Risk Factors for Lead Poisoning Among Cuban Refugee Children

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SYNOPSIS

Objectives. This study was designed to explore whether parental activities such as repairing cars, welding, and rebuilding car batteries are risk factors for lead poisoning among Cuban refugee children in Miami-Dade County.

Methods. The authors performed a cross-sectional study of 479 children aged 12–83 months who had lived in Cuba during the six months prior to immigrating to the U.S. Lead levels were obtained, and parents provided information on demographics, home/neighborhood environment in Cuba prior to immigration, family/occupational factors prior to immigration, and child behavior factors.

Results. Of 479 children, 30 (6.3%) had *elevated blood lead levels* (EBLLs), defined as ≥10 μg/dL, based on the Centers for Disease Control and Prevention action level. In multivariate analysis, racial/ethnic identification other than white, living in a home built after 1979, car repair in the home or yard, eating paint chips, and male sex were independently associated with EBLL.

Conclusions. Risk factors for lead poisoning among immigrant children may differ from those among U.S.-born children. Screening of immigrant children who may have been exposed in their country of origin and education of immigrant parents about lead exposure hazards associated with activities such as car repair should be considered in the design of lead poisoning prevention and control programs.

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Immigrant children, particularly those from developing countries, may be at higher risk of lead poisoning than children born in the United States.[1–3] Therefore, the American Academy of Pediatrics recommends screening children who have emigrated or been adopted from countries where lead poisoning is prevalent.[4] About one-third of the children case-managed by the Miami-Dade County Health Department (MDCHD) Childhood Lead Poisoning Prevention Program (CLPPP) are immigrants. Immigrants to Miami-Dade County principally come from Latin American and Caribbean countries. Sources of lead exposure for children in Latin American and Caribbean countries can include leaded gasoline, paint, leaded-glazed ceramics, ethnic remedies, industries such as battery recycling, and cottage industries such as battery repair and the production of pottery or ceramics.[5–13]

In Miami-Dade County, many immigrant children diagnosed with lead poisoning have been identified through screening by the MDCHD Refugee Health Assessment Center (RHAC). The RHAC is a federally funded program administered by the Florida Department of Health that provides comprehensive health evaluations at no charge to immigrants eligible for assistance and services through the U.S. Office of Refugee Resettlement, usually within days of arrival in the United States.

In 2001–2002, more than 90% of the people evaluated at the RHAC were Cuban "refugees," "asylees" or "parolees." *Refugees* are people who have left their country because of persecution or fear of persecution; *asylees* are refugees who have applied for and received asylum since their arrival in the U.S., and Cuban/Haitian *parolees* are Cubans or Haitians allowed "to enter the United States under emergency conditions or when that alien's entry is considered to be in the public interest."[14] Given that asylees are a subset of refugees and that parolees are eligible for refugee services through the Office of Refugee Resettlement, we use the term "refugee" in the remainder of this report to encompass all three categories.[15]

Since October 1999, children ranging in age from 6 months to 6 years have been routinely screened for lead poisoning at the RHAC. Screening for lead poisoning at the RHAC is monitored every three months by CLPPP staff to maintain an annual screening rate of at least 95% of the children aged 6 months to 6 years served by the RHAC.

From October 1999 through September 2001, prior to the present study, the prevalence of blood lead levels ≥10 μg/dL among children aged 12–83 months seen at the RHAC was 12.0% (95% confidence interval [CI] 10.6, 13.4), 5.5 times the estimated prevalence rate of 2.2% (95% CI 1.0, 4.3) among 1- to 5-year-old children in the United States in 1999–2000.[16] Newly arrived refugee and other immigrant children can benefit from blood lead screening if further exposure is prevented by ensuring that their new homes are lead-safe and that their families are not continuing any practices that may expose their children to lead.

