Follow-Up Screening of Lead-Poisoned Children Near an Auto Battery Recycling Plant, Haina, Dominican Republic

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In August 1997 we performed a follow-up survey of 146 lead-poisoned children from a community near a previously active auto battery recycling smelter in Haina near Santo Domingo, Dominican Republic. Our follow-up survey confirmed a severe incidence of elevated blood lead (BPb) and erythrocyte protoporphyrin/zinc protoporphyrin (EP-ZnPP) levels. The mean BPb level was 32 µg/dL and the mean EP-ZnPP level was 128 µg/dL. The frequency distribution of BPb showed that only 9% of the children had BPb levels below the currently acceptable 10 µg/dL threshold level, 23% had between 10 and 19 µg/dL, 40% had between 20 and 39 µg/dL, 27% had between 40 and 99 µg/dL, and the remainder had > 100 µg/dL. These findings are significantly greater than the mean BPb and EP-ZnPP levels of 14 and 35 µg/dL, respectively, in a comparison group of 63 children in Barsequillo, 4 miles away. BPb frequency distributions for these groups were < 10 µg/dL (42%), 10–19 µg/dL (32%), and 20–39 µg/dL (16%); in the remaining 10%, BPb levels were between 40 and 99 µg/dL. Similarly, the corresponding frequency distribution of EP-ZnPP levels in Haina children were proportional to the severity of lead poisoning and significantly higher than those of the Barsequillo comparison group. This study reveals that at least 28% of Haina children require immediate treatment; of these, 5% with lead levels > 70 µg/dL are also at risk for severe neurologic sequelae, and urgent action is imperative. ***Key words*:** **auto batteries, blood lead, Carribean, environmental pollution, erythrocyte protoporphyrin, graphite furnace (AAS), hematofluorometer, iron deficiency, lead poisoning, smelting.** ***Environ Health Perspect*** **107:917–920 (1999). [Online 19 October 1999]**
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Childhood lead poisoning is now recognized as the number one preventable global environmental disease of children. Lead poisoning affects children's health and development, especially in densely populated urban and industrial cities (*1–6*). Communities near lead, copper, zinc, and battery recycling smelters have been severely poisoned with these metals from emissions, dust, and particulates from such facilities (*7–15*). A low-to-moderate level of lead poisoning, even in the absence of overt clinical symptoms, results in irreversible loss of intelligence, behavior and neuromotor problems, and poor school performance (*16–24*). In the presence of underlying iron deficiency, the absorption of lead from various sources increases (*25,26*), thus aggravating the toxic effects of lead. Moreover, iron deficiency, by itself, causes neuropsychologic deficits in children (*27–29)*. Blood lead (BPb) levels < 10 µg/dL are now universally accepted as the low-level lead exposure threshold.

A lead screening survey of 116 children in the coastal Caribbean community of Haina (located approximately 10 miles from Santo Domingo, Dominican Republic) was conducted in March 1997 (*15*). This community is located next to an auto battery recycling plant that was shut down by the government soon after our initial report (*15*). However, during our August 1997 revisit to the site, metallic scrap and mixed residual soil and solid materials were still scattered about, some in partially packed torn plastic bags and containers stacked both inside and outside the former plant. This report primarily concerns a follow-up study of previously diagnosed lead-poisoned children and smelter workers from the Haina community that were screened 6 months earlier (*15*). We compared venous BPb and erythrocyte protoporphyrin/zinc protoporphyrin (EP-ZnPP) levels of these children with those of Barsequillo, the nearest community with a large number of children. Barsequillo, which is approximately 4 miles from Haina, has similar socioeconomic status and dietary customs. We also present a comparison of BPb and EP-ZnPP levels of 15 workers in 1996 and 1997 and those of a select group of children from Haina in 1997 and 1998.

Materials and Methods

Venous blood specimens (2–3 mL) from children and workers were collected in heparinized Becton Dickinson (Franklin Lakes, NJ) vacutainer tubes. Immediately after collection, each blood specimen was vigorously mixed by inverting several times to prevent microclot formation (*30*); specimens were analyzed the following week for BPb. BPb levels were measured on a Perkin-Elmer graphite furnace spectrophotometer model 4100ZL (Perkin-Elmer, Norwalk, CT) (*31*).

EP-ZnPP levels were measured onsite using an Aviv hematofluorometer HF model 206 (Aviv Biomedical, Lakewood, NJ) (*32*), and the levels were later confirmed at the laboratory using Kaulson HF model 2001 (JEC, Xian, China) (*6*).

