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Journal

American Journal of Public Health, 106(1)

ISSN

0090-0036

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Publication Date

2016

DOI

10.2105/ajph.2015.302873

Health Profiles of Newly Arrived Refugee Children in the United States, 2006–2012

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Objectives. We conducted a large-scale study of newly arrived refugee children in the United States with data from 2006 to 2012 domestic medical examinations in 4 sites: Colorado; Minnesota; Philadelphia, Pennsylvania; and Washington State.

Methods. Blood lead level, anemia, hepatitis B virus (HBV) infection, tuberculosis infection or disease, and *Strongyloides* seropositivity data were available for 8148 refugee children (aged < 19 years) from Bhutan, Burma, Democratic Republic of Congo, Ethiopia, Iraq, and Somalia.

Results. We identified distinct health profiles for each country of origin, as well as for Burmese children who arrived in the United States from Thailand compared with Burmese children who arrived from Malaysia. Hepatitis B was more prevalent among male children than female children and among children aged 5 years and older. The odds of HBV, tuberculosis, and *Strongyloides* decreased over the study period.

Conclusions. Medical screening remains an important part of health care for newly arrived refugee children in the United States, and disease risk varies by population. (*Am J Public Health*. Published online ahead of print November 12, 2015: e1–e7. doi:10.2105/AJPH.2015.302873)

Each year, approximately 35 000 children enter the United States as refugees, defined as immigrants who enter the United States through the Department of State's Refugee Resettlement Program to receive protection from persecution.[1,2] An additional 200 000 to 250 000 immigrant children receive lawful permanent residency in the United States each year, meaning that they are permitted to remain in the United States indefinitely.[2] Overall, 3.7% of children living in the United States (including 7.7% of Latino children and 16.7% of Asian children) were born overseas.[3]

Although immigrant children constitute an important and growing sector of the US child population, comprehensive guidelines for clinicians caring for children new to the United States are lacking. In part, this has been because data on the health status of immigrant and refugee children have been limited. With a few exceptions, studies have been limited to small samples of children and have not allowed detailed analysis by age, gender, or country of origin.[4–16] Larger studies of refugees rapidly become out of date as countries of origin change.[17–19]

Despite these limitations, the Centers for Disease Control and Prevention (CDC) has used the best available data to develop screening guidelines that are specific for refugees and that have been implemented by many state and local departments of public health, as well as clinicians specializing in refugee health services.[20] These guidelines recommend a minimum set of screening tests for infectious, nutritional, and environmental health problems (e.g., tuberculosis [TB], anemia, and elevated blood lead [EBL] levels). Some screening tests (e.g., anemia) are recommended for all children, whereas others (e.g., schistosomiasis) are recommended only for children from regions with endemic disease. Screening usually takes place within 90 days (and preferably within 30 days) of arrival in the United States as part of a domestic medical examination. Lacking other recommendations, these guidelines have also been adopted by some clinicians specializing in health care for other populations of immigrant children in the United States.

We describe results from the first large-scale study to our knowledge of newly arrived refugee children in the United States by using data from 2006 to 2012 domestic medical examinations in 4 states. This study is important because it demonstrates that it is feasible to create a unified refugee health data set by using public health data from multiple states and that a data set of this type can be used to examine the value of existing screening guidelines. In addition, this analysis includes subgroup data by age, gender, country of origin, and country of departure that may be used to refine population-specific screening guidelines for immigrant children. Finally, it includes tests for temporal trends to determine whether conditions previously believed to be prevalent among refugee children have become more or less common over time.

METHODS

This is a retrospective, observational study with data from 4 sites that have implemented CDC guidelines: Colorado Department of Public Health and Environment's Refugee Health Program, Minnesota Department of Health's Refugee Health Program, Thomas Jefferson University's Department of Family and Community Medicine (Philadelphia, Pennsylvania), and Washington State Department of Health's Refugee Health Program. After agreeing upon core data elements, each site provided de-identified demographic and domestic medical examination data for children aged younger than 19 years who arrived in the United States from January 1, 2006, through December 31, 2012 (n = 10 113). Because different sites had implemented electronic data collection at different times, 1 site provided data for the full study period, 1 site for 2007 to 2012, 1 site for 2009 to 2012, and 1 site for 2012 only. We cleaned and linked data to create a unified data set.

