Bull Environ Contam Toxicol
DOI 10.1007/s00128-011-0346-4

Lead Poisoning Among Arab American and African American Children in the Detroit Metropolitan Area, Michigan

Jerome Nriagu · Raghavendra Senthamarai-Kannan · Hikmet Jamil · Monty Fakhori · Summer Korponic

Received: 25 November 2010 / Accepted: 20 June 2011

Abstract This study explored the hypothesis that acculturation is a risk factor for childhood lead poisoning in the Detroit area of Michigan. Blood lead levels (BLLs) were determined in 429 Arab American and African American children, aged 6 months to 15 years, who were receiving well-child examination in three Women, Infant, and Children (WIC) clinics in the city. Mean BLL was 3.8 ± 2.3 μg/dL (range: 1–18 μg/dL) and 3.3% of the children tested had blood lead values above the 10 μg/dL level of concern. Neither the age of the dwelling units nor ethnicity of the child was significantly associated with the BLL. Multivariable analyses instead identified a number of acculturation-related factors that are associated with elevation in blood lead including paternal education, language spoken at home (English only, English and Arabic, or Arabic only), home ownership, smoking in the home, and exposure of child to home health remedies. The difference in blood lead between Arab American children from families where Arabic only versus Arabic and English is spoken at home was found to be statistically significant. This study provides information showing that immigrant children are at heightened risk of being poisoned by lead which can be useful in identifying groups at risk of atypical exposures.

Keywords Lead poisoning · Ethnic minority · Low income children · Arab American children · African American children

J. Nriagu (✉)
Department of Environmental Health Sciences, School of Public Health University of Michigan, Ann Arbor, MI 48109, USA
e-mail: jnriagu@umich.edu

R. Senthamarai-Kannan
Department of Epidemiology, School of Public Health University of Michigan, Ann Arbor, MI 48109, USA

R. Senthamarai-Kannan
Center for Research on Ethnicity, Culture and Health, School of Public Health University of Michigan, Ann Arbor, MI 48109, USA

H. Jamil · M. Fakhori · S. Korponic
Arab Chaldean Council, Southfield, Lathrup Village, MI 48076, USA

H. Jamil
Division of Occupational and Environmental Health, Department of Family Medicine and Public Health Sciences, Wayne State University School of Medicine, Detroit, MI, USA

In response to several lead poisoning prevention and control measures, the number of preschool children in the United States with elevated blood lead levels (>10 μg/dL) has decreased significantly during the last decade, from 7.6% of children under 6 years of age in 1997 to 1% in 2007 (CDC 2011). Because of the unequal distribution of predisposing factors, however, the risk for childhood lead poisoning remains high in some communities, especially where low income families or pregnant women live in old housing with lead paint (CDC 1997; Carlisle et al. 2009), or where immigrant and refugee families from developing countries have settled (Rastogi et al. 2007; Vaidynathan et al. 2009). In consequence, the CDC (1997) has recommended targeted screening plans aimed at high risk groups as an important strategy in national programs on childhood lead poisoning. The Detroit metropolitan area is at the cross-roads in terms of its communities at high risk of childhood lead poisoning (Nriagu et al. 2006). The US

Published online: 02 July 2011

American Housing Survey (2000a, b) showed that more than 80% of housing units in many neighborhoods in Metro Detroit were built before 1950. The city has the highest prevalence of elevated blood lead levels in the State of Michigan (DDHWP 2005). In 2004, nearly 6% of 32,973 children (aged 6 years or younger) tested for lead in Detroit had elevated blood levels (DDHWP 2005). According to the recent US Census Bureau figures, Detroit is now the poorest city in the nation, with about 30% unemployment rates. Nearly 40% of its residents and over one-half of the city's children live below the official federal poverty level of $19,157 (in terms of household income for a family of four). In addition, the Detroit area contains over 500,000 Arabs and Chaldeans, representing one of the largest concentrations of Arabs living outside the Middle East (second only to Paris). The local Arab American population has been increasing through primary and secondary immigration by approximately 5,000 to 6,000 individuals per year, in addition to an estimated 17,000 new refugees that have arrived in this area since August 2008 (ACCESS 2011), and this trend is a continuing phenomenon. A recent survey found that over 80% of the Arab American households, a major minority group in Metro Detroit live on a household annual income of less than $20,000.00 and that the adult unemployment rate is about 50% (ACCESS 2011). As a result of unemployment and immigration status, a majority of the Arab American families in the Detroit area lack quality health services, are less likely to receive routine medical procedures and have high rates of morbidity and mortality (Johnson et al. 2008). Wayne County, where Detroit is located, was recently ranked as the least healthy Michigan county based on health factors such as access to care, quality of clinical care, socio-economic, and physical environmental factors (County Health Factors Ranking 2010). By most indicators, communities in Metro Detroit should be fertile grounds for pervasive childhood lead poisoning (Nriagu et al. 2006). With the exception of one study on children in a Yemini neighborhood in Detroit (Taylor and Holtrop 2007), there have been few published reports to assess the prevalence of childhood lead poisoning among Arab-American children relative to the rates for other low-income and minority children in the Metro Detroit area.