Results

The BPb and EP-ZnPP concentrations of the children in Haina and Barsequillo are presented in Table 1. The mean BPb level of Haina children was 32 µg/dL (range 6–130 µg/dL) and the mean EP-ZnPP level was 128 µg/dL (range 18–565 µg/dL) as compared to mean BPb (14 µg/dL; range 4–54 µg/dL) and EP-ZnPP (35 µg/dL; range 20–99 µg/dL) levels for the comparison Barsequillo children. The frequency distribution and the severity of lead poisoning in Haina children 6 months after the closure of the battery recycling, as compared to the children of Barsequillo, are illustrated in Figure 1. In Haina, only 9% of children had BPb levels < 10 µg/dL, the Centers for Disease Control and Prevention threshold level (*16,17*); 23% were between 10 and 19 µg/dL, 40% were between 20 and 39 µg/dL (medical intervention-indicated moderate lead poisoning), 27% were between 40 and 99 µg/dL (high-level lead poisoning), and the remaining 1% had BPb levels ≥ 100 µg/dL (severe lead poisoning) that required urgent treatment. In other words, 68% of the children were at the medical intervention

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Table 1. Blood lead (BPb) and erythrocyte protoporphyrin/zinc protoporphyrin (EP-ZnPP) levels of children in Haina and Barsequillo, Dominican Republic.

	Haina[a]		Barsequillo[b]	
Parameter	BPb (µg/dL)	EP-ZnPP (µg/dL)	BPb (µg/dL)	EP-ZnPP (µg/dL)
Mean	32	128	14	35
Median	28	67	10	29
SD	19.1	120.5	10.2	15.5
Minimum	6	18	4	20
Maximum	130	565	54	99

SD, standard deviation.
[a]Exposed community; n = 146. [b]Nonexposed community; n = 63.

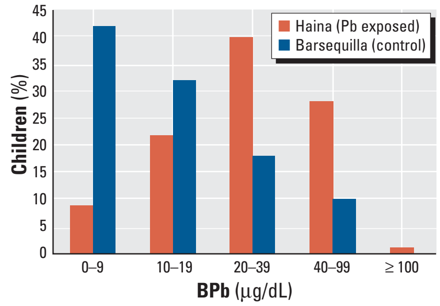

Figure 1. Comparison of frequency distribution of blood lead (BPb) levels of Haina and Barsequillo children.

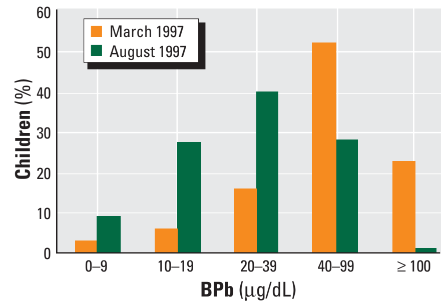

Figure 3. Comparison of frequency distribution of blood lead (BPb) levels of Haina children before and after the closure of the battery recycling plant.

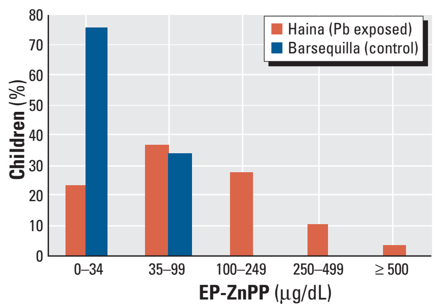

Figure 2. Comparison of frequency distribution of erythrocyte protoporphyrin/zinc protoporphyrin (EP-ZnPP) levels of Haina and Barsequillo children.

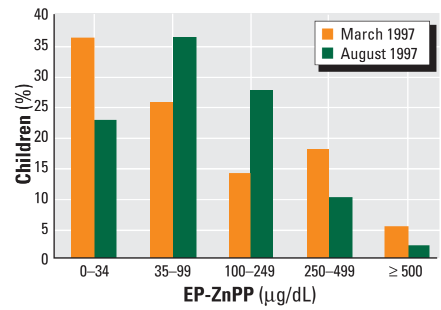

Figure 4. Comparison of frequency distribution of erythrocyte protoporphyrin/zinc protoporphyrin (EP-ZnPP) levels of Haina children before and after the closure of the battery recycling plant.

Table 2. Blood lead (BPb) and erythrocyte protoporphyrin/zinc protoporphyrin (EP-ZnPP) levels of children in Haina, Dominican Republic.

	March 1997[a]		August 1997[b]	
Parameter	BPb (µg/dL)	EP-ZnPP (µg/dL)	BPb (µg/dL)	EP-ZnPP (µg/dL)
Mean	71	159	32	128
Median	60	62	28	67
SD	46.5	202.0	19.1	120.5
Minimum	9	16	6	18
Maximum	234	1,300	130	565

SD, standard deviation.
[a]The March 1997 survey (n = 116) was done when the battery recycling plant was ordered to shut down. [b]The August 1997 follow-up study (n = 146) was done 6 months later.

