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# Dental Caries of Refugee Children Compared With US Children

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**ABSTRACT.** *Objective.* Dental care is a major unmet health need of refugee children. Many refugee children have never received oral health care or been exposed to common preventive oral health measures, such as a toothbrush, fluoridated toothpaste, or fluoridated water. Oral health problems among refugee children are most likely to be detected first by pediatricians and family practitioners. Given the increased influx of refugees into the United States, particularly children, it is important for the pediatric community to be aware of potential oral health problems among refugee children and be able to make referrals for treatment and recommendations for the prevention of future oral diseases. The purpose of this study was to describe the prevalence of caries experience and untreated decay among newly arrived refugee children stratified by their region of origin and compared with US children.

*Methods.* Oral health assessments were conducted within 1 month of arrival to the United States as part of the Refugee Health Assessment Program of the Massachusetts Department of Public Health. The outcome variables include caries experience and untreated decay. Caries experience is determined by the presence of an untreated caries lesion, a restoration, or a permanent molar tooth that is missing because it has been extracted as a result of dental caries. Untreated caries is detected when 0.5 mm of tooth structure is lost and there is brown coloration of the walls of the cavity. Comparisons of the refugee children with US children in Third National Health and Nutrition Examination Survey data were made using  $\chi^2$  test of independence and multiple logistic regression.

*Results.* Oral health screenings were performed on 224 newly arrived refugees who ranged in age from 6 months to 18 years and had a mean age of 10.6 years (SD: 4.82; median: 10.7 years). African refugees represented 53.6%, with the majority from Somalia, Liberia, and Sudan. Eastern European refugees composed 26.8% of the study sample. The remaining 19.6% come from a number of countries, such as Afghanistan, Pakistan, and the Middle East. Refugee children had 51.3% caries experience and 48.7% with untreated decay. Caries experience in refugees varied by region of origin, with 38% from Africa exhibiting a history of caries compared with 79.7% of Eastern Europeans. The highest proportion of children

with no obvious dental problems was from Africa (40.5%) compared with 16.9% from Eastern Europe. US children had caries experience similar to that of refugees (49.3%) but significantly lower risk of untreated decay (22.8%). Comparisons between refugee children and US children found significant differences for treatment urgency, untreated caries, extent of dental caries, and presence of oral pain. White refugee children, primarily from Eastern Europe, were 2.8 times as likely to have caries experience compared with white US children, with 9.4 times the risk of untreated decay compared with white US children. In contrast, African refugee children were only half as likely to have caries experience compared with white US children (95% confidence interval: 0.3-0.7) and African American children (95% confidence interval: 0.3-0.7). However, African refugee children were similar to African American children in risk of untreated decay (odds ratio: 0.94).

*Conclusion.* African refugee children had significantly lower dental caries experience as well as fewer untreated caries as compared with similarly aged Eastern European refugee children. They were also less likely to have ever been to a dentist. Possible reasons for these findings may include differences in exposure to natural fluoride in the drinking water, dietary differences, access to professional care, and cultural beliefs and practices. The prevalence of caries experience and untreated caries differed significantly between refugee children and US children. These differences varied significantly by race. When refugee children were compared with US children, the African refugee children had only half the caries experience of either white or African American children. However, African refugee children had similar likelihood of having untreated caries as compared with African American children, despite that very few African children had previous access to professional dental care. These findings are consistent with previous studies on health disparities in the United States. White refugee children, primarily from Eastern Europe, were also 3 times as likely to have caries experience compared with either white or African American children and were 9.4 times as likely to have untreated caries as white US children. Refugee children are more likely to establish primary medical care before seeking dental treatment. With the limited access to dental care among refugees, pediatricians should be particularly alert to the risk of oral diseases among refugee children. *Pediatrics* 2004; 114:e733-e740. URL: [www.pediatrics.org/cgi/doi/10.1542/peds.2004-0496](http://www.pediatrics.org/cgi/doi/10.1542/peds.2004-0496); *children, dental caries, health disparities, oral health, refugees.*

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ABBREVIATIONS. PROH, Program for Refugee Oral Health; NHANES III, Third National Health and Nutrition Examination Survey; CI, confidence interval; OR, odds ratio.