We excluded children missing all outcomes data (1.9%). We categorized the remaining sample by country of origin (meaning the country in which the child's family originated regardless of whether the child was born in a different host state) and the study cohort was limited to children from countries with at least 500 participants or children from the Democratic Republic of the Congo (DRC). We categorized children by country of origin rather than host country because refugee children often live within communities that may be geographically or socially isolated. For example, most Bhutanese refugee children were born in refugee camps in Nepal but had limited interactions with Nepali society; in the data set, these children were categorized as Bhutanese. The analysis focused on children from countries with more than 500 participants to allow for subgroup analyses by age and gender. We made an exception for the DRC because the United States expects to resettle up to 50 000 Congolese refugees in the next 5 years and additional information about this population is timely and needed by the pediatric and public health communities. The final analytic sample included 8148 children from Bhutan, Burma, DRC, Ethiopia, Iraq, and Somalia. Children from Burma were then subcategorized as having arrived in the United States from Thailand (Burma–Thailand) or Malaysia (Burma–Malaysia), as a previous study had identified differences in nutritional status between these 2 populations.[21]

Demographic data included age at the time of arrival in the United States, gender, year of arrival in the United States, country of origin, country of departure (the country in which the child was living before arrival in the United States), and the interval between the day of arrival in the United States and the domestic medical examination.

Outcomes were limited to conditions routinely assessed and reported during the domestic medical examination: blood lead level, anemia, hepatitis B virus (HBV) infection, TB, and *Strongyloides*. Elevated blood lead was reported for children younger than 8 years from 2008 to 2012 and defined as 5 or more micrograms per deciliter per current CDC guidelines. (For comparison with previous work, results are also shown using the older definition of 10 or more micrograms per deciliter.[22]) Anemia was defined by using age- and gender-specific US norms for either hemoglobin or hematocrit.[23] Hepatitis B infection was defined as HBV surface antigen–positive. Tuberculosis was defined as either a Mantoux tuberculin skin test (TST) greater than or equal to 10 millimeters or a positive serum interferon-γ release assay (IGRA). Primary data (e.g., radiography) that would allow differentiation between latent TB infection and active TB disease were not available, but each state database included a categorical variable for TB diagnosis (latent infection, active disease, or previously treated TB). *Strongyloides* infection (defined as a positive test for serum *Strongyloides stercoralis* antibodies) was reported only by 1 site and only from 2010 to 2012, when widespread screening was implemented.

Because each site implemented screening protocols for different outcomes at different times, the number of children screened for each outcome ranged from 2030 (*Strongyloides*) to 7935 (TB). Three sites reported blood lead levels from 2008 to 2012, and of children screened by these 3 sites, 4.7% had missing values. Two sites reported hemoglobin or hematocrit (2.5% missing). Three sites reported HBV surface antigen (2.3% missing). Four sites reported TST, IGRA, or both (2.6% missing). We included *Strongyloides* serology results because published data are limited. Demographic characteristics of children with and without missing values are included in Table A (available as a supplement to the online version of this article at http://www.ajph.org). Children with missing lead, anemia, and HBV results were younger than those with nonmissing results.

We used χ^2 and Fischer exact tests to compare outcomes by country of origin, age group, and gender. To examine changes in prevalence over time, we used logistic regression to describe the relationship between each outcome and year of arrival in the United States. We adjusted models for age, gender, and country of origin. The TB model also included test type (TST or IGRA) and anemia. We included test type because differences in the specificity of TST and IGRA have previously been documented in foreign-born populations from high-prevalence regions.[24] We included anemia as a proxy for malnutrition-related anergy, which may result in false-negative or indeterminate results for both types of TB test.[25] We did not include receipt of the antituberculosis vaccine Bacillus Calmette–Guérin (BCG) in the model, as these data were not available. We did not include data source (site) in the final models, as we did not identify differences in outcomes by site during exploratory analyses.

