for the children's health.

The average of blood lead levels registered in La Oroya (33.6 ug/dl) was higher than that of the area close to the mineral concentrate deposits (25.6 ug/dl), of Pasco (14.9ug/dl), Iquitos (11.4 ug/dl), Lima and Callao (7.1 ug/dl), without considering the area close to the mineral concentrate deposits, Arequipa (6.4 ug/dl), Trujillo (5.0 ug/dl), and Chimbote (1.0 ug/dl). Based on the study results, it is urgent to coordinate between the Health sector and the local sectors of Mining, Industry, Transportation, Education, Local Governments and the Company the development of coordinated and joint intervention plans to lower blood lead levels in children and any possible adverse effects.

CONCLUSIONS AND RECOMMENDATIONS

- The results concerning blood lead levels obtained from the population tested at La Oroya suggest an important environmental exposure to lead, the most evident in the city being the metallurgical complex of La Oroya. The average of blood lead levels in children under the age of 10 years was 33.6 ug/dl, and in the population over the age of 10 years the average was 36.5 ug/dl, exceeding by three times the permissible limit of 10 ug/dl established by the WHO.

- The value of blood lead levels greater than 10 ug/dl are directly related to lead in the environment generated by the Plant's emissions.
- It is necessary to implement an environmental epidemiological monitoring system (that includes a complete medical and psychological evaluation to determine the growth and intellectual development effects, particularly on the children) at the short-, medium, and long-term to assess the blood lead levels of the inhabitants of La Oroya, associated with the intervention measures.
- The children presented higher blood lead levels (43.5ug/dl) in La Oroya Antigua, and the greatest values in adults were registered in Santa Rosa de Sacco (39.9ug/dl); these results merit a more thorough study to determine the reason for the difference in these results.
- It is necessary to develop a Local Environmental Management program between the Heath, Mining, Industry, Transportation and Education sectors, the Local Government, and the Company to carry out joint and coordinated intervention measures to decrease blood lead level values and possible adverse effects on the population exposed to the metallurgical complex's emissions.
- Medical treatment is not recommended, otherwise the person [to be treated] is removed from the source site, or the source of exposure is eliminated. Children receiving medical treatment and who later return to live in their normal environment, contaminated with lead, quickly regain the levels presented prior to treatment; this acute increase in blood lead levels may have adverse effects.

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"The permanent fight against
environmental aggressions normally
determines responses that are
understood as fleeting discomforts."

INTRODUCTION

The majority of illnesses that attack man have a conditioning or triggering causal substratum, environmental in nature, with a low genetic or biological proportion. The permanent fight against environmental aggressions normally determines responses that are subjectively understood as fleeting discomforts, where man almost constantly experiences the consequences of this permanent adaptation under the continuous changes in his environment. From an ecological point of view, health is the permanent unstable balance between the interaction of man and his environment, understanding, hence, health as the continuous triumph in the fight against environmental aggressions; within this environmental context, factors related to life habits and styles are considered.

Modern life has contributed its advantages to humanity permitting better living conditions, but concurrently it has placed the validity of the notion of progress in question, by increasing the risks to which it is exposed. Industrial development has created the dumping of vast quantities of contaminating substances into the environment, without an adequate control to ensure their safe handling. Lead is a metal widely used in the industry that enters into our organism through respiratory or digestive means, accumulating in the bones, and damaging the central nervous system. Children in the first years of life are the most vulnerable to the effects of lead as they are in full development, permanently and easily affected depending on the length of period of exposure and the level of concentration in the environment.

This study was conducted in the city of La Oroya, the location of the largest and oldest metallurgical complex in the country that processes lead, among other metals. Initially, La Oroya was founded as a mining camp and over time became a city permanently exposed to air, ground and water contamination produced by the metallurgical complex. Consequently, the purpose of this study is to evaluate the blood lead levels of the children, given that they are the most vulnerable population. This research will allow us to collect other pertinent data to evaluate the magnitude of the current problem, evaluate the magnitude of other sources of lead exposure, important in obtaining an integral control of the exposure, and commence a monitoring system that will permit the monitoring of changes associated with the interventions put into effect to control lead intoxication.

> “Man almost constantly experiences the consequences of this permanent adaptation under the continuous changes of his environment.”

HISTORICAL OUTLINE

Lead intoxication has been known since the 2nd century B.C.—it was the first metal used by man since ancient times. The Greek physician Dioscorides claimed that “lead makes one lose his mind”, Hippocrates described the effects of chronic lead exposure on one’s health, and Tanquerel des Planches was the person to make the most thorough description of the effects of lead intoxication.

In 1897, in Brisbane, Australia, lead intoxication in children was described for the very first time, associated to painted guard rails, and in 1920, in the city of Brisbane, the first accord directed toward preventing intoxications by lead-based paint was put into effect. In the United States, during the first decade of the 20th century, lead poisoning or occupational intoxication caused by these types of paints was first described.

At the beginning of the 20th century, it was thought that if a child recovered from an acute state of intoxication, there would be no aftereffects. However, in 1943, Byers and Lord refuted this thinking in their reports involving 20 children that had overcome acute lead intoxications, of which 19 clearly presented manifestations of behavioral disorders or mental retardation. At the beginning of the 1970’s, various studies were conducted to analyze in detail the health effects of lead, whereby some showed a correlation with a decrease in cognitive functions, however these studies proved to be controversial. Since then, more sophisticated research has been conducted, better designed and with a general consensus as to the relationship between lead intoxication and cognitive functions.

To the extent the amount of research grew, the blood lead levels began to gradually drop to levels that, at first, were considered acceptable for the organism. As such, in 1960, the acceptable limit was 60 ug/dl, in 1971 that level dropped to 40 ug/dl, in 1975 to 30 ug/dl, to reach in Mexico, by 1985, a level of 25 ug/dl, and in 1995 the highest limit for blood lead levels was 15 ug/dl, and for the Centers for Disease Control and Prevention of the United States the acceptable limit for blood lead levels is 10 ug/dl.

In Peru lead was known and used since the Inca period, and its use was continued during colonial times. Large-scale production began with the founding of the La Oroya smelter in 1922, and increased until reaching present day levels. The largest deposits are found in the Peruvian mountain range.

> "Health is the continuous triumph in the fight against environmental aggressions. In this environmental context factors relating to life habits and styles are taken into consideration."

PREFACE

During the Earth Summit held in 1992 at the United Nations Conference on the Environment and Development–CUNAMAD—it was indicated that our prospects for [good] health depended on the proper and sustainable development of our natural and social environment.

Health cannot be separated from a multitude of environmental elements as diverse as air. The Agenda 21 plan of action of the CUNAMAD during the next years is not only directed toward national and local health leaders, but also toward decision-making officials of all sectors of the government, outlining a broad and stable cooperation necessary at both the national and international levels to ensure the survival of the human race and increase its wellbeing.

The chapter on "Protecting and Promoting Human Health" of Agenda 21 identifies the priority areas of the program that address the chiefly ignored health necessities and contrary environmental conditions. Among said areas are the reduction of health risks presented by contamination and environmental hazards.

During the Summit of the Americas held in Miami, Florida in December 1994, the Heads of State of 34 countries from the Western Hemisphere, including Peru, signed a plan of action that included an environmental initiative, an alliance for the prevention of contamination. Under this initiative, the respective governments committed to develop and implement national plans of action to gradually reduce the use of lead as an additive in gasoline. In 1995, another technical meeting was held in Puerto Rico where two projects were developed to reduce risks linked to lead.

