Children's Environmental Health in Argentina:

An Epidemiological Examination of Lead Exposure in School Aged Children

Asociación Argentina de Médicos por el Medio Ambiente
AAMMA

Canadian Institute of Child Health
Institut canadien de la santé infantile

Sociedad Argentina de Pediatría

Children's Environmental Health in Argentina:

An Epidemiological Examination of Lead Exposure in School Aged Children

Researched and Prepared by:
Daniel Beltramino, Argentine Society of Paediatrics (SAP); Linda Longerich, Memorial University of Newfoundland; Shelley Callaghan, Canadian Institute of Child Health (CICH); Lilian Corra, Asociación Argentina de Médicos por el Medio Ambiente (AAMMA); Verónica Monti, Asociación Argentina de Médicos por el Medio Ambiente (AAMMA); Argelia Lenardón, National University of Litoral; Jorge Scanetti, National University of Litoral; Carlos Gonzalez, National University of Misiones; Juan Carlos Bossio, National Institute of Respiratory Diseases "Dr. Emilio Coni".

Graphic Design:
Blackbird Publications, Communication & Design

Project undertaken with the financial support of the Government of Canada provided through the Canadian International Development Agency (CIDA).

Projet réalisé avec l'appui financier du gouvernement du Canada agissant par l'entremise de l'Agence canadienne de développement international (ACDI).

Canadian International Development Agency   Agence canadienne de développement international   Canada

Proyecto realizado con el apoyo financiero del Gobierno de Canadá, provisto a través de la Agencia Canadiense de Desarrollo Internacional (ACDI).

Electronic copies of the *Children's Environmental Health in Argentina: An Epidemiological Examination of Lead Exposure in School Aged Children* can be downloaded in English or Spanish at:

Asociación Argentina de Médicos por el Medio Ambiente — www.aamma.org

Argentine Society of Paediatrics — www.sap.org

Canadian Institute of Child Health—
http://www.cich.ca/Publications.html

Printed in Argentina

Esta publicación también está disponible en inglés con el título: "Children's Environmental Health in Argentina: An Epidemiological Examination of Lead Exposure in School Aged Children"

This publication does not necessarily reflect the perspective and opinions of the funding agencies or individuals that collaborated in the process.

Children's Environmental Health in Argentina:

An Epidemiological Examination of Lead Exposure in School Aged Children

Asociación Argentina de Médicos por el Medio Ambiente

AAMMA

Canadian Institute of Child Health
Institut canadien de la santé infantile

Sociedad Argentina de Pediatría

Por un niño sano en un mundo mejor

Table of Contents

Acknowledgements

The Asociación Argentina de Médicos por el Medio Ambiente (AAMMA), Canadian Institute of Child Health (CICH) and the Argentine Society of Paediatrics (SAP) would like to recognize the support provided by the Canadian government through the Canadian International Development Agency (CIDA-ACDI). Without this support and cooperation it would not have been possible to conduct the study and produce this report entitled: Children's Environmental Health in Argentina: An Epidemiological Examination of Lead Exposure in School Aged Children.

The Asociación Argentina de Médicos por el Medio Ambiente (AAMMA), Canadian Institute of Child Health (CICH) and the Argentine Society of Paediatrics (SAP) would also like to recognize the hard work and commitment from the following institutions and individuals who shared their experience and vision in the development of this document.

Institutions

- National Secretariat of Determinants of Health and Sanitary Relations, Ministry of Health of Argentina
- Coordinating Unit of Health and the Environment, Ministry of Health of Argentina
- Unit of Health and Environment, Secretariat of Environment and Sustainable Development, Chief of the Cabinet of the Presidency
- National Bureau of Maternal and Child Health, Ministry of Health of Argentina
- National Bureau of Promotion and Protection of Health, Ministry of Health of Argentina
- National Program of Children's Environmental Health, National Bureau of Maternal and Child Health, Ministry of Health of Argentina
- National Unit of Chemical Substances and Products, Secretariat of Environment and Sustainable Development, Chief of the Cabinet of the Presidency
- National University of Misiones
- National University of Litoral
- Sub-commission of Child Health and Environment, Argentine Society of Paediatrics (SAP)
- National Institute of Respiratory Diseases "Emilio Coni" (INER)
- "Todos por la Vida", Zárate
- Municipality of Zárate
- Municipality of Posadas
- Health Canada
- University of Ottawa, Canada
- World Health Organization

Individuals

- Maria Graciela Acuna, Zárate School District
- Yue Chen, University of Ottawa, Canada
- Osvaldo Cossa, "Todos por la Vida", Zárate
- Ernesto De Titto, Secretariat of Environment and Sustainable Development
- Maria Angélica Flores, Ministry of Health of Argentina
- Susana García, Ministry of Health of Argentina
- Gines González García, Ministry of Health of Argentina
- Louise Hanvey, Canadian Institute of Child Health
- Pablo Issaly, Secretariat of Environment and Sustainable Development
- Robin Moore-Orr, Canadian Institute of Child Health
- Adela Penna, Ministry of Health of Argentina
- Julia Piñero, Argentine Society of Paediatrics
- Atilio Savino, Ministry of Health of Argentina
- Janice Sonnen, Canadian Institute of Child Health
- Ana Speranza, Ministry of Health of Argentina
- Lorenzo Gonzalez Videla, Secretariat of Environment and Sustainable Development

Children's Environmental Health in Argentina:
An Epidemiological Examination of Lead Exposure in School Aged Children

Daniel Beltramino[1], Linda Longerich[2], Shelley Callaghan[3], Lilian Corra[4], Verónica Monti[4], Argelia Lenardón[5], Jorge Scagnetti[5], Carlos Gonzalez[6], Juan Carlos Bossio[7].

[1]Argentine Society of Paediatrics (SAP), [2]Memorial University of Newfoundland, [3]Canadian Institute of Child Health (CICH), [4]Asociación Argentina de Médicos por el Medio Ambiente (AAMMA), [5]National University of Litoral, [6]National University of Misiones, [7]National Institute of Respiratory Diseases "Dr. Emilio Coni"

Children's Environmental Health in Argentina: An Epidemiological Examination of Lead Exposure in School Aged Children is one of several activities that took place between 2004–2007 as part of a larger project entitled: *Measuring the Environmental Impact on Children's Health in the Southern Cone*. The main activities of the project included: a survey to the pediatricians who are members of the Argentine Society of Paediatrics, coordination of two case studies (one examining lead exposure in children and the other examining pesticide exposure in children); and, the development of *The Profile of Children's Environmental Health in Argentina*.

The *Measuring the Environmental Impact on Children's Health in the Southern Cone Project* is coordinated by a Steering Committee consisting of Canadian and Argentinean partners. In Canada the partners consist of: Health Canada; the University of Ottawa and the Canadian Institute of Child Health (CICH). In Argentina, the partners consist of: the Ministry of Health and Environment of Argentina, the Argentine Society of Paediatrics (SAP) and the Asociación Argentina de Médicos por el Medio Ambiente (AAMMA).

1.0 Introduction

1.1 Lead — background

Lead has been a well-known environmental pollutant for thousands of years. It is found in mineral deposits in nature and represents 0.002% of the earth's crust.

Millions of tons of lead are produced and used annually around the world.[1] Due to human activity, an alarming increase in the concentration of lead in the environment has been observed, especially during the second half of the 20th Century.

Lead is very persistent in the environment and through air, water and soil it enters the food chain contaminating living organisms. In adults and children lead is absorbed by ingestion, inhalation and through the skin. In adults between 5–15% of ingested lead is absorbed; in children ingested lead absorption can be as high as 30–50%. In both children and adults, approximately 40% of inhaled lead is absorbed by the lungs and although cutaneous absorption of inorganic lead is insignificant, organic compounds containing lead are absorbed completely through the skin.

Once inside the body, lead is transported through blood to different organs and deposits in bones. The half-life of lead in blood is considered to be between 20 and 40 days. In cases of calcium deficiency, the absorption of lead and its deposition in bone increases.[2] Lead is slowly excreted from the body mainly in urine, for that reason chronic exposure even at low levels results in accumulation.[1] In bones and teeth the half-life of lead is 25 years. However, during pregnancy and nursing when bone desorption can occur, lead deposited in the mothers bone cells can re-enter the blood stream.

Children are especially vulnerable to lead while in the womb as lead can cross the placenta, potentially damaging the fetus' central nervous system.