RESULTS

Eligible children with at least 1 nonmissing screening value are described in Table 1. Children from Burma–Malaysia and Iraq were somewhat more likely to be aged younger than 5 years and children from Ethiopia and Somalia were somewhat more likely to be older than 10 years compared with children from other countries. The majority of children from Ethiopia and Somalia had arrived in the United States before 2009, whereas most children from Bhutan, Burma, DRC, and Iraq arrived in the United States in 2009 or later. Language data are not shown. However, children from Bhutan predominantly spoke Nepali during the domestic medical examination (99%). Children from Burma–Thailand were more likely to speak Karen and related dialects (89.9%). Children from Burma–Malaysia predominantly spoke Burmese (59.4%) or Chin (27.5%), a language group from northwest Burma. Children from the DRC, Ethiopia, and Somalia predominantly spoke Kiswahili (76.4%), Oromo (65.8%), and Somali (96.0%), respectively. Countries of departure are shown in Figure A (available as a supplement to the online version of this article at http://www.ajph.org); the major countries of departure for each country of origin are shown in the Figure B (available as a supplement to the online version of this article at http://www.ajph.org).

Prevalence data by country of origin and age are shown in Table 2. Among children from Bhutan, blood lead levels of 10 or more micrograms per deciliter were relatively uncommon (1.4%). However, 1 in 4 (26.8%) children had EBL of 5 or more micrograms per deciliter, and EBL was common among all age groups. Anemia was also prevalent among all age groups (10.7% overall) and among both male and female children (10.3% and 11.2%, respectively). Hepatitis B infection was uncommon (0.7%) and no children younger than

TABLE 1—Demographic Description of Refugee Children Who Arrived in 4 US States From 2006 to 2012, by Country of Origin

Characteristic	Bhutan	Burma via Thailand	Burma via Malaysia	DRC	Ethiopia	Iraq	Somalia
No.	1002	2437	298	212	605	716	2878
Female, %	46.2	49.8	45.3	50.5	47.9	47.2	48.4
Median age, y (IQR)[a]	10 (4, 14)	9 (4, 13)	6 (2, 12)	10 (5, 14)	13 (7, 16)	7 (4, 12)	11.5 (7, 16)
Median screening interval, d (IQR)	48 (34, 71)	40 (26, 55)	55 (35, 84)	41 (32, 69)	44 (27, 60)	42 (26, 61)	43 (27, 62)
Year of arrival, %							
2006–2008	2.2	24.4	0.0	2.8	62.0	6.0	57.0
2009–2010	43.7	31.9	42.3	62.3	17.0	48.2	20.1
2011–2012	54.1	43.7	57.7	34.9	21.0	45.8	23.0

Note. DRC = Democratic Republic of the Congo; IQR = interquartile range. The sample comprised 8148 children aged 0–18 years who arrived in participating states from 2006 to 2012 and who contributed domestic medical examination screening data for at least 1 of the following: blood lead level, hepatitis B surface antigen, hemoglobin, hematocrit, interferon-γ release assay, Mantoux tuberculin skin test, or anti–*Strongyloides stercoralis* immunoglobulin G.
[a]Age on the day of arrival in the United States.

5 years had HBV. Tuberculosis (16.1%) was prevalent, although active disease was not (0.1%). *Strongyloides* was moderately prevalent (3.1%).