The goals of this pilot study are to: (1) determine the prevalence of elevated blood lead levels in children aged 6 months to 15 years who were receiving a well-child examination in three Women, Infant, and Children (WIC) Clinics of Metro Detroit area; (2) compare the blood lead levels among African-American children, Arab American children of immigrant (Arabic spoken only at home) and American born (both English and Arabic spoken at home) families; and (3) assess the effects of acculturation factors on blood lead levels in the study population.

Materials and Methods

The population for this cross-sectional study consisted of a convenience sample of 429 children who attended three WIC clinics in the Detroit metropolitan area from August 2006 to September 2007. Children enrolled into the study received the blood lead screening as part of their routine well-child visit. Exclusion criteria included children scheduled for a follow-up test or treatment for existing elevated blood lead levels, hematological disorders, neurological or behavioral problems from other causes, and refusals.

A staff nurse approached parents or guardians in the waiting area of a clinic. After informing them about the study, those parents who wished to participate were asked to complete a consent form and a detailed questionnaire. An Arabic-speaking translator was available to assist those who required translation of the questionnaire from English to Arabic and/or to answer questions. Blood samples were collected using a standardized technique (capillary blood lead finger-stick test) and were analyzed for lead by inductively coupled plasma-mass spectrometry (ICP-MS) at Michigan Department of Community Health Laboratory, Lansing Michigan (MDCH 2010).

The survey instrument comprised five major domains: (1) socio-demographic characteristics (age, gender, ethnicity, primary spoken language, parental education, smoking, and family income relative to the federal poverty line threshold of $23,400); (2) children's environmental lead exposure (housing characteristics such as age of the house, home ownership, housing condition, plumbing, prior testing of home for lead, location of home close to a factory, home improvement activities (paint scraping or remodeling), and parental smoking habits); (3) children's behavioral risk factors (hand-to-mouth activity, sucking thumb and fingers, playing on pavements or with furry toys); (4) parental occupational and/or vocational exposure risk factors; and (5) cultural practices (use of traditional ethnic cosmetics or remedies).

The questionnaire requested parents or guardians to self-declare their level of English proficiency (writing, reading, speaking), educational level, ethnicity, socioeconomic status, and demographic characteristics. Responses for race/ethnicity were self-reported as being African American, Arab American, Chaldean, non-Hispanic white, Hispanic, or other. Throughout the text, the term "Whites" was used to designate non-Hispanic Whites, "African American or blacks" for non-Hispanic blacks, and "others" referred to children of Asian/Pacific Islanders, Hispanics of all non-Mexican–American origin and non-Hispanics from racial groups other than white or black. Based on the 2006 federal poverty guidelines for a five-member family, the data on socioeconomic status

contained information on annual income of the family, the number of children under fifteen, and the number of adults in the household supported by this income. Because of the ethnically diverse study sample, an effort was made to ascertain any possible influence of culturally relevant practices that might have increased exposure to lead. The questions on ethnic-specific concerns pertained to potential risks associated with the use of cosmetics such as application of kohl/Surma/Saoott to the eye; and the use of Azarcon, Alarcon, Greta, Rueda, Coral, Kandu, Ghasard, Lozeena, Pay-loo-ha, Cebagin and Bint al dahab as a home remedy for intestinal illness (e.g., constipation, diarrhea, colic).

Data obtained from completed survey questionnaires were entered separately by two data entry staff into Microsoft Access database. Entries were compared to ensure accuracy and then verified and cleaned for any discrepancies. Data were analyzed using SAS (version 9.1.3) and SPSS (version 15.0) software for Windows. All hypothesis tests used a two-sided significance level of <0.05. Chi-square tests were used to examine categorical bivariable variables and for continuous variables, the mean, median, and standard deviations (SD) were computed. Blood lead level was the main outcome measure and was treated as continuous variable in this study. The blood lead levels of 10 μg/dL or higher were considered elevated or at risk for developing lead poisoning. Natural logarithmic (log) transformation was used to normalize data for statistical tests when an assumption of normal distribution was required.

