

# Evaluation of Lead Levels in Children Living near a Los Angeles County Battery Recycling Facility

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This cross-sectional study examined the association between environmental lead measurements surrounding a Los Angeles County battery recycling facility and the blood lead levels of the children living nearby. Environmental lead measurements and blood lead levels of young children living in a community adjacent to a stationary lead source were compared to those living in a community without a stationary lead source. Predictors of blood lead level were identified. The blood lead levels of the children living near the secondary lead smelter were within the normal range (<5 µg/dl). The absence of ground cover was associated with slightly increased blood lead levels; however, this increase was not of biological significance. Lead levels in surface soil near the stationary lead source were elevated compared to the control community; however, the soil lead levels were typical of urban soil. No public health impact was detected in the potentially affected community, which may be due in part to controls recently installed at the stationary lead source. **Key words:** children, environmental exposure, lead poisoning, smelter, soil. *Environ Health Perspect* 104:314–317 (1996)

Emissions from stationary lead facilities have the potential to contribute to the overall lead burden of young children living in close proximity to such sources (1–4). Levels of lead in ambient air greater than 2 µg/m<sup>3</sup> as a monthly average and soil levels in excess of 1000 ppm have been shown to be associated with elevated blood lead levels in children (5). Excessive absorption of lead in young children has been shown to result in developmental impairment and long-term damage to the central nervous system (6,7). The precise magnitude of these contributions has not been well-characterized to date in populations residing near lead facilities in Southern California.

The objective of this study was to examine the association between ambient air and soil lead levels surrounding a stationary lead source in Los Angeles County and the blood lead levels of the children living in close proximity. Young children living near the stationary source were the focus of this study, as they are most vulnerable to the effects of lead (8). Young children play outside in potentially lead-contaminated soil and have hand-to-mouth behavior that increases the potential for exposure. Once exposed, young children have more intestinal lead absorption than adults (7). In addition, the developing neurological systems of young children are more susceptible to the neurotoxic properties of lead compared to the neurological systems of adults (8).

The battery recycling facility under study was selected for several reasons. The facility had a history of lead emissions that exceeded the California and U.S. EPA ambient lead standard (1.5 µg/m<sup>3</sup>), and preliminary soil measurements in the com-

munity surrounding the facility revealed that lead levels were elevated. In addition, the site under study processes 148,920 tons of lead each year and is the largest processor of lead in Los Angeles, Orange, Riverside, and the nondesert portion of San Bernadino counties in California. Finally, meteorologic data for the area surrounding the facility indicate that winds move predominantly in the direction of the neighboring residential community, thereby potentially exposing its inhabitants.

## Materials and Methods

A cross-sectional study design was used. An exposed community located adjacent to a large battery recycling facility was identified. A community without a stationary lead source was selected as the control community. The intention was to select a control community that was similar to the exposed community with respect to demographics, vehicular traffic patterns, and housing stock.

From November 1992 through July 1993, project staff conducted door-to-door surveys in the two study areas to identify children who were eligible to participate in the project. Children who were eligible to participate in the project were between 1 and 5 years of age and were required to have lived in their home for at least 3 months before data collection. This was due to the fact that a child's blood lead level at a given point in time reflects the previous 30–60 days of lead exposure (8). Lead exposures of interest in this study were only those that occurred while the child lived in the exposed or control community.

A team of two, consisting of a phlebotomist and an environmental health technician, went to each home to collect venous blood samples from the children and environmental samples from the household. Indoor environmental samples included a household dust sample and two paint samples from the child's main play area. In addition, any imported ceramic ware used for storing, cooking, or serving food was tested for lead using a lead swab test kit. Samples collected outside the home included four composite soil samples, two outdoor paint chips, and ambient measurements for lead. The four outdoor soil samples were collected from the backyard, front yard, around the path leading to the home, and from the side of the house. Ambient lead measurements were collected every 3 days in a representative location in the exposed and control communities.

All paint and soil samples were analyzed for lead using flame atomic absorption spectroscopy (9,10), and blood lead analysis was conducted using graphite furnace atomic absorption spectroscopy (11). We analyzed household dust samples for lead using acid digestion and flame atomic absorption (12). A split sample was collected for 10% of the blood, paint, and soil lead samples and sent to a second laboratory for confirmatory analyses. Field blank samples of household dust were also collected in

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10% of the households to monitor for any possible contamination.

The quantitation limit of the analytical procedure used to evaluate lead in the blood was 5 µg/dl, the concentration of the lowest routine control sample used. Observations identified with a value below the detection limit were assigned a value of 2.5 µg/dl, the midpoint between 0 and 5 µg/dl.

