ENVIRONMENTAL HEALTH

The Association of Lead-Contaminated House Dust and Blood Lead Levels of Children Living on a Former Landfill in Puerto Rico

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Exposure to lead in children living on a former landfill in Vega Baja-Puerto Rico, a United States Environmental Protection Agency (USEPA) designated Superfund Site, is a major health concern. Direct contact with lead-contaminated soil is considered a major exposure source. However, there is a lack of information regarding the contribution of lead-contaminated house dust to children's blood lead concentrations. This study evaluated the relationship between lead contaminated-house dust and children's blood lead levels. Blood from 42 children, aged 6 years old or less, and dust from 29 houses were analyzed for lead, and face-to-face interviews were performed to gather information on potential risk factors for high blood lead levels. Blood lead levels ranged from 0.97 to 7.79 µg/dL. Lead values for floors fluctuated from 0.12 to 98.30 µg/ft^2, with 17% of houses surpassing the USEPA standard of 40 µg/ft^2. Multiple regression analysis showed that lead in window sills, toy chewing and soil eating habits were significant predictors of blood lead levels. Further investigations aimed at assessing the long-term effects of constant exposure to environmental lead in these children are warranted.

Key words: Lead, House dust, Blood, Puerto Rico, Children, Superfund site, Wipe sampling technique

Since lead has no biological function, the ideal level in the human body should be zero. However, traces of this metal are frequently detected in the human population because of its widespread environmental distribution (1). Children 6 years of age and younger are particularly more vulnerable to lead poisoning because they can absorb as much as 50% more than adults which absorb from 5-10% of ingested lead (1). Blood lead levels ≥10 µg/dL have been associated with impaired intelligence, neurobehavioral development, aggressive behavior, developmental effect, hyperactivity, weight loss, renal effects, anemia and effects on vitamin D metabolism in children (1-6). The Centers for Disease Control and Prevention (CDC) has established that blood lead levels ≥10 µg/dL must result in intervention by the pertinent health institutions to identify the sources of contamination and reduce the risk of exposed children (1). Among major sources and pathways of lead exposure, contamination by soil and paint-generated dust particles inside houses are considered major contributors to increase blood lead levels in children (1, 7-10). To prevent lead toxicity, the United States Environmental Protection Agency (USEPA) recently promulgated new standards for residential dust lead (11). Lead is considered a health hazard if it is greater than 40 µg/ft^2 on floors and greater than 250 µg/ft^2 on interior window sills (11).

Children of low socioeconomic status tend to live in close proximity to agricultural and industrial areas, or contaminated sites with hazardous substances. This is the case of children living on a metal-contaminated former landfill known as "Brisas del Rosario", located near the town of Vega Baja, in the northern coast of Puerto Rico (12) as shown in Figure 1. Approximately 200 houses of

Figure 1. Map of Puerto Rico showing the Municipality of Vega Baja where the impacted community of "Brisas del Rosario" is located.

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"Brisas del Rosario" were constructed on the former Vega Baja Solid Waste Disposal Site (VBSWDS), currently classified as a USEPA Superfund Site (Figure 1) (12). Past soil sampling conducted by the Puerto Rico Environmental Quality Board (PREQB) and the USEPA revealed significant lead levels, achieving concentrations as high as 14,000 µg/g (12). Therefore, according to the PREQB and the USEPA, a major route of exposure to lead for children from "Brisas del Rosario" is contaminated soil. However, there is a lack of information regarding the exposure to house dust lead, and how this exposure source may contribute to increase blood lead levels in children from this community. Although state and federal agencies have recommended frequent cleaning of houses to remove unwanted dust, or washing hands after association with contaminated soil, no formal study has been conducted to determine levels of lead-contaminated house dust, nor it has been evaluated the efficiency of house cleaning in removing lead-contaminated dust as recommended by health agencies. It is important to know lead levels in house dust because of its strong association with blood lead concentrations (1,7-10). For instance, an increase of dust lead loading from background to 200 µg/ft^2 could produce an increase of 23.3% in the percentage of children with blood lead levels > 10 µg/dL (8).

This preliminary study examined the relationship between lead in settled house dust and lead in blood of children living in the community of "Brisas del Rosario". In addition, the contribution of various housing and socio-demographic characteristics to blood lead levels in children was evaluated. This is the first report in Puerto Rico associating blood lead concentrations in children with house dust lead levels.