The first project was to enable the development of national plans of action to eliminate lead from gasoline by 2001. The second was aimed at creating a list of health and environmental risks related to the exposure to difference sources of lead. This list would support the national plans for the reduction of blood lead concentrations to levels consistent with the standards set by the World Health Organization.

To meet this commitment, the Multi-sector Commission for the Management and Coordination of the Air Quality Improvement and Removal of Lead from Gasoline Program was created, by Supreme Resolution No. 057-97 MTC, in Peru, under the charge of the Ministry of Transportation, Housing and Construction. For the development of these activities, the commission is assisted by technical commissions from the Transportation, Mining and Health sectors, linked to the areas of regulation, fuel specifications, air quality and environmental monitoring—these last two areas are under the responsibility of the Ministry of Health – General Directorate for Environmental Health (DIGESA).

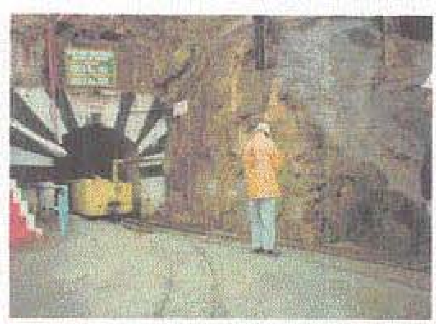
According to the objectives proposed by the Multi-sector Commission, the Ministry of Health, through DIGESA, conducted a study to determine blood lead levels in a select group of the population of Lima and Callao—this area was selected for presenting the largest urban development and possessing the large circulation of automobiles. The study began in July 1998 and concluded in March 1999.

To conduct this study, the United States Agency for International Development—USAID—donated to DIGESA equipment and supplies necessary for the study's development, providing personnel training on the handling of said equipment, and technical assistance for conducting the study, with the CDC, to confirm the results of the samples taken from the environment. When the equipment was inaugurated and handed over to DIGESA, the members of the Multi-sector Commission for the Management and Coordination of Air Quality Improvement and Removal of Lead from Gasoline Program were present.

Subsequently, the study was replicated in the provinces of Arequipa, Trujillo, and Iquitos. This is the study conducted in the city of La Oroya.

1 OVERVIEW

1.1 CHARACTERISTICS OF LEAD AND ITS USES



Lead is found in the interior layers of the earth; its presence in the environment is due to various processes: extraction, smelting, refining, product manufacturing, disposal and recycling. The most common form in which it is found is galenite (lead sulfur), which is also its most important commercial source. Other lead minerals are cerussite (lead carbonate), anglesite (lead sulfate), lead chromate, molybdenum, phosphate, chlorohydrate, and lead vanadate. Their presence on the surface is owed to economic interests.

Lead minerals are separated in the grinding process, polished by water, and classified by gravity and flotation. Metallic lead is a gray-blue color, soft and malleable, easy to smelt and mold. Its chemical symbol is Pb, it has an atomic weight of 207.2, density of 11.3, a melting point of 327°C, a boiling point of 1,620°C and a temperature of 550 - 600°C. Lead evaporates and combines with oxygen in the air to form lead oxide; the most important organic compositions are tetraethyl lead, trimethyl lead, and lead stearate. Lead is frequently used in different industrial processes such as paints, piping, ceramics and batteries, as an anti-detonator for gasoline or in the manufacturing of used products.

In the construction industry and in chemical plants, lead is used to provide flexibility and rust resistance for sheets and pipes. It is also used as a protective sheath for cables, as an ingredient in welding, and as a filler in the automobile industry. It serves as protective material for ionizing radiations. It is used in metallized protective layers for reserve batteries and in heat-treating water baths for stretching wires. Lead is present in a great variety of alloys and its compositions are prepared and used in vast amounts in many industries.

Other metals such as antimony, arsenic, tin and bismuth can be added to lead to improve its mechanical or chemical properties, and lead can be added to alloys such as bronze, brass and steel to obtain certain desirable characteristics.

Among the most common organic compounds are lead monoxide (PbO), lead dioxide (PbO_2), lead tetroxide (Pb_3O_4), lead sesquioxide (Pb_2O_3), lead carbonate, lead sulfate, lead chromate, lead arsenate, lead chlorate, lead silicate, and lead nitrate. The organic compositions of industrial importance include lead tetraethyl $Pb(C_2H_5)_4$, lead acetate, lead phthalate, lead silicate, lead stearate, lead palmitate, lead oleate and lead naphthalene.

40 % of lead is used as a metal in 25% of alloys, and 35% in chemical compounds; lead oxides are used in electric battery plates and accumulators (Pb_3O_4), as additive compounds in the manufacturing of rubber (PbO), as an ingredient in paints (Pb_3O_4) and as a component of glazes, varnishes and glass.

Lead salts form the base for many paints and pigments: lead carbonate and lead sulfate are used as white pigments, and lead chromates provide yellow, orange, red and green chrome. Lead arsenate is an insecticide, lead sulfate is used in the composition of rubber or elastics, lead acetate is used extensively as a drying agent, and lead tetraethyl is used as an anti-detonator in gasoline.

Lead, because of its physical and chemical characteristics, is an element that does not erode or disintegrate during the different stages of its processing, constituting a health hazard for the present and future generations.

1.2 LEAD SOURCES AND FORMS OF EXPOSURE

Various lead sources and forms of exposure have been identified (see Fig. 1), which vary in importance according to the characteristics of the different populations.

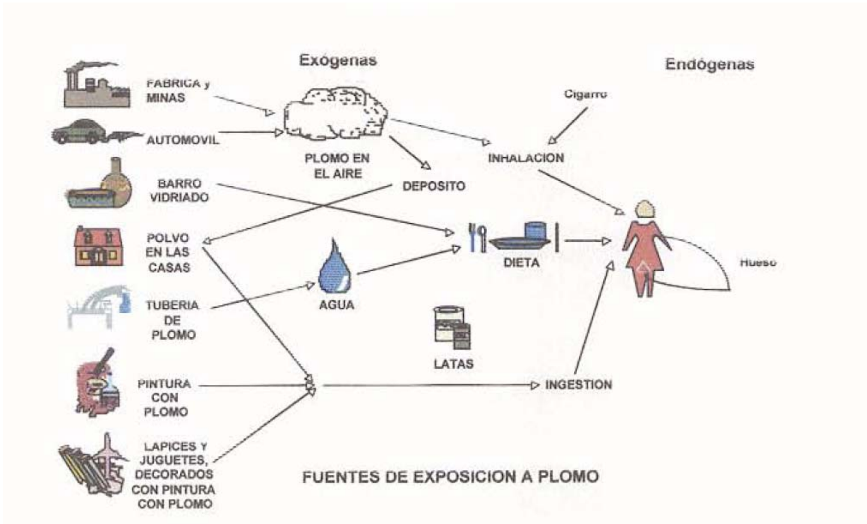
Populations that inhabit urban areas and use leaded gasoline, are, undoubtedly, exposed to what would there be the most important source of exposure (leaded gasoline), whereas populations that live in industrial areas, or in proximity to industrial areas, the main source of exposure is the industry that uses lead.

There are also residual, intra-domestic occupational sources, such as domestic lead smelting, the manufacturing of arts and crafts and others that, taking place within the family household and under improper hygienic and safety conditions, affect the entire family (children, pregnant women, and the elderly) and the neighbors. Other sources of exposure include lead-based paint, used in homes to cover walls or exterior structures.

Within the home, walls covered with lead-based paint can deteriorate and peel off in small pieces onto the floor, which can then be ingested by children crawling around, who later put their contaminated hands into their mouths. Lead can also be ingested by small children while biting and sucking on toys and pencils that are decorated with lead-based paints.

