Lead Poisoning Among Refugee Children Resettled in Massachusetts, 1995 to 1999

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ABSTRACT. *Objective.* **Lead poisoning has been reported among immigrant and refugee populations in the United States; however, prevalences of elevated blood lead (BPb) and risk factors have not been described fully among newly arrived refugee children. This study was conducted to address this lack of data.**

Methods. **We performed analysis of BPb levels among a cohort of refugee children, aged <7 years, who arrived in Massachusetts between July 1, 1995, and December 31, 1999. Gender, age, birthplace, time of year of lead testing, intestinal parasitoses, anemia, and growth retardation were examined as predictors of elevated BPb.**

Results. **BPb levels ≥10 μg/dL were found in 11.3% of 693 children shortly after their arrival in the United States. Children from developing countries had the highest prevalences, including 27% of Somalis and Vietnamese. Country of birth was the strongest predictor of elevated BPb. No association between elevated lead and age was found. Among 213 children with BPb tests ≥6 months after the initial test, 7% had newly elevated levels of ≥10 μg/dL.**

Conclusions. **The prevalence of elevated BPb levels in recently arrived refugee children is more than twice that of US-born children. Children who are at particular risk are those from developing countries where environmental exposures are more ubiquitous. In addition, a significant percentage of refugees acquired elevated levels after arrival, thus suggesting the importance of follow-up testing of refugee children. Refugee status should be considered a risk factor for lead poisoning.** ***Pediatrics* 2001;108:158–162;** ***refugees, immigration, lead, pediatrics.***

ABBREVIATIONS. BPb, blood lead; RHAP, Massachusetts Refugee Health Assessment Program; CDC, Centers for Disease Control and Prevention; HAZ, height-for-age Z score; WAZ, weight-for-age Z score; WHZ, weight-for-height Z score; NHANES III, Third National Health and Nutrition Examination Survey; CI, confidence interval; SD, standard deviation.

On April 21, 2000, a 2-year-old Sudanese refugee girl died from acute lead poisoning.[1] With a blood lead (BPb) level of 392 μg/dL, she became the first child in the United States known to have died from lead poisoning in 10 years. The previous US lead-related death was attributed to ingestion of lead paint.[2] Public health authorities later confirmed that the girl was likely to have entered the United States with a preexisting lead burden but that her life-threatening exposure was deteriorating lead paint in the child's US home.[1] She had been in the United States for only 5 weeks.

In recent years, Massachusetts has been 1 of the top 10 destination states for refugees who resettle in the United States. Since 1985, 43 287 refugees have entered Massachusetts. Once in the United States, many refugees undergo health screening. The content of such screening varies widely from state to state. In Massachusetts, a state with high environmental lead exposure and vigorous lead poisoning prevention laws, the refugee health screening includes a BPb level for children who are younger than 7 years.

Lead poisoning has been reported among past refugee populations that resettled in the United States, mainly from Southeast Asia[3,4]; however, the only recent study that reported elevated BPb was conducted by clinicians in Maine and involved a relatively small sample of refugee children who were younger than 6 years.[5] Similarly, a recent report about internationally adopted children documented lead poisoning as an important health issue and suggested that lead exposure occurred before migration to the United States.[6] This report is notable also because of the large percentage of its subjects that came from the former Soviet Union, the primary region of origin of refugees who entered the United States during the 1990s. Very little is known about BPb levels and environmental exposures of refugee children in their home countries or countries of first asylum, now greatly diversified as compared with those of refugees who entered the United States in the 1970s and 1980s.