During the first 6 years of life, children are at higher risk of lead exposure due to their physiology, biology and behaviour patterns. At this age children are exploring their environments orally resulting in greater hand-to-mouth activity and frequent contact with the ground. In addition, children have increased absorption capacity (4 to 5 times greater than adults) and a decreased ability to excrete lead. Finally it should be noted that the brain is most vulnerable to lead in the first 5 years of life as the hematoencephalic barrier is not fully developed at this stage. Nutrition also plays a key role with iron and calcium deficiencies increasing the absorption of lead within the body[3]. In general, males are at greater risk of having high blood lead levels than females based on their social behaviour.[4,5]

Symptoms in children vary according to lead exposure levels. The most common are: anaemia (≥25 μg/dl); anorexia, abdominal pain, constipation and vomiting (≥60 μg/dl); migraines, lethargy, coma and convulsions (>70 μg/dl). While, children exposed to chronic low lead levels do not have immediate clinical symptoms, long-term control studies have reported: lower intellectual quotients (IQ); reading and learning difficulties; hearing and attention problems (hyperactivity, disorganization, inability to follow directions); memory loss; and behavioural problems (aggressive-criminal behaviour), among others.

The sources of frequent exposure to lead include: leaded gasoline; industrial waste; lead smelters; lead paints; ceramic and porcelain glazing; lead pipes; food cultivated in contaminated soil; food cans sealed with lead; children's plasticine and paints; cosmetics; jewelry; proximity to auto repair shops using lead batteries or oils; and proximity to open garbage burning, among others. Lead exposure and contamination tends to be higher in those children that live in poverty and/or manipulate lead as part of their work/play activities.

Recent publications[5,6,7,8] indicate that blood lead levels in children can be related to socioeconomic status. Important risk factors for increased lead levels are: precarious housing, over-crowding, malnutrition, living near landfills, industry or contaminated sites, low education level of parent and child labour.

Climatic conditions can also increase the amount of lead found in the urban atmosphere.[8] There are studies that indicate that high atmospheric levels of lead appear during periods of high humidity. In the summer months the amount of atmospheric lead is greater due to increases in surface moisture, particulate matter, temperature and wind speed.[8]

1.2 Evolution of knowledge

At the beginning of the 20th century, lead poisoning was considered an acute occupational illness affecting adults with blood lead levels below 80 µg/dL considered "normal." This threshold for lead toxicity was accepted at this time, as the lowest level causing symptoms of acute intoxication.

The adverse effects of acute lead poisoning in the development of children became evident in 1940 due to the publication of long-term effect studies.[9] These studies reported effects on intellect, behaviour and some psychomotor functions.

Since 1950, several researchers have conducted studies that provided additional information on the impacts of long-term lead exposure. Differences between children and adults regarding lead absorption, distribution and metabolism were reported and long-term effects of chronic toxicity, in particular those affecting the central nervous system were described. Independent studies carried out in the 70's[10] described a reduction in the Intellectual Quotient (IQ) and neurobehavioral alterations in exposed children that had never presented acute toxicity symptoms.[1]

With this new information on the special vulnerability of children to lead, the toxicity threshold accepted by the United States Centres for Disease Control (CDC) as a limit for intervention in 1960 (60 µg/dL) decreased until it reached 10 µg/dL in 1990. This limit is currently accepted by the WHO. However it should be noted that new studies are demonstrating that even at blood lead levels below 10 µg/dL measurable damage in the cognitive function of children can be seen.[7]

In Argentina, few studies have been published on lead poisonings, and those which have been published do not report the average blood lead levels of children and its evolution in time. However, work in this important area is taking place in Argentina by a host of researchers including:

Astolfi et al (1965)[11] and Giménez et al (1979)[12] both on acute lead poisoning related to children; and, Hansen et al (1995–6)[13]; Rovirosa et al (2000)[14]; Durán et al (2000)[15]; Rogers et al (2002)[16] and Fernández et al (2005)[17], who investigated blood lead levels in groups of asymptomatic children.

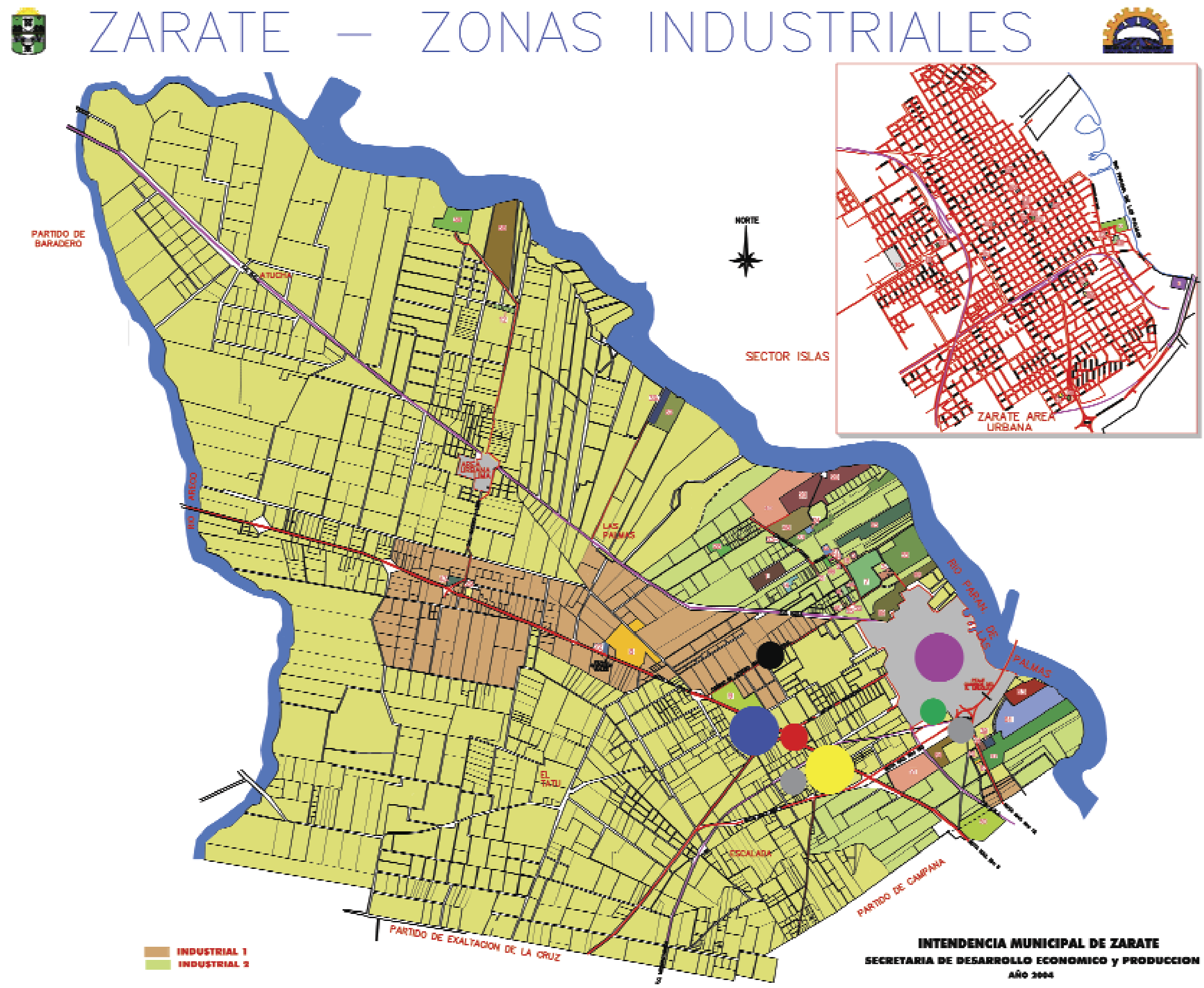
Successful interventions have been based on the elimination of sources of exposure. A good example is the dramatic reduction in blood lead levels of children in the United States after the elimination of leaded gasoline. In 1996 lead was eliminated from gasoline in Argentina[18]. Although no national studies have been conducted to measure the impact of this intervention it could be predicted that blood leads were reduced as a result.

1.3 Background on Zárate, Buenos Aires Province

Zárate is located next to the Paraná de Las Palmas River; this area includes the towns of Zárate, Lima and Escalada. It occupies a surface area of 1,202 km^2 and has a population of 101,271[19]. The city of Zárate itself has a population of 86,686, 28% of which are under 15 years of age[19] with a population density of 76.4 people/km^2.

Zárate has an Industrial Park comprised of 72 companies (Figure I). Companies participate in a long list of industrial activities, including: treatment, incineration and final disposal of industrial waste; chemical recovery (solvents, other); treatment and preservation of wood; pesticide and agrochemical production, asphalt and insulation emulsions; chemicals to treat leather, production of lead batteries and records; automotive manufacturing; cement plants; pulp and paper plants; and a nuclear power plant, among others.

FIGURE 1[20]: MAP OF ZÁRATE SHOWING THE LOCATION OF SCHOOLS Nº 8 AND 12, LANDFILLS, NEIGHBORHOODS AND CLOSED LEAD SMELTER.