Results of interviews conducted with immigrant parents from 1999 through 2001 by CLPPP staff indicate that in the country of origin there are often multiple potential sources of lead exposure, such as peeling paint or parents' occupational exposure to lead. It is not known how common exposure to these potential hazards is among children without lead poisoning, so it is not possible to compare potential exposure sources between affected and unaffected children. Risk factors that were noted frequently during interviews included repairing cars, welding, and rebuilding car batteries in the home or yard. These activities may continue in this country if parents are not educated about the associated lead exposure hazards. For example, children from two separate families in rural North Carolina developed lead poisoning in 1981 due to recycling and burning of automobile batteries in their homes.[17]

The objective of the present study was to explore risk factors associated with lead poisoning among Cuban refugee children arriving in Miami, Florida. We hypothesized that parental activities related to car repairs, welding, and rebuilding car batteries were the most important risk factors for lead poisoning among these children.

METHODS

Study population and data collection

We performed a cross-sectional study of children aged 12–83 months screened at the RHAC from November 26, 2001, through July 26, 2002. The first 560 age-eligible children whose parents consented to study participation were enrolled. After the parent provided consent, a phlebotomist drew venous blood for the lead screen, as well as other routine tests. The specimens were tested at the Florida Department of Health Bureau of Laboratories. While waiting for all family members to have full medical exams, a parent completed a self-administered questionnaire. A nurse practitioner was available to answer any questions.

The Spanish-language self-administered questionnaire included items on sociodemographic characteristics, home and neighborhood environment in the child's country of origin, family and occupational exposure prior to immigration, and the child's behavior. These items included all potential lead risk factors that had been identified during the in-depth interviews of families of all refugee children with lead poisoning during the three years prior to the survey. Race/ethnicity was included as a demographic variable because of the concern in the U.S. about racial/ethnic disparities in lead poisoning. The racial/ethnic categories on the questionnaire were black, white, and "other" (with space provided for respondents to specify a category).

Two additional inquiries on the questionnaire require elaboration: house paint and housing age. Use of homemade paint, *cal* or *lechada*, is prevalent in Cuba. According to information from recent Cuban immigrants, this paint contains lime, glue, and water; lead is not believed to be one of the ingredients. We inquired whether the home in which the child lived prior to immigration was painted in part or in whole with this homemade product or commercial paint to determine if either source was a risk factor. The lead content of commercial paints sold in Cuba is unknown. Housing age was categorized into four groups in the questionnaire to reflect different political and economic periods in Cuba's recent history: (*1*) before 1950 (the period with the highest concentrations of lead in U.S. paint, which may have been imported into Cuba); (*2*) 1950–1959; (*3*) 1960–1979 (reflecting the beginning of Fidel Castro's government in 1959 and the imposition of the U.S. embargo in 1960, which likely changed available building materials); and (*4*) after 1979 (a period of worsening economic conditions).

Data analysis

For the purpose of analysis, response categories "no" and "unknown" were grouped together for comparison with "yes" responses, as were response categories "often," "sometimes," and "rarely" for comparison with "never" responses, in order to avoid empty cells. *Lead poisoning*, or an elevated blood lead level (EBLL), was defined as ≥10 μg/dL of whole blood from a venous specimen. Although there is evidence of adverse effects of lead at levels <10 μg/dL, EBLL was defined as ≥10 μg/dL since it is the definition used for surveillance in the state of Florida and because 10 μg/dL is the Centers for Disease Control and Prevention's (CDC) action level.[18–21] Children with an EBLL were case-managed per the CLPPP's protocol.

Data from the surveys were manually entered into a Microsoft Access database.[22] To examine associations between risk factors and lead poisoning, we conducted bivariate and multivariate analyses using SAS 8.02.[23] Any variable associated with EBLL in the bivariate analysis at a $p \leq 0.2$ was included in the multivariate analysis. In multiple logistic regression analyses, a stepwise selection method was used to exclude or include factors in a sequential fashion, with $p<0.05$ the criterion for inclusion. Institutional review board approval was obtained from the Florida Department of Health Review Council for Human Subjects.