From the early 1970s until the early 1990s, refugees who entered the United States came largely from 2 regions: Southeast Asia (predominantly Vietnam) and the former Soviet Union (predominantly Russia). In recent years, however, the United States has witnessed great diversification of the regions and countries of origin for refugees. Although fewer refugees now come from Southeast Asia, larger numbers come from many of the countries of the former Soviet Union, as well as Bosnia and other countries of the former Yugoslavia, Somalia, Congo, Rwanda, Sudan, West Africa (Liberia and Sierra Leone), Iraq (including Kurds), Cuba, and Haiti. Refugees also arrive from Western Europe. For many Bosnian fam-

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Received for publication Jul 6, 2000; accepted Jan 19, 2001.
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ilies, Germany was their country of first asylum before coming to the United States, and many young ethnically Bosnian refugee children were born in Germany.

In mid-1995, refugee medical screening in Massachusetts was consolidated as the Refugee Health Assessment Program (RHAP), under the auspices of the Massachusetts Department of Public Health, with clinical services contracted to a limited network of clinical sites. This has facilitated collection of uniform data on health and demographics of refugees; 90% of refugees who entered Massachusetts in the past 2 years completed screening. We undertook analysis of the prevalence of elevated BPb levels in specimens drawn from newly arrived refugee children during medical screening in Massachusetts. This was done to describe the lead burden and factors that predict elevated BPb in this cohort of recent refugees about whom no previous systematic study of lead poisoning (and related findings of anemia and growth failure) has been conducted.

METHODS

The term *refugee* applies to children who were eligible for refugee medical screening as defined by US law (the Immigration and Nationality Act, as amended by the Refugee Act of 1980). The US government's definition of a "refugee" is largely that defined by the United Nations' Convention Relating to the Status of Refugees.[7] All medical screening, data collection, and analysis were conducted pursuant to United States regulations (45 CFR §400.107).

Federal regulations stipulate that refugee medical screening must take place within 90 days of arrival in the United States; therefore, all initial lead samples were collected during that time interval. Between July 1, 1995, and December 31, 1999, RHAP clinicians tested refugee children who were younger than 7 years for BPb level. Refugees were screened at 16 contracted clinic sites around Massachusetts; however, nearly half of the children were screened at only 2 sites. Data forms were forwarded to the RHAP. In addition, Massachusetts state regulations (105 CMR §460.070) require reporting of all BPb testing results to the Massachusetts Department of Public Health, thus providing follow-up lead levels for refugee children who are in need of subsequent testing.

Initial specimens were obtained by venous sampling. During the study period, 65% of the BPb screening samples in the state were tested at either the State Laboratory or a satellite laboratory at the former Boston City Hospital with the use of graphite furnace atomic absorption spectrophotometry. The other blood samples were tested at commercial and hospital laboratories certified by the Clinical Laboratories Improvement Act for BPb analysis and reported to the state agency that is responsible for lead poisoning prevention and control. Follow-up levels, drawn 6 or more months after relocation to Massachusetts, were available for 213 children.

Anthropometric measurements included height and weight. Height generally was measured as recommended by the Centers for Disease Control and Prevention (CDC): supine for infants and toddlers younger than 2 years and erect for older children.[8] Indices were calculated with the use of Epi Info, version 6.04b (CDC, Atlanta, GA), based on National Center for Health Statistics data and accepted as international standards.[8,9] Z scores (standard deviations from the reference median) were assessed for height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ). A z score of -2, therefore, corresponds to the 2.3 percentile. Although the standard in such analyses, a z score of -2 represents a lower cutoff than the 5th percentile commonly used in US clinical pediatric practice for diagnosing poor growth. Acute undernutrition, or wasting, was assessed by WHZ for children who met Epi Info's anthropometric criteria for the calculation. These criteria for males are age from 12 to 138 months and height from 49 cm to <145 cm. For females, they are age from 12 to 120 months and height from 49 cm to <137 cm. Chronic undernutrition, or stunting, was assessed by HAZ. Although traditional anthropometric analyses would use a cutoff z score of -2 to determine prevalences of wasting or stunting, we chose to analyze z scores as continuous variables to be able to detect more subtle differences in growth parameters and assess the contribution of elevated BPb to growth impairment in the entire population, not just the minority with stunting or wasting as defined by z scores of <-2.