Materials and Methods

Subjects. Forty-two children, from 29 houses located on "Brisas del Rosario" community, were included in this study conducted from January to March 2001. They had to meet the following requirements: (1) have 6 years of age or less, and (2) had lived in the same house for at least 6 months. After explaining the purpose of the study, parents or custodians who accepted to participate were asked to sign an informed consent form approved by the Medical Sciences Campus Institutional Review Board. A face-to-face interview was performed to parents or custodians of children to gather socio demographic, behavioral, health and nutritional information of children.

Blood sampling and analyses. Recruited children were cited at a Family Practice Clinic located near "Brisas del Rosario" for blood sampling conducted by a certified nurse, with the assistance of a pediatric doctor. About 3 cc of venous blood were collected wearing powder-free gloves in sterile 10.25 x 64 mm lavender top Vacutainer tubes with the anticoagulant K_3EDTA (Becton Dickinson, Franklin Lakes, NJ) as recommended by the Environmental Health Laboratory Sciences (Method 1080B) of the CDC for the analysis of lead (1). In addition, a separate venous blood sample, without anticoagulant, was obtained for a Sequential Multiple Analyzer (SMA)-20 tests, and total serum iron analyses. Blood samples were immediately placed in an ice-cooler, transported to the laboratory, and stored at -20°C. Under aseptic laboratory conditions using a laminar flow-hood, aliquots of 1 mL of blood samples with anticoagulant were transferred to properly labeled 6-mL polypropylene tubes for lead determination and the remaining used for a complete blood cell (CBC) count test. Blood lead concentrations were determined by initially diluting 100 µL of whole blood samples 10 times with a solution containing 0.5% Triton X-100, 0.2% nitric acid, and 0.2% ammonium phosphate. Blanks (field and laboratory), a standard reference material (SRM) "955b" containing known lead levels in bovine blood (National Institute of Standard and Technology, Gaithersburg, MD), and spiked blood samples with a known lead solution were used to validate the analytical method as part of the quality control (QC) process. Blood samples were analyzed in duplicates.

House dust sampling and analyses. In order to maximize the relationship between the exposition to lead-contaminated house dust with lead concentrations in blood, house dust samples were taken within a week after the sampling of the child's blood. The same day of house dust sampling, a second questionnaire was administered to gather information regarding the child's house general history and conditions (e.g., minor renovations, paintings, last day of house cleaning) and eating habits of locally home-grown plants and/or animals.

House dust sampling protocols have been described extensively elsewhere (7,13-14). Briefly, a minimum of four interior floor dust samples (e.g., child's bedroom, principal entrance, living room, and kitchen) were collected per house by wiping uniformly inside a 1 ft^2 polyvinyl chloride (PVC) tube with a K-mart "Little Ones" baby wipe to obtain dust lead loading (µg/ft^2). Also included was the window sill of the child's bedroom, with the area determined with a measuring metric line after sampling the accumulated dust. Each dust sample was placed in a pre-identified plastic bag that was stored inside another plastic bag corresponding to the sampled house. In the field, dust samples were placed in an ice-cooler to be transported to the laboratory, and stored at -20°C. Between house dust samplings, each PVC tube was cleaned with 0.5% nitric acid and distilled deionized water, and dried. Field blanks for each house consisted in wipes used to clean PVC tubes prior to dust sampling.

Dust samples were digested with 10 mL concentrated nitric acid in Teflon vessels using a microwave oven model MSP 1000 (CEM Corp, Matthews, NC) (15). After digestion, samples were filtered using Whatman No. 41 filter papers. Filtrates were collected in 100-mL graduated plastic cylinders and diluted to 50 mL with 1% nitric acid. Prior to dilution, plastic bags containing dust samples were rinsed with 1% nitric acid and the rinsate transferred to corresponding graduated cylinders. The digested solution was transferred to 50-mL polypropylene tubes (Corning Incorporated, Corning, NY), and ready for Atomic Absorption Spectrophotometry (AAS) analysis.

The digestion's QC consisted of field blanks (a wipe used to clean the PVC tube prior to dust sampling), laboratory blanks consisting of wipes exposed under laboratory conditions (also known as "matrix blanks"), and Teflon vessels with acid solution alone. Known amounts of the SRM-2583 "Trace elements in indoor dust" from the National Institute of Standards and Technology (Gaithersburg, MD) weighed on a wipe, and spiked wipes with a known lead solution were also included as part of the QC. Laboratory blanks, SRM and spiked wipes were included in every digested batch consisting of 24 samples.

