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A Community-Initiated Study of Blood Lead Levels of Nicaraguan Children Living Near a Battery Factory

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ABSTRACT

Objectives. In response to requests by parents in Managua, Nicaragua, whose neighborhood borders a battery factory, 97 children were tested for blood lead, as were 30 children in a neighborhood without an obvious source of environmental lead.

Methods. Venous blood was examined by atomic absorption spectrophotometry. Educational workshops were conducted.

Results. Mean blood lead levels were 17.21 ± 9.92 μg/dL in the index children and 7.40 ± 5.37 μg/dL in the controls ($P < .001$).

Conclusions. Children living near the battery factory are at increased risk of lead poisoning. The parents were able to petition the government to control the factory emissions and to improve appropriate health services. The factory is now closed. (*Am J Public Health.* 1998;88:1843–1845)

The manufacture of lead-acid batteries contributes to environmental lead pollution and the risk of lead poisoning in factory workers and nearby residents.[1,2] In Nicaragua, car battery factories have operated since the 1970s. One of the largest, FANABASA, is located in Barrio Pablo Ubeda, in southeast Managua. We undertook the present study in response to complaints by parents living near FANABASA[3,4] and on the basis of previous knowledge of seriously elevated blood lead levels among Nicaraguan battery factory employees.[5,6]

Before the initiation of the study, a series of meetings was held so that residents, community leaders, and health workers could explore ways to ameliorate the problem. In February 1996, it was agreed that blood lead levels of the children should be determined, the data thus generated to be used to document whether there existed a health threat to the children of the barrio. If so, a persuasive appeal could then be made to the government for regulatory controls of factory emissions and for appropriate medical interventions. An educational program for the community was part of the project.

Methods

Study Site and Population

Barrio Pablo Ubeda arose in the southeast part of Managua as a spontaneous settlement of the urban poor. There are no paved streets, and the vast majority of houses have dirt floors. There are over 600 households; the average household has 5 members.

Directly fronting the eastern border of the neighborhood is the FANABASA factory, which has operated in this locale for 15 years. The factory employed approximately 200 persons until 1994, when it was downsized to 30 workers. Neighbors noted large amounts of black smoke coming from the factory at night, the result of the burning of empty battery boxes. The wind in the area blows from east to west.

The organization of educational activities and sampling of the population were made possible by the support of the Movimiento Comunal (Community Movement) and community residents who made their homes available for blood drawing and workshops. The doctor at the local health post provided follow-up for children with elevated lead levels. More serious cases were referred to the pediatric hospital, Hospital Infantil "La Mascota."

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A census was taken of all children from birth to 13 years of age living within 200 m of the factory. Among almost 500 children listed, every fifth child (97 in all) was selected for inclusion in the study population. A group of 30 children and adolescents from a neighborhood farther east in the city, Villa Venezuela, served as controls. Villa Venezuela is demographically and environmentally similar to Barrio Pablo Ubeda (i.e., with respect to traffic patterns, drinking water sources, housing conditions, absence of lead-hazard cottage industries), but it has no battery factory.

Data Collection

Basic data about the children were provided by their parents. The blood samples were analyzed in the laboratory of the National Reference and Diagnostic Center of the Ministry of Health. This laboratory participates in the monthly proficiency testing program of the US Centers for Disease Control and Prevention (CDC).

Venous blood samples were taken by means of Vacutainers with an anticoagulant. The samples were transported to the laboratory and analyzed with a flame atomic absorption spectrophotometer, the lead having previously been extracted with organic solvent. This technique has been described elsewhere.[7]

The educational component of the project consisted of regularly scheduled small seminars where community members learned about the sources, effects, and measures for prevention of lead poisoning. Pamphlets from the United States and Mexico were used because there is no material on this subject produced locally.

Results

The blood lead levels (PbB) of the 97 children of Barrio Pablo Ubeda aged 6 months to 13 years (mean = 6.4 years) averaged 17.21 ± 9.92 μg/dL; 80% were ≥ 10 μg/dL, the CDC "level of concern": "Blood lead levels [in the range 10–14 μg/dL] should trigger community wide childhood lead poisoning prevention activities. Children in this range may need to be rescreened more frequently."[8] More assertive interventions are specified at levels of 15 μg/dL and higher.

The 30 children in the Villa Venezuela control group were aged 1 to 14 years (mean = 7.9). Their mean PbB was 7.40 ± 5.37 μg/dL; 30% of the values were 10 μg/dL or above. The *t*-test statistic is significant for the PbB difference-between-means at $P < .001$. (Table 1).