For descriptive purposes, we obtained frequencies and counts for all variables. We combined "Arab Americans" and "Chaldeans" into a new variable ("Arab American"); similarly, "Hispanics" and "Others" into ("others") for analysis purposes. To alleviate the problem of item non-response for income questions, we dichotomized this variable into "above the poverty line" (with federal poverty thresholds [FPT] greater than or equal to $23,400) and "below the poverty line" (with FPT less than or equal to $23,400). Univariable analyses were performed to estimate independent associations between various explanatory variables and the health outcome (i.e., blood lead levels). With the exception of demographic variables [age and body mass index (BMI)], the rest of the variables were treated as either categorical or dichotomous. The general linear regression model was used to create a preliminary model. Each explanatory variable with a significance level of 0.10 was chosen for entry into the preliminary model, which was then subjected to a backward elimination and stepwise regression procedure for exclusion of variables with a cut-off p-value of 0.20 from the preliminary model. Confounding or correlations were tested when an excluded variable in the model changed the value of the estimate by 10% or more. Variables, selected using these methods, were included in the final multiple linear regression model.

Results and Discussion

Table 1 shows the relationships between blood lead and the socio-demographic, housing and risk behavioral characteristics of the study population (sample size, $n = 429$). Average age of the children was 3.4 years (range, 6 months through 15 years). Gender distribution was quite uniform among racial and ethnic groups in the sample with near equal inclusion of boys (216) and girls (213). There were more than twice as many African-American children (264) compared to Arab American (129) with small numbers of Caucasians (5.8%) and other unspecified groups (2.6%). The BLL increased from <2.0 μg/dL for children <1 year old to 4.7 μg/dL for children 2–3 years and then declined to 3.4 μg/dL for children older than 6 years (Fig. 1a). The untransformed distribution of blood lead levels was slightly skewed to the right (skewness = 0.19) (Fig. 1b). Average blood lead level for the entire study population was 3.8 ± 2.3 μg/dL (range: 1–18 μg/dL). Of the 14 (3.3% of) children who had elevated blood lead levels (>10 μg/dL), eight were African-American children, five were Arab-American children, and one was Caucasian child.

The association between blood lead level and gender, ethnicity, maternal education, family income or age of dwelling units was not statistically significant (Table 1). The fact that most (>80%) of the houses were built before 1978 would make it difficult to document the influence of house age on blood lead. Likewise, most of the families (87%) lived below the federal poverty income level and any slight differences in income levels would not be expected to affect the BLLs in a significant manner. Among other likely determinants of blood lead levels that were considered in this study, weak to strong correlations were found between blood lead levels and home ownership ($p = 0.09$), age ($p < 0.0001$), smoker in a household ($p = 0.01$), paternal education ($p = 0.06$), primary language spoken in household ($p = 0.01$), previous testing of home for lead ($p = 0.05$), removal of shoes before entering a home ($p = 0.01$), child playing on sidewalks or yard ($p = 0.05$), child playing with furry toys ($p = 0.02$), and exposure of child to traditional cosmetics and home health remedies ($p = 0.05$) (Table 1). With the exception of child's age, most of these covariates can be culturally mediated (Teppala et al. 2010).

The differing demographic and exposure characteristics between the African American (AfriA) and Arab American (ArabA) children are shown in Table 2. We have further subdivided the ArabA children into those from mono-lingual families (only Arabic spoken at home and presumed to be

Table 1 Association of blood lead with demographic, housing and child behavioral characteristics