Complete blood counts were obtained to assess for anemia. For children who were younger than 8 years, anemia was defined as having a hemoglobin or hematocrit value less than the age- and gender-specific Third National Health and Nutrition Examination Survey (NHANES III) 5th percentile cutoff values of 11.0 to 11.5 g/dL and 32.9% to 34.5%, respectively.[10] Although evidence exists to support lower cutoff values for blacks,[10] no such baseline data are available for native Africans. Therefore, we chose not to adjust cutoff hemoglobin values for African children.

The minimum detection limit for BPb at the former Boston City Hospital was <5 μg/dL. Thus, BPb could not be analyzed as a continuous variable. BPb values were dichotomized as <10 or ≥10 μg/dL. With the use of Epi Info, bivariate analyses were conducted on all variables to examine the relationships between independent variables and BPb elevation. Bivariate models also were constructed to compare risk of BPb ≥10 μg/dL in refugee children versus known risk in the US age-matched population.[11] The odds of BPb elevation (BPb ≥10 μg/dL) for children from each of the specified regions also was compared with known risk in the US age-matched population.

Multivariate logistic regression was used to construct models comparing risk for lead poisoning by birthplace with the use of SAS for Windows version 6.1 (SAS Institute, Cary, NC). On the basis of risk patterns found in preliminary analyses, birth place was dichotomized as Northern Eurasia or not Northern Eurasia. Countries that were included in Northern Eurasia were those of the former Yugoslavia (mainly Bosnia), the newly independent states of the former Soviet Union (mainly Ukraine and Russia), and Germany. Because of limited numbers, other countries were grouped in bivariate analyses by region as follows, with the predominant country of origin in parentheses: Africa (Somalia), Asia (Vietnam), Near East (Iraq including Kurds), and non-US Americas (Cuba and Haiti). These then were grouped as non-Northern Eurasia in multivariate analyses.

Saturated models were constructed with the use of variables that were significant at the bivariate level of $P < .15$. Independent variables included birth place, season of testing, mean HAZ, mean WAZ, and anemia. A final model was developed with the use of a stepwise logistic regression procedure, which permitted reexamination, at every step, of the variables incorporated into the model in previous steps allowing only those variables with grouped P values <.05 to stay in the model.[12] Including an interaction term, birth place, and screening during warm weather did not improve the fit of the final model (log likelihood ratio test $P > .10$). Twenty-five children were excluded from multivariate analyses because of missing data, typically complete blood count results or growth parameters.

RESULTS

BPb levels from samples drawn shortly after arrival in the United States were available for 693 children who entered Massachusetts between July 1, 1995, and December 31, 1999. Overall, 11% of children had elevated BPb, a prevalence that is 2.7 times that of comparably aged US-born children (95% confidence interval [CI]: 1.9, 4.1). The proportion of children with elevated lead levels varied by birth place. Levels also varied by nationality, but birth place was a better predictor of current exposure, as many refugee children were born in countries other than the birth countries of their parents.

Children from countries described as Northern Eurasia had prevalences of elevated BPb similar to those found among comparably aged US-born children. None of the 33 Bosnian children born in Germany had elevated levels in contrast to 7% of the 136 children born in the former Yugoslavia. Of 371 children from the former Soviet Union (including 150 from Ukraine and 58 from Russia), 6% had elevated levels (Fig 1).

In contrast to those children from Northern Eurasia, children from other countries had very high prevalences of elevated BPb. Of the 15 children who were born in Central America and the Caribbean (Cuba and Haiti), 40% had BPb ≥ 10 μg/dL. Among 43 Asians, 37% had elevated BPb. Of 33 Vietnamese children, 27% had elevated BPb. Of 79 African children, 27% had elevated BPb, including 27% of 56 Somalis. Of 16 children from the Near East, 25% had elevated levels (Fig 1).