Foods can be contaminated with lead during their preparation or storage in handcrafted (low temperature) ceramic recipients, which can be decorated with a lead-based varnish, or foods stored in cans sealed with lead welding. Additionally, water can also be an important source of exposure to lead, mainly when it is transported through lead pipes or lead-welded pipes.

Figure 1



SOURCES OF LEAD EXPOSURE

1.3 HEALTH EFFECTS OF LEAD

The practically universal exposure to lead has brought about researches conducted by many scientists to determine the possible adverse health effects this metal could cause on entering into contact with the organism, documenting over the past decades a countless number of effects.

The absorption of inorganic lead compounds occurs through respiratory and digestive means, whereas organic compounds are absorbed through the skin. Gastric hydrochloric acid can cause intestinal absorption, but the majority of lead ingested is eliminated through the feces. Lead absorbed through the blood is transported to all organs and tissues, and more than 90% of the lead is retained by the erythrocytes, however lead tends to accumulate in the bones. Elimination mainly occurs through urine and feces. Lead in feces mainly comes from non-absorbed lead.

Inorganic lead causes contractions in the vascular peripheral system and affects blood circulating to the tissues, forming flat bones. The hematopoietic effects occur before observing signs and symptoms. Lead shortens the life of the erythrocytes and damages the hemoglobin synthesis.

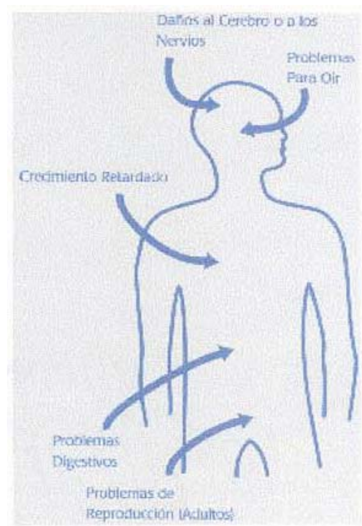
The most important information obtained was to recognize that children are part of the population most vulnerable to the damaging effects of lead. There is a greater scheme of lead absorption by children than for adults (WHO, 1995b). Preschoolers present additional, important sources of lead because they explore their surroundings with their hands and mouth, thus carrying lead dust found on the floor, playing with peeling toys containing lead-based paints, and chipped walls with lead-based paint. Consequently, children present higher blood lead levels in their organisms, compared to adults, confirmed by blood analyses. Additionally, post-natal blood lead levels increase after the age of six months, progressively incrementing until reaching the mobility stage of children (including the stage prior to mobility) and until the hand-mouth activities stage.

1.3.1 SIGNS AND SYMPTOMS OF LEAD INTOXICATION IN CHILDREN

Lead intoxication manifests itself through a series of symptoms, almost none of which have a typical predominance of subjective symptoms over objective signs.

For those children that do not present encephalopathy, lead intoxication can be characterized by one or several of the following symptoms: decrease in physical activity, lethargy, anorexia, sporadic vomiting, intermittent abdominal pain and constipation. In the cases of acute intoxication, encephalopathy can be diagnosed with the following symptoms: coma, convulsions, changes in behavior, apathy, lack of coordination, vomiting, altered states of consciousness, and loss of recently acquired skills (Piomeli et al 1984).

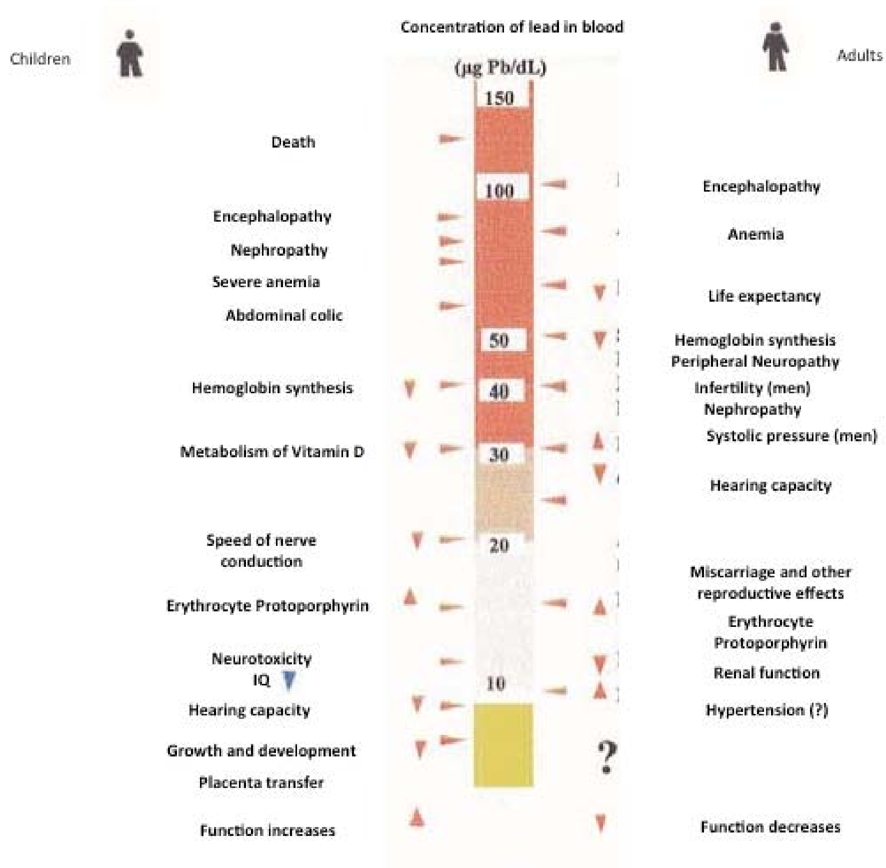
Exposure to lead during the first two years of life presents developmental delay risks, as well as deficiencies in cognitive functions.



Lead can interfere in almost all of the organism's functions and its affect on and alteration of the organs varies according to the dose of exposure (Fig. 2), however, the damage that has lately caused the greatest concern is the decrease in intellectual capacity, associated in various studies with the exposure to lead during the first stages of life, either in the prenatal stage or during the first two years of life. Recent epidemiological research suggests that blood lead levels, even when low, are also related to a decrease in the child's intelligence, not only to neurobehavioral or fine motor skill problems, as previously thought.

Estimates concerning the impact of lead on a child's intellectual development indicate that for each microgram of lead in the blood there is a decrease by 0.25 points in the Intelligence Quotient (IQ). This decrease may seem small on an individual level, however at the population level it is important. The exposure of a population to a lead average of 20 g/dl will increase by 68% the number of individuals with IQ levels lower than 65 points, and a decrease by 42% of subjects with high IQs greater than 135. (Mauricio Hernández – 1996).

Figure 2
Effects of Lead on the Health of Children and Adults



1.4 VULNERABLE POPULATION

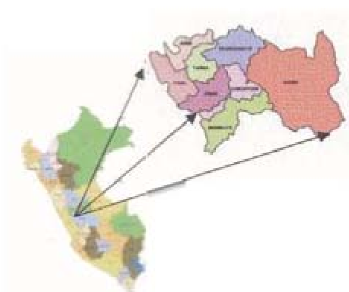
A large part of the world's population presents a detectable amount of lead in the organism, however this metal has no function whatsoever in the human body. Children and persons with low economic resources are the vulnerable populations, more susceptible to suffer health issues as they are exposed to high levels (by living or working in highly contaminated environments), an inadequate nutrition low in nutrients, with access to a limited supply of water, in proximity to contaminated soil and dust (the most common mode of lead transmission is present in the recreational areas of the children, as children tend to place their fingers and objects into their mouth), in addition to the

infrequent washing of hands, all of which facilitate the entry and accretion of lead in the organism.