Variables	n = 429	(%)	*p* value	Variables	n (n = 429)	(%)	*p* value
Age (months)			<.0001	Household income relative to federal poverty level (FPL)			0.25
6–12	1	0.2		<FPL	369	87.4	
13–24	103	23.7		>FPL	53	12.6	
25–36	73	17.1		Do parents smoke?			0.52
37–48	85	19.8		None	303	71.5	
49–60	93	21.7		Father only	67	15.8	
61–72	63	14.7		Mother only	39	9.2	
>72+	12	2.8		Both	15	3.54	
Gender			0.33	Does anyone in the household smoke?			0.01
Boys	216	50.5		No	253	59.4	
Girls	212	49.5		Yes	167	39.2	
Ethnicity			0.33	Cigarette consumption/day			0.53
African Americans	264	61.5		None	303	71.5	
Arab/Chaldean	129	30.1		1–10 cigs	50	11.8	
Caucasian	25	5.8		10–20 cigs	51	12	
Others	11	2.6		>20 cigs	20	4.7	
Primary language spoken at home			0.01	Does child suck its fingers?			0.15
Arabic only	87	20.3		Sometimes	100	23.4	
English only	286	67		Always	18	4.2	
Both	52	12		Never	310	72.4	
Other	3	0.7		Home ownership			0.09
Paternal education			0.06	Rented	322	75.6	
Less than or equal to HS	168	41.1		Owned	104	24.4	
Some post HS	182	44.5		Home undergone recent repair?			0.49
College graduate	59	14.4		Yes	58	14	
Maternal education			0.53	No	354	86	
Less than or equal to HS	141	33.2		Any water damage wall, roof, etc.?			0.61
Some post HS	221	51.7	Owned	Yes	28	6.9	
College graduate	64	15.1		No	379	93.1	
Do you have any pets at home?			0.58	Child plays with furry toys?			0.02
Yes	53	12.5		Sometimes	278	66	
No	372	87.5		Always	36	9	
Has a child in home been tested for lead?			0.05	Never	109	26	
Yes	76	20		Within last year, was child diagnosed with cold?			0.1
No	303	80		Yes	204	49.3	
Remove shoes before entering home?			0.01	No	210	50.7	
Yes	245	58		Does child use any home remedies?			0.06
No	180	42		Yes	25	6	
Does child play on sidewalks, yards?			0.05	No	396	94	
Yes	166	39.1		Was house built before 1978			0.55
No	258	60.9		Yes	354		
				No	75		

recent immigrant/refugee families; ArabA-Group 1) and those from bilingual families (both English and Arabic are spoken at home and the children are presumed to be born in the USA; ArabA-Group 2). Although there is no statistical difference in BLL between AfriA and ArabA children ($p = 0.14$), more AfriA children tend to have BLLs >3 μg/dL (76%) compared to ArabA children (67%). A different insight emerges when the African American children are

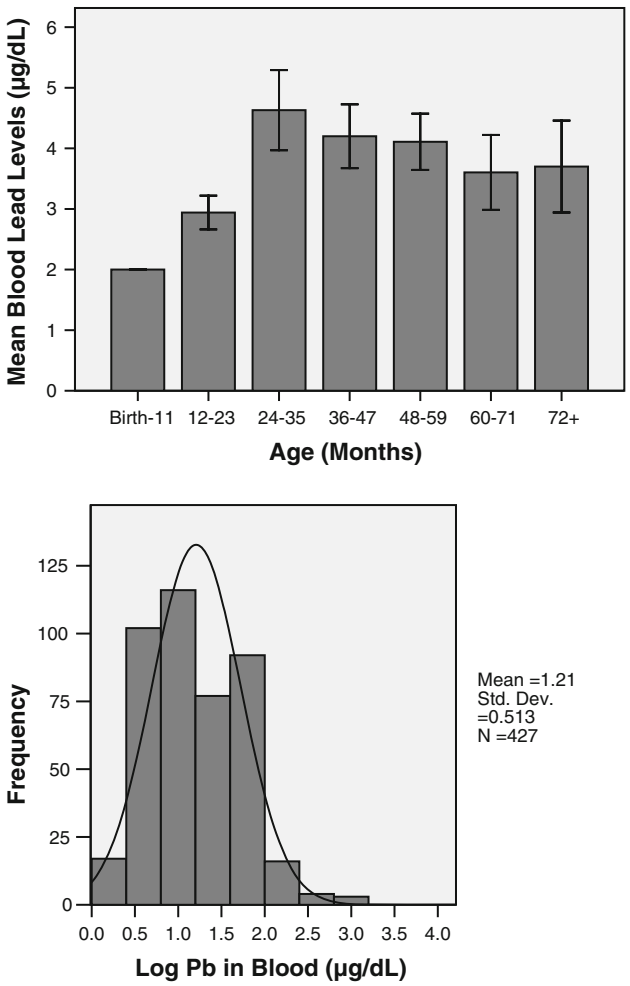

Fig. 1 Distribution of blood lead levels according to children's ages (*top*) and the frequency graph (*bottom*). Mean value shown in *bottom* figure is the log value