In bivariate analyses of the 668 children with complete data, we found that boys were no more likely than girls to have elevated lead levels. In addition, lead levels did not vary by age. Elevated BPb levels were associated with birth outside Northern Eurasia, pathogenic intestinal parasites, testing during the warm weather months of May through October, anemia, and lower mean HAZ and WAZ. However, we found no relationship between BPb elevation and WHZ, a more accurate measure of acute nutritional status than WAZ (Table 1).

In a final logistic regression model, children who were born outside Northern Eurasian countries were 7.3 times more likely than those born in Northern Eurasia to have elevated BPb levels (95% CI: 4.3, 12.4). When controlling for birth place and HAZ, we also found that children who were tested during the months of May through October were 2.4 times more likely to have elevated levels as other children (95% CI: 1.4, 4.1) and that children with higher mean HAZ were less likely to have a BPb ≥10 μg/dL (odds ratio, 0.8; 95% CI: 0.7, 0.97). Mean WAZ, anemia, and parasitic infection were not associated significantly with elevated BPb in this model.

BPb levels that were drawn at least 6 months after relocation were available for 213 children. Children who were retested were younger than those who were not retested (31.4 months [standard deviation (SD): ±17.3] vs 47.0 months [SD: ±22.6]; $P < .0001$). Of those retested, 21 (10%) had levels ≥10 μg/dL. Nine of the children with subsequent elevated BPb had previously elevated levels in samples drawn during their refugee health assessment shortly after arrival in the United States. However, 12 children who did not have elevated BPb on arrival in Massa-

TABLE 1. Characteristics of Refugee Children 0 to 6 Years Old With BPb Levels ≥10 μg/dL Resettled in Massachusetts: 1995 to 1999

Characteristic	Number (%)	Unadjusted Odds Ratio (95% CI)
Birth place		
Outside Northern Eurasia	43/137 (31)	7.3 (4.4, 12.0)
Northern Eurasia	31/531 (6)	
Season of testing		
May–October	42/281 (15)	2.1 (1.3, 3.3)
November–April	32/387 (8)	
Hemoglobin (g/dL)		
<Age-adjusted threshold	20/115 (17)	2.0 (1.1, 3.4)
≥Age-adjusted threshold	54/553 (10)	
Pathogenic intestinal parasite		
≥1	17/100 (17)	1.8 (1.01, 3.3)
0	57/568 (10)	
Gender		
Male	42/348 (12)	0.8 (0.5, 1.3)
Female	32/320 (10)	
Nutritional status		
Weight-for-height z score (n = 662)		
<−2	3/23 (13)	1.2 (0.4, 4.1)
≥−2	71/639 (11)	
Height-for-age z score (n = 668)		
<−2	8/50 (16)	1.6 (0.7, 3.5)
≥−2	66/618 (11)	
Weight-for-age z score (n = 666)		
<−2	4/22 (18)	1.8 (0.6, 5.5)
≥−2	70/644 (11)	
	Mean (SD)	***P* Value***
Mean Z score		
Weight-for-age	−0.2 (1.0)	<.001
Weight-for-height	0.31 (1.6)	.6
Height-for-age	−0.6 (1.9)	<.001
Age (mo)	42.5 (21.2)	.9
Months since arrival in United States	1.0 (0.8)	.99

* Compared with children with blood lead <10 μg/dL.