LEGEND

- School Nº 8 (red)
- School Nº 12 (green)
- Garbage waste disposal where open burning of garbage takes place (grey)
- Meteor neighbourhood (purple)
- Cuartel III neighbourhood (blue)
- 4 Esquinas neighbourhood (yellow)
- Closed lead smelter (black)

Source: Secretary of Economic Development and Production from the Municipality of Zárate (2004) http://www.zarateproductivo.com.ar/plano.pdf

In 2004, a lead smelter and recycling plant in the Industrial Park's property was closed under Resolution N° 495/04 from the Department of Environmental Policy of the Municipality of Zárate, because several lead poisoning cases were reported by factory workers. Later that year, the Secretary of Health of the Municipality of Zárate reported an increase in blood lead levels in some children and teachers attending a local school 300 meters from the closed factory (School N° 19). The school was immediately closed with children and staff sent to other schools. Most of the children and staff were relocated to School N° 8 and School N° 12, 3,000 and 5,000 meters from the closed factory respectively, but both still inside the perimeter of the Industrial Park.

In 2005, the Municipality of Zárate, through the NGO "Todos por la Vida", asked the Steering Committee of the project *Measuring the Environmental Impact on Children's Health in the Southern Cone* to carry out a study to measure blood lead levels of students attending schools N° 8 and N° 12. Prior to approaching the Steering Committee with this request the NGO received permission from parents and teachers associated with these two schools.

The study was carried out by Steering Committee partners, with collaboration from the Faculty of Biochemistry and Biological Sciences of the National University of Litoral, the National Institute of Technology Development for the Chemical Industry, the National Institute of Epidemiology "Emilio Coni" and the active participation of the Municipality of Zárate, the NGO "Todos por la Vida", Zárate's school district and the Schools N° 8 and N° 12 Administration. The Project was also Declared of Educational Interest by the Ministry of Education of the Province of Buenos Aires.

2.0 Objectives

Main objective

- To investigate the blood lead levels of students in two educational establishments located within the Industrial Park of the city of Zárate.

Secondary objective

- To identify the probable sources of exposure in children that presented blood lead levels of 10 μg/dL or higher.

3.0 Population, materials and methods

The study was developed in the city of Zárate, Province of Buenos Aires (Argentina), between March 2005 and April 2006.

The study's population included 421 students of both sexes, ages 4 to 16 years of age that attended two schools located inside the perimeter of the Industrial Park of the city of Zárate, belonging to the Ministry of Education of the Province of Buenos Aires: School N° 8 had 153 students and School N° 12 had 268 students. The students from both schools came from homes qualifying as having at least one or more unsatisfied basic necessities (UBN) including: unsafe housing; without a functioning bathroom; over-crowding, incomplete schooling of the parents, and families with less than subsistence level income. In general, children attending these two schools lived in neighbourhoods with unpaved streets, without sewers, with restricted access to drinking water and without waste collection services.

A descriptive, cross sectional study was carried out. All students from both schools were invited to participate in the study. Those that accepted the invitation formed part of a non-random convenient sample. Participation in the study was voluntary, anonymous and free of charge.

Inclusion parameters required that participants were students of either school N° 8 or N° 12 of the city of Zárate, between 4 and 16 years of age, had signed consent forms (by parents or guardians) and answered the epidemiology questionnaire. Exclusion parameters included religious objections to blood extraction, treatment with chelating agents up to 6 months prior to the study and refusal by the children themselves at any stage of the study including during blood sampling.

The study was approved by the Ethical Committees of the National University of Litoral (Argentina) and the University of Ottawa (Canada). Confidentiality of children's personal data was ensured through the Personal Data Protection Law 25.326[21]. The National University of Litoral took the responsibility of protecting and handling all collected information. Personal information was coded so that children were not identifiable by name. In order to carry out the study in these schools, all necessary permits were negotiated from the School Council of the Ministry of Education of the Province Buenos Aires.

3.1 Study development

3.1.1 Information prior to the study stage

Two information meetings were conducted in each of the participating schools prior to the study. Students, parents/guardians, administrative and educational staff participated in the meeting.

At the meetings information was provided on exposure to lead, the ways in which exposure can occur, potential health effects, the special vulnerability of children, prevention and treatment options. Also, information was provided on the characteristics of the study, the reasons for blood sampling in order to identify the participants' blood lead levels and the way in which samples would be obtained. Students were invited to participate with parents/guardians being informed that their child could only participate if they signed the informed consent form and responded to the questionnaire.

As part of the meetings, students, parents/guardians and teachers were invited to ask questions to clarify anything they did not understand. The project was publicly presented in the city of Zárate and disseminated by local communication sources.

3.1.2 Questionnaire distribution and collection, blood sampling and presentation of results

The distribution and collection of questionnaires, blood sampling and presentation of results was carried out at the schools. Data on the children such as *school attended*, *personal data*, *school grade* was collected through the questionnaire. Via the questionnaire parents/guardians were also asked about situations that could increase risks of lead exposure (housing, work, etc.).

Blood sampling was carried out by professionals from the Faculty of Biochemistry and Biological Sciences of the National University of Litoral who used clean, disposable gloves for each sample, protective clothes and safety goggles. The children's hands were first washed with soap and warm water, the selected finger was then cleaned with ethyl alcohol (70%) and dried with absorbent gauze. The finger was then punctured on the side, not on the finger pad. The first drop of blood was cleaned with absorbent gauze, the second drop after applying gentle pressure was used to fill the blood sampling capillary of the LeadCare® equipment[22]. Finally, after cleaning the exterior of the capillary with absorbent gauze to remove any excess blood, the sample was immediately mixed with the reagent. All steps indicated by the LeadCare® manufacturer were then followed until results were displayed.

Results were compiled and presented to the parents in sealed envelopes, during individual meetings and in presence of school authorities.

3.1.3 Follow-up of students with blood lead levels of 10 µg/dL or greater

The group of children that had blood lead levels of 10 µg/dL[23] or greater were subdivided into two groups: the first group of children had blood lead levels of 10 to 19 µg/dL (Group 1) and the second group of children had blood lead levels of 20 µg/dL or greater (Group 2). For both groups the standards recommended by for USA Centres of Disease Control (CDC) were applied (Table 1: Categorization of Blood Lead Levels (µg/dL) by action (CDC)) and it was suggested to parents/guardians that once the study was completed, children should receive continued medical supervision.

Group 1 included children with blood lead levels ≥10 µg/dL. An in-depth follow-up interview was conducted with parents/guardians to further determine possible exposure risks. During the interviews blood lead levels were released in sealed envelopes. Parents/guardians were questioned in detail on the probable sources of lead exposure and ways to avoid exposures were suggested. Recommendations regarding children's personal hygiene, home cleaning, water and food preparation methods were offered. If there were other children in the family that had not participated in the study, it was suggested they see a health professional for blood lead testing.

Group 2 consisted children with blood lead levels ≥20 µg/dL. An in-depth follow-up interview was conducted with parents/guardians of these children to further determine possible exposure risks. With Group 2 parents/guardians, the procedure described for Group 1 (above) was followed. But in addition to individual interviews, home visits of all Group 2 children were took place with a social worker from the Municipality of Zárate. The visits were carried out under the supervision and in collaboration with the Secretary of Health of the Municipality of Zárate.

Thirty days after individual interviews with Group 2 parents/guardians, an additional blood sample was taken for follow-up lead level determination, again following the recommendations outlined in Table 1. The results of the second blood test were released to the parents/guardians in a sealed envelope during second interview. It was strongly recommended during the interviews that these children receive on-going medical supervision after the completion of the study.

Table 1. Categorization of Blood Lead Levels (µg/dL) by action (CDC)

Blood Lead Level, µg/dl	Recommended Action
10-14	Repeat testing within 3 months Evaluate sources of lead contamination Educate: clean hands and mouth
15-19	Repeat testing within 2 months Evaluate sources of lead contamination Educate: clean hands and mouth Refer to health care
20-44	Repeat testing within 1 month Evaluate sources of lead contamination Educate: clean hands and mouth Refer to health care
45-69	Repeat testing within 1 month Evaluate sources of lead contamination Educate: clean hands and mouth Refer to health care Chelation treatment
70 or higher	IMMEDIATE HOSPITALIZATION Chelation with two drugs

Source: Managing Elevated Blood Lead Levels Among Young Children: Recommendations from the Advisory Committee on Childhood Lead Poisoning Prevention, US Centres for Disease Control, 2002
http://www.cdc.gov/nceh/Lead/CaseManagement/caseManage_chap3.htm

3.2.0 Analytical techniques

According to the World Health Organization (WHO) recommendations, portable measuring equipment was used, using an electrochemical technique called LeadCare® (CDC protocol for lead in blood number: NCCLS document C40-TO ISBN 1-56238-437-6). The method has a detectable range of 1.4 to 65.0 µg/dL. The volume of each sample was 50 µL of blood.