Unmet dental needs are the single most frequently reported health need of children.<sup>1,2</sup> Pediatricians and family physicians are a critical component in oral health as they are often the first to see these children. In fact, in a national survey of pediatricians, 90% responded that they had an important role in identifying dental problems and counseling families on the prevention of dental caries.<sup>3</sup> Because refugee children may be more likely to establish primary medical care before seeking dental care, it is important for pediatricians and family physicians to be aware of the oral health needs of refugee children.

In 2002, the United Nations estimated that there were >12 million refugees worldwide.<sup>4</sup> They have been defined as people who are outside their native country and cannot return because of a well-founded fear of persecution because of race, religion, nationality, political opinion, or membership in a particular social group.<sup>4</sup> Refugees present with a wide range of unique health care needs, reflecting conditions in their native countries, time in migration, and experiences in refugee camps. Refugees' countries of origin reflect current world political conditions. Although during the past 3 decades refugees who entered the United States were primarily from the former Soviet Union and Southeast Asia, more recently there have been increasing numbers from Eastern Europe, Africa, the Middle East, and Central Asia.<sup>5</sup>

Many refugees originate from areas where disease control, diagnosis, and treatment are lacking and war or civil unrest has disrupted the function of health care systems. For example, refugee children frequently experience malnutrition, anemia, and poor growth<sup>6</sup> and are also at an increased risk for certain conditions, such as hepatitis, intestinal parasitoses, latent tuberculosis infection, and dental problems.<sup>7-10</sup> Vastly different health care beliefs, as well as cultural and linguistic barriers, contribute to their difficulties in gaining access to health care services in the United States.

Several studies have noted a high prevalence of dental disease and unmet dental care needs in refugees. Chilean and Polish refugees in Sweden have been shown to have poorer oral health status compared with corresponding Swedish population groups.<sup>11</sup> Similarly, refugee children in Holland were found to have inferior oral health status compared with Dutch children, with 85% of refugee children having a history of dental caries.<sup>12</sup> In 1986, the World Health Organization documented high levels of dental caries in the former Yugoslavia when compared with other Europeans.<sup>13</sup> Because of war and deteriorating socioeconomic conditions, the previously poor state of oral health in the former Yugoslavia has subsequently worsened.<sup>14</sup> In 1996, a study of adult refugees and immigrants in Italy also found a greater burden of dental problems, with higher caries prevalence, poorer oral hygiene, and greater unmet dental needs being particularly high among Yugoslav refugees.<sup>15</sup>

In the United States, an assessment conducted in San Francisco in the late 1980s of recently arrived

refugee and immigrant school children from Asia, Central America, and the Philippines found that 77% of the refugee and immigrant children needed dental treatment, as compared with 25% of comparably aged US children. In addition, refugee children, as compared with immigrant children, had more caries in their permanent teeth but fewer caries in their primary teeth and fewer serious dental conditions.<sup>16</sup>

In contrast, a study in Israel of refugees from rural areas of Ethiopia noted relatively low rates of dental caries in refugee children, with only 13.2% of 5- to 6-year-olds and 18.2% of 12-year-olds exhibiting dental caries.<sup>17</sup> It is interesting that none of these Ethiopian children had ever been to the dentist before emigration to Israel. All foods consumed by these Ethiopian refugees in their native culture were homemade without the use of refined sugar, which is typical of many parts of Africa. Throughout East Africa, dental caries prevalence is low compared with developed countries, with a lower prevalence in rural versus urban areas.<sup>18</sup> In addition, differences have been noted in caries prevalence between high and low socioeconomic groups, with the prevalence and severity of dental caries generally higher among privileged Africans who reside in urban centers, where sugar consumption is limited to those of a higher socioeconomic status and considered a luxury. In contrast to the indigenous African rural diet that is low in refined sugar, refugees are often exposed to dietary changes that may include increased quantities of refined sugar. Such dietary changes may be compounded by disrupted family eating patterns within refugee camps, with these new disrupted patterns persisting as refugees resettle in a new country.<sup>18</sup>

All newly arrived refugees in the United States are entitled to a comprehensive health assessment on arrival through the Federal Refugee Act of 1980 (45CFR§400.107). In Massachusetts, the medical screening of newly arriving refugees was consolidated in 1995 as the Refugee Health Assessment Program under the auspices of the Massachusetts Department of Public Health. The program is contracted to a limited network of clinical sites around the state. An earlier report by the program's medical providers noted that 63% of newly arrived refugee children in Massachusetts had significant oral health problems, which were the most prevalent health problems among these children.<sup>6</sup> As a result, oral health assessments by a dental hygienist were incorporated into the Refugee Health Assessment Program with the establishment of the Program for Refugee Oral Health (PROH). PROH was first implemented at the International Clinic of Boston Medical Center, the largest clinical site in the state. This report presents data collected in 2001-2002 from a cohort of refugee children, stratified by their region of origin. Comparable oral health data from children who live in the United States was obtained from the Third National Health and Nutrition Examination Survey (NHANES III). The results of these analyses provide new information on the oral health status of diverse refugee populations.