A deficient health has a close relationship with poor living conditions and, at the same time, intensifies pressures on demographic growth and fast urbanization with respect to the environment's capacity. Poverty, the incapacity of an individual or home to maintain a minimum standard of life, is associated with grave economic discrepancies between groups of countries and segments of the population.

In developing countries the poor urban sector is not only larger, but its exposure to natural and human-produced environmental risks is generally more serious, as in the case of La Oroya – Junín, an eminently mining city with a high environmental contamination.

1.5 GENERAL CHARACTERISTICS OF LA OROYA



La Oroya is located in the province of Yauli, Junín department, at a height of 3,745 MASL, and a surface area of 388,420 Km^2, sitting at a southern latitude of 11°31'03" and a western longitude of 75°17'S", with an average temperature of 14°C, varying between -5°C and 17°C.

La Oroya has a population of 33,043 inhabitants (information provided by DISA), of which 4,000 are workers at the Metallurgical Plant; the other inhabitants depend indirectly on the mining activity. The child population is comprised of 8,045 inhabitants (the distribution of ages can be observed in Table 1), the number of women of childbearing age (WCA) is 8,421, and of pregnant women 1,159; the number of births per year is 918, with a population density of 68.95.

The illiterate population is comprised of 2,732 inhabitants, of which 500 are men and 2,232 are women. The student population at the initial and primary education stages in La Oroya and Santa Rosa de Sacco is 7,028 children (Tables 2 and 3 show the distribution by level and areas).

With respect to water and sewage services, 38.2% of the population (12,628 inhabitants) has access to both services, and 15.7% only to water services (5,188 inhabitants). There are two companies that supply water to the population of La Oroya, one is the Municipal Company – EMSAPA – that extracts the water from two sources: a stream and a spring, both bearing the name of SHINCAMACHAY, and the other is the Company DOE RUN, that provides water to its workers, extracting it from the Thisgo river. There are 1,390 domestic connections, 16 public fountains, 292 commercial connections, and 42 state connections (health and education) that depend on the Municipal Company. DOE RUN has 6,534 connections, supplying water to 30% of the population that work for the Company, and their families.

The urban hub has 32% of its surface with access corridors and roadways and 22% with sidewalks, with a vehicle circulation comprised of 80% minibuses, 10% automobiles and the remaining 10% omnibuses.

As the soil, water and air are contaminated, the plants absorb these minerals through their roots and store them in their tissue, affecting their normal growth and development, thus explaining the significant deterioration of the natural ecosystem and lack of cultivation areas. La Oroya has currently reduced the impacted cultivation areas of 14,190 hectares since 1941, to 3,800 hectares in 1996. It is therefore possible that the few foodstuffs produced in La Oroya destined for animal or human consumption contain traces of lead and other elements in their composition.

A large portion of the foodstuffs available in La Oroya comes from different places. The vegetables come from Tarma; potatoes, corn, lima beans and peas from Huancayo; yuccas and fruit from Chanchamayo and Satipo; and cheeses and meats from the Junín province. In this area, as in other locations in the sierra, there is a custom of eating “dried meats”, where meats are prepared at home by drying them impregnated with salt and hanging them outside. During this process the meats are contaminated with emissions emanating from the metallurgical plant, through the air.

1.5.1 THE METALLURGICAL PLANT OF LA OROYA

Traditionally, the La Oroya complex is know as the smelter of La Oroya, considered the metallurgical capital of the country, comprised of a set of smelters where metals such as copper, lead and zinc are processed, and later completed in the refineries. The Copper smelter was built in 1922, the lead smelter in 1928, and the zinc refinery in 1952. Currently, copper, lead, zinc, silver, gold, cadmium, and sub-products such as bismuth, indium, tellurium, tin, arsenic, antimony and selenium are all processed.

The Smelter is located in La Oroya Antigua, parallel to the main highway, and the Refinery is in La Oroya Nueva. The city of La Oroya, initially, was founded as a mining camp and over time has turned into a city.

1.5.2 DESCRIPTION OF LEAD PROCESSING

Lead concentrates reach La Oroya through trucks or rail to the preparation plant, where their quality is determined. The concentrates are then smelted with lime and silica, obtaining a homogenous substance that later passes through an agglomeration stage where the mixture is burned to remove sulfur, forming a porous mass called sinter. Sinter is mixed with coke and the lead produced passes through the copper extraction or decoppering phase, and later molded and transported by rail to the refinery, where it is refined electrolytically.

The silver metallic contents are recovered in the form of sludge, and returned to the smelter to be treated in the anodic waste plant. Currently the refined lead market of the metallurgical complex accounts for 40% of the national industry.

1.6 ENVIRONMENTAL STUDIES OF LEAD CONDUCTED BY DIGESA

1.6.1 AIR QUALITY

DIGESA conducted an air quality study in La Oroya between August 31st and September 6th, 1999, determining the principal stable and mobile sources of contamination in the area.

Stable sources include the smelter and the refinery, currently owned by DOE RUN. The operations and processes performed in the metallurgical complex of La Oroya currently make up the main source of particulate matter and gas emissions in the area.

Mobile sources include automobiles (cars, minibuses, minivans, omnibuses and trucks, among others) circulating in the main avenues and streets of La Oroya, and the national rail company ENAFER PERU-Oroya.

The highest levels of atmospheric contamination were detected in the vicinities of the La Oroya Antigua smelter, becoming more acute during moments of calm and changes in wind direction, where the contaminant concentrations in the air considerably surpass the respective standards of Air Quality for sulfur dioxide (SO_2), Total Particulate Matter (TPM), Particles Less than 10 Microns (PL10), and Atmospheric Lead (Pb).

It is worth mentioning that the main atmospheric contamination problem of the city of La Oroya is linked to the presence of lead in the air that reached, during the evaluation period, a maximum concentration level of 27.53 ug/m3, a value exceeding by 17.5 times the quarterly standard of 1.5 ug/m3 for lead established by the Environmental Protection Agency of the United States (EPA).

1.6.2 QUALITY OF WATER BODIES

Contamination produced by the metallurgical activity not only involves air resources, but also water resources. The river belongs to the Yauli province, Junín department, and covers the districts of Yauli and part of La Oroya. It has an extension of 31 Km. before reaching the Mantaro river, and 800 meters before reaching the city of La Oroya there is a narrow gorge, with no defined valleys. During its course, the river receives important discharges originating from the metallurgical mining operations of the area. DIGESA assessed the quality of water of the Yauli river during its entire course, classifying it as Class VI waters (Waters pertaining to a preservation zone for aquatic fauna and recreational or commercial fishing).

2 OBJECTIVES

The following objectives were set for the study:

a) Determine blood lead concentrations in a selected group of children aged between 2 and 10 years in order to have a basal level on which we could evaluate changes in concentrations relating to different interventions.
b) Identify environmental, socioeconomic and behavioral factors influencing blood lead levels.
c) Outline blood lead levels in children under the age of 10 years, and in adults, in order to have a basal level on which we could evaluate the changes in such concentrations relating to different interventions.