Counter et al. (1998) analyzed duplicate samples to investigate blood lead levels from venous blood comparing two methods: *ESA LeadCare and Atomic Absorption Spectrometry in graphite oven*. The correlation coefficient was (r)=0.829. Pineau et al. (2002) also compared both methods obtaining a correlation coefficient of r=0.95.

For the calibration of the LeadCare®equipment, the atomic absorption spectroscopy reference method with graphite oven technique was used. Calibration of the LeadCare® equipment was done by the Central Service of Large Instruments (SECEGRIN) of the Regional Center of Development and Technology (CERIDE-UNL/CONICET) that analyzed 40 blood samples in parallel using the atomic absorption spectroscopy reference method. This resulted in a correlation coefficient (r) of 0.87.

3.3.0 Statistical analysis

A database was created using Epi INFO software[24]. Data was recorded and analyzed using the Epi INFO software. Charts and figures were created using Microsoft Excel or Word software.

Comparison of means was done using a Student t-test. Where variances of the two means differ, non-parametric analysis was performed using Kruskal-Wallis test for two groups (equivalent to Chi-square). Comparison of proportions among groups was carried out using the Chi-square test with Yates correction. Where an expected value was less than 5, Fisher exact test was used. For all statistical tests, significance was accepted at the 95% level ($p \leq 0.05$). The analysis was carried out by researchers from the National Institute of Respiratory Diseases "Emilio Coni" (INER) and Memorial University of Newfoundland.

4.0 General results

4.1 Sample characteristics

4.1.1 Age, gender and school

The sample included 291 boys and girls, 4 to 16 years of age. 129 attended School N° 8 (69 females and 60 males) and 162 attended School N° 12 (86 females and 76 males).

Sample characteristics from both schools, by age and gender are presented in Table 2.

There was no significant statistical difference between the two schools with regard to sampling distribution by gender. On the other hand, there was a significant difference in age distribution between the two schools. In the sample from School N° 8, there were significantly more children less than 6 years of age compared to School N° 12 ($\chi^2 = 8.9$, $p<0.001$).

TABLE 2. SAMPLE CHARACTERISTICS BY AGE AND GENDER FROM TWO SCHOOLS IN ZÁRATE. BUENOS AIRES PROVINCE (N=291)

Age and gender	School Nº 8		School Nº 12	
	Number	%	Number	%
< 5				
Female	3	27.3	0	
Male	8	72.7	0	
Total	11	8.5	0	0.0
5–9				
Female	26	55.3	43	55.8
Male	21	44.7	34	44.2
Total	47	36.4	77	47.5
10–14				
Female	34	63.0	43	51.8
Male	20	37.0	40	48.2
Total	54	41.9	83	51.2
≥15				
Female	6	35.3	0	0.0
Male	11	64.7	2	100.0
Total	17	13.2	2	1.2
TOTAL	**129**		**162**	

4.2 Blood lead levels

The concentration of lead in blood from 291 children had a mean of 6.3 µg/dL, standard deviation 6.0 µg/dL, median 4.3 µg/dL and mode 1.8 µg/dL. Forty-two of 291 children (14.4%) had blood lead levels greater than or equal to 10.0 µg/dL. Eleven children (3.8%) had blood levels greater than or equal to 20.0 µg/dL.

The distribution of blood lead levels of 291 children by gender from both schools is presented in Table 3.

School N° 8 had a significantly higher percentage of children with blood levels ≥10 µg/dL (19.4% vs 10.5%, $\chi^2=3.90$, $p=0.048$). The two students with blood lead levels >35 µg/dL both attended

Table 3. Blood lead level distribution in children by gender from both schools in Zárate, Buenos Aires Province (n=291).

Pb in blood (µg/dL)	Total #	Total percent	School Nº 8						School Nº 12					
			Both genders		Females		Males		Both genders		Females		Males	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0–4.99	165	56.7%	73	56.6%	47	68.1%	26	43.3%	92	56.8%	49	57.0%	43	56.6%
5–9.99	84	28.9%	31	24.0%	12	17.4%	19	31.7%	53	32.7%	30	34.9%	23	30.3%
10–14.99	22	7.6%	12	9.3%	6	8.7%	6	10.0%	10	6.2%	6	7.0%	4	5.3%
15–19.99	9	3.1%	7	5.4%	3	4.3%	4	6.7%	2	1.2%	1	1.2%	1	1.3%
20–24.99	3	1.0%	2	1.6%	1	1.4%	1	1.7%	1	0.6%	0	0.0%	1	1.3%
25–29.99	4	1.4%	1	0.8%	0	0.0%	1	1.7%	3	1.9%	0	0.0%	3	3.9%
30–34.99	2	0.7%	1	0.8%	0	0.0%	1	1.7%	1	0.6%	0	0.0%	1	1.3%
35–40.99	2	0.7%	2	1.6%	0	0.0%	2	3.3%	0	0.0%	0	0.0%	0	0.0%
total	291	100%	129	100%	69	100%	60	100%	162	100%	86	100%	76	100%
≥ 10	**42**	**14.4%**	**25**	**19.4%**	**10**	**14.5%**	**15**	**25.0%**	**17**	**10.5%**	**7**	**8.1%**	**10**	**13.2%**

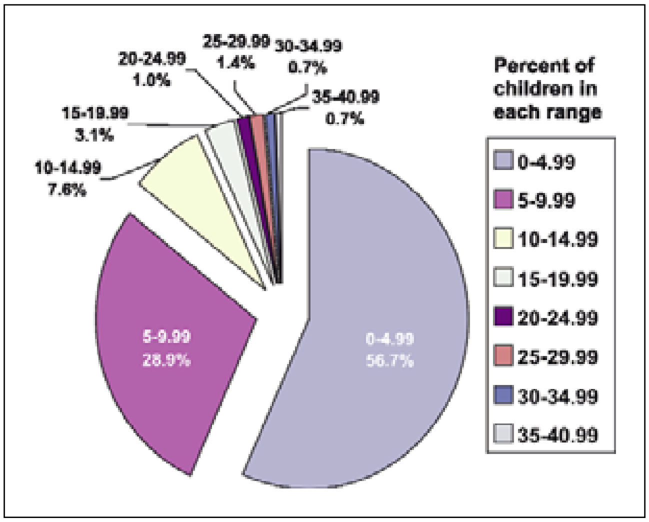
School Nº 8. However, there was no significant statistical difference in the mean blood lead levels between the two schools: School Nº 8, 6.8 µg/dL and School Nº 12, 5.8 µg/dL.

There was no statistically significant difference in gender distribution for children with blood levels ≥10 µg/dL compared to those <10 µg/dL. However, significantly more males had blood levels ≥20 µg/dL compared to females (10, males; 1 female; χ^2 9.12, p=0.01).

Looking at age, a significantly higher proportion of children less than 6 years of age had blood lead levels ≥10 µg/dL compared to those age 6 to 16 (44% compared to 13%; χ^2 = 9.4, p<0.004; Fisher exact p=0.003). However, there was no significant difference in the mean age for children with blood levels ≥10 µg/dL compared to those <10 µg/dL.

The proportion of children with blood lead levels under 10 µg/dL was 85.6% when both schools were considered (249/291 children). The mean blood level for these children was 4.3 µg/dL, standard deviation 2.3 µg/dL, median 3.7 µg/dL and a mode 1.8 µg/dL. Mean blood level for those children with blood levels ≥10 µg/dL was 17.6 µg/dL, standard deviation 1.2 µg/dL, median 14.4 µg/dL and mode 11.0 µg/dL. The overall relative distribution of blood lead levels in all children is shown in Figure 2.

Figure 2. Blood Lead Ranges, µg/dL, Percent of children in each range



4.3 Indicators and risk factors for increased blood lead levels

The following questions on the parent questionnaire provided information on possible indicators and/or risk factors for increased blood lead levels (Table 4).

1. *Were or are the parents/relatives exposed to lead?*
2. *Do the parents/relatives work in contact with lead?*
3. *Is the child involved in any work related activities?*
4. *Did the parent or guardian complete primary school?*
5. *Has the child repeated one or more school levels/grades?*

Having parents or relatives exposed to lead was a significant indicator for higher blood lead levels in children. Significantly more children with blood levels ≥10 µg/dL had repeated grade levels in school. Education of parents or guardians was also a significant indicator for higher child blood lead levels. It is of interest that results from this initial questionnaire indicate that neither having a parent working with lead or the child working is related to higher child blood levels (see Section 4.4 below).