RESULTS

Enrollment

Of the 685 children examined at the RHAC from November 26, 2001, through July 26, 2002, 560 (81.8%) were enrolled. The principal reason for children not being enrolled was their arrival at the RHAC on evenings, weekends, or holidays when staff members were not available to administer the questionnaire. No parents refused. Statistically significant differences by case status (with EBLL vs. without EBLL), sex, or race/ethnicity were not found between those enrolled and not enrolled in the study ($p>0.05$).

Of the 560 enrolled children, 14 (2.5%) did not meet the age criterion (aged 12–83 months). Of those age-eligible, 502 children were born and lived in Cuba during the six months prior to immigration, according to parental report. Of these, 23 (4.6%) had a missing lead test result. Because the majority of enrolled children and all children with EBLLs were of Cuban origin, we restricted our analysis to the 479 age-eligible refugee children with lead test results who had lived in Cuba during the six months prior to immigrating to the U.S. Of these, 30 (6.3%; 95% CI 4.1, 8.5) had EBLLs. The prevalence of EBLLs was higher among those screened during the dry season (November to April) than among those screened during the rainy season (May to October), but the difference did not reach statistical significance (7.1% vs. 5.0%; $p=0.44$). The median time from entry to the United States to enrollment in the study was 20 days (interquartile range 15), and all but two children (neither with EBLL) were tested within three months of their arrival in the United States.

Risk factors for lead poisoning

The majority of children in our sample were boys (52.5%), most were in the 2–6 year age range (83.7%), and most were categorized as white (92.0%). The following factors were associated with EBLL in bivariate analysis: male sex, racial/ethnic category other than white, living in a home built after 1979, outdoor play areas not covered with cement, car batteries used in home or yard, contact with fishing weights, contact with an adult whose job involved car repair, eating paint chips, and eating dirt ($p \leq 0.05$) (Table 1). Parental education, contact with an adult whose job was welding, welding or car repair in the home or yard, and batteries rebuilt at a friend's house were not associated with EBLLs ($p>0.05$) but were entered in the multivariate analysis because the p-values were ≤0.2.

Although seven children with EBLLs reportedly lived near industrial pollution sites in Cuba, upon review of the reported source of pollution, we found that only two of these children had lived near sites with potential lead hazards. Municipality of residence, visiting a friend's house where cars were repaired, number of hours of child's outdoor play per day in Cuba, and number of years living in the most recent home in Cuba were also not significantly associated with EBLLs ($p>0.25$) (not shown).

We also inquired about children's contact with adults whose jobs involved rebuilding batteries, construction, making lead weights, burning lead-painted wood, making stained glass or pottery, mining, making bullets, refinishing furniture, or repairing electronic equipment, but these kinds of occupational exposures were not reported for any of the children with EBLLs. Repair of electronic equipment at the child's, relatives', or friends' homes and rebuilding batteries in the home or yard were reported for few children and none of the children with lead poisoning. Contact with fishing weights, which was associated with EBLLs ($p<0.05$), was excluded from the stepwise regression model because of unrealistically high point estimates and standard errors (SEs), suggesting that this was an artifact due to the small number of children in our sample exposed to this potential risk factor. This exclusion did not cause a considerable change in the estimated coefficients and the adjusted odds ratios (ORs) for the remaining variables in the final model. Increasing the default significance level to $p<0.1$ and the level required for remaining in the model to $p<0.15$ did not change the variable selection. Stepwise selection did not result in inclusion of any of the two-way interaction effects for variables remaining in the final model. Hosmer and Lemeshow partition test indicated a good fit of the model to the data ($\mu^2=3.6058$; $df=5$; $p=0.61$).[24] Being identified as black or multiracial, being male, living in housing in Cuba built after 1979, living in homes where car repairs were performed, and having been observed eating paint chips were independently associated with EBLLs in the multivariate analysis (Table 2).