3 METHODOLOGY

3.1 STUDIED POPULATION

The study of random selection was conducted in the city of La Oroya between November 22nd and 28th, 1999, selecting preschoolers and schoolchildren ranging in age between 2 and 10 years, and members of the population older than 10 years of age. The educational centers and the population were selected by applying epidemiological criteria, ensuring that they were located at different distances of the smelter, in commercial or residential areas with intense vehicle traffic, and of a medium to low socioeconomic level. DISA and the OGE of Huancayo – Junín participated in the selection.

The selection of 346 children was made in 11 initial and primary educational centers located in La Oroya Antigua, La Oroya Nueva and Santa Rosa de Sacco. Children between the ages of 2 and 6 years (n=90) whose ages ranged between 3 and 6 years were selected from 4 Initial Educational Centers, and children between the ages of 6 and 10 years (n=256) were selected from Primary Educational Centers. The participating population over the age of 10 years (n=199) was selected from the same locations.

The work procedure applied to the educational and hospital centers was specific to each center.

3.2 SOURCES OF INFORMATION

To obtain information, we designed a brief, survey-like questionnaire, directed towards the parents or the person responsible for caring for the children, through direct interviews, lasting between 10 to 15 minutes. The survey enquired as to the physical characteristics of the child, the characteristics of the homes and their location, exposure to vehicle traffic, risk behaviors of the child, behavior, school performance, sources of environmental contamination, other sources of exposure and the occupation of the parents. The survey conducted for recent postpartum women also considered the following characteristics: exposure to lead during pregnancy and previous exposures, occupation of the mother and of the partner, smoking habits, nutritional habits and reproductive history.

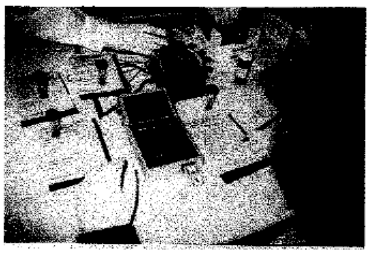
3.3 ETHICS

Only those children that presented a written authorization by their parents or the person responsible for their care, and accompanied by them, participated in the study.

3.4 WEIGHT AND HEIGHT MEASUREMENTS

The children were weighed using a scale with a precision of 100g, and measured with a metric tape measurer with a precision of 1 cm., in the school and hospital centers. For procedural reasons, the children were weighed and measured wearing their clothes.

3.5 DETERMINING LEAD IN BLOOD



State-of-the-art technology was used to measure lead in blood, allowing a faster circulation in the delivery of the results, requiring a minimum sample of blood. Two portable “Lead Care” equipment were used based on an anodic voltammetry, with a sensibility of 1.4 and 65 ug/dl, adequate for measuring blood lead concentrations.

Confirmatory analyses were conducted when the results obtained with the Lead Care equipment exceeded 30 ug/dl, using the conventional technique based on atomic absorption.

3.5.1 BLOOD SAMPLING

The washing of hands, particularly the fingertips, was a very important first step in determining the presence of lead, as the blood samples were taken from the ring finger, by pricking the finger using disposable lancets. The quantity required was three drops (50 ug).

For confirmatory analyses using the conventional technique, a blood sample of 3 cubic centimeters was required, obtained though venous puncture, whereby it was necessary to request the consent of the child’s parent or guardian.

Measures were taken so that the work environment was lead-free; additionally the medical supplies and equipment used for study were lead-free. The blood sampling process and analyses were conducted on a table with a lead-free cover, to minimize external contamination; laboratory personnel were duly wearing white uniforms and used disposable gloves that were disposed of if contaminated with blood.

3.6 DATA ANALYSIS

An electronic questionnaire was created and data entry was conducted using the statistical program EPI – INFO 6.04b and Stata 5.0, creating tables and frequencies of the registered variables to identify important blood lead predictors. Univariate analysis was conducted for all variables to detect and correct out-of-range values and digitization errors. Subsequently, to explore the differences between the different studied variables, bivariate and multivariate models were used. Given that the ages and area of residence resulted in important predictors for blood lead concentrations, the correlations between the different variables was evaluated adjusted by difference in age and area of residence. The statistical adjustment was made by including said variables into the regression models or stratifying the sample—for the latter, separate analyses were conducted for each study area. Once the important predictors of lead in blood were identified, multivariate analyses were conducted, where the effect of the different variables was jointly evaluated. Blood lead levels were analyzed on a continuous scale; for statistically significant tests, the natural logarithm transformation was used to normalize the distribution of blood lead concentration. The relation between the studied variables bearing the risk of having blood lead levels over 10 ug/dl, 20 ug/dl and 44 ug/dl was also evaluated. For this analysis, the measurement variable was transformed into an indicator variable using models of logistical regression. Bivariate analyses were conducted. Subsequently, regression models were applied, considering the effect of the different variables jointly. Blood lead levels were analyzed on a continuous quantitative scale, the statistically significant tests were conducted using the multiple, lineal regression; a chi-squared test was used to evaluate the relation between the qualitative variables; Kruskall-Wallis tests was used to compare the average blood lead levels with the different qualitative variables that had more than two categories. Tables and charts were created using the program Microsoft Excel, and the present report was drafted using Microsoft Word.

4 RESULTS

During the period between November 22nd and 28th, 1999, 545 people were tested, both children and adults, in three selected areas of the city of La Oroya: La Oroya Antigua, La Oroya Nueva and Santa Rosa de Sacco. The 346 children between the ages of 3 and 9 years were selected from 11 education centers, and the 199 inhabitants over the age of 10 years were also selected from the aforementioned three locations.

4.1 CHARACTERISTICS OF THE CHILD POPULATION

The average age of the children was 7.0 years, with a standard deviation (S.D.) of 1.4 years. The average of lead in blood of those children who participated in the study was 33.6 ug/dl (n=346), S.E=12.9, Geometric Measurement=32.8 ug/dl, where 99.1% presented blood lead levels greater than 10 ug/dl, and 85.9% greater than 20 ug/dl. 67.0% were concentrated in the 20.1 to 44 ug/dl range (see Table and Chart No. 3).

4.1.1 BLOOD LEAD LEVELS ACCORDING TO AGE

The highest average of blood lead levels was registered in children between the ages of 2 and 4 years, 38.9 ug/dl, whereas for the children between the ages of 8 and 10 years, the average of blood lead levels was 30.6 ug/dl. The minimum value was 6.9 ug/dl and the maximum 79.9 ug/dl, registered in the group of children between the ages of 4 and 6 years. (See Table and Chart No. 1).

4.1.2 BLOOD LEAD LEVELS ACCORDING TO LOCATION

A) LA OROYA ANTIGUA

In La Oroya Antigua the average of blood lead levels was 43.5 ug/dl (n= 39), S.E. and G.M. where 100% presented levels greater than 10 ug/dl, and 99.3% levels greater than 20 ug/dl, where 58.3% were concentrated in the 20 to 44 ug/dl range. (See Table and Charts Nos. 4 and 5).

B) LA OROYA NUEVA

In La Oroya Nueva the registered average of blood lead levels was 26.6 ug/dl (n=162), where 98.2% presented levels greater than 10 ug/dl, and 74.7% levels greater than 20 ug/dl. 71.6% were concentrated in the 20.1 to 44 ug/dl range. (See Table and Charts Nos. 4 and 5).

C) SANTA ROSA DE SACCO

The registered average of blood lead levels in Santa Rosa de Sacco was 28.61 ug/dl (n=45), where 100% presented levels greater than 10 ug/dl, and 86.7% presented levels greater than 20 ug/dl, where 82.2% were concentrated in the 20.1 to 44 ug/dl range. (See Table and Chart Nos. 4 and 5).