Parents were also asked to indicate possible home conditions which could lead to increased lead exposure to their children and family. Of the 291 children, only 79 parents provided information about possible sources of lead exposure (Table 5) in this initial questionnaire. Of these 79 responses, 42 (52%)

Table 4. Possible indicators and risk factors for elevated blood lead levels

Indicator	Blood lead concentration ≥10 µg/dL n=42		Blood lead concentration <10 µg/dL n=249		χ^2 (with Yates correction)	p=
	Yes/total n	% Yes	Yes/total n	% Yes		
1. Parents/relatives exposed to lead	14/31	45%	49/191	26%	4.08	**0.043***
2. Parents/relatives work in contact with lead	3/30	10%	12/182	6%	Fisher exact	0.70
3. Child involved in any work related activities	12/35	34%	60/202	30%	0.12	0.73
4. At least one parent or guardian with incomplete primary school	16/33	48%	59/201	29%	3.93	**0.047***
5. Child repeated one or more school levels/grades	17/37	46%	61/217	28%	3.92	**0.048***

* *statistically significant*

Table 5. Responses to question on possible home lead exposure

		All children (n=291)	≥10 µg/dL (n=42)	≥20 µg/dL (n=11)
Home/work located in industrial area	Yes No *No response*	42 37 *212*	4 5 *33*	1 3 7
Home/work located near landfill, garbage dump or incinerator	Yes No *No response*	34 124 *212*	4 14 33	3 5 7
Lead in water pipes	Yes No *No response*	7 72 212	1 8 33	0 4 7
Lead in paint	Yes No *No response*	3 76 212	0 9 33	0 4 7

indicated exposure could be due to home and work located in an industrial area and 34 (43%) indicated exposure could be due to home and work located near a landfill, garbage dump or incinerator.

For those that gave possible exposure information, there was no significant difference in responses by parents of children with blood lead levels ≥10 µg/dL or for those with blood lead levels ≥20 µg/dL.

4.4 Follow-up of students with blood lead levels of 10 µg/dL or greater

Of 291 children in the study, 42 (14.4%) presented blood lead levels equal or greater to 10 µg/dl. Of these, 31 had blood lead levels from 10 µg/dl to 19.9 µg/dl and for the purposes of follow-up, these children were assigned to Group 1. The other eleven children who had levels ≥20µg/dl were assigned to Group 2.

Group 1: Of the 31 children of this group, 17 females and 14 males. An in-depth follow-up interview was conducted with their parents/relatives to further determine possible exposure risks. At this second interview, 55.0% (17/31) admitted that their children were involved in the collection of metal and other types of waste materials; 23.0% (7/31) said they lived near landfills where waste is burned regularly; 13% (4/31) responded that they worked in automobile machine shops located in their own homes and that children joined in the tasks of the shop. Of the 3 remaining parents (7.5%), one was a plumber, another manipulated different metals and the third lived with relatives in a house next to a closed car battery factory.

Group 2: Of the 11 children of this group, 10 males and 1 female. Six attended School N° 8 and 5 attended School N° 12. For Group 2, an in-depth follow-up interview and visits to their houses and surroundings were conducted with their parents/relatives to further determine possible exposure risks. In addition, a second blood lead test was carried out in 10 of the 11 members of this group. The remaining boy was not present on the test day. He was visited at home, but their parents refused the second test. Follow-up information on Group 2 is shown in Table 6.

Table 6. Follow-up information on age, gender, blood lead tests and probable sources of lead exposure from children in Group 2 (n=11)

Age in years	Gender	1º blood lead test (µg/dL)	2º blood lead test (µg/dL)	Probable source of exposure to lead
4	male	41.6	32.4	Played in or around the car machine shop
9	male	39.9	28.2	Lived in a contaminated site (closed factory)
10	male	33.2	No data	Child Labour. Metal collection and recycling garbage for re-sale
6	male	32.2	21.4	Child Labour. Metal collection and recycling garbage for re-sale
15	male	28.5	31.6	Child Labour. Metal collection and recycling garbage for re-sale.
14	male	27.6	27.5	Child Labour. Metal collection and recycling garbage for re-sale.
14	male	27.5	33.7	Child Labour. Metal collection and recycling garbage for re-sale.
12	male	27.1	28.3	Child Labour. Metal collection and recycling garbage for re-sale.
12	male	23.4	16.3	Child Labour. Metal collection and recycling garbage for re-sale.
5	female	21.5	18.7	Lived near a waste disposal site where waste was regularly burned
15	male	21.3	24.5	Child Labour. Metal collection and recycling garbage for re-sale

For the 10 children in Group 2 completing the second round of blood testing, 5 had decreased blood lead levels, 4 increased and one showed no change. No child in Group 2 had follow-up levels less than 10 µg/dL and only 2 out of 10 had decreased to levels below 20 µg/dL.

Parents indicated in the follow-up interview that 8 of 11 (73%) of the children in Group 2 were involved in collection of waste material for re-sale. The remaining three were either living or playing near a waste or contaminated site.

5.0 Discussion

5.1 Sample characteristics

In this study, participation was voluntary, anonymous and free of charge A non-random convenience sample was considered the most appropriate method to follow the open relationship that had been forged with the parents/guardians and students of both schools. 69.1% of the total number of students that attended the two schools accepted, freely, to participate in the study.

There were no statistically significant differences in gender distribution between the two schools that were studied, but there was a difference in age distribution. School Nº 12 had fewer children age 15 or greater and no children less than 5 years of age, significantly different from School Nº 8.

5.2 Blood lead levels

5.2.1 Previous studies

There are no published studies in Argentina with sufficiently representative samples that can provide an estimate of change in average blood lead levels of Argentinean children over the last two decades. For this reason, it is impossible to evaluate the impact of environmental measures aimed at decreasing lead exposure. Of all these measures, the most important was the elimination of lead tetraethyl from gas which occurred in Argentina in 1996.

Although there are no studies which can be directly compared to each other and the findings from this report, there have been several studies (published and un-published) that have measured blood lead levels in asymptomatic Argentinean children. They differed in their objectives, socio-economic levels, age of participants and in some cases the techniques used to measure blood lead levels. A summary of these studies and related findings can be found in Table 7.

The American Academy of Pediatrics (AAP)[3] states that in spite of the successful decrease with respect to the blood lead levels of American children due to the elimination of leaded gasoline, there are still risks of lead exposure for children from low income families and those residing on the periphery of cities (close to highways, garbage dumps, etc.).

TABLE 7. ARGENTINEAN STUDIES OF BLOOD LEAD LEVELS IN ASYMPTOMATIC CHILDREN

Reference	Study area	Age group	Sample Description	N	Mean µg/dL	Percent ≥10 µg/dL
Hansen 1996[13]	Cordoba	6 month–9 years	N/A	172	7.7	26.7%
Rivirosa 2000[14]	Greater Buenos Aires and Interior	3 months–13 years	N/A	203	5.2	9.6%
Duran 2000[15]	Capital and Greater Buenos Aires	1 to 24 months	Industrial area of Matanza-Riachuelo river basin	48	9.8	39.6%
Rogers 2002[16]	Capital and Buenos Aires Province	9 to 36 months	Middle class	100	3.2	3.0%
Fernandez 2006[17]	Cordoba	4 to 14 years	70% with UBN	30	4.5	0.0%

AAP recommends that the levels of lead in blood in those groups of children be tested and monitored regularly and that families be educated on prevention and possible sources of exposure.

5.2.2 Data obtained in the present study

In this study carried out in Zárate (n=291), children came from low income families with unsatisfied basic necessities and at high risk for certain types of lead exposure. In this study, 14.4% (42/291) of the children had blood lead levels ≥10 µg/dL, and of these children the mean blood level was 17.6 µg/dL, with a median of 14.4 µg/dL. Of these children, 4% had blood lead levels ≥20 µg/dL and 2 children exceeded 35 µg/dL.

When analysing the group of children with blood lead levels ≥20 µg/dl, it was found that the number of males was significantly more than the number of females. This is in agreement with information reported by the international literature that attributes higher risk of exposure to males due to their social behaviour.[4,5]

In this study, significantly more children from School Nº 8 had high blood lead levels compared to School Nº 12. This may be due to a difference in age distribution in the samples from the two schools because the sample from School Nº 8 had more children less than 6 years of age. This study found that a significantly higher proportion of children less than 6 years of age had blood lead levels ≥10 µg/dL compared to those age 6 to 16.

5.3 Indicators and risk factors for increased blood lead levels

5.3.1 Initial questionnaire results

Results from the initial parent questionnaire showed a significant relationship between child blood lead levels ≥10 µg/dL and: parents or relatives exposed to lead; parent or guardian with incomplete primary school and child repeating one or more grades. No significant relationship was found between child blood lead levels and parents working with lead or if the child of the study was involved in any work related activities. Very few parents indicated the presence of home/work conditions that could be related to increased risks of lead exposure. Very few parents indicated as probable sources of lead exposure lead paint, lead water pipes, or home/work location near industry, waste dumps and/or incinerators. Follow-up interviews with parents provided a more complete and accurate picture of exposure risks for those children with higher lead levels. (see Section 5.32)

5.3.2 Follow-up of students with blood lead levels of 10 µg/dL or greater

All children that participated in the study lived under environmental conditions that involved lead contamination risks. However, it was decided that follow-up should only occur with children having blood lead levels from 10 to 19.9 µg/dL (Group 1) and those with levels equal or greater than 20 µg/dL (Group 2), following CDC recommendations. The mean blood lead levels of children in these two groups was four times higher than those that had blood lead levels of less than 10 µg/dL.