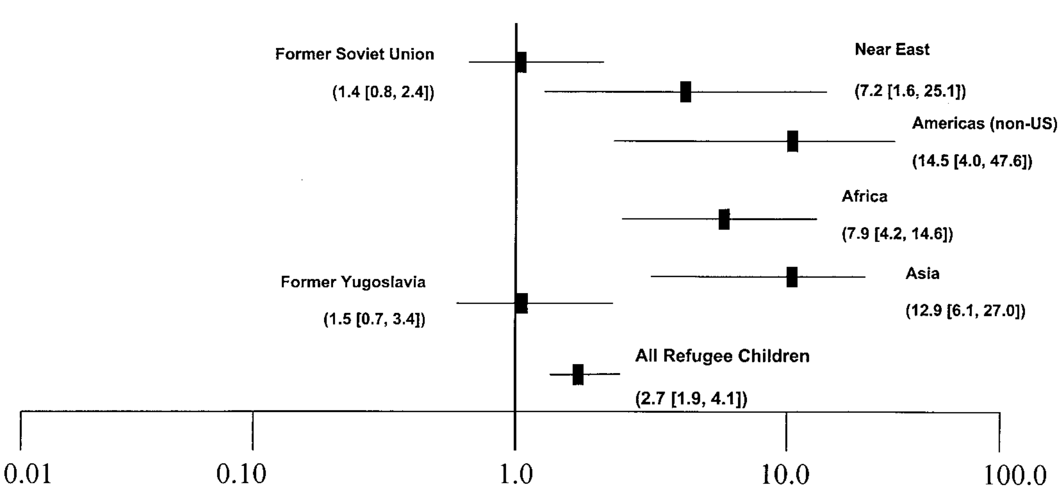

Fig 1. Odds of BPb elevation by birth place for 660 refugee children who resettled in Massachusetts between 1995 and 1999, compared with similarly-aged US children (95% CI in brackets).

chusetts had subsequent BPb levels at least 3 μg/dL higher than the initial level. The average increase was 4.9 μg/dL. The rate of new elevated BPb among children who were retested was higher than that of US children of the same age (5.9% vs 4.4%).[11]

DISCUSSION

The prevalence of elevated BPb levels in refugee children is more than twice that of US children. Children who are at particular risk are those from developing countries that are major sources of refugees who enter the United States. These include Vietnam and Somalia, countries that accounted for more than 95% of the children from Asia and Africa. In addition, Haitian and Cuban children may be at high risk of elevated BPb, although their numbers in this study are limited. Similarly, the high prevalences seen in this sample's limited numbers of children from developing countries suggest a larger problem of lead exposure in the developing world that warrants further investigation. Children from the former Soviet Union and Yugoslavia also are more likely than US children to have elevated BPb; however, the prevalences are lower than that of other refugee children. With a larger sample size, it is possible that these latter findings would have reached statistical significance.

Although age-related risk is well-documented in US children,[13] we did not find an association between age and risk for elevated BPb in the refugee children. This likely is attributable to the broader environmental exposures in other parts of the world, particularly the use of leaded gasoline. The risk for lead poisoning presented here follows the pattern of worldwide leaded gasoline distribution with high use in Africa, the Near East, Cuba, and Haiti and no or minimal use in Europe and Russia. Unfortunately, the lack of data on the distribution of leaded gasoline in Central Asia and Eastern Europe prevents further examination of the effect in this sample.[14]

Other exposures that are unlikely to vary by age include industrial emissions, use of traditional medicines that contain lead, and consumption of foods that are contaminated with lead through ceramic bowls and lead pots and cooking utensils.[15] These exposures also may be compounded by increased absorption of lead as a result of poor dietary content of iron and calcium.[16]

The high degree of dietary insufficiency also limits interpretation of the association between lower mean HAZ and elevated BPb. In this cross-sectional study, it was not possible to evaluate whether lower mean HAZ was an independent risk factor for BPb elevation, or vice versa. The high risk of elevated BPb among children from Africa and Asia is notable also because of high prevalences of stunting in Somalian and Vietnamese children.[17] However, stunting is a condition that most likely is multifactorial in etiology with significant contributions more likely to come from nutritional deficits and socioeconomic factors than from elevated BPb.