We conducted additional metal analyses for a random sample of approximately half of the backyard soil samples in each community to evaluate whether other metals associated with battery recycling were present in the soil. The additional metals examined in the soil were antimony, arsenic, cadmium, and copper. Inductively coupled plasma emission spectroscopy was used to analyze the soil for the additional metals.

A detailed questionnaire was administered to the child's parent or guardian. The questionnaire ascertained information on a child's play behavior, major recent changes in the yard such as soil removal or paving, painting or paint removal, household members employed in lead-exposed occupations, and any hobbies of household members involving lead exposure. All questionnaires were translated into Spanish and administered to the parent or guardian by a bilingual project staff member in the Spanish-speaking households. Results from the mapping of backyard soil lead measurements in the exposed community are described. Backyard soil samples were mapped because backyard soil is the least likely to be affected by lead from vehicle emissions.

We compared the demographic data on the study group to that for the general population to assess whether the study group was representative of the general population. Descriptive statistics for all environmental and biological data are presented, including the arithmetic mean, standard deviation, and 95% confidence intervals (CIs). Geometric means (GM), geometric standard deviations, and 95% CIs are also presented for variables that are not normally distributed to better illustrate the central tendency of these data. Comparisons between the study and control areas were conducted with *t*-tests using the SAS system (13). If variables were not normally distributed, the data were log-transformed and the *t*-tests were conducted on the log-transformed data. Multiple regression analysis was conducted using the SAS software (13), and the results are presented.

## Results

Of the 147 eligible households in the exposed community, data collection was

completed in 95 households (65%). Of the 172 eligible households in the control community, data collection was completed for 92 households (53%). There were 122 children, ages 1–5, living in the study households in each of the two communities.

Table 1 shows the demographic characteristics of the children in the exposed and control communities. The children in the exposed community were slightly older than the children in the control community, more likely to be white, and more likely to speak English. The sex of the children, age of housing, and household income distribution were similar in the two communities.

The demographic characteristics of the exposed and control communities were compared to those of the general population of the two communities and were found to be similar overall (data not shown). There were slightly more Latino children in the exposed and control study groups, however, than in the respective general populations.

Data on lead in the soil, paint, household dust, and air for the exposed and control communities are shown in Table 2. The *t*-tests that compare the log-transformed means of these variables are also

**Table 1.** Demographic data for exposed and control communities

Variable	Exposed		Control	
	N <sup>a</sup>	%	N <sup>a</sup>	%
Age (years)				
1	15	12	19	15
2	19	16	29	24
3	25	20	22	18
4	33	27	29	24
5	30	25	23	19
Sex				
Male	57	47	64	53
Female	65	53	58	47
Ethnicity				
Hispanic	75	61	73	60
White	37	30	24	20
Black	0	0	14	11
Asian	8	7	11	9
Other	2	2	0	0
Primary language				
English	93	76	77	63
Spanish	25	17	35	29
Other	4	3	10	8
Household income				
<\$15,000	26	21	29	24
\$15–29,000	28	23	17	14
\$30–44,000	24	20	34	28
\$45–59,000	21	17	19	16
\$60–74,000	14	12	12	10
>\$75,000	5	4	9	7
Not available	4	3	2	2
Age of housing unit				
Pre-1950	51	42	55	45
1950 and later	32	26	22	18
Not available	39	32	45	37

<sup>a</sup>Sample size is number of children.

presented. The soil lead, dust lead, outdoor paint lead, and air lead levels were higher in the exposed than in the control community. In contrast, the lead content of the indoor paint samples in the two communities was not appreciably different.

Results of other metals examined in the soil are presented in Table 3. The levels of antimony and cadmium were higher in the exposed community, and the soil arsenic