DISCUSSION

Prevalence of lead poisoning

We found that the prevalence of lead poisoning among children screened at the RHAC was lower (6.4%) than that found during previous years (12%) but still almost three times the estimated prevalence of 2.2% for 1- to 5-year olds in the United States.[16] One possible explanation for the lower prevalence of lead poisoning than in previous years may be the changing socioeconomic level of Cuban refugees

Table 1. Demographic characteristics and risk factors for lead poisoning among Cuban refugee children with and without elevated blood lead levels (EBLLs), November 26, 2001–July 26, 2002, Miami, Florida (*N*=479 children)

		Blood lead ≥10 μg/dL (n=30)		Blood lead <10 μg/dL (n=449)		
Variable	n	*Number*	*Percent*	*Number*	*Percent*	*p-value*
Sociodemographic characteristics						
Sex						<0.001[a]
Male	251	25	10.0	226	90.0	
Female	227	5	2.2	222	97.8	
Age group						0.80[a]
12–23 months	78	4	5.1	74	94.9	
24–83 months	401	26	6.5	375	93.5	
Racial/ethnic category						0.02[a]
Black or multiracial	37	6	16.2	31	83.8	
White	428	24	5.6	404	94.4	
Mother's education						0.17[a]
≤9 years	69	7	10.1	62	89.9	
>9 years	393	22	5.6	371	94.4	
Father's education						0.19[a]
≤9 years	78	7	9.0	71	91.0	
>9 years	370	19	5.1	351	94.9	
Province of residence 6 months prior to immigration						0.70[a]
City of Havana	202	11	5.5	191	94.5	
Other	272	18	6.6	254	93.4	
Residential area						0.57[a]
Urban	63	5	7.9	58	92.1	
Rural	391	23	5.9	368	94.1	
Home/neighborhood environment factors in Cuba						
Home						0.25
House	376	21	5.6	355	94.4	
Apartment	102	9	8.8	93	91.2	
Length of residence						0.71[a]
1 year	33	1	3.0	32	97.0	
>1 year	441	27	6.1	414	93.9	
Year home built						0.03
Before 1950	83	2	2.4	81	97.6	
1950–1959	80	2	2.5	78	97.5	
1960–1979	100	5	5.0	95	95.0	
After 1979	198	20	10.1	178	89.9	
Chipping paint in home						0.53[a]
Yes	155	7	4.5	148	95.5	
No	308	19	6.2	289	93.8	
House paint						0.54[a]
Home-made paint (*lechada)*	268	18	6.7	250	93.3	
Commercial paint	176	9	5.1	167	94.9	
Outdoor play area cover						0.04[a]
Cement	263	11	4.2	252	95.8	
Other (e.g., grass, dirt)	213	19	8.9	194	91.1	
Construction work or paint removal last six months in home						0.42[a]
Yes	175	12	6.9	163	93.1	
No/unknown	295	15	5.1	280	94.9	
Industrial pollution within 1 km of home						0.45[a]
Yes	85	7	8.2	78	91.8	
No/unknown	384	22	5.7	362	94.3	
Major road within one block of home						0.70[a]
Yes	183	13	7.1	170	92.9	
No/unknown	286	17	5.9	269	94.1	

continued on page 183

Table 1 (continued). Demographic characteristics and risk factors for lead poisoning among Cuban refugee children with and without elevated blood lead levels (EBLLs), November 26, 2001–July 26, 2002, Miami, Florida (*N*=479 children)