Earlier reports about refugee and immigrant children with lead poisoning in the United States suggested traditional medicines, pottery, and cooking utensils as likely sources of lead.[3,18] Another report about Southeast Asian refugee children did not find such associations.[4] This latter study suggested that in the sampled refugee population, particularly when compared with other populations in the same geographic area, other sources of ongoing environmental lead exposure may be involved and that limited use of preventive health services and education may be important factors that are associated with persistently high BPb levels.[4,19]

Many immigrants enter the United States from these countries and others with similar health and environmental profiles. Such countries include India, China, the Philippines, and the Dominican Republic. Also, some children who emigrate from the same countries as refugee children may enter the United States with regular immigrant visas instead of refugee visas. As such, these children would not be eligible for refugee health assessment. This may occur more commonly among immigrants from Vietnam and the former Soviet Union; however, these children come from sociodemographic circumstances that are very similar to those of refugees. A good example is the orphan adopted from the former Soviet Union. Thus, studies of refugee populations may give important insights into the health status of other immigrant populations.

Currently, the American Academy of Pediatrics[20] as well as the CDC[21] do not include foreign birth as a possible risk factor for lead poisoning and instead suggest targeted testing of "children of ethnic or racial minority groups who may be exposed to lead-containing folk remedies" and "children who have emigrated (or been adopted) from countries where lead poisoning is prevalent."[20] However, this study suggests that because of the broad risk of lead exposure for refugees from all studied countries except Germany, clinicians should simply consider refugee status or birth in such developing and former socialist countries as risk factors for elevated BPb.

We are not able to comment on more specific exposure risks among these children for 2 reasons. First, the study data were collected through a screening program that lacks longitudinal follow-up of patients. Second, most elevated levels were between 10 and 20 μg/dL, a range that would not prompt formal public health investigation of exposure or environmental risk beyond the physician–patient encounter. Our data also are limited because low BPb values were not available in all cases. As a result, BPb levels had to be categorized. This categorization may have resulted in a diminution of the effect of birth place on BPb level.

Another limitation of the study may be in using comparisons with NHANES data. BPb data from clinically derived samples may not be directly comparable to NHANES data both because clinicians may test only those children with an identifiable risk and because of the survey's sampling methodology. However, given that 90% of recently arrived refugee children who resettled in Massachusetts were tested, it is unlikely that our estimates are biased. In addition, in this study, we were interested in providing pediatric clinicians with a useful estimate of the risk of refugee children compared with that of a known population.

BPb levels declined over time in the United States for many (73%) of the retested children with initial elevated levels. This suggests that lead exposure of most refugee children occurred before migration to the United States, as in the case of international adoptees.[6] For a number of other children, however, this study reveals evidence of new lead exposure after arrival in the United States, with a prevalence of elevated BPb among retested refugee children that may be nearly twice as high as that of US children of the same age.

In many states, lead testing is not a part of refugee screening because lead is not considered to be a significant environmental hazard in some parts of the United States. Thus, many primary care practitioners who follow American Academy of Pediatrics or CDC guidelines might not test refugee children after resettlement in the United States if they were unaware of the risk of lead exposure in particular countries or unable to elicit a history of use of traditional remedies (not to be unexpected given the significant cultural and linguistic barriers that refugee patients face). As a result, children with undiagnosed elevated BPb may be at risk of continued exposure through the use of cultural-specific exposures, including traditional remedies, as well as ongoing exposure to lead paint in the United States. Such children may not receive services such as parent education; reduction of residential lead hazards; referral to the Supplemental Nutrition Program for Women, Infants, and Children; or educational support.[15]

Nearly all refugee children are eligible for Medicaid for a minimum of 8 months after arrival in the United States, and lead testing complies with Medicaid's Early and Periodic Screening, Diagnosis, and Treatment requirements for clinical care of young children. This study underscores the importance of these policies. BPb screening should be included in medical screening of all newly arrived young refugee children so that appropriate medical, educational, and environmental management may be initiated promptly. Given similarities between refugee and immigrant populations, clinicians should consider testing of immigrant children from developing and former socialist countries as well. In addition, because of the evidence of lead exposure after arrival in the United States, follow-up testing should be performed on refugee children who live in areas of the United States with known risk of environmental lead exposures.

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