**Table 2.** Comparisons between environmental data for exposed and control communities

Lead	Exposed	Control
Average of soil samples (ppm) <sup>a</sup>		
Arithmetic mean	125	104
SD	77	159
95% CI	109, 141	72, 137
<i>n</i>	92	92
Geometric mean	107	82
SD	3	3
95% CI	106, 108	82, 83
<i>n</i>	92	92
<i>t</i> (log-transformed)		3.2
<i>p</i>		0.002
Indoor dust (ppm)		
Arithmetic mean	183	177
SD	101	241
95% CI	163, 203	116, 239
<i>n</i>	95	59
Geometric mean	157	144
SD	3	3
95% CI	157, 158	143, 145
<i>n</i>	95	59
<i>t</i> (log-transformed)		2.06
<i>p</i>		0.04
Indoor paint (ppm)		
Arithmetic mean	735	930
SD	880	2442
95% CI	554, 916	401, 1459
<i>n</i>	91	82
Geometric mean	436	480
SD	2	4
95% CI	436, 436	479, 481
<i>n</i>	91	82
<i>t</i> (log-transformed)		-0.3
<i>p</i>		0.8
Outdoor paint (ppm)		
Arithmetic mean	6511	3532
SD	11663	5689
95% CI	4166, 8856	2330, 4734
<i>n</i>	95	86
Geometric mean	1773	1313
SD	3	3
95% CI	1772, 1774	1312, 1314
<i>n</i>	95	86
<i>t</i> (log-transformed)		2.3
<i>p</i>		0.02
Ambient lead (µg/m <sup>3</sup> )		
Arithmetic mean	0.06	0.03
SD	0.05	0.006
95% CI	0, 0.1	0, 0
<i>n</i>	34	25
Geometric mean	0.05	0.03
SD	2.7	2.7
95% CL	0, 1.0	0, 1.1
<i>n</i>	34	25
<i>t</i> (log-transformed)		2.9
<i>p</i>		0.007

<sup>a</sup>From backyard, front yard, and path.

**Table 3.** Distribution of antimony, arsenic, cadmium, and copper (ppm) in a random sample of soil samples in exposed and control communities

Metal	Community	Mean	SD	95% CI	n
Antimony	Exposed	5.2	0.6	5.0, 5.4	51
Antimony	Control	4.9	1.0	4.6, 5.2	45
$t = 2.3; p = 0.02$					
Arscopic	Exposed	19.6	5.3	18.1, 21.1	51
Arscopic	Control	23.9	8.3	21.5, 26.3	45
$t = -3.03; p = 0.003$					
Cadmium	Exposed	0.9	1.2	0.6, 1.2	51
Cadmium	Control	0.6	0.4	0.5, 0.7	45
$t(\log\text{-transformed data}) = 2.2; p = 0.03$					
Copper	Exposed	72.4	265.8	0, 145.4	51
Copper	Control	40.6	24.1	33.6, 47.6	45
$t(\log\text{-transformed}) = -0.3; p = 0.8$					

concentration was higher in the control community. There were no differences in levels of copper in the soil in the two communities.

A comparison of blood lead levels of children in the two communities is shown in Table 4. Arithmetic and geometric mean blood levels were slightly higher in the exposed community.

Two regression models that include the major predictors of the log-transformed blood lead levels are shown in Table 5. As shown in the models, the absence of ground cover was a predictor of a child's blood lead level. The inclusion of backyard soil lead and household dust lead added to the model's predictive power. When backyard soil lead levels were mapped, there was a geographical clustering of slightly elevated backyard soil lead levels in the residential area closest to the stationary lead source (data not shown).

Imported pottery from which children ate food was identified in 13% ( $n = 27$ ) of the households in the exposed community and in 22% ( $n = 48$ ) of the households in the control community. Of the pottery identified, 41% tested positive for lead in the exposed community and 31% tested positive for lead in the control community.

Results of the split environmental samples were consistent between the two laboratories, and there was no contamination of the household dust blank samples.

## Discussion

The participation rates in this study, although low, are typical for a project of this type (14). The over-representation of Hispanics in the study groups may be explained by the fact that Hispanics tend to have larger families and subsequently more young children, rendering Hispanics more likely to be eligible to participate in the project.

The fact that the children in the exposed community are older, white, and more likely to speak English could intro-

duce a bias in which the children in the exposed community are at less risk for lead poisoning for demographic reasons (7). This could partially explain the lack of an appreciable difference between the blood lead levels in the exposed and control communities. However, the mean blood levels of the children in the exposed community did not vary when stratified by age, ethnicity, or language spoken.

**Table 4.** Blood lead levels ( $\mu\text{g/dl}$ ) in exposed and control communities<sup>a</sup>

	Exposed	Control
Arithmetic mean	3.8	3.5
SD	1.9	1.9
95% CI	3.5, 4.1	3.2, 3.8
n	122	122
Geometric mean	3.5	3.1
SD	3.2	3.0
95% CI	2.9, 4.1	2.6, 3.6
n	122	122
$t(\log\text{-transformed}) = 1.8; p = 0.07$		

<sup>a</sup>Blood lead levels measured at the analytical detection limit of  $<5 \mu\text{g/dl}$  were assigned a value of  $2.5 \mu\text{g/dl}$ , the midpoint between 0 and  $5 \mu\text{g/dl}$ .