4.1.3 BLOOD LEVELS PER EDUCATIONAL CENTER

In La Oroya Antigua 5 educational centers were evaluated: 3 primary educational centers and 2 initial educational centers.

A) LA OROYA ANTIGUA

The children of the initial educational centers evaluated in La Oroya Antigua presented averages of blood lead levels 5 times greater than the permissible limit. This average was higher with respect to that of the children in the primary educational centers who presented 4 times the permissible limit, detailed below.

INITIAL EDUCATIONAL CENTERS: HEREDEROS DE CACERES and BASADRITO.

The ages of the children ranged between 3 and 5 years. The I.E.C. of Herederos de Cáceres registered the highest average of blood lead levels—55.2 ug/dl—where 50% were concentrated in the 44 to 70 ug/dl range, exceeding by 5 times the permissible limit, followed by the I.E.C. Basadrito, where 75% were concentrated in the 40.1 to 70 ug/dl range. None of the participating children of both these I.E.C.s presented values less than 10 and 20 ug7dl. (See Table and Chart Nos. 6 and 7).

PRIMARY EDUCATIONAL CENTERS: JORGE BASADRE, MANUEL SCORSA, NUESTRA SEÑORA DE FATIMA

In the Primary Educational Centers, the ages of the children ranged between 6 and 10 years. The highest average of blood lead levels was registered in the E.C. Jorge Basadre, with an average of 47.3 ug/dl, where 70.6% were concentrated in the 44.1 to 70 ug/dl range, followed by the E.C. Manuel Scorsa, registering an average of blood lead levels of 42.5 ug/dl, where 59.6% were concentrated in the 20.1 to 44 ug/dl range, and the E.C. Nuestra Señora de Fátima, where the average of blood lead levels was 38.5 ug/dl, where 75.9% were concentrated in the 20.1 to 44 ug/dl range. (See Table and Charts Nos. 6 and 7).

B) SANTA ROSA DE SACCO

In Santa Rosa de Sacco, 3 educational centers were tested: 2 initial educational centers and 1 primary educational center. The average of blood lead levels was slightly higher in the children of the initial educational level than those in the primary level.

INITIAL EDUCATIONAL CENTERS: SAN PABLO, NUESTRA SEÑORA DE FATIMA

The ages of the children ranged between 3 and 6 years, where the highest average of blood lead levels was registered in the I.E.C. San Pablo, of 32.2 ug/dl, where 57.1% were concentrated in the 20.1 to 44 ug/dl range, and 28.6% in the 10.1 and 20 ug/dl range, followed by the I.E.C. Nuestra Señora de Fátima, which presented an average in blood lead levels of 28.5 ug/dl, where 88.9% were concentrated in the 20.1 to 44 ug/dl range. (See Table and Charts Nos. 8 and 9).

PRIMARY EDUCATIONAL CENTER: DANIEL ALCIDEZ CARRION

The ages of the children at the primary education level ranged between 6 and 9 years. The average of blood lead levels in the E.C. Daniel Alcide Carrión was 27.4 ug/dl, where 85% were concentrated in the 20.1 to 44 ug/dl range. (See Table and Chart Nos. 8 and 9).

C) LA OROYA NUEVA

In La Oroya Nueva, 3 educational centers were tested: 1 initial educational center, and 2 primary educational centers. The average of blood lead levels registered in the initial educational center was slightly higher than those registered in the primary educational centers.

INITIAL EDUCATIONAL CENTER: BARCIA BONIFATY

The age of the children of the Initial Educational Center Barcia Bonifaty ranged between 4 and 6 years, presenting an average of blood lead levels of 29.2 ug/dl, where 83.7% were concentrated in the 20.1 to 44 ug/dl range. (See Table and Chart Nos. 10 and 11).

PRIMARY EDUCATIONAL CENTERS: FRANCISCO BOLOGNESI AND MIGUEL GRAU

In the Primary Educational Centers, the age of the children ranged between 6 and 9 years. The E.C. Francisco Bolognesi presented the highest average blood lead levels, 27.8 ug/dl, where 73.8% were concentrated in the 20.1 to 44 ug/dl range, followed by the E.C. Miguel Grau, whose average of blood lead levels was 22.9 ug/dl, where 57.3% were concentrated in the 20.1 to 44 ug/dl range. (See Table and Chart Nos. 10 and 11).

4.1.4 SOURCES OF LEAD EXPOSURE

A) RISK HABITS – HAND-MOUTH TYPE

Items investigated were those of fingers and objects placed in the mouth, eating, biting or sucking on pencils, crayons, play-dough, storybooks, toys and dirt. On analyzing the information, the habit of putting one's fingers into one's mouth was observed in 50.6% (n=175) of the children, and 46.8% (n=162) were observed to suck on wooden pencils (see Table and Chart No. 16). With respect to the materials from which the toys the children played with were made of, the predominant material was plastic, 94.5% (n=327). (See Table and Chart No. 16). 44.5% (n=154) of the parents stated that their children washed their hands sometimes, and 37.8% frequently (n=131). (See Table and Chart No. 17).

B) VEHICLE TRAFFIC

In this variable the following points were observed: the density of vehicle traffic, the mode of transportation to the education center, the wait time for transportation, and the proximity of the home to the transportation routes. With respect to vehicle density, 38.5% of the surveyed population stated that they lived close to high traffic routes, and 25.1% close to medium traffic routes. (See Table and Chart No. 18).

With respect to the modes of transportation to the educational centers, 57.4% stated that they walked to the center, and 39.7% used modes of transportation. (See Table and Chart No. 13). 42.1% used motorized vehicles as modes of transportation, and 10.3% waited for transportation for more than 15 minutes.

When asking the parents about the children's recreational areas, 50% replied the household, and 39.7% said both environments (house and street). (See Table and Chart No. 14).

39.0% of the studied population stated that they lived on streets or roads, and 29.0% on avenues, in passageways or cross-sections. (See Table and Chart No. 20).

C) PAINT

Concerning this point, the parent or guardian was questioned as to the paint used in the home or rooms, where 51.4% said they were painted once a year, and on specifying the paint used, 59.5% stated to have used washable paint. (See Table and Chart No. [missing from original text]).

D) OBTAINING WATER

The average value of lead in drinking water, from the samples obtained in La Oroya, was 0.025 mg/L, whereas the permissible limit is 0.01 mg/L (according to the WHO), with differences between the areas. (See Annex No. 4).

When asking about the supply of drinking water, 36.4% stated that they obtained their supply from the public fountain, 29% from the cylinders covered with tar and paint, and 28% have a domestic hook-up.

With respect to the mode of water consumption, 50% stated to drink boiled water, and 47.7% directly from the faucets.

E) OCCUPATION OF PARENTS

With respect to the occupations of fathers with high levels of lead in blood, those most noteworthy were watch guards (22%), workers of the metallurgical plant (21.7%), and other occupations related to the use of lead (15.3%). By taking their work clothes home, these fathers were exposing the health of their children and relatives. With respect to the mothers' occupations, 68.8% were housewives, and 12.7% dedicated to commerce.

4.1.5 EXPOSURE TO LEAD RELATED TO BEHAVIOR

A) SCHOOL PERFORMANCE

With respect to school performance, 6.9% failed a school year, and 18.2% failed an initial level year. In terms of school performance, 2.3% obtained low grades (less than 10), 40.5% regular grades (between 11 and 14), and 57% obtained grades higher than 14.

Results showed that 2.47% of the children with low school performance presented an average blood lead level of 13.4 ug/dl, whereas this average is slightly higher than those that performed well. On asking if a child had failed a school year, 3.06% responded yes; said children presented an average blood lead level of 18.7 ug/dl, higher than those who did not fail. (See Table and Chart No. 21).