Among children from Burma via Thailand, 23.7% of children had EBL, although only 1.9% of children had blood lead levels of 10 or more micrograms per deciliter. Lead levels of 10 or more micrograms per deciliter were most common among children aged younger than 2 years (5%). Anemia was also prevalent (22.8%) and was most common among children aged younger than 5 years (35.1%). Anemia affected 23.2% of male and 22.4% of female children, with the highest prevalence among children younger than 5 years (35.1%). Hepatitis B infection was moderately prevalent (4.6%) and predominantly affected children aged 5 years or older. One in 10 children had a positive test for TB (< 1 in 1000 children had active disease) and 4.1% of evaluable children had a positive *Strongyloides* serology.

Among children from Burma via Malaysia, no children had a blood lead level of 10 or more micrograms per deciliter. However, 10.5% of children had EBL of 5 or more micrograms per deciliter. Only 5.5% of children were anemic, and no children had HBV infection. Tuberculosis was prevalent (17.9%), although active disease was not (0.7%). *Strongyloides* was moderately prevalent (2.5%), although these results should be interpreted cautiously as only 40 children had evaluable data.

Because approximately equal numbers of Burmese-speaking children arrived in the United States via Thailand (n = 208) and Malaysia (n = 177), we performed a subgroup analysis of Burmese-speaking children to try to examine the relative influence of departure country and ethnic group (using language as an imperfect proxy for ethnicity, as many Burmese-speaking refugees belong to non-Bamar ethnic minorities). An EBL of 5 or more micrograms per deciliter was more prevalent among Burmese-speaking children living in Thailand (20.2%) than those living in Malaysia (13.7%). Burmese-speaking children living in Thailand also had higher rates of anemia (10.7% vs 4.2%) and HBV infection (7.5% vs 0%). Tuberculosis was less common among Burmese-speaking children living in Thailand (10.0% vs 16.8%).

Among children from the DRC, blood lead levels of 10 or more micrograms per deciliter were somewhat prevalent (3.0%) and EBL of 5 or more micrograms per deciliter was common (25.0%). Anemia was less prevalent than among children from Bhutan and Burma–Thailand, although it was still common (14.4%). Anemia was equally common among male and female children (13.9% and 14.9%, respectively). Hepatitis B infection was moderately prevalent (4.5%), as was TB (19.5%). No children were diagnosed with active TB disease. The prevalence of *Strongyloides* was 6.3% but should be interpreted with caution because of the small number of children (n = 32) with evaluable data (data not shown).

The health profile for children from Ethiopia was similar to that of children from the DRC, with a few key differences: Fewer children from Ethiopia had EBL (13.1%) and nearly 1 in 3 children had a positive TB test (31.1%). The prevalence of active TB was 0.7%.

Among children from Iraq, 1.4% of children had blood lead levels of 10 or more micrograms per deciliter but 19.9% had EBL of 5 or more micrograms per deciliter. Anemia was not highly prevalent (5.6%), no children had HBV, and only 5.9% of children had a positive TB test (none of whom had been diagnosed with active TB). Iraqi children had a relatively high rate of *Strongyloides* seropositivity (8.3%).

Among children from Somalia, 1.7% of children had blood lead levels of 10 or more micrograms per deciliter but 19.8% had EBL of 5 or more micrograms per deciliter. Anemia was common among both male and female children (20.4% and 22.5%, respectively) and was most prevalent among children aged younger than 5 years. Hepatitis B infection was moderately prevalent (3.6%), predominantly among children aged 5 years or older. Tuberculosis was common (28.5%); active TB was not (0.8%). Positive *Strongyloides* serology was detected among 2.1% of evaluable children.

In the fully adjusted model, the odds of HBV and TB were higher among male versus female children (Table 3). The odds of anemia deceased slightly with age (Figure C, available as a supplement to the online version of this article at http://www.ajph.org). The odds of

TABLE 2—Prevalence of Selected Conditions Among Refugee Children Who Arrived in 4 US States From 2006 to 2012, by Age and Country of Origin