Lead analysis. The analysis of lead from blood and dust samples was performed using an AAS Model Analyst 800 (Perkin Elmer, Norwalk, CT) with Zeeman effect background correction. Digested dust samples were initially analyzed by the Direct Aspiration Flame Mode with a limit of quantitation (LOQ) of 100 µg/L, and followed by the Graphite Furnace Mode with a LOQ of 1.0 µg/L when better sensitivity was required. Blood lead levels were determined by the Graphite Furnace Mode with a quantitation limit of 0.5 µg/L. The linear calibration curve was accepted after obtaining a correlation coefficient of 0.995 or better. A matrix modifier consisting of ammonium phosphate and magnesium nitrate was added to digested dust samples during the AAS analysis to minimize interferences and improve the LOQ.

Statistical analysis. A mean dust lead loading (overall house dust) was calculated for each house representing an average value of five samples per house (child's bedroom and its window sill, principal entrance, living room, and kitchen). Information gathered from face-to-face interviews was recorded in a database designed with the use of Epi-Info version 6.04d (Epidemiology Program Office CDC, Atlanta, GA). All statistical analyses were performed using SAS® version 8e for Windows (SAS Institute Inc., Cary, NC). Summary statistics were calculated for quantitative variables, while frequency distributions were obtained for qualitative variables. Normality of data was evaluated using the Shapiro-Wilk statistic (16). Since the distribution of lead in blood and dust samples was skewed, a log (10) transformation was used before performing regression analyses. The Generalized Estimating Equations (GEE) approach was used since responses (e.g., socio demographic characteristics, children habits, housing characteristics and lead in dust levels) of subjects within a household were assumed to be correlated. GEE incorporates within-household correlation into the estimation of simple and multiple regression parameters (also known as Cluster Analysis) (17). Simple linear regression models of blood lead levels as a function of sociodemographic and environmental characteristics were fitted for subjects with two replicates of lead in blood and with five surface dust samples per house. Those variables with p values below 0.10 in the bivariate analysis were entered into a multiple linear regression model to determine the effect of individual characteristics on blood lead levels after controlling for potential confounders.

Results

Of the 42 children enrolled, one child was excluded from the regression analyses because of insufficient blood sample. Therefore, 41 children from 28 houses were included in the analysis. Of the 41 children and 28 houses, 30 children (73%) representing 20 houses (71%) were from the VBSWDS of "Brisas del Rosario". The rest of the houses, 7 houses (10 children) and one house (one child) were located approximately within 1 and 4 miles radius of the VBSWDS, respectively. The median age of the study subjects was 4 years and their median weight was 17.5 kg (Table 1). Children spent a median time of 22 hours daily in their homes, and 3 hours daily in their backyards (Table 1). The median time of house construction was 15 years. Seventy-six percent of the children were females, and nearly 79% of the parents owned the house sampled in the study (Table 2).

Table 1. Housing and socio demographic characteristics of study population.

Characteristic	N	Median	25th and 75th percentiles
Age in years	41	4.0	2, 4
Weight in kilograms	20	17.5	12.5, 20.4
Number of people living in the house	41	5.0	4, 6
Number of hours that the child spends inside the house	37	22	16, 24
Number of hours that the child spends in the backyard	38	3	2, 7
Years of house construction	31	15	7, 23

Table 2. Housing and socio demographic characteristics.

Characteristic	N	Frequency	Percentage
Female sex	41	32	76.2
Owned house	41	33	78.6
Renovations in the last 5 years	40	30	75.0
Daily floor cleaning	41	13	30.9
Weekly window cleaning	41	10	24.4
Presence of roof filtrations	41	16	38.1
Presence of area carpets in the home	41	12	29.3
Finger chewing	41	33	78.6
Perceived low intellectual functioning capacity	41	20	48.8
Monthly income less than $1,000	40	31	77.5
Consume animals from backyard*	40	15	37.5
Consume plants from backyard†	41	31	75.6
Use vitamins or supplements	39	35	89.7

* Includes chickens, rabbits, ducks, pigs, lambs and pigeons
† Includes fruits, vegetables and seasoning plants

Table 3. Arithmetic and geometric mean lead levels in house dust (µg/ft^2) and blood samples (µg/dL) for children in the study.