B) BEHAVIOR

When we asked the parents of children participating in the study as to the child's behavior, 27.2% indicated that the child was easily distracted, 30.9% said they were highly hyperactive, and 23.7% said the child was highly irritable. (See Table and Chart No. 19).

4.2 CHARACTERISTICS OF THE POPULATION

199 persons over the age of 10 years participated in the study, where the maximum age was 83 years, and the average was 35 years. S.E.=16.2 ug/dl, G.M.=28.6 coming from La Oroya Antigua % (n=102), La Oroya Nueva % (n=75), and Santa Rosa de Sacco % (n = 22), presenting an average of blood lead levels of 36.5 ug/dl.

4.2.1 BLOOD LEAD LEVELS IN THE POPULATION ACCORDING TO AGE

The minimum age was 10 years, and the maximum 83 years. The population was divided according to age range, where persons over the age of 60 years did not present values greater than 70 ug/dl. For the age range between 10 and 15 years, the highest percentage (8.9 ug/dl of the total) was registered between 20 and 44 ug/dl.

4.2.2 BLOOD LEAD LEVELS ACCORDING TO LOCATION

A significant variation was observed between locations. The highest average was registered in Santa Rosa de Sacco, 39.9 ug/dl (n=102), with an S.E.=15.2, followed by La Oroya Antigua, 35.8 ug/dl (n=77) with an S.E.=16.6, and the lowest value of blood lead was registered in La Oroya Nueva, 33.8 ug/dl (n=22) with an S.E.=19.1 ug/dl. The maximum value of lead in blood was registered in La Oroya Nueva, with 83 ug/dl.

4.2.3 BLOOD LEAD LEVELS ACCORDING TO EDUCATION LEVELS.

With respect to the education level of the persons, the highest percentage of the participants, 47.3% (n=95) had had secondary schooling and registered blood lead levels in ranges greater than 10, up to 70 ug/dl, where the concentration of the greatest percentage, 25.4% (n=51) was in the 20.1 to 44 ug/dl range.

4.2.4 BLOOD LEAD LEVELS ACCORDING TO MARITAL STATUS

The predominant marital status was married, 49.7% (n=100), the greatest percentage, 23.9% (n=48), of blood lead levels was concentrated in the 20.1 to 44 ug/dl range.

4.2.4 BLOOD LEAD LEVELS ACCORDING TO VEHICLE TRAFFIC

Of the total of persons tested, 22.4% (n=45) stated that their homes were located in a passageway, of which 1.5% (n=3) presented blood lead levels higher than 70 ug/dl. 41.8% (n=84) stated that their homes were located on a street, where the highest levels of lead in blood were between 10.1 and 70 ug/dl, concentrating in the 20.1 to 44 ug/dl range. The remaining participants did not state where they lived.

With respect to vehicle traffic, none of the persons questioned declared to live in an area with high vehicle traffic, and did not present blood lead levels greater than 70 ug/dl. The highest percentage, 19.4% (n=39), were concentrated in the 20.1 to 44 ug/dl range.

5 ARGUMENT

Infants and children comprise the population most vulnerable to elevated levels of lead exposure, which increases according to the situation of poverty, lack of access to drinking water and sewage services, malnutrition, susceptibility, as well as habits and customs. Added to these risk factors are the proximity to the contaminating source, constant emissions and high concentrations of lead particles in the atmosphere.

One of the main reasons that explain why children present higher blood lead levels is because they tend to explore their surroundings with their hands and mouths (by ingesting dust with lead particles from surfaces, objects and walls with lead-based paint), whereby ingesting is the principal means for lead to enter the organism (Barrtrop and Khoo, 1975; Johnson and Tenuta, 1979).

On the other hand, children’s organisms, given their fast metabolisms, have the capacity to absorb lead in higher percentages than adults: children absorb approximately 50% of the lead through their diet, while adults tend to have an absorption rate of around 5% to 10%. Mahaffey, in 1981, demonstrated that when the amount of lead ingested exceeds 5 mg/Kg of the body weight, children relatively absorb and retain more lead.

Currently, the exact level of lead exposure is unknown, as is the critical age in which sign and symptoms of intoxication present themselves. The same occurs in relation to the irreversible effects; however, the age in which this problem could present itself would be during early infancy, when 50% of the nervous system is being developed. Some studies report that the higher velocity of accumulation, and therefore an increase in blood lead levels, is observed around the age of two years (DIGESA 1999)(López 1999).

Blood lead levels are the result of a dynamic process, and constitute the product of recent exposures. The CDC has classified blood lead levels in 5 ranges, where the greatest range is 70 ug/dl, classified as a medical emergency that could lead to an encephalopathy and death. Survivors of encephalopathies could be victims of incapacitating consequences for the rest of their lives, and present convulsions and mental retardation.

Hernández 1996, recommends medical treatment starting from 40 ug/dl, and not between 10 and 40 ug/dl; such treatment has an important medical complication risk. Actions recommended for children with values between 10 and 40 ug/dl are the identification and control of sources. According to the CDC, at these levels the following decreases occur: in hemoglobin synthesis, in vitamin D levels in the metabolism, in the speed of nerve conduction, in hearing, in growth and in intellectual quotient levels.

Some research affirms that blood lead concentrations are higher in populations living in proximity to fixed sources of lead emissions. These studies showed an average of lead in blood of children aged 2 to 7 years, in Brazil, of 39.0 ug/dl, and in children aged 1 to 6 years, in Nicaragua, of 11.5 ug/dl (OPS/WHO/ECO 1996).

Dust contaminated with lead is found in the air and ground, transported in clothes and shoes and brought to the home, especially by workers and watch guards who work or live in areas close to the lead smelter, increasing the levels of lead in children's blood (Abbritti et al, 1922).

In the study conducted in La Oroya, we used prior information on the existing levels of contamination in the area, especially in La Oroya Antigua, where the results of the air quality evaluation with respect to lead were alarming. The highest levels of air contamination were detected during the morning, especially at 11:00 a.m., exceeding by 17.5 times the standard level. It is necessary to consider this as children, when playing, tend to increase their respiratory frequency, taking in larger volumes of air, and, finding themselves in a contaminated environment, increase their blood lead levels.

La Oroya Antigua's drinking water also presented slightly high values of lead, in relation to those values of La Oroya Nueva and Santa Rosa de Sacco, which increases the amount of exposure by children to lead.

Based on results obtained in the evaluation of air and water quality, conducted by DIGESA, in the La Oroya Metallurgical Plant, it is estimated that the soil is also contaminated with lead particles, among other chemical substances, which are absorbed by the plants' roots, plants that constitute part of the population's and livestock's food, where the latter (livestock) is finally consumed by man, thus forming another means of lead entering the organism, although in lesser value. Also, if there is no customary habit of washing vegetables before eating them, the leaves could contain these lead particles, among others, contaminating them or uncovered foodstuffs.

During our study we corroborated the affirmation that the highest levels of lead in blood were present in areas in close proximity to the main source, which, in this case, is the smelter. The average blood lead levels in La Oroya Antigua was 43.5 ug/dl, in Santa Rosa de Sacco 28.7 ug/dl, and in La Oroya Nueva 26.6 ug/dl. It is possible that factors such as thermal inversion influenced these results.