Condition	Bhutan	Burma via Thailand	Burma via Malaysia	DRC	Ethiopia	Iraq	Somalia
Elevated blood lead level, no.	358	844	134	64	99	281	485
≥ 10 μg/dL: 0 to < 8 y, %	1.4	1.9	0.0	3.1	1.0	1.4	1.7
≥ 5 μg/dL: 0 to < 8 y, %	26.8	23.7	10.5	25.0	13.1	19.9	19.8
≥ 5 μg/dL: < 2 y, %	23.1	25.2	7.3	. . .	. . .	8.9	10.6
≥ 5 μg/dL: 2 to < 5 y, %	29.0	25.3	9.0	22.5	12.3	23.2	19.7
≥ 5 μg/dL: 5 to < 8 y, %	23.2	19.4	. . .	. . .	. . .	19.1	25.5
Anemia, no.	858	2355	236	202	578	517	2751
0–18 y, %	10.7	22.8	5.5	14.4	16.3	5.6	21.4
< 5 y, %	12.9	35.1	5.4	18.4	18.1	6.9	32.2
5 to < 12 y, %	9.1	21.1	2.6	16.2	14.3	4.2	19.8
≥ 12 y, %	10.9	15.6	9.0	11.1	16.7	6.3	19.2
Hepatitis B surface antigen, no.	298	1952	64	44	511	308	2446
0–18 y, %	0.7	4.6	0.0	4.5	5.3	0.0	3.6
< 5 y, %	0.0	0.6	. . .	. . .	3.6	0.0	1.1
≥ 5 y, %	0.9	6.1	0.0	5.9	5.5	0.0	4.0
Tuberculosis, no.	973	2395	291	205	589	696	2786
0–18 y, %	16.1	10.4	17.9	19.5	31.1	5.9	28.5
Strongyloides serology, no.	162	946	40	32	125	97	628
2010–2012, %	3.1	4.1	2.5	6.3	5.6	8.3	2.1
2010, %	6.2	8.7	. . .	. . .	13.0	12.2	4.9
2011–2012, %	1.0	1.5	. . .	. . .	1.3	4.2	0.5

Note. DRC = Democratic Republic of the Congo. The sample size was n = 8148. The denominator for each cell equals the number of children from that region, age, and gender who had a nonmissing test result. Results are not shown for cells where n < 30. Lead level is reported only for children younger than 8 years and for the years 2008 to 2012, as missingness rises to above an acceptable level among older children (> 15%) and before 2008 (> 20%). Anemia was defined as a hemoglobin or hematocrit below the age- and gender-specific cutpoints established by the US Centers for Disease Control and Prevention (Table 6, Yip et al.[23]). Tuberculosis was defined as either a positive interferon-γ release assay or a Mantoux tuberculin skin test ≥ 10 mm as reported during the domestic medical examination. The prevalence of *Strongyloides stercoralis* antibodies is reported for children from 2010 to 2012.

HBV infection and tuberculosis increased with advancing age.

In both unadjusted and fully adjusted models, the odds of HBV infection, TB, and *Strongyloides* were lower among children who arrived in the United States more recently (Table 3).

The odds of TB were also lower among children diagnosed with IGRA compared with those diagnosed with TST (Table 3). For the majority of the sample, the diagnosis of TB was based either upon TST (n = 5866) or IGRA (n = 1858); results for both tests were reported for only 219 children. As shown in Table 4, the overall prevalence of TST greater than or equal to 10 millimeters (21.5%) was higher than the prevalence of a positive IGRA (11.8%), although the concordance between TST and IGRA was relatively good for children from a subset of countries (e.g., Bhutan). Even when we excluded children aged 4 years or younger (as these children are more likely to have recently received the BCG vaccine), the prevalence of TST greater than or equal to 10 millimeters (25.2%) was higher than the prevalence of a positive IGRA (12.4%).

DISCUSSION

This is the first US study to our knowledge to use multistate public health screening data to describe the health profiles of refugee children by country of origin, age, and gender. This study demonstrates that such studies are feasible and that these data can be used in a relatively timely manner to inform ongoing public health programs and policies.