Table 3. Blood lead (BPb) and erythrocyte protoporphyrin/zinc protoporphyrin (EP-ZnPP) levels of children and battery recycling plant workers,[a] Haina, Dominican Republic.

	Children[b]		Workers[c]	
Parameter	BPb (µg/dL)	EP-ZnPP (µg/dL)	BPb (µg/dL)	EP-ZnPP (µg/dL)
Mean	32	128	61	269
Median	28	67	63	292
SD	19.1	120.5	16	111
Minimum	6	18	31	62
Maximum	130	565	99	415

SD, standard deviation.
[a]August 1997 follow-up survey. [b]n = 146. [c]n = 15.

level. In comparison, 42% of Barsequillo children had BPb levels < 10 µg/dL, 32% were between 10 and 19 µg/dL (level of concern), and only 26% were at the medical intervention level. One child had a BPb level of 54 µg/dL, the highest BPb level.

The frequency distribution of EP-ZnPP levels of Haina and Barsequillo children nearly 6 months after the shutdown of the battery recycling plant is presented in Figure 2. In Haina 23% of the children were below the 35 µg/dL iron deficiency and/or chronic lead poisoning threshold level as compared to 76% in Barsequillo. Thirty-seven percent of Haina children had EP-ZnPP levels between 35 and 99 µg/dL as compared to 34% of the Barsequillo control group. The remaining 40% of Haina children had EP-ZnPP levels > 100 µg/dL, and none of the Barsequillo children examined had EP-ZnPP levels > 99 µg/dL.

A comparison of BPb and EP-ZnPP levels of children measured in the initial March 1997 survey (n = 116) and the follow-up August 1997 survey (n = 146) are presented in Table 2. The relative frequency distribution of BPb and EP-ZnPP is illustrated in Figures 3 and 4. The data show that the mean BPb level of Haina children was lowered from an initial mean level of 71 µg/dL in March to 32 µg/dL in August; similarly, the mean EP-ZnPP level of 159 µg/dL in March was lowered to 128 µg/dL in the August 1997 follow-up survey (Table 2).

The mean BPb and EP-ZnPP levels of the battery recycling plant workers and adult controls are presented in Table 3. The mean BPb level of workers was 61 µg/dL (range 31–99 µg/dL) and the mean EP-ZnPP was 269 µg/dL (range 62–415 µg/dL).

The change in BPb and EP-ZnPP levels of a group of 15 workers and children between 1996 and 1998 is presented in Table 4. In the October 1996 screening of workers, which initiated this project, the mean BPb level of workers was 89 µg/dL and the EP-ZnPP level was 350 µg/dL, as compared to BPb and EP-ZnPP levels of 61 µg/dL and 269 µg/dL, respectively, in August 1997. Similarly, a selected group of 25 children in August 1997 had a mean BPb level of 66 µg/dL, which increased to 81 µg/dL in August 1998, most likely due to continued lead exposure from the environment while clean up of the site was in progress. This coincides with the corresponding mean EP-ZnPP level of 207 µg/dL in August 1997 versus 185 µg/dL in August 1998 (Table 4).

Discussion

The present follow-up survey confirms that there was and continues to be a serious lead poisoning problem among the children living adjacent to the previously active battery recycling plant in Haina. This follow-up survey was necessary for a number of reasons. First, the confirmation using venous specimens was required to eliminate the possibility of finger-prick micro blood collection contamination, which occurred in the initial survey (*15*), and to identify those children who would need immediate treatment and follow-up. Second, the study assessed the impact of the shutdown of the battery recycling facility in spreading airborne and environmental lead to the adjacent community children. Third, the screening was expanded to include more children than was possible in the March 1997 survey.

From the data in Table 1, it is apparent that there are significant differences between mean BPb and EP-ZnPP levels of Haina children as compared to those in the comparison community of Barsequillo. Barsequillo is

Table 4. Mean blood lead (BPb) and erythrocyte protoporphyrin/zinc protoporphyrin (EP-ZnPP) levels of battery recycling plant workers and children.