**Table 5.** Multiple regression models predicting log-transformed blood lead levels

Variable	Parameter estimate	SE	t	p
<b>Model 1 (<math>n = 235</math>)<sup>a</sup></b>				
Intercept	0.9674	0.1975	4.899	0.0001
Age	-0.003368	0.001603	-2.101	0.0367
Sex	0.07759	0.05377	1.443	0.1504
Backyard soil	0.07109	0.0422	1.685	0.0934
Lead (log-transformed)				
Ground cover	0.30834	0.080575	3.827	0.0002
<b>Model 2 (<math>n = 190</math>)<sup>b</sup></b>				
Intercept	0.5298	0.2874	1.844	0.0668
Age	-0.002963	0.001764	-1.679	0.0948
Sex	0.01099	0.05878	1.735	0.0844
Background soil	0.07479	0.04474	1.671	0.0963
Lead (log-transformed)				
Household dust lead (log-transformed)	0.07677	0.04626	1.660	0.0987
Ground cover	0.30135	0.084305	3.575	0.0004

<sup>a</sup>Nine children were not included in these analyses due to missing information on backyard soil lead levels;  $R^2 = 0.1154$  for model 1.

<sup>b</sup>Fifty-four children were not included in this model due to missing data on dust lead or backyard soil lead;  $R^2 = 0.1489$  for model 2.

In general, the study group is fairly representative of the population from which it was sampled. The data on the age of the housing in the two communities are not reliable because approximately one-third of both study group participants had no knowledge of the year in which their home was built.

The blood lead levels in the community near the secondary lead smelter and the control community are below  $10 \mu\text{g/dl}$ , the Centers for Disease Control's definition of normal (8). The blood lead levels in the exposed community are slightly higher than those in the control community, but the difference is not biologically significant.

As shown in the regression models, there is an inverse association between age and blood lead level, a finding that is consistent with other research (8). The absence of ground cover is also associated with an increase in blood lead levels which is consistent with literature that demonstrates that ground cover can serve as a barrier for soil lead exposure in children (8).

Soil lead levels were higher in the exposed than in control community (GM =  $107 \text{ ppm}$  versus  $82 \text{ ppm}$ ); however, the mean soil lead level of the exposed community is not unlike soil lead levels typically found in urban soil (15,18). In fact, the majority of the soil samples in both communities were less than  $200 \text{ ppm}$ . The EPA's recently issued interim guidelines for cleanup levels in residential soil is  $400 \text{ ppm}$  (16). The soil samples in the community near the secondary lead smelter are well below this recommended cleanup level.

The finding of higher soil antimony levels in the exposed community compared to the control community supports the assertion that the lead in the soil in the

exposed community is in some part due to emissions from the battery recycling facility, as antimony in particular is associated with the recycling of batteries (17). The levels of antimony and cadmium in the soil are low, however, compared to the California hazardous waste definitions for metals in the soil of 500 ppm for antimony and 100 ppm for cadmium (19). It is unlikely that exposure to the low concentrations of antimony and cadmium detected in the soil near the smelter will result in any adverse health effects in the children living in close proximity.

In addition, a pattern of elevated backyard soil lead levels is seen in the residences closest to the facility. Thus, there is some supporting evidence that the elevated levels of lead in the soil in the exposed community is at least partially due to the emissions from the facility. However, the lead in this soil does not appear to contribute to the body burden of the young children in this community, as shown in the distribution of blood lead levels.

The levels of air lead in the exposed community are higher than those in the control community. However, it should be noted that the mean air lead measurement of  $0.05 \mu\text{g}/\text{m}^3$  in the exposed community is 30 times lower than the EPA ambient lead standard of  $1.5 \mu\text{g}/\text{m}^3$  for a 30-day average.

There is no standard for household dust levels for comparison purposes. Using the same standard as that used for soil lead levels as an approximate comparison, the mean dust level of 157 ppm in the exposed community is also well below the EPA recommended cleanup level of 400 ppm.

Overall, there are slightly elevated environmental lead levels in this community located adjacent to a secondary lead smelter. However, there is no measurable public health impact of these elevations. The lead source under study historically

had excessive lead emissions. In more recent years, controls have been implemented at the facility to reduce lead exposure to the community. The primary control instituted at the facility before data collection for this study was a bag-house equipped with HEPA filters. It appears that the HEPA filtration system installed at the battery recycling facility may have contributed to reductions in recent lead emissions to the surrounding residential community. It had been believed that the historical emissions were present in the community's soil, thereby influencing more recent childhood lead exposures. Based on the results of this research, it appears that this is not the case for this Los Angeles County battery recycling facility and the surrounding community.

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