compared separately with each group of the Arab American children. The average BLL for African American children (3.96 µg/dL) is similar to the average for ArabA children of recent immigrant/refugee families (4.1 µg/dL) but significantly different from the mean value for Arab American children born in this country (2.8 µg/dL). Factors that may explain the higher BLLs among African American children compared to Arab American children born in the USA include differences in measures of acculturation such as socio-economic status (32% of Arab American fathers had college level education compared to 14% for African American fathers, and 48% of the Arab American parents owned their homes compared to only 18% for African American parents); smoking in the home (46% among African American families compared to 28% for Arab American families) (Teppala et al. 2010). These results suggest that acculturation tends to reduce the risks for lead poisoning among the Arab American children born in this country compared to the African American children. However, more Arab American children (14%) are exposed to home remedies (Table 2, columns 2, 3) compared to African American children (0.8%) and this may be an important route of lead exposure for many Arab American children involved in the study. In this connection, the difference in exposure of ArabA-Group 1 (18%) and ArabA-Group 2 (6.8%) children to home health remedies, a proxy for acculturation, should also be noted.

An important inference from Table 2 is that many demographic characteristics and exposure covariates are different between the two groups of Arab American children. These acculturation related factors include paternal education (66% of fathers of presumed immigrant/refugees children completed high school education compared to 28% for fathers of children born in the USA); home ownership (31% for ArabA-Group 1 parents compared to 48% for ArabA-Group 2 parents); playing with furry toys (56% for ArabA-Group 1 compared to 36% for ArabA-Group 2 children); and exposure of a child to home remedies (18% for ArabA-Group 1 compared to only 6% for ArabA-Group 2 children). In consequence, there is a statistically significant difference ($p = 0.01$) between the BLLs for the two groups of Arab American children (Table 2) with more children of immigrant/refugee families reporting BLLs >5 µg/dL (34%) compared to children presumed to be born in this country (10%).

The similarity in BLLs between African children (3.96 µg/dL) and the Arab American children of Group 1 (4.1 µg/dL) is interesting. Although there are slight differences in home ownership (18% for African American families versus 31% for ArabA-Group 1), the most important risk factor that was different was exposure of children to home remedies (0.8% for African American families versus 18% for ArabA-Group 1) (Table 2). These results suggest that either the children of immigrant/refugee families came to the US with elevated levels of lead in their bodies or that these families currently lack the acculturation features that seem to reduce the exposure risk for Arab American children presumed to be born in this country.

The proportion of children less than 6 years old with elevated BLLs (>10 µg/dL) has declined in Michigan from 5.5% in 2001 to 1.1% in 2008 and 0.8% in 2010 (MDCH 2010). Our study done in 2007/2008 found a rate (3.3%) that was considerably higher than the statewide average. The prevalence rate for our study is higher than the average (2.3%) for the city of Detroit in 2010 (MDCH 2010). The proportions of children in Michigan and Detroit with BLLs >5 µg/dL were 6.3% and 13%, respectively in 2010, and are lower than the value of >25% from this study. The higher prevalence rate that we have found is consistent with the fact that 87% of children that participated in this study were from families with household incomes of less

Table 2 Comparison of socio-demographic and risk characteristics of African American children with those of Arab American children