Measurement	N	Arithmetic mean	Geometric mean (GM)	95 % Confidence Interval of the GM
Lead in blood	41	2.52	2.28	1.99, 2.63
Lead in principal entrance	29	8.07	2.58	1.44, 4.63
Lead in living room	29	6.89	1.89	1.08, 3.31
Lead in kitchen	29	7.71	2.42	1.37, 4.26
Lead in child's bedroom	29	8.65	2.08	1.12, 3.83
Lead in window sill of child's bedroom	29	10.87	6.40	4.33, 9.46
Lead in overall house dust	29	8.43	4.06	2.59, 6.35

QC protocols showed no significant contamination with lead in vials, wipes or solutions. The average percent recovery ± standard deviation of lead in the SRM 955b for blood lead was 101± 5.9% at the 4.04 µg/dL level and 96.8 ± 3.8% at the 10.30 µg/dL, while the SRM 2583 for house dust (85.9 µg/g) was 74.0 ± 11.6%. Average concentrations of lead in house dust field blanks were 0.13 ± 0.06 µg/ft^2, while laboratory blanks were 0.37 ± 0.47 µg/L for digested clean nitric acid solution, and 0.22 ± 0.22 µg/L for digested clean wipes. Lead concentrations for blanks in the blood analysis were below the LOQ.

Table 4. Percentile distribution of arithmetic mean lead levels in children's blood (µg/dL) (n=41) and house settled dust (µg/ft^2) (n=29).

Measurement	Minimum	25%	50%	75%	95%	99%	Maximum
Lead in children's blood	0.97	1.63	2.32	3.19	4.30	7.79	7.79
Lead in overall house dust	0.71	1.89	3.73	7.47	25.90	50.70*	50.70*
Lead in principal entrance	0.12	1.06	2.58	4.41	44.21*	49.92*	49.92*
Lead in living room	0.27	0.61	1.62	3.72	13.47	98.30*	98.30*
Lead in kitchen	0.29	0.97	2.10	9.27	26.69	60.65*	60.65*
Lead in child's bedroom	0.25	0.56	1.45	3.39	35.48	64.90*	64.90*
Lead in window sill of child's bedroom	1.18	3.28	6.06	12.90	33.00	55.84	55.84

*Value exceeded USEPA standard of 40 µg/ft^2 for lead in dust on floors

Blood lead concentrations of study children were below the CDC standard of 10 µg/dL, with the highest value being 7.79 µg/dL. The geometric mean of lead in children's blood was 2.28 ± 1.53 µg/dL with a 95% confidence interval ranging from 1.99 to 2.63 (Table 3). Percentile distribution of lead in children's blood and dust samples are shown in Table 4, with values that exceeded the USEPA standard for floors identified with an asterisk. Eight dust samples distributed in five houses (17% of the houses sampled) had higher values than the USEPA standard for floors (40 µg/ft^2). Houses that exceeded the USEPA house dust lead standard for floors were from the VBSWDS. None of the houses had dust lead concentrations that surpassed the USEPA standard for window sills (Table 4).

Tables 5 and 6 show the relation between children's blood lead levels and socio demographic characteristics and habits estimated by simple linear regression analysis. Statistically significant associations ($p<0.05$) were found between blood lead levels and toy chewing habit, perceived low intellectual functioning capacity, lead in the principal entrance and in the window sill of the child's bedroom. Marginal statistically significant associations ($0.05<p<0.10$) were obtained with house roof filtrations, soil eating habit, and average overall lead in house dust.

To simultaneously adjust for factors to be associated with blood lead levels in the bivariate analysis, a multiple linear regression model was constructed (Table 7). This model showed statistically significant associations between blood lead levels and the following variables: lead in window sills of the child's bedroom (p=0.0347), soil eating habit (p=0.0311) and toy chewing habit (p=0.0074).

Table 5. Associations of children's blood lead levels with socio demographic and environmental characteristics using a simple linear regression model* (N=41).