Overall, these results support current CDC recommendations to screen newly arrived refugee children for EBL, anemia, HBV infection, TB, and *Strongyloides*. Population-specific adjustments to these guidelines may also be warranted. For example, universal HBV screening may not be necessary for children from regions where the prevalence of HBV among children is comparable to that in the United States (0.6%).[26] However, the denominator for this test was relatively small. Given the morbidity and mortality associated with HBV infection, larger studies are recommended before changing current practice. And there is no doubt that universal screening remains warranted for pregnant adolescents to prevent the vertical transmission of infection. Population-specific guidelines may also be more difficult to implement without sophisticated, population-specific decision-support tools embedded in the electronic medical record.[27]

The health profile of children from Burma via Thailand, who were predominantly Karen, was substantially different from that of children from Burma via Malaysia, suggesting that the living environment before departure for the United States plays a major role in determining health risks. For example, most refugee children living in Malaysia live in urban environments, receive regular health care, and experience relatively little food insecurity.[28,29] By contrast, most refugee children living in Thailand reside in refugee camps in a rural, border region, where they may have irregular access to preventive health services, depend upon food packages provided by nonprofit agencies, and may be exposed to environmental risks unique to rural areas (e.g., the use of lead-contaminated car batteries as household electrical sources).[30] Country of departure may be particularly important when one is assessing disease risk for children, as many children are born in host countries rather than their parents' country of origin. Ongoing US refugee health surveillance efforts focusing upon new refugee groups should be designed to allow the detection of differences between children from different countries of departure.

TABLE 3—Change in the Odds of Elevated Blood Lead, Anemia, Hepatitis B Infection, Tuberculosis, and *Strongyloides stercoralis* Antibodies Among Refugee Children Who Arrived in 4 US States From 2006 to 2012

Variable	Lead		Anemia		Hepatitis B Infection		Tuberculosis		*S. stercoralis*	
	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)
Year of arrival in the United States	0.93 (0.86, 1.01)	0.94 (0.87, 1.02)	0.95 (0.93, 0.98)	0.96 (0.94, 0.99)	0.87 (0.82, 0.93)	0.89 (0.82, 0.96)	0.77 (0.75, 0.79)	0.90 (0.83, 0.93)	0.15 (0.08, 0.25)	0.15 (0.08, 0.26)
Age in years		1.02 (0.97, 1.07)		0.94 (0.93, 0.95)		1.19 (1.15, 1.24)		1.10 (1.09, 1.12)		0.96 (0.91, 1.00)
Gender (Ref = female)		1.16 (0.95, 1.43)		0.99 (0.88, 1.11)		1.89 (1.40, 2.54)		1.28 (1.13, 1.45)		0.91 (0.57, 1.46)
Country of origin (Ref = Bhutan)										
Burma–Thailand		0.84 (0.64, 1.12)		2.23 (1.84, 2.98)		7.71 (1.87, 31.77)		0.52 (0.41, 0.66)		1.42 (0.54, 3.71)
Burma–Malaysia		0.33 (0.18, 0.60)		0.42 (0.23, 0.77)		. . .		1.12 (0.75, 1.68)		0.5 (0.06, 4.49)
DRC		0.93 (0.50, 1.71)		1.45 (0.93, 2.28)		7.88 (1.05, 59.42)		1.11 (0.74, 1.66)		1.68 (0.30, 9.34)
Ethiopia		0.42 (0.22, 0.79)		1.72 (1.25, 2.36)		4.05 (0.92, 17.71)		1.28 (0.97, 1.67)		2.00 (0.61, 6.61)
Iraq		0.68 (0.47, 0.99)		0.45 (0.29, 0.69)		. . .		0.34 (0.23, 0.52)		2.39 (0.74, 7.68)
Somalia		0.68 (0.49, 0.93)		2.32 (1.81, 2.97)		2.97 (0.70, 12.53)		1.24 (0.99, 1.55)		0.68 (0.24, 1.98)
Anemia (Ref = yes)								1.02 (0.86, 1.20)		
Tuberculin skin test ≥ 10 mm (Ref = yes)								0.71 (0.57, 0.88)		