## METHODS

### Refugee Data

Oral health assessments of newly arriving refugees were conducted as part of the Refugee Health Assessment Program starting in January 2001. This article reports findings from screenings completed by September 2002. The screenings of refugee children were performed within 90 days of arrival in the United States. A dental hygienist visually screened each refugee child by using a penlight and a disposable mirror. An intra-oral examination was performed on each child to detect the presence of any oral pathology. A parent and/or a child was interviewed about the last dental visit of the child and whether the child currently had oral pain. These interviews were conducted through hospital interpreters, when needed. Data were collected from a retrospective chart review of the medical records. Oral health findings and demographic information for each refugee child in the study were recorded. Demographic information included age, gender, race/ethnicity, and country of origin. The Institutional Review Board of the Boston University Medical Center approved and monitored the study.

The Basic Screening Survey of the Association of State and Territorial Dental Directors was the survey instrument used for information on caries experience, untreated caries, treatment urgency, and early childhood caries.<sup>19</sup> Caries experience is determined by the presence of an untreated caries lesion, a restoration (which presumably was once a caries lesion), or a permanent molar that is missing because it was extracted as a result of dental caries. Untreated caries is detected when the screener can readily observe the following criteria: (1) a loss of at least 0.5 mm of tooth structure at the enamel surface and (2) brown to dark-brown coloration of the walls of the cavity. Early childhood caries is defined as any child  $\leq 3$  years old with any 1 of his or her upper 6 primary anterior teeth decayed, filled, or missing as a result of caries. Treatment urgency code is an estimate of how soon the child should visit the dentist for clinical diagnosis and necessary dental treatment. Treatment urgency is classified into the following categories: (1) "urgent/emergency care" is defined as needing treatment within 24 hours for signs and symptoms including pain, infection, and swelling or soft-tissue ulceration of  $>2$  weeks' duration; (2) "early care" is defined as needing dental treatment that should be administered within several weeks for problems such as caries without signs or symptoms, spontaneous bleeding of the gums, or suspicious white or red soft-tissue lesions; and (3) "no obvious problem" indicates that the child can forgo dental examination and treatment until his or her next regular checkup.<sup>19</sup>

In addition to treatment urgency, the extent of dental caries was assessed and classified as follows: (1) no obvious caries; (2) 1 to 4 carious surfaces; (3) 5 to 9 carious surfaces; and (4)  $\geq 10$  carious surfaces. This caries assessment was adapted from an index used by the US Department of Labor's Job Corp.<sup>20</sup>

### NHANES III Database

Children with dental examinations from the NHANES III database were compared with the refugee children. A total of 11296 children between the ages of 2 years of age and 16.9 years of age were included in this comparison group. Information gathered from dental examinations was used to construct the following parameters for comparison with the refugee database: (1) treatment urgency, (2) caries experience, (3) untreated caries, (4) dental caries, (5) presence of dental pain, and (6) presence of oral pathology. Some parameters (treatment urgency, caries experience, untreated caries, and dental caries) were created from the dental information available from the NHANES III database. The NHANES III database involves complex, multistage sampling in which racial minorities were oversampled to obtain detailed information on these groups. To compensate for the complex nature of sampling, we used weighting in all comparisons involving NHANES III so that population-based estimates could be obtained.

NHANES III dental screenings were visual/tactile screenings, whereas the refugee screenings were a visual-only screening. On the basis of previous studies, these 2 methods are comparable in the detection of dental caries.<sup>21,22</sup>

## Statistical Analysis

The refugee children were categorized into 1 of 3 regions of origin: Africa, Eastern Europe, and other. Initial comparisons of demographic information (age group, race, and gender) and oral health parameters for these 3 refugee groups were made using  $\chi^2$  tests of independence. Initial comparisons of oral health parameters between the refugee children and US children as represented by NHANES III were conducted using a weighted  $\chi^2$  analysis to adjust for the complex sampling of NHANES III.