The follow-up procedures carried out with these two groups of children allowed for an important contact with the parents/guardians that facilitated the detailed analysis of the probable sources of exposure and ways to remove children from these sources.

During follow-up, individual meetings with the 31 parents/guardians of Group 1 students (blood lead levels ranging between 10 µg/dL and 19.9 µg/dL), 21 of them (67.7%) said that their children were involved in activities that could expose them to lead including: collection of metal and other types of waste materials and work in automobile machine shops. Seven of them (22.6%) said they lived near landfills where waste was burned regularly. Of the remaining parents, one was a plumber, another manipulated different metals and the third lived with relatives in a house next to the car battery factory that was closed.

Something similar occurred with parents/guardians of Group 2 students (blood lead levels ≥20 µg/dL). Eight of them mentioned that their children were involved in the collection of metal and other types of waste materials. The child with the highest blood lead level in the study frequently played in a machine shop. Another child lived near a closed lead smelter, and the only female in the group lived near a landfill site where waste was burned regularly.

During the original parent/guardian questionnaire, only 12 out of the 42 parents of children from Groups 1 and 2 provided affirmative answers to the question, "*Is the child involved in any work related activities?*". In the follow-up interviews for Groups 1 and 2, parents/guardians indicated that 29 out of the 42 children (69.0%) were involved in work activities. Twenty five of them worked collecting metal and other types of waste materials. Informal collection of waste materials is a common practice in most Argentinean cities. Paper, cardboard, glass containers, metals and other materials are gathered, classified and sold. The value of metals is generally superior to other materials. It is common for children to take part in collection activities as well as classification. Collection and classification of waste materials is carried out in the open at landfills where garbage is burned and children are exposed to the sun, pollutants and diseases, among other environmental threats.

There are several possibilities as to why some parents did not, in the initial questionnaire, state that their children worked. First, many parents/guardians do not recognize the tasks that children carry out as work, especially when that are related to assisting the parents/guardians. Secondly, parents/guardians may be consciously omitting this information for fear of legal sanctions. Lastly, parents/guardians may rely on income generated by their children and be concerned about the possible financial hardship that not having them work could bring to the family. Unfortunately the reasons for reluctance to omit child labour goes beyond the scope of the present study but certainly reflects a need to look into this further.

For the 10 children out of 11 in Group 2 completing the second round of blood testing, 5 had decreased blood lead levels, 4 increased and one showed no change. No child in Group 2 had follow-up levels less than 10 µg/dL and only 2 out of 10 had decreased to levels below 20 µg/dL.

The mean half-life of lead in blood is considered to be between 20 and 40 days. The follow-up blood sample at 30 days may not have been sufficient time to see significant decreases in blood lead levels in these children even if their exposure was decreased. Based on this it is essential that children with high blood lead levels receive ongoing medical supervision to monitor their blood lead levels over time.

6.0 Study strengths and limitations

6.1 Strengths

a. Sampling took place in the schools, an environment that children knew and could trust.

b. The study was requested by parents and teachers, with strong support from the community, school administrators, Municipality of Zárate, and different health professionals.

Some of the children who participated in the lead study

c. The use of portable LeadCare® equipment allowed investigators to go to the schools and carry out the study where the selected school population sample congregated, avoiding the transfer of students to hospitals or health centers. The blood sample was obtained quickly and with little pain by puncturing the finger. It was also possible to repeat the sample at the same moment if required, reducing cost of analysis.

d. During the preparation stage of the present study, the Central Service of Large Instruments (SECEGRIN) of the Regional Center of Development and Technology (CERIDE-UNL/CONICET) analyzed 40 blood samples in parallel using the atomic absorption spectroscopy reference method. This resulted in a correlation coefficient (r) of 0.87.

e. A non-random convenience, sample that was anonymous and free of charge was chosen because it was considered appropriate for the objectives of the study and in agreement with the open relationship that had been forged with parents/guardians and students during previous meetings. 69.1% of the total number of students that attended the two schools accepted, voluntarily, to participate in the study.

f. At all stages of the study parents/guardians, teachers, administrators, local and provincial officials were involved through repeated community or individual meetings.

6.2 Limitations

a. Although previous studies documented in the Discussion provide some reference values for blood lead levels in Argentine children, for this study, there is no control group of children that can be compared to the children that participated in this study.

b. The sample was not randomized. Voluntary participation could have created bias. The fact that parents wanted their children to be investigated could mean that they suspected probable exposure to lead.

c. Comparing both schools, there were statistically significant differences in the sampling distribution regarding certain age groups.

d. There were a low percentage of answers received in the original parent's questionnaire.

7.0 Conclusions and recommendations

Conclusion 1:

More than 14% of the children studied in Zárate had blood lead levels warranting some type of follow-up according to CDC recommendations.

Recommendations:

Disseminate the conclusions of the study to parents/guardians, teachers and school administrators, authorities of the Municipality of Zárate and Ministry of Education of the Province of Buenos Aires, including ways to reduce the risk of lead exposure.

Conclusion 2:

Eleven children out of 291 had blood lead levels equal to or greater than 20 μg/dL. Ten of them completed the second round of blood testing. All of these children continued to show blood lead levels greater than 10 μg/dL after a 1 month follow-up blood test.

Recommendations:

- Encourage parents/guardians to continue medical follow-up for all children with elevated blood lead levels with the goal to reach non-intervention levels (<10 μg/dL) for every child.
- Encourage parents/guardians with other children/adults in these homes to have their blood lead levels tested.
- Increase awareness among health professionals of the need for continued follow-up of children presenting with elevated blood lead levels.

Conclusion 3:

Children with elevated blood lead levels were likely to participate in the collection and processing of scrap and waste material for re-sale. Living in homes near waste sites, incinerators or industrially contaminated sites are also probable sources of lead contamination. Ten of the 11 children with blood lead levels of 20 µg/dl or greater were boys.

Recommendations:

Encourage continued meetings on environmental health issues between parents/guardians, schools and the community. Focus discussions on environmental risks, particularly those associated with child labour.

Encourage the local government, the community and schools to provide adult education classes on environmental hazards in the community.

Incorporate classes on children's environmental health in the educational curriculum of schools with special emphasis on issues related to lead contamination.

Conclusion 4:

In this study, a significantly higher proportion of children less than 6 years of age had blood lead levels ≥10 µg/dL compared to those age 6 to 16.

Recommendations:

Educate parents/guardians of younger children about reducing lead exposure with a focus on hand-to-mouth risks.

8.0 Endnotes

1 Protecting children from harmful chemical exposures. Document prepared by the Intergovernmental Forum on Chemical Safety Working group. Intergovernmental Forum on Chemical Safety (IFCS) November 2003. *www.ifcs.ch*

2 WHO Training Module: Lead. World Health Organization, WHO. 2005 *www.who.int/ceh*

3 "Pediatric Environmental Health", 2nd Edition, Committee on Environmental Health, American Academy of Pediatrics, Associate Editor, 2003.

4 Brody DJ, Pirkle JL, Kramer RA, Flegal KM, Matte TD, Gunter EW, et al, Blood lead levels in the US population: phase 1 of the Third National Health and Nutrition Examination Survey (NHANES III, 1988 to 1991). *JAMA*. 1994;272:277–283.

5 Griffith DA, Doyle PG, Wheeler DC, Johnson DL. A tale of two swaths: urban childhood blood-lead levels across Syracuse, New York. *Ann Assoc Am Demogr.* 1998;88:640–665.

6 Canfield RL, Henderson CR, Cory-Slechta DA, Cox C, Jusko TA, Lanphear BP. Intellectual impairment in children with blood lead concentrations below 10 µg per deciliter. *N Engl J Med.* 2003;348:1517–1526.

7 Lamphear BP, et al. Environmental exposure to lead and children' intelligence at blood lead concentrations below 10 micrograms per deciliter. *Pediatr Res* (2001)49:16A.

8 Laidlaw MAS, Mielke HW, Filippelli GM, Johnson DL, Gonzalez CR. 2005. Seasonality and children's blood lead levels: developing a predictive model using climatic variables and blood lead data from Indianapolis, Indiana, Syracuse, New York, and New Orleans, Louisiana (USA) *Environ Health Perspect* 113:793–800. doi:10.1289/ehp.7759.