Characteristic	Parameter estimate (b)	Standard Error (SE)	P-value	R^2 (%)†
Female sex	0.0611	0.0631	0.3324	2.44
Age in years	0.0196	0.0161	0.2239	2.49
Time of residency in years	0.0018	0.0029	0.5319	1.29
Time of house construction in years	0.0012	0.0031	0.6948	0.61
House renovations	0.0506	0.0660	0.4435	1.52
Frequency of cleaning				
Floors (every day)	0.0488	0.0670	0.4670	1.31
Windows (every week)	0.0378	0.0988	0.7022	0.65
House roof filtrations	0.1038	0.0599	0.0829	6.64
Area carpets in the house	0.0264	0.0550	0.6314	0.44
Child habits:				
Washes hands before eating	0.0599	0.0734	0.4143	2.27
Finger chewing	0.0188	0.1048	0.8573	0.16
Eats soil from backyard	0.1002	0.0562	0.0747	4.57
Toy chewing	0.2079	0.0650	0.0014	21.15
Perceived low intellectual functioning capacity	0.1286	0.0451	0.0043	2.09
Family monthly income less than $500	0.0496	0.1008	0.6224	1.19
Consume plants from backyard‡	0.0028	0.0857	0.9741	0.00
Consume animals from backyard§	0.0183	0.0801	0.8189	0.21
Use vitamins or supplements	0.0346	0.1532	0.8216	0.30
Days since the last house cleaning	0.1038	0.0709	0.1432	6.20

* Blood lead levels have been log transformed
† Percentage of variation in children's blood lead levels explained by each variable
‡ Include fruits, vegetables and seasoning plants
§ Include chickens, rabbits, ducks, pigs, lambs and pigeons

Table 6. Associations of children's blood lead levels with house dust samples using a simple linear regression model* (N=28).

Characteristic	Parameter estimate (b)	Standard Error (SE)	P-value	R^2 (%)†
Overall house dust	0.1408	0.0797	0.0774	10.25
Principal entrance	0.1288	0.0573	0.0245	15.63
Living room	0.0649	0.0470	0.1670	3.63
Kitchen	0.0647	0.0504	0.1999	4.02
Child's bedroom	0.0350	0.0555	0.5281	1.32
Window sill of child's bedroom	0.1688	0.0809	0.0368	12.37

* Lead levels in blood and dust samples have been log transformed
† Percentage of variation in children's blood lead levels explained by each source

The presence of roof filtrations was marginally associated (p=0.099) with blood lead levels. Lead in dust of the main entrance did not reach statistical significance (p=0.6959) after controlling for lead in dust of window sills, soil eating habit, toy chewing habit and house roof filtrations. This regression model explained 32.8% of the variation in children's blood lead levels.

Table 7. Association of children's blood lead levels with selected characteristics using a multiple regression analysis*†.

Characteristic	Parameter estimate (b)	Standard Error (SE)	P-value
Lead in dust of the principal entrance	0.0257	0.0659	0.6959
Lead in dust of window sills	0.1510	0.0715	0.0347
House roof filtrations	0.0965	0.0585	0.0990
Soil eating habit	0.1032	0.0479	0.0311
Toy chewing habit	0.1832	0.0684	0.0074

* Lead levels in blood and dust have been log transformed
† The entire model explains 32.8% of the variation in children's blood lead levels

Discussion

Even though lead in dust from window sills of the child's bedroom did not exceed the USEPA standard of 250 μg/ft², it is a significant contributor to blood lead levels. Similar results were obtained by Lanphear et al. (18) with windows troughs being a major source of lead exposure in children. Although blood lead levels did not exceed the CDC blood lead standard, lead exposure in "Brisas del Rosario" from house dust in window sills and some children habits like toy chewing and soil eating may contribute to an increase in blood lead levels. Similar significant predictors related to child habits have been observed in other studies (1,9,19,20). This finding is consistent with the CDC argument that hand-to-mouth activities in lead-contaminated house dust could increase the probability of getting higher concentrations of lead in children's blood with ≤6 years of age (1). Since these habits could significantly contribute to lead in blood levels of children, parents need to be more aware of their habits in order to reduce exposure to lead-contaminated house dust.

Although no significant association was observed in the multiple regression analysis between overall house dust lead measurements and blood lead levels, lead in house dust reached significance in the simple linear regression analysis with the principal entrance and the window sill of the child's bedroom. It was found that lead in dust at the principal entrance (R^2=15.63%) improved the variation explained in blood lead levels by a higher percentage than the overall house dust (R^2=10.25 %). The fact that the principal entrance is more accessible to outdoor areas and frequently transited by people and pets bringing lead-contaminated dust, may help explain the improved association with blood lead concentrations (10).