Multiple logistic regression models were constructed to test the difference in the prevalence of untreated caries and the prevalence of caries experience between refugee children and US children (NHANES III) while adjusting for confounding by age, gender, and race and effect modification by race. Weighting again was used to compensate for the complex sampling of NHANES III. Because only 8 refugee children had the racial classification of "other" and had a similar distribution of untreated caries and caries experience to white refugee children, they were grouped with white refugee children when fitting the multiple logistic regression models.

## RESULTS

The refugee study sample consisted of 224 refugee children between the ages of 6 months and 18 years with a mean age of 10.6 years (SD: 4.82; median: 10.7 years). There were 47.3% boys (106 of 224) and 52.7% (118 of 224) girls. Distribution by race revealed 38.8% (87 of 224) white, 57.6% (129 of 224) African, and 3.6% (8 of 224) other. African refugee children represented 53.6% (121 of 224) with the majority originating from Somalia (25.8%; 31 of 121), Liberia (21.7%; 26 of 121), and Sudan (18.3%; 22 of 121). Eastern European refugee children composed 26.8% (60 of 224) of the study sample and were primarily from Bosnia. The remaining 19.6% (44 of 224) of refugee children came from a number of countries, in particular, Afghanistan/Pakistan (39%; 17 of 44), the Middle East (18%; 8 of 44), and other countries (43%; 19 of 44). Refugee children were divided into 3 general regions: Africa, Eastern Europe, and other (Table 1).  $\chi^2$  tests of independence were conducted to test whether age, gender, and race varied by region of origin. No significant differences in the distribution of age ( $P = .222$ ) or gender ( $P = .366$ ) by region of origin were detected. As expected, the distribution of race did vary significantly according to region of origin ( $P < .001$ ), with refugees from Africa consisting primarily of blacks (95.9%; 116 of 121) and refugees from Eastern Europe consisting primarily of whites (96.6%; 57 of 59).

When possible, the parent or the child was interviewed about past dental visits and toothbrush use in his or her country of origin. Because of time constraints, data for these parameters were collected for a subset of the total sample (Table 2). Refugee children from Africa were the least likely ever to have been to a dentist (12.8%) and the least likely to have used a toothbrush in their home countries (10.2%).

Distribution of treatment urgency, caries experience, untreated caries, and dental caries varied significantly according to region of origin. For treatment urgency, 5% (6 of 121) of children from Africa were classified as needing urgent dental care compared with 32.2% (19 of 59) of children from Eastern Europe and 13.6% (6 of 44) of children from other areas. The highest proportion of children with no obvious dental problems was from Africa: 40.5% (49 of 121).

**TABLE 1.** Demographic Information by Region of Origin

Parameters	Africa	Eastern Europe	Other	P*
Age group				
<6 y	16.5% (20/121)	30.5% (18/59)	15.9% (7/44)	.222
6 to < 12 y	37.2% (45/121)	32.2% (19/59)	34.1% (15/44)	
≥12 y	46.3% (56/121)	37.3% (22/59)	50.0% (22/44)	
Gender				
Male	45.5% (55/121)	44.1% (26/59)	56.8% (25/44)	.366
Female	54.5% (66/121)	55.9% (33/59)	43.2% (19/44)	
Race				
White	4.1% (5/121)	96.6% (57/59)	56.8% (25/44)	<.001†
Black	95.9% (116/121)	3.4% (2/59)	25.0% (11/44)	
Other	—	—	18.2% (8/44)	

— indicates no data.

\* Based on  $\chi^2$  tests of independence.

† For testing, race was dichotomized into white and nonwhite.

**TABLE 2.** Oral Health Habits by Region of Origin

Parameters	Africa	Eastern Europe	Other	P*
Ever been to the dentist?				
No	87.2% (68/78)	46.2% (6/13)	73.3% (22/30)	.005
Yes	12.8% (10/78)	53.8% (7/13)	26.7% (8/30)	
Used toothbrush in home country?				
No	89.8% (53/59)	35.7% (5/14)	79.2% (19/24)	<.001
Yes	10.2% (6/59)	64.3% (9/14)	20.8% (5/24)	

\* Based on  $\chi^2$  tests of independence.

In contrast, 16.9% (10 of 59) of children from Eastern Europe and 34.1% (15 of 44) of children from other areas had no obvious dental problems. Overall, caries experience in the refugee children was 51.3%. Caries experience also varied by region of origin, with 38.0% (46 of 121) from Africa exhibiting a his-

tory of caries compared with 79.7% (47 of 59) of Eastern Europeans and 50% (22 of 244) of children from other areas (Table 3).