		Blood lead ≥10 μg/dL (n=30)		*Blood lead <10 μg/dL (n=449)*		
Variable	*n*	*Number*	*Percent*	*Number*	*Percent*	*p-value*
Family/occupational factors in Cuba						
Car batteries used in home/yard						<0.01[a]
Yes	62	10	16.1	52	83.9	
No	414	20	4.8	394	95.2	
Welding done in home/yard						0.20[a]
Yes	50	5	10.0	45	90.0	
No	423	23	5.4	400	94.6	
Cars repaired in home/yard						0.07[a]
Yes	40	5	12.5	35	87.5	
No	418	22	5.3	396	94.7	
Batteries rebuilt at a friend's house						0.15[a]
Yes	33	4	12.1	29	87.9	
No	438	26	5.9	412	94.1	
Contact with fishing weights						<0.01[a]
Often/sometimes/rarely	6	3	50.0	3	50.0	
Never	462	27	5.8	435	94.2	
Contact with adult whose job involved welding						0.11[a]
Yes	49	6	12.2	43	87.8	
No	430	24	5.6	406	94.4	
Contact with adult whose job involved repairing cars						0.05[a]
Yes	46	6	13.0	40	87.0	
No	433	24	5.5	409	94.5	
Child behavior factors in Cuba						
Child seen eating paint chips						0.03[a]
Often/sometimes/rarely	51	7	13.7	44	86.3	
Never	419	23	5.5	396	94.5	
Child seen eating dirt						0.05[a]
Often/sometimes/rarely	125	13	10.4	112	89.6	
Never	346	17	4.9	329	95.1	
Child played with homemade metal toys						0.34[a]
Yes	19	2	10.5	17	89.5	
No	453	28	6.2	425	93.8	
Child played with BB guns						0.25[a]
Often/sometimes/rarely	15	2	13.3	13	86.7	
Never	454	28	6.12	426	93.8	
Child attended day care/spent time away from home workdays						0.69[a]
Yes	161	8	5.0	153	95.0	
No	312	20	6.4	292	93.6	

NOTE: Due to missing values, the *n* for some variables is less than 479.

[a]Fisher's exact test

arriving in the area. Some evidence exists for this. The proportion of refugees arriving in South Florida by raft or boat has declined due to tighter border patrols since September 11, 2001, while the relative proportion of those arriving by plane has increased (Personal communication, Onelia Fajardo, MPH, DrBA, Miami-Dade County Health Department, Refugee Health Assessment Center, July 2003); those traveling by plane may be of higher socioeconomic level than those traveling by boat or raft. Alternatively, some secular trend toward lower lead exposure in Cuba may exist, but we have no information regarding this.

Risk factors for lead poisoning

Our analysis confirmed our hypothesis that car repair in the home or yard was associated with lead poisoning. Contact with an adult whose job involved repairing cars was associated with lead poisoning in the bivariate but not multivariate analysis. This was due to the considerable overlap between

Table 2. Logistic regression model of lead poisoning among Cuban refugee children by potential risk factors, November 26, 2001–July 26, 2002, Miami, Florida (n=421 children)

Factor	*Odds ratio*	*95% Wald confidence interval*
Black or multiracial[a]	7.63	2.39, 24.37
Home built after 1979[b]	4.75	1.76, 12.81
Car repair done in yard[c]	3.17	1.02, 9.84
Child often, sometimes, or rarely seen eating paint chips[d]	3.21	1.12, 9.20
Male[e]	4.51	1.59, 12.77

NOTE: Due to missing values, n=421 for this table.

[a]Referent category: white

[b]Referent category: home built in 1979 or before

[c]Referent category: no car repair in yard

[d]Referent category: child never seen eating paint chips

[e]Referent category: female

factors: car repair in the home or yard and adults with car repair jobs. Car repair, particularly radiator repair, is a known source of lead exposure among mechanics.[25–30] Adults with occupational lead exposure can bring home lead-contaminated dust on their skin, hair, shoes, and clothing.[30–33] The fact that the car repair activities reportedly occurred in the home or yard suggests that there may have been soil contamination in the yard, as well as house dust contamination, and that children may have had direct contact with car radiators or batteries. An investigation of homes with battery repair shops in Jamaica found high levels of lead in soil and house dust, as well as lead poisoning among household members of all ages.[11] This risk factor has important implications for prevention efforts. Immigrant parents who have worked on cars or with car batteries in the past may use this skill at their new workplaces or in their new homes. Therefore, they need to be educated about the dangers of bringing home lead-contaminated dust on clothing or shoes and of repairing cars or manipulating batteries in their yards.