Note. AOR = adjusted odds ratio; CI = confidence interval; DRC = Democratic Republic of the Congo; OR = odds ratio. Elevated blood lead level was defined as ≥ 5 micrograms per deciliter. Children aged 8 years or older at the time of the arrival in the United States and children who arrived in the United States in 2006 and 2007 were excluded, as missingness rises to above an acceptable level among older children (> 15%) and before 2008 (> 20%). Anemia was defined as a hemoglobin or hematocrit below the age- and gender-specific cutpoints established by the US Centers for Disease Control and Prevention (Table 6, Yip et al.[23]). Hepatitis B infection was defined as a positive hepatitis B surface antigen. Children from Burma–Malaysia and Iraq were excluded from the model because of 0 cells. Tuberculosis was defined as either a positive interferon-γ release assay or a Mantoux tuberculin skin test ≥ 10 millimeters as reported during the domestic medical examination. The prevalence of *S. stercoralis* antibodies is reported for children from 2010 to 2012; year of arrival was modeled as a dichotomous variable (2010 vs 2011–2012), with 2010 as the reference year.

The strong associations between HBV infection, gender, and age bear further investigation. Before the advent of national HBV vaccination programs, vertical transmission and early childhood horizontal transmission had been the major causes of HBV infection among children in Asia and Africa, and infection was prevalent even among very young children.[31–34] Following the implementation of vaccination programs in the late 1990s and early 2000s, however, rates of infection in young children have decreased.[35] Results from our study cohort, which has very few infected young children, are consistent either with widespread early childhood HBV vaccination or with an increased risk in horizontal transmission in early adolescence. Male gender is also an unexplained, although not entirely unexpected, risk factor for HBV infection in this cohort.[34] Subsequent analyses of this data set will examine trends in HBV exposure and vaccination status.

Tuberculosis prevalence estimates were strongly influenced by test modality, consistent with previous pediatric studies suggesting that TST may be associated with higher rates of false-positive diagnosis than IGRA.[36] Under current guidelines, both TST and IGRA are accepted TB screening tests for refugee children aged 5 years and older.[37] However, additional studies are clearly needed to definitively identify the preferred test modality for children.

The overall prevalence of *Strongyloides* infection was 3.7%. There was a sharp drop in prevalence among children arriving in the United States after 2010. Notably, the CDC had initiated a program to provide routine, presumptive treatment of *Strongyloides* for US-bound refugees living in Thailand in 2011.[38] However, the same trend was also observed among children who arrived in the United States from Nepal and Kenya, where presumptive predeparture treatment was not implemented until 2013. This suggests that other factors, such as improved sanitation, may also have contributed to this change.

Limitations

This study has a number of limitations. We were unable to examine outcomes for major ethnic subgroups, as the best available proxy (language used during the domestic medical

TABLE 4—Prevalence of Tuberculosis Among Refugee Children Aged 0–18 Years Who Arrived in 4 US States From 2006 to 2012 by Country of Origin

Test	Total	Bhutan	Burma via Thailand	Burma via Malaysia	DRC	Ethiopia	Iraq	Somalia
Tuberculosis (TST ≥ 10 mm), no.	6077	603	1749	204	150	520	471	2380
0–18 y, %	21.5	15.9	10.5	23.0	20.7	33.1	6.2	31.3
Tuberculosis (IGRA+), no.	2077	398	724	102	58	79	257	459
0–18 y, %	11.8	16.1	10.5	9.8	15.5	17.7	4.7	13.3

Note. DRC = Democratic Republic of the Congo; IGRA = interferon-γ release assay; TST = Mantoux tuberculin skin test. Results are from TST compared with IGRA results

examination) may result in the misclassification of individuals who speak more than 1 language. For example, Karen families who speak Karen and Burmese may be categorized as "Burmese-speaking."