On the basis of  $\chi^2$  tests of independence, differences among the 3 refugee groups were noted for caries experience, untreated caries, and dental caries.

**TABLE 3.** Distribution of Oral Health Parameters by Region of Origin

Parameter	Africa	Eastern Europe	Other	P*
Treatment urgency				
No obvious problem	40.5% (49/121)	16.9% (10/59)	34.1% (15/44)	<.001
Early dental care	54.5% (66/121)	50.8% (30/59)	52.3% (23/44)	
Urgent dental care	5.0% (6/121)	32.2% (19/59)	13.6% (6/44)	
Caries experience				
No caries experience	62.0% (75/121)	20.3% (12/59)	50.0% (22/44)	<.001
Caries experience	38.0% (46/121)	79.7% (47/59)	50.0% (22/44)	
Untreated caries				
No untreated caries	65.3% (79/121)	23.7% (14/59)	50.0% (22/44)	<.001
Untreated caries	34.7% (42/121)	76.3% (45/59)	50.0% (22/44)	
Dental caries				
No obvious caries	65.3% (79/121)	22.0% (13/59)	47.7% (21/44)	<.001
1-4 carious surfaces	15.7% (19/121)	13.6% (8/59)	15.9% (7/44)	
5-9 carious surfaces	14.9% (18/121)	25.4% (15/59)	25.0% (11/44)	
≥10 carious surfaces	4.1% (5/121)	39.0% (23/59)	11.4% (5/44)	
Oral pain present				
No pain	89.3% (108/121)	84.7% (50/59)	93.2% (41/44)	.390
Pain	10.7% (13/121)	15.3% (9/59)	6.8% (3/44)	
Early childhood caries				
No	83.3% (10/12)	78.6% (11/14)	100% (6/6)	1.000†
Yes	16.7% (2/12)	21.4% (3/14)	—	
Oral pathology				
Normal	91.7% (110/120)	82.8% (48/58)	90.9% (40/44)	.205
Abnormal	8.3% (10/120)	17.2% (10/58)	9.1% (4/44)	
Gingival bleeding				
No	79.5% (93/117)	80.0% (40/50)	95.2% (40/42)	.057
Yes	20.5% (24/117)	20.0% (10/50)	4.8% (2/42)	
Calculus				
No	49.1% (57/116)	40.0% (20/50)	54.8% (23/42)	.348
Yes	50.9% (59/116)	60.0% (30/50)	45.2% (19/42)	

— indicates no data.

\* Based on  $\chi^2$  tests of independence.

† Based on Fisher's exact test comparing Africa and Eastern Europe only.

Refugee children from Africa had the fewest dental needs; children from Eastern Europe had the greatest. Of particular note, 65.2% of African children had no visible evidence of dental caries, whereas only 22.0% of children from Eastern Europe had no evidence of dental caries. No significant differences among the 3 refugee groups were detected for oral pain, presence of early childhood caries, or oral pathology.

In comparisons between refugee children and US children, significant differences were found between the refugee children and the US children (NHANES III) for treatment urgency ( $P < .001$ ), untreated caries ( $P < .001$ ), extent of dental caries ( $P < .001$ ), and presence of oral pain ( $P < .001$ ). In terms of dental treatment urgency, 77.7% of US children exhibited "no obvious problem" compared with only 33.0% of refugee children. Similarly, 77.2% of US children had no untreated caries, whereas only 51.3% of refugee children had no untreated caries (Table 4).

### Multivariate Analysis

The prevalence of untreated caries differed significantly between refugee children and US children. These differences varied significantly by race. When adjusted for age and gender, white/other refugee children were 9.4 times as likely to have untreated caries compared with white US children (95% confidence interval [CI]: 6.1–14.7), 5.4 times as likely compared with African American children (95% CI: 3.4–8.4), and 4.4 times as likely compared with other US children (95% CI: 2.7–7.0). In contrast, African refugee children were only twice as likely to have untreated caries compared with white US children (95% CI: 1.4–3.0) and not significantly different from Af-

rican American children (odds ratio [OR]: 1.16; 95% CI: 0.8–1.7) or other US children (OR: 0.94; 95% CI: 0.6–1.4; Table 5).