	Workers[a]		Children[b]	
Period/activity	BPb (μg/dL)	EP-ZnPP (μg/dL)	BPb (μg/dL)	EP-ZnPP (μg/dL)
October 1996 (peak active battery recycling)	89	350	–	–
March 1997[c]	–	–	71	159
August 1997 (6 months after battery recycling shut down)	61	269	66	207
August 1997 (controls)	4	35	–	–
August 1998[d] (1 year after battery recycling plant shut down)	–	–	81	185

[a] n = 15, mean age 35 years. [b] n = 25, mean age 6–7 years. [c] n = 116, mean age 6 years. [d] n = 25.

in contrast to the capital city of Santo Domingo, which is 13 miles away. Santo Domingo has a lot of small- and large-scale industrial activity and a significant number of vehicles that use leaded gasoline. Only 9% of children in Haina are in the currently acceptable range of ≤ 9 μg/dL. Mean BPb levels were significantly lowered, from 71 μg/dL in March 1997 to 32 μg/dL in August 1997, during the 6-month period after the closure of the battery recycling facility. As expected, the mean EP-ZnPP levels of 159 μg/dL in March 1997 decreased to 128 μg/dL in August 1997. The March 1997 levels were also measured at a time when the smelting activity near the community had just peaked and administrative steps were initiated to dismantle the facility. Over a 6-month period BPb levels in Haina dropped significantly, as is evident by the increased number of children in the lower ranges of lead (Figure 3). However, because of chronic lead poisoning, most children had extremely high EP-ZnPP levels in March—up to 1,300 μg/dL. These levels have dropped relatively slowly, as is evident by the gradual shift of EP-ZnPP levels downward (Figure 4). This would be expected in most chronically and severely lead-poisoned cases, even in the absence of significant and continued reexposure to lead, because the lead mobilizes from bones and soft tissues and continues to inflict biologic damage, resulting in high EP-ZnPP levels that are maintained for a long period. Unfortunately, because of economic and administrative reasons, the perilous condition still prevails, as shown by comparisons of BPb and EP-ZnPP levels from 25 children screened in 1997 and again in 1998 (Table 4).

Based on our recent studies and on previous reports and recommendations to the government presented in the initial survey (*15*), the relocation of the community children still seems to be an option to prevent continued exposure of children to this toxic metal-contaminated environment. After our March 1997 visit, significant progress was made to close down the facility. However, the assortment of waste materials, some of which were poorly packed and meant for proper disposal, remained at the site and continued to be a hazard to the neighborhood. We understand that some site clean-up activity has begun. Heavy soil contamination with lead near battery repair shops is a major source of lead poisoning of children in the Carribbean and in other developing countries (*33*). The relationships between soil lead and BPb concentrations resulting from past mining and ore processing (milling) activities and from operating smelters have been compared (*34*). The impact of mine waste-derived lead in soil (usually in the form of lead sulfide) and on BPb is less than that for lead in soil derived from smelters, vehicles, or paint sources. The larger particle size of the lead sulfides means that they are absorbed less in the gastrointestinal tract as compared to other lead species from smelters and recycling plants. Therefore, expensive clean-up actions for lead-contaminated soil in and around lead smelting or recycling facilities, such as those in Haina, to achieve ultimate reduced BPb levels in children may be debatable as a beneficial long-term public health effort.

Treatment of a selected group of severely poisoned children has recently been initiated. Based on the mean BPb levels of severely lead-poisoned Haina children and those of pregnant women from earlier and present groups, recent newborns in the community are expected to have high BPb levels and should be further investigated. Studies from similar situations have shown persistent high BPb levels in both mothers and newborns (*35*). This issue should be of equal or perhaps greater concern to the local public health authorities because the detrimental effect of lead causes far more severe damage in fetuses and newborns than in children or adults. This report confirms that BPb levels of children living close to an uncontrolled hazardous lead smelter facility can be significantly lowered by closure of the facility. Prohibiting the operation of such facilities near residential areas—and vice versa—in the Caribbean islands and elsewhere is necessary. Successful chelation treatment and outcome of lead-poisoned children from such locations can only be achieved by relocating them to safe areas away from their hazardous environment.

An ongoing BPb and EP-ZnPP monitoring and follow-up program is essential for such locations to assist in implementing a remedial action. Even from these limited data it appears that significant lead poisoning in some children still persists at the same or at even higher levels than before, and relocation of the children appears to be a preferred and a viable option even though it appears unlikely to occur. Otherwise, the severity of poisoning and the negative health impact on children will continue to expand. This investigation reveals the seriousness of uncontrolled recycling of used auto batteries for the recovery of lead, which is causing devastating lead poisoning in communities like Haina. The large number of batteries present at the site in March 1997 suggests that the source of these used batteries may not necessarily be from the Dominican Republic alone but perhaps also may be contributed from neighboring countries. Therefore, an expanded survey throughout the Dominican Republic and other Caribbean islands is strongly recommended to identify similar facilities and to take appropriate action. This should be brought to the immediate attention of agencies such as the World Health Organization, the World Bank, U.S. aid funds, and other international humanitarian agencies and foundations.

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