9 Berney B. Round and Round it Goes: The epidemiology of childhood lead poisoning, 1950-1990. IN *Illness and the Environment: A Reader in Contested Medicine*. Kroll-Smith S, et al. (eds) New York University Press: New York; 2000, pp 215-257.

10 United States Department of Health and Human Services and ATSDR. Case Studies in Environmental Medicine. Lead Toxicity. September 2002. *http://www.atsdr.cdc.gov/HEC/CSEM/lead/lead.pdf* Accessed 20 September 2003

11 Astolfi E, Giménez ER, Parral J, Vallejo NE. Intoxicación plúmbica en el niño. *Rev Asoc Med Arg* 1965;vol ( )443-449.

12 Giménez ER, Vallejo NE, Izurieta EM, Albiano NF, Iarlori R. Intoxicación por plomo en la infancia: aporte clínico, bioquímico, epidemiológico y experimental. *Rev Hosp. Niños Buenos Aires* 1979;21:192-213.

13 Hansen C, Buteler R, Procopovich E, Pagan G, Díaz B, Gait N et al. Niveles de plomo en sangre de niños de la Ciudad de Córdoba. *Medicina* (Buenos Aires) 1999;59:167-170.

14 Rovirosa A, Uicich R, Fernández-Alvarez A, Sánchez-de la Puente M, O'Donnell A. Niveles de plomo en sangre de niños de Buenos Aires. Póster presentado en el Congreso de Pediatría, Salta, 2000.

15 Durán P. Estudio PLAC: plomo, anemia y funciones cognitivas, 2000. Experiencia LatinoAmericana, Salud Infantil y Plomo en Argentina. *Salud Pública de Mexico*. 2003

16 Rogers, V; Méndez, J; Uicich R; O'Donnell, A., Departamento de Pediatría del Hospital Alemán y CESNI. "Determinación de niveles de plomo en sangre de una población de clase media". Poster presented at the Argentine Society of Paediatrics Annual Congress, Mar del Plata, 2003.

17 Fernández R; Vilkelis A, Corrés E, Butinoff, M, Ferreira F, Romano N, Determinación de Metales en población infantil del Barrio Ituzaingó, ciudad de Córdoba, Hospital Infantil Municipal, Córdoba, Argentina. *Jornadas Interdisciplinarias de Toxicología*, 2006.

18 Resolución 54/96 de la Ex Secretaría de Obras y Servicios Públicos de la Argentina.

19 Instituto Nacional de Estadísticas y Censo, INDEC, Censo Nacional 2001.

20 Secretaria de Desarrollo Económico y Producción de la Municipalidad de Zárate, 2004, *http://www.zarateproductivo.com.ar/plano.pdf*

9.0 Other documents consulted

Asociación Argentina de Médicos por el Medio Ambiente, El niño y su ambiente: Guía de consejos para proteger a los niños de los peligros ambientales, AAMMA, 2005.

Berlin M. Mercury, In: Friberg L., Nordberg GF, Vouk v. eds,. Handbook on the toxicology of metals, 2nd ed. Amsterdam, Elseiver, 1986: 386–445

CDC 1997. Screening Young Children for Lead Poisoning: Guidance for State and Local Public Health Officials. Atlanta, GA: Centers for Disease Control and Prevention.

CDC, Childhood Lead Poisoning Prevention Program (*www.cdc.gov/nceh/lead/lead.htm*)

Foro Intergubernamental sobre Seguridad Química – IFCS, "Protección de los niños de la exposición química peligrosa", Documento elaborado por el Grupo de Trabajo del Foro Intergubernamental sobre Seguridad Química, noviembre 2003 – *www.ifcs.ch*

Haley and Talbot , Geographic Analysis of Blood Lead Levels in New York State Children Born 1994–1997, Bureau of Environmental and Occupational Epidemiology, New York State Department of Health, Troy, New York, USA, *Environ Health Perspect. 2004 November; 112*(15): 1577–1582.

Landrigan PJ, Schechter CB, Lipton JM, Fahs MC, Schwartz J. Environmental pollutants and disease in American children: estimates of morbidity, mortality, and costs for lead poisoning, asthma, cancer, and developmental disabilities. *Environ Health Perspect. 2002;110*: 721–728.

Lynn Goldmon & Nga Tran, Toxics End Poverty: The Impact of Toxic Substances on the Poor in Developing Countries, World Bank, 2002.

Mielke HW, Dugas D, Mielke PW Jr, Smith KS, Smith SL, Gonzales CR. Associations between soil lead and childhood blood lead in urban New Orleans and rural Lafourche Parish of Louisiana. *Environ Health Perspect. 1997;105*: 950–954.

Rozman K, Klaassen CD. Absorption, Distribution and Excretion of Toxicants. In: Klaasren CD, *et al.*(eds): Casarett and Doull's Toxicology. *The basic Science of Poisons.* 5th edition. McGraw-Hill., Inc.: New York,. 1996 pp 91–112.

Ruth Etzel, Md, PhD, Editor; Sophie Balk, MD, Pediatric Environmental Health 3rd Edition, American Academy of Pediatrics, Associate Editor, 2003.

Schneuplein R, et al. Differential sensitivity of children and adults to chemical toxicity. Biological basis. *Regul Toxicol Pharmacol (2002)35*: 429–447.

Selevan SG, *et al*. Identifying Critical Windows of Exposure for Children's Health. *Environ Health Perspect (2000)108* (Suppl 3): 451–597).

Stein J, *et al*. In harm's way: toxic threats to child development. *J Dev Behav Pediatr (2002) 23* (1 Suppl): S13–22

Susana Isabel García, MC y Raúl Mercer, MC, MSP, "Salud infantil y plomo en Argentina", *Salud Pública de México / vol.45, suplemento 2 de 2003*.

UNEP – WHO, A Call to Action — Using indicators to Measure Progress on Children´s Environmental Health, 2002.

WHO, Making a Difference: Indicators to Improve Children's Environmental Health, 2003.

Appendix A

Examination of blood lead levels in school aged children from the City of Posadas, Misiones Province

1.0 Background

In addition to the original study conducted in Zárate[1], the Steering Committee of the *Measuring the Environmental Impact on Children's Health in the Southern Cone* Project decided that the *Profile of Children's Environmental Health in Argentina* should include a preliminary pilot study to determine the blood lead levels in school aged children from a non-industrial area of the Province of Misiones. In keeping with the original objectives of the Zárate study, it was the intention of this pilot study to recruit from an area with homes with Unsatisfied Basic Necessities (UBN).

For this purpose, School N° 783 located in an outlying neighborhood of the city of Posadas was selected. This school is located in a non-industrial neighborhood, near informal waste disposal sites and characterized as a precarious urban area without basic sanitation services.

2.0 Information on the City of Posadas, Misiones Province

The city of Posadas is the capital of the Province of Misiones. The city is located on the left riverbank of the Paraná River, southwest of the Province, with a population of 252,981[2]. Thirty-five percent of the population of Posadas is under 15 years of age[2]. It is the most populated city of the Province of Misiones and at the moment it is one of the most active and growing cities in the whole North East Region of Argentina. Since Posadas is the capital of the Province, almost all government offices are located here. The main economic activity of the Province revolves around agriculture and forestry. The main industries related to this activity are located inside the Province.

3.0 Objectives

The objective of the study was to investigate the blood lead levels in school aged children in a school located in the periphery of the city of Posadas, Misiones Province.

4.0 Population, materials and methods

The study was developed in the city of Posadas, Misiones Province (Argentina), during the months of March and April 2006. The population included 213 students of both sexes, ages 5 to 16 years attending School N° 783 located in an outlying neighbourhood of the city of Posadas, under the responsibility of the Ministry of Education of the Province of Misiones.

The majority of students came from homes qualifying as having at least one or more unsatisfied basic necessities (UBN) including: unsafe housing; without a functioning bathroom; over-crowding, incomplete schooling of the parents, and families with less than subsistence level income. In general they lived in neighborhoods with unpaved streets, without sewers, with restricted access to drinking water and without waste collection services.

A descriptive, cross sectional study was carried out. All students from School Nº 783 were invited to participate in the study. Those that accepted the invitation formed part of a non-random convenience sample. Participation in the study was voluntary, anonymous and free of charge.

Inclusion parameters required that participants were students of School Nº 783 of the city of Posadas between 5 and 16 years of age and had signed consent forms (by parents or guardians). Exclusion parameters included religious objections to blood extraction, treatment with chelating agents up to 6 months prior to the study and refusal by the children themselves at any stage of the study including during blood sampling.

The study was approved by the Ethical Committees of the National University of Misiones (Argentina) and the University of Ottawa (Canada). Confidentiality of children's personal data was ensured through the Personal Data Protection Law 25.326[3]. The National University of Misiones took the responsibility of protecting and handling all collected information. Personal information was coded so that children were not identifiable by name. In order to carry out the study in this school and conduct all research activities on site, all necessary permits and approval were negotiated from the School Council of the Ministry of Education of the Province of Misiones, with help from local authorities.