White/other refugee children were 4.6 times as likely to exhibit untreated caries compared with African refugee children (95% CI: 2.6–8.2). Children 6 to <12 years of age were 1.6 times as likely to have untreated caries compared with children <6 years of age. However, children  $\geq 12$  years old were not significantly more likely to have untreated caries compared with children <6 years old. Untreated caries did not vary significantly by gender.

As to caries experience, white/other refugee children were 2.8 times as likely to have caries experience compared with white US children (95% CI: 1.8–4.5) and compared with African American children (95% CI: 1.7–4.5). White/other refugee children were not significantly more likely to have caries experience compared with other US children (OR: 1.5; 95% CI: 0.9–2.5). In contrast, African refugee children were only half as likely to have caries experience compared with white US children (95% CI: 0.3–0.7) and African American children (95% CI: 0.3–0.7). African refugee children were only one quarter as likely to have caries experience compared with other US children (95% CI: 0.18–0.40).

White/other refugee children were 5.7 times as likely to have caries experience compared with African refugee children (95% CI: 3.2–10.3). As would be expected, the prevalence of caries experience increased significantly with age. Children between 6 and 12 years of age were 3.9 times as likely to have caries experience compared with children <6 years of age, and children  $\geq 12$  years old were 5.1 times as likely to have caries experience compared with chil-

**TABLE 4.** Distribution of Oral Health Parameters for Refugee Children and Children From NHANES III Database

	NHANES III	Refugee	<i>P</i> *
Treatment urgency			
No obvious problem	77.7% (8781/11296)	33.0% (74/224)	<.001
Early dental care	19.1% (2163/11296)	53.1% (119/224)	
Urgent dental care	3.1% (352/11296)	13.8% (31/224)	
Caries experience			
No caries experience	50.7% (5725/11297)	48.7% (109/224)	.550
Caries experience	49.3% (5572/11297)	51.3% (115/224)	
Untreated caries			
No untreated caries	77.2% (8724/11296)	51.3% (115/224)	<.001
Untreated caries	22.8% (2572/11296)	48.7% (109/224)	
Dental caries			
No obvious caries	77.2% (8724/11296)	51.3% (115/224)	<.001
1–4 carious surfaces	15.6% (1761/11296)	14.7% (33/224)	
5–9 carious surfaces	4.1% (459/11296)	19.6% (44/224)	
$\geq 10$ carious surfaces	3.1% (352/11296)	14.3% (32/224)	
Oral pain present			
No pain	98.8% (11166/11296)	88.8% (199/224)	<.001
Pain	1.2% (130/11296)	11.2% (25/224)	
Oral pathology			
Normal	90.4% (10209/11296)	89.2% (199/223)	.568
Abnormal	9.6% (1087/11296)	10.8% (24/223)	
Gingival bleeding†			
No	35.5% (988/2784)	69.6% (64/92)	<.001
Yes	64.5% (1796/2784)	30.4% (28/92)	
Calculus†			
No	50.9% (1333/2620)	22.6% (21/93)	<.001
Yes	49.1% (1287/2620)	77.4% (72/93)	

\* Based on weighted  $\chi^2$  tests of independence.

† Restricted to children  $\geq 12$  years old, because NHANES III database included gingival information only for children  $\geq 12$  years old.

**TABLE 5.** Multiple Logistic Regression Models for Predicting Untreated Caries and Caries Experience

Parameter	Untreated Caries		Caries Experience	
	OR	95% CI	OR	95% CI
Group and race				
NHANES III				
White	1.00		1.00	
Black	1.76	(1.57–1.97)	1.00	(0.90–1.11)
Other	2.17	(1.82–2.58)	1.83	(1.54–2.18)
Refugees				
White/other	9.43	(6.06–14.7)	2.79	(1.75–4.46)
Black	2.03	(1.40–2.95)	0.49	(0.34–0.71)
Age group				
<6 y	1.00		1.00	
6 to <12 y	1.61	(1.44–1.80)	3.88	(3.51–4.29)
≥12 y	1.01	(0.90–1.14)	5.05	(4.55–5.61)
Gender				
Female	1.00		1.00	
Male	0.94	(0.86–1.03)	0.91	(0.84–0.98)

dren <6 years of age. As to gender, boys were only 91% as likely to have caries experience compared with girls (95% CI: 0.84–0.98).

### DISCUSSION

African refugee children had significantly lower dental caries experience as well as fewer untreated caries, as compared with similarly aged Eastern European refugee children. They also were less likely