TABLE 1—Blood Lead Levels in Index and Control Children: Nicaragua, 1996

	Pablo Ubeda (Index) (n = 97)	Villa Venezuela (Control) (n = 30)
Mean PbB ± SD, μg/dL	17.21 ± 9.92	7.40 ± 5.37*
Range	0–41	0–20
% ≥ 10 μg/dL	80	30

*$P < .001$.

TABLE 2—Distribution of Blood Lead Levels in the Index and Control Children for Ages ≤ 5 and ≥ 6 Years: Nicaragua, 1996

	Pablo Ubeda (Index)		Villa Venezuela (Control)	
	6 mo–5 y	6 y–13 y	1.5 y–4 y	6 y–14 y
PbB, μg/dL				
0–9	8	11	5	16
10–19	14	28	2	6
20–44	17	9	1	0
Total	39	58	8	22
Mean age, y	3.3	8.6	2.4	9.9
Mean PbB ± SD, μg/dL	18.8 ± 11.4	16.6 ± 9.0	9.8 ± 6.6*	6.67 ± 4.8**

*For children ≤ 5 years of age in both groups, $P = .18$ (not significant).
**For children ≥ 6 years of age in both groups, $P < .01$.

Because there were relatively more school-aged persons in the control than in the test group, the distributions of the blood lead levels of those aged 5 years and younger and 6 years and older are tabulated separately (Table 2). In both the Pablo Ubeda and Villa Venezuela populations, children aged 5 years and younger had higher blood lead levels.

Discussion

Elevated blood lead levels in children exposed to lead-emitting industrial or mining operations, and to "cottage industry" home or backyard repair and recycling of batteries, have been documented in many countries.[9–12] The public health response to such findings should be termination of toxic emissions and abatement of existing contamination; removal of children from the identified sources is usually not an option.

For various political and economic reasons, governmental authorities are often ineffective agents of remediation, although in some settings, communities can themselves be agents of change.[13] In Barrio Pablo Ubeda, where a battery factory appeared to compromise the well-being of the children, parents and community leaders took the initiative of seeking documentation for their concerns. The resulting study showed that 80% of the tested children in Barrio Pablo Ubeda had blood lead levels at or above the CDC "level of concern," a rate 2.7 times higher than that found in 30 children in a demographically similar community that does not have a battery factory.

Twenty-five of the 97 index children fell into the CDC's Class III (i.e., PbB = 20–44 μg/dL). The highest values were 38, 40, and 41 μg/dL. At those levels, there could be clinical evidence of lead poisoning (inhibition of hemoglobin synthesis, interference with vitamin D metabolism), but the health consequences of the prevailing elevations of blood lead are usually demonstrable only on a population basis as cognitive and developmental deficits.

Protocols for the second phase of the study, neuropsychological and developmental evaluations, had been prepared, but limited resources necessitated delaying their implementation; the delay was accepted in favor of the more immediate goal of blood lead analyses. At present, the second phase has been funded and is proceeding.

Similarly, environmental sampling for lead was deferred. However, earlier studies in Managua[2] and other communities[14] established the nature of emissions from unregulated lead-processing facilities and the long-term retention of lead in soil.[15] There is, as well, evidence of improvement in environmental or physiological indices when offending factories have been shut or their emissions controlled[9,10,15] or when occupational exposure has been interrupted.[16]

The finding that 30% of the control children had PbB greater than 10 μg/dL was unexpected. There is no obvious major source

of lead in Villa Venezuela except the one common to all urban areas of Nicaragua, leaded gasoline and its residua. This study was conducted before its outcomes could have been affected by government-mandated increases in the availability of unleaded gasoline.[17]

The 4-month educational campaign, aimed principally at parents of lead-poisoned children, increased the level of understanding of the problem, of the methods of prevention such as dust control and hand-washing, and of awareness of the possibility of long-lasting effects even after the principal source of pollution may have been removed. The support provided to the project by Movimiento Comunal has enabled Barrio Pablo Ubeda to become a more cohesive community.

Conclusion

There have been recent indications that heavy metal pollution is associated with social dysfunction[18] and that lead neurotoxicity is associated with aggressive and/or antisocial behavior in children,[19] even beyond the well-documented cognitive and developmental deficits.[21,22] Despite economic constraints that dictate budgetary priorities, it is the obligation of civil society to address the tragedy of suboptimal functioning of its children. This is especially urgent when a cause is identifiable and preventable, as in the case of lead poisoning.[23,24]

The people of Barrio Pablo Ubeda have the evidence in hand; they have presented it to the Nicaraguan authorities and media, and they are hopeful that their government will attend to their needs.

Addendum

Shortly after the blood analyses were completed, FANABASA was closed. According to a spokesperson for the Nicaragua Ministry of Natural Resources and the Environment, the closing was a response to public disapproval of the battery factory. □

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