5.0 Study development

5.1 Information prior to the study

Information meetings were conducted in the participating school prior to the study. Students, parents/guardians, administrative and educational staff participated in the meeting.

At the meetings information was provided on exposure to lead, the ways in which exposure can occur, potential health effects, the special vulnerability of children, prevention and treatment options. Also, information was provided on the characteristics of the study, the reasons for blood sampling in order to identify the participants' blood lead levels and the way in which the sample was to be obtained. Students were invited to participate with parents/guardians being informed that their child could only participate if they signed the informed consent form.

As part of the meetings, students, parents/guardians and teachers were invited to ask questions to clarify anything they did not understand.

5.2 Blood sampling and presentation of results

Blood sampling was carried out by researchers from the Toxicology and Legal Chemistry Class from the Faculty of Exact, Chemical and Natural Sciences of the National University of Misiones who used clean, disposable gloves for each sample, protective clothes and safety goggles. The children's hands were first washed with soap and warm water, the selected finger was then cleaned with ethyl alcohol (70%) and dried with absorbent gauze. The finger was then punctured on the side, not on the finger pad. The first drop of blood was cleaned with absorbent gauze, the second drop after applying gentle pressure was used to fill the of blood sampling capillary of the LeadCare®equipment. Finally, after cleaning the exterior of the capillary with absorbent gauze to remove any excess blood, the sample was immediately mixed with the reagent. All steps indicated by the LeadCare®equipment manufacturer were then followed until results were displayed on the screen.

Although blood lead levels were obtained quickly, results were presented to the parents 30 days after sampling, in sealed envelopes, during individual meetings and in presence of school authorities.

5.3 Analytical techniques

According to the World Health Organization (WHO) recommendations, portable measuring equipment was used, using an electrochemical technique called LeadCare®(CDC protocol for lead in blood number: NCCLS document C40-TO ISBN 1-56238-437-6). The method has a detectable range of 1.4 to 65.0 µg/dL. The volume of each sample was 50 µL of blood.

Counter et al. (1998) analyzed duplicate samples to investigate blood lead levels from venous blood comparing two methods: *ESA LeadCare and Atomic Absorption Spectrometry in graphite oven*. The correlation coefficient was (r)=0.829. *Pineau et al. (2002)* also compared both methods obtaining a correlation coefficient of r=0.95.

For the calibration of the LeadCare®equipment, the atomic absorption spectroscopy reference method with graphite oven technique was used. Calibration of the LeadCare®equipment was done by the Central Service of Large Instruments (SECEGRIN) of the Regional Center of Development and Technology (CERIDE-UNL/CONICET) that analyzed 40 blood samples in parallel using the atomic absorption spectroscopy reference method. This resulted in a correlation coefficient (r) of 0.87.

5.4 Statistical analysis

A database was created using Epi INFO software[5]. Data was recorded and analyzed using the Epi INFO software. Charts and figures were created using Microsoft Excel or Word software.

Comparison of means was done using a Student t-test. Where variances of the two means differ, non-parametric analysis was performed using Kruskal-Wallis test for two groups (equivalent to Chi-square). Comparison of proportions among groups was carried out using the Chi-square test with Yates correction. Where an expected value was less than 5, Fisher exact test was used. For all statistical tests, significance was accepted at the 95% level ($p \leq 0.05$). The analysis was carried out by researchers from the National Institute of Epidemiology "Emilio Coni" and Memorial University of Newfoundland.

6.0 Results

6.1 Sample characteristics

The sample included 81 students, 5 to 16 years of age attending School N° 783 (41 females and 40 males). Sample characteristics by age and gender are presented in Table 1.

Gender distribution was normal in this sample and there were no significant difference in the population with regard to gender by age group.

TABLE 1. SAMPLE CHARACTERISTICS BY AGE AND GENDER FROM STUDENTS OF SCHOOL Nº 783.

Age and gender	Posadas	
	Number	%
5–9		
Female	14	60.9
Male	9	39.1
Total	*23*	*28.4*
10–14		
Female	25	45.5
Male	30	54.5
Total	*55*	*67.9*
15–16		
Female	2	66.7
Male	1	33.3
Total	*3*	*3.7*
TOTAL	81	

6.2 Blood lead levels

The concentration of lead in blood from 81 children had a mean of 5.8 µg/dL, standard deviation 4.3 µg/dL, median 4 µg/dl and mode 4 µg/dL. The distribution of blood lead levels by gender is presented in Table 2.

TABLE 2. BLOOD LEAD LEVEL DISTRIBUTION IN CHILDREN BY GENDER FROM SCHOOL Nº 783 IN POSADAS, MISIONES PROVINCE.

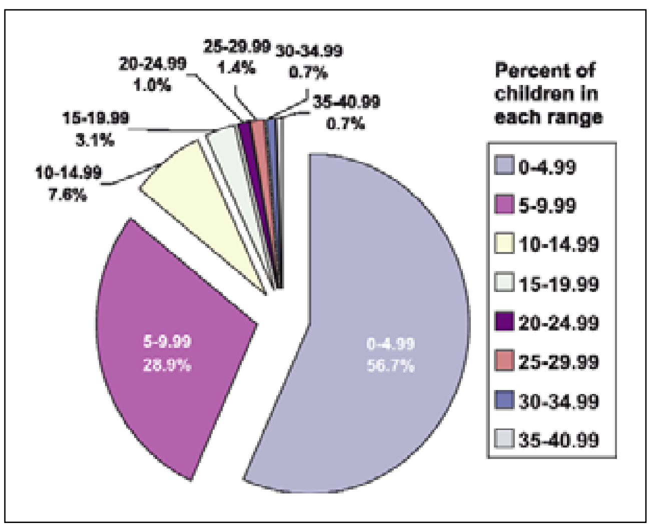
BP in blood (µg/dl)	Posadas, School Nº 783					
	Both genders		Females		Males	
	No.	%	No.	%	No.	%
Total	**81**	100.0	**41**	**100.0**	**40**	**100.0**
0–4.9	**43**	53.1	24	58.5	19	47.5
5–9.9	**25**	30.9	12	29.3	13	32.5
10–14.9	**10**	12.3	5	12.2	5	12.5
15–19.9	**2**	2.5	0	0.0	2	5.0
20–24.9	**0**	0.0	0	0.0	0	0.0
25–34.9	**1**	1.2	0	0.0	1	2.5
35 +	**0**	0.0	0	0.0	0	0.0
≥10	**13**	**16.0**	**5**	**12.2**	**8**	**20.0**

The proportion of children with blood lead levels of 10 µg/dL[6] or greater was 16%. The mean for these children was 13.5 µg/dL, standard deviation 4.8 µg/dL, median 11.0 µg/dL and mode 11.0 µg/dL. There were no significant differences in the proportion of children with blood levels ≥10 µg/dL due to gender or age group. Only one child had a blood lead level greater than 20 µg/dL.

For the 84% of children with blood lead levels under 10 µg/dL, the mean was 4.3 µg/dL, standard deviation 1.9 µg/dL, median 4.0 µg/dL and mode 4.0 µg/dL. The majority of children (53.1%) had blood lead levels less than 5 µg/dL.

The distribution of blood lead levels for children in School Nº 783 in Posadas is presented in Figure 1.

FIGURE 1. BLOOD LEAD RANGES, µg/dL, PERCENT OF CHILDREN IN EACH RANGE



7.0 Discussion and conclusions

There was no significant difference in mean blood lead levels in children from Posadas (5.8 µg/dL) in this study compared to those studied in Zárate (6.3 µg/dL)[1]. There was no significant difference in the proportion of children with blood lead levels

≥10 μg/dL from Posadas (16%) compared to those studied in Zárate (14%).

This study of blood lead levels in children in Posadas was intended as a preliminary pilot test site representing a non-industrial area in Misiones. Therefore, unlike the main study in Zárate, no detailed information on risk factors was gathered in Posadas. However, it should be noted that in both studies, participants were recruited from areas with homes with unsatisfied basic necessities. Regardless of location, children living in conditions of unsatisfied basic necessities can be at risk for adverse environmental contamination.

8.0 Endnotes

1 National Institute of Statistics and Census. INDEC. National Census 2001.

2 *http://www.iijusticia.edu.ar/legislacion/HabeasData.htm*

4 LeadCare® is a portable device that measures blood lead levels using a finger prick method. Results are calculated within 5–10 minutes.

5 Epi INFO software is a word processing, database and statistics software for epidemiology. The programme was produced by the Epidemiology Program Office, Centers for Disease Control and Prevention, and the Global Programme on AIDS, World Health Organization, and is provided free of charge for use by the public health community.

6 Maximum blood lead level allowed by the World Health Organization. WHO.