Variable	African American	Arab American		Speak Arabic only at home (immigrants/refugees)		Speak both Arabic and English at home (US Born)	
	n (%)	n (%)	*p* value	n (%)	*p* value	n (%)	*p* value
Blood lead levels			0.14		0.009		0.002
Lead level <3 μg/dL	63 (23.9)	43 (33.3)		22 (27.5)		20 (46.5)	
Lead level 3–5 μg/dL	124 (47.2)	54 (41.8)		31 (38.8)		21 (38.9)	
Lead level >5 μg/dL	76 (28.9)	32 (24.8)		27 (33.7)		3 (9.4)	
Gender			0.64		0.19		0.66
Male	134 (50.6)	62 (48.0)		42 (52.5)		20 (32.3)	
Female	131 (49.4)	67 (52.0)		38 (47.5)		24 (35.8)	
Paternal education			<.0001		0.0002		0.002
≤High school (HS)	75 (30.2)	67 (52.8)		53 (66.2)		13 (19.4)	
Some post HS	138 (55.6)	36 (28.3)		18 (22.5)		17 (47.2)	
College graduate	35 (14.2)	24 (18.9)		9 (11.2)		12 (50.0)	
Home ownership			<.0001		0.04		0.38
Rented	214 (81.7)	80 (62.0)		55 (68.7)		25 (31.3)	
Owned	48 (18.3)	49 (38.0)		25 (31.3)		19 (38.8)	
Anyone in the family smoke			0.0004		0.66		0.80
Yes	120 (46.5)	35 (27.6)		21 (26.2)		11 (31.4)	
No	138 (53.5)	92 (72.4)		59 (73.8)		31 (33.7)	
Any child in home tested for lead			<.0001		0.12		0.11
Yes	66 (29.1)	8 (6.7)		3 (3.8)		5 (62.5)	
No	161 (70.9)	112 (93.3)		75 (96.2)		33 (29.4)	
Child plays on sidewalk			0.20		0.87		0.77
Yes	97 (37.0)	56 (43.7)		35 (44.3)		20 (35.7)	
No	165 (63.0)	72 (56.3)		44 (55.7)		24 (33.3)	
Child plays on furry toys			<.0001		0.09		0.04
Never	34 (13.0)	62 (49.2)		44 (70.9)		15 (24.2)	
Sometimes	198 (75.6)	60 (47.6)		32 (53.3)		26 (43.3)	
Always	30 (11.4)	4 (3.2)		2 (50)		2 (50)	
Child used any home remedies			<.0001		0.13		0.09
Yes	2 (0.8)	18 (14.0)		14 (77.8)		3 (16.7)	
No	255 (99.2)	111 (86.0)		66 (59.5)		41 (36.9)	

than $20,000 – well below the federal poverty line threshold. A community outreach project to screen children in Detroit neighborhoods found that 6.2% of immigrant Yemeni children had blood lead levels above 10 μg/dL (Taylor and Holtrop 2007), consistent with our finding of high lead exposure risk among Arab American children. Our study population consisted of children of low income and immigrant families enrolled in WICK program. Although testing children in Medicaid is legally mandated, not all WIC children are enrolled in Medicaid (Binns et al. 2001; Vaidynathan et al. 2009). This study serves to draw attention to a need for testing all WICK children for blood lead.

The literature on lead poisoning among immigrant children living in the US is very limited. Previous studies of refugee and internationally adopted children have reported higher prevalence rates of BLLs among children born in Asian, African, Central American, and Caribbean countries compared to the general population of US children (Geltman et al. 2001; Tehranifar et al. 2008). Children migrating to Detroit from the Middle East countries can have elevated BLLs as a result of prior exposure to lead before they arrive in the US (Morales et al. 2005). Exposure to lead may persist in children after resettlement in Detroit from use of lead-containing glazes, medications, or jewelry brought or imported from home countries (Nriagu et al. 2006). As this study further shows, once the Arab American children arrive in Detroit, they are constrained to live in old and poorly maintained houses and hence become susceptible to lead-based paint hazards in their homes.

Malnutrition may also contribute to increased lead absorption among this vulnerable population (Mahaffey et al. 1986). Our findings are consistent with those of other published studies reporting that immigrant children are at heightened risk of being poisoned by lead acquired from their place of prior residence and/or resettled areas in the US.

An important observation from this study is the big disparity in the screening of low income African American households for blood lead (29%) compared to the Arab American households (6.7%); in fact, less than 4% of the ArabA-Group 1 households have ever had a child tested for blood lead (Table 2). The similarity in prevalence rates for BLLs among the African American and Arab American children in Detroit suggests a need for considering recent immigration as a risk factor for childhood lead poisoning and allocating resources for targeted screening and intervention measures in the immigrant communities of Arab Americans which seem be equally at great risk. The collateral need for increasing the awareness about childhood lead poisoning in the immigrant communities using culturally and linguistically appropriate metrics should also be highlighted.

This study has several limitations. The cross-sectional design employed limited our ability to assess causality. The self-report method used to capture the information on risk factors could have introduced response bias and led to misclassification of principal exposure routes. The study population was recruited using a convenience sample method and hence might not be representative of all children in the Metro Detroit area. Finally, our analysis was based implicitly on an additive model and did not address potential interactive effects.

Acknowledgments We thank Ms. Hana Tomah, Ms. Randa Hashwi, and Ms. Selvia Alnarraie for assisting with data collection. Funding support was provided by University of Michigan, School of Public Health's Center for Research, Ethnicity, Culture and Health fellowship training grant (to RSK).

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