The relationship between blood lead levels of children and housing characteristics such as renovations, interior painted surfaces, or construction activity have been previously studied (7-10, 20-22). Of the housing characteristics evaluated in this study, only house roof filtration was marginally associated with blood lead levels in children in the multiple regression analysis. This finding could be explained by the fact that there is lead in the roof construction materials that leak down the house.

Blood lead levels below the CDC standard of 10 µg/dL could have an effect in children's academic performance during preschool years (6). Although blood lead levels were lower than the CDC standard, a statistically significant association between "perceived low intellectual functioning capacity" and blood lead levels was observed in the simple linear regression analysis. Low intellectual functioning capacity was not determined using formal psychometric tests, but rather by parental perception. Since this community has been studied by various state and federal agencies, there may be a tendency to over-reporting poor intellectual capacity by parents living in this community. However, there is some evidence of the low intellectual functioning capacity of children living in "Brisas del Rosario". Academic skills and general point average index (GPA) in children (1st to 6th grade) living in "Brisas del Rosario" were lower than children living outside this community that attended the same school (23). The multiple linear regression model calculated in this study explained 32.8% of the variation in children's blood lead levels. Other important predictors of blood lead concentrations, such as lead in soil, water and paint need to be incorporated in future investigations.

This study had some limitations that should be acknowledged. First, children were not randomly selected. Therefore, results obtained in this study may not be representative of all children living in "Brisas del Rosario". In addition, of the 41 children, only 30, representing 20 houses, were from the former VBSWDS of "Brisas del Rosario". The rest of the children were from areas of the community outside the contaminated site. Second, selection bias might have arisen if parents of children having six years of age or less with high blood lead levels refused to participate. Third, the number of houses and children was small probably resulting in a low study power, thus reducing the probability of finding significant associations. Fourth, a single sampling of blood possibly missed the blood lead concentration peak. Since lead in blood has a half-life of approximately 30 days, measurements of blood lead is a marker of recent exposure returning to normal levels even when exposure is excessive (24).

We conclude that, although blood lead levels of children living in "Brisas del Rosario" community did not exceed the CDC standard, our results suggest that blood lead levels increase with exposure to dust in the window sill of the child bedroom, and with soil eating and toy chewing habits. Since 17% of the houses had at least one sample with lead in dust higher than the USEPA standard for floors, there is a risk of exposure to high lead concentrations in dust for the participating children. Therefore, analytical epidemiological studies should be conducted to assess the long-term effects of constant exposure to environmental lead in children living in the former VBSWDS of "Brisas del Rosario". Since there is no "safe level" of blood lead below which children are not affected (25), continuing monitoring of children living in "Brisas del Rosario" is warranted in order to implement effective preventive strategies.

Resumen

La salud de los niños que viven en un antiguo vertedero localizado en Vega Baja, Puerto Rico es de gran preocupación por la exposición a plomo. Este vertedero ha sido incluido en el Programa de Superfondo de la Agencia Federal de Protección Ambiental de los Estados Unidos (USEPA) por ser un lugar altamente contaminado. El contacto directo con suelo contaminado con plomo es considerado una ruta importante de exposición. Sin embargo, la contribución del plomo asociado al polvo

acumulado en los hogares a los niveles de plomo en la sangre de los niños de esta comunidad no ha sido estudiada. Por lo tanto, se tomaron muestras de sangre de 42 niños con 6 años de edad o menos y muestras de polvo en 29 hogares. También se llenó un cuestionario para identificar factores de riesgo que pudieran aumentar los niveles de plomo en la sangre. Los valores de plomo en sangre variaron de 0.97 a 7.79 µg/dL. Los niveles de plomo en el polvo del piso fluctuaron entre 0.12 y 98.30 µg/pie^2, donde 17% de las casas sobrepasaron el estándar establecido por USEPA de 40 µg/pie^2 para polvo en el piso. El análisis de regresión múltiple demostró que el plomo acumulado en el borde de las ventanas, al igual que los hábitos de masticar juguetes y comer suelo, contribuyen significativamente a los niveles de plomo en la sangre. Se recomienda que se realicen estudios que evalúen los efectos crónicos de la exposición a plomo en los niños de esta comunidad.

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