Surprisingly, newer—not older—housing in Cuba was associated with lead poisoning. The majority of these reported newer homes were single-family houses. To better understand this, we attempted to re-contact the parents of all children with EBLLs. We were able to contact five families. In one case, a new home was an addition to an older structure and not a completely new building. Thus, in this case, some exposure to older building materials containing lead may have occurred during construction. None of the parents of these five children were aware of any materials made of lead in their newer homes.

Additional analyses also did not help explain the association between newer housing and lead poisoning. No association was found between age of housing and proximity to major roads or between age of housing and type of paint. Also, no association was found between age of housing and contact with an adult whose activities potentially involved exposure to lead (e.g., car repair, work with car batteries, work with pottery or stained glass, welding, repair of electronic equipment, construction, making lead weights, burning lead-painted wood, mining, making bullets, or refinishing furniture). Car repairs or use of car batteries in the home or yard were not associated with housing age either. The unexpected association between newer housing and lead poisoning should be further investigated.

Another factor associated with EBLL was the child reportedly eating paint chips. It is not known, however, if the paint chips contained lead. Cuba restricted the use of lead in indoor paint in 1934.[34] However, we were unable to locate information about the source of paint and policy regarding lead in paint used during the past 45 years. Neither chipping paint in the home nor the type of paint (store-bought or homemade) was associated with EBLL. The association between EBLL and a child reportedly eating paint chips may reflect pica behavior, which may include consumption of other lead-contaminated material such as soil. In the bivariate but not multivariate analysis, eating dirt was associated with EBLL.

Male sex was associated with EBLL, which may be due to behavioral differences between boys and girls. In the Second and Third National Health and Nutrition Examination Surveys (NHNES), the prevalence of EBLL (defined as blood lead ≥ 30 μg/dL in the Second survey and ≥ 10 μg/dL in the Third) was higher among boys than girls, but the differences were not statistically significant.[35,36]

Parental identification of the child as black or multiracial was also associated with EBLL. Reportedly, residential segregation by race/ethnicity does not exist in Cuba, so residential environmental exposure should not differ by race/ethnicity. However, there may be socioeconomic, nutritional, or cultural differences by race/ethnicity in Cuba that we were unable to measure. Alternatively, the result may be an artifact due to the small number of black/multiracial children with EBLLs.

Limitations

This study has several limitations. First, the results may not be generalizable to immigrants from other countries. Sources of lead exposure can differ between countries.[37] However, parental activities, including cottage industries, have been associated with childhood lead poisoning in other Caribbean countries, so such risk factors should be considered for immigrants from all Caribbean countries.[11,12] Second, the study relied solely on reporting by parents who had little knowledge about lead poisoning and may not have been able to identify lead hazards in their community or home. Environmental investigations of the homes in Cuba where the children were presumably exposed were not possible.

Conclusions

As we move toward the goal of elimination of lead poisoning in the United States, it is important that we screen not only children exposed in the U.S., but also immigrant children who may have been exposed in their country of origin. Immigrant children are likely to locate in poorer inner-city neighborhoods in the U.S. and be exposed to new or additional lead hazards. In interviewing immigrant parents of children with lead poisoning, CLPPP staff members found that many immigrant parents have less understanding about potential sources of lead and the hazards that lead exposure presents for their children than U.S.-born parents. Thus, immigrant parents should be included in lead poisoning prevention education efforts. It is important that parents be educated about the dangers of bringing home lead-contaminated dust on clothing or shoes from the workplace, as well as the importance of not continuing activities such as car repair and car battery manipulation in the home or yard that may put their children at risk.

Finally, our results add to the evidence that lead exposure sources can differ between countries and that, as in the United States, exposure to lead disproportionately affects certain geographic areas and population groups.[37,38] Therefore, epidemiologic investigations are needed in countries where the lead poisoning problem is currently not well described so that prevention and control measures can be appropriately tailored to the country's problem.

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