The amount of lead particles that are emitted by the metallurgical plant, and transported through the air by wind, seems to be the main reason for the high values of blood lead levels in children. No significant difference was found between the children that spent greater amounts of time in their homes with those that played in the street. To the extent that smoke is dispersed in the air breathed by the population, it is feasible that lead enters through the respiratory system. When dust falls to the ground, the streets, sidewalks, and houses are contaminated, subsequently entering the children's organisms. Also, when the children bring their hands to their mouths, they enable the entry of lead through the digestive system.

The highest values of blood lead levels were detected in children ranging from the ages of 2 to 4 years, with no significant difference between children over the age of 4 up to 10 years, on whom the study was conducted. The level of exposure remains to be determined, when signs and symptoms occur.

The two initial educational centers located in La Oroya Antigua, close to the Smelter, presented the highest blood lead level averages, 55.2 and 53.7 ug/dl, exceeding by 5 times the permissible limit according to guidelines set by the WHO, classified, according to the CDC, as moderately elevated.

On comparing the average of blood lead levels of the Primary E.C. Jorge Basadre in La Oroya Antigua (47.5 ug/dl), the closest to the smelter, where children between the ages of 6 and 10 years were tested, with the average of blood lead levels (40.7 ug/dl) obtained from the Primary E.C. María Reiche del Callao of children the same age, the deposit of mineral concentrates was identified as the main source.

In the study, 2 children and 3 members of the population between the ages of 16 and 60 years were detected with blood lead levels higher than 70 ug/dl. On examination, they did not present characteristic signs or symptoms, nor did they evidence a clinical-toxicological correlation (namely, they did not present evidence of serious anatomic-physiological changes or changes in the psychological sphere, in the sensitive motor skills areas, neurobehavioral or intelligence areas). However, these blood lead levels are of considerable importance to put into effect intervention actions.

With respect to the habits of children of La Oroya, where 50.6% put their hands into their mouths, and where 16.8% declare to always wash their hands, it is understandable that the values of lead in blood are high. The scarce or low frequency of hand-washing increases the risk for children to present high blood lead levels, by putting their fingers into their mouths, enabling the ingestion of these lead particles which are deposited on all surfaces (ground, walls, streets, sidewalks, floors of construction material) and objects, into the organism.

Blood lead levels increase in the group of children who suck and bite on wooden pencils (46.8% and 16.2%, respectively). The toys the parents buy their children are usually made of plastic and painted with red and yellow colors, where the paint of these toys is another source of contamination as they are peeled by the children by putting them into their mouths or by their hands.

In La Oroya Antigua, the main location of the facilities of the smelter of the Metallurgical Complex, and in surrounding areas, the population constantly carries lead particles in their clothes after exposure to the complex's emissions. The level of contamination in the clothing increases the closer the proximity to the complex. In relation to the occupation of the fathers, 22% were watch guards, 21.7% were workers at the metallurgical plant, and

15.3% were dedicated to other occupations related to the use of lead. In relation to the occupation of the mothers, 68.8% were domestic housewives, and 12.7% were dedicated to commerce.

Concerning the population studied who were over the age of 10 years, the average of blood lead levels was higher in Santa Rosa de Sacco, followed by La Oroya Antigua and La Oroya Nueva. By crossing the different variables analyzed with respect to the levels of lead in blood, we observed that these were indifferent as the greatest percentage of 54.7% of lead in blood was always concentrated in the 20 to 44 ug/dl range (n=110).

CONCLUSIONS

1. The study conducted on 346 children ranging between the ages of 2 to 10 years, in the three locations of La Oroya, presented an average of blood lead levels of 33.6 ug/dl, where 99.1% exceeded the permissible limit (WHO). 0.9% presented values less than 10 ug/dl, corresponding to children who had recently moved to the area. The highest value of lead in blood was 38.6 ug/dl, detected in the age group corresponding to children between 2 and 4 years of age.

2. The blood lead levels obtained from La Oroya Antigua were, in comparison to the other two locations (Santa Rosa de Sacco and La Oroya Nueva), the highest. The average was 43.5 ug/dl, where preschoolers presented the highest levels (55.2 ug/dl), and the lowest level, 38.5 ug/dl, was registered with schoolchildren up to 10 years of age.

3. With respect to the population evaluated from a clinical standpoint, no signs or symptoms of chronic lead intoxication were observed.

4. Only 2.6% of children presented grades lower than 11 points, for which school performance is not greatly affected by the environmental exposure to lead, considering that the average of blood lead levels of children from La Oroya was three times greater than the permissible limit.

5. A reduced percentage of family parents (20%) stated that their children presented problems associated to distraction, hyperactivity and irritability.

6. The different variables analyzed did not influence the blood lead levels presented in the tested population, suggesting that the high blood lead levels of the population over 10 years of age tested is due to emissions emanating from the metallurgical complex.

7. The average blood lead level of the tested population in the city of La Oroya over the age of 10 years was three times over the permissible limit (10 ug/dl, considered as the same limit for children), and are found within the values of occupational exposure.

RECOMMENDATIONS

1. Establish an Environmental Monitoring System, through:

1.1 The environmental monitoring of air, water, food, and soil resources, both urban and marginal urban, with a predetermined calendar.

1.2 The biological monitoring of the children and adult population of the three locations studied. The concentration of lead as well as its metabolites shall be determined.

2. According to the results obtained from measuring lead in blood, children shall be psychologically evaluated. We recommend treatment criteria if the case so warrants.

3. Establish treatment criteria for both children and adults, as well as the initiation levels of such treatment.

4. The formation of a work group with all parties involved in the problem, so as to jointly find solutions.

5. Stimulating community participation to change behaviors to decrease environmental lead exposure, under the advice of the health and education sectors.

RECOMMENDATIONS

HOMES AND SCHOOLS

After detecting that the time of day when the concentration of lead in the air is highest is at 11:00 a.m., it is necessary to coordinate with the education sector for the implementation of the following measures:

- Avoid recesses at 11:00 a.m., or physical education classes. Teachers and parents must be asked to promote and supervise a continued habit of hand-washing on the part of the children.
- Clean the patio after wetting to remove dust particles containing lead from the floor and walls of places where the children play.
- In the event the ground is a dirt floor, grass from the area must be sown, which will not require much water. Place a damp cloth in the entrance of the pavements of the educational centers and in each doorway of each classroom.
- Necessary measures must be taken with respect to cleaning personnel so that the cleaning of the educational center is performed during the indicated time slots (before school commences, before recess, and after school).
- The time in which the population must remain indoors with windows shut is 11:00 a.m. Housecleaning must take place on a daily basis and again after 11:00 a.m., even when one has remained indoors with the windows shut.
- All surfaces must be cleaned with a damp cloth to lower the children's contact with particles. Foods and cooking utensils must be permanently covered.

MUNICIPALITY

The Municipality must increase the population's access to water and sewage systems, and avoid or decrease the frequent water shortages to enable the continuance of hygienic habits, especially the washing of hands.

METALLURGICAL COMPANY

The metallurgical company must participate in the work group involving the sectors (Mining, Health, Education, Transportation, Industry and Agriculture), and the local government, to support the actions arising from the work group.

MINISTRY OF HEALTH

The Ministry of Health must implement a promotional, preventive program concerning environmental lead exposure, especially in La Oroya Antigua.

MINISTRY OF AGRICULTURE
The Ministry of Agriculture must conduct joint efforts to identify the sources of lead in foods (vegetables, meats and milk) from local production, and subsequently conduct intervention actions that bring about a decrease in blood lead levels.

MINISTRY OF ENERGY AND MINING
The Ministry must participate in the work group to emphasize the measures to control the contaminating sources of the Metallurgical Company DOE RUN.

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