Because lead data were not available for the majority of children aged older than 8 years, we cannot comment on the use of universal lead screening for older children. Our TB data do not differentiate between T-SPOT (Oxford Immunotec Inc, Marborough, MA) and QuantiFERON-TB Gold (QIAGEN Inc, Valencia, CA), and we had insufficient data to correlate TB screening results with previous receipt of BCG vaccine. Furthermore, anemia is a poor proxy for malnutrition, so adjusted models for TB do not fully account for the impact of anergy.

Because we used serum antibody levels as a marker for *Strongyloides* infection, children aged younger than 12 months and children recently treated with antiparasitics may be classified as *Strongyloides*-positive as a result of maternal transfer of antibodies or the slow decline in antibody levels following treatment.[39] This may have overestimated the prevalence of *Strongyloides* infection. *Strongyloides* prevalence estimates should also be interpreted cautiously because the relatively high proportion of children with missing values may be indicative of selective testing rather than universal screening. Future studies replicating this work with more recent data are expected to address many of these limitations.

Conclusions

The creation of a multistate, pediatric refugee health data set is feasible, and we suggest that data be pooled regularly (e.g., every 2 years) to update these results. When feasible, these analyses should focus upon both country of origin and country of departure, as the health profiles of refugee children from a single country of origin (e.g., Burma) may be variable depending on the country of departure (e.g., Thailand and Malaysia). State refugee health programs should also consider including refugee camp as a variable within existing refugee screening databases, as these data may allow for better monitoring of the health status of children from very large, semipermanent refugee camps such as Mae La (Thailand), Dadaab (Kenya), Kakuma (Kenya), and Zaatari (Jordan).

These data are important for monitoring and adapting the CDC's existing refugee screening guidelines. For example, our results raise questions about universal HBV screening for children from countries where the prevalence of HBV among children is comparable to the prevalence among children in the United States, although future studies with larger sample sizes are necessary to confirm these findings. Pooled refugee health screening data should also be used to provide population-, age-, and gender-specific prevalence estimates to clinicians caring for refugee children. In the future, it may be most cost-effective and timely for the CDC to conduct rapid health assessments of large refugee populations before immigration to the United States.

The results of this study may also be of value to clinicians caring for nonrefugee immigrant children from low- and middle-income countries in Asia and Africa. Although there are often differences between refugee and nonrefugee populations, these data may offer some insight into the health status of children from regions where living conditions are comparable to those of refugee children and where other population-specific data are lacking. For example, nonrefugee immigrant children from rural Somalia are likely to benefit from screening for EBL, anemia, HBV, tuberculosis, and *Strongyloides*. However, additional work is necessary to develop screening guidelines for other populations of immigrant children, particularly children from countries with large US permanent resident populations, such as Mexico, China, India, and the Philippines.[2] ■

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This article was accepted August 17, 2015.

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B. Mamo, K. Yun, and W. M. Stauffer conceptualized the study. J. Matheson, C. Payton, K. C. Scott, B. L. Stone, B. Mamo, and K. Urban contributed data. L. Song and K. Yun prepared the unified data set. K. Yun led the analysis and preparation of the article. All of the authors made critical contributions to the analysis and article preparation.

Acknowledgments

K. Yun received support from PolicyLab at the Children's Hospital of Philadelphia and in part from the National Institute of Child Health and Human Development (1K23HD082312-01A1). K. C. Scott and C. Payton received support in part from a cooperative agreement with the Centers for Disease Control and Prevention (CDC; CDC-RFA-CK12-1205).

The authors thank Austin "Chad" Hill for assistance creating Figure A and the anonymous reviewers whose comments improved this work.

Note. The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of the CDC or the Department of Health and Human Services. These data were supplied, in part, by the Colorado, Minnesota, and Washington departments of public health, which specifically disclaim responsibility for any analysis, interpretation, or conclusions.

Human Participant Protection

This study was approved by the institutional review board at Thomas Jefferson University. Use of existing, de-identified data were exempt from institutional review board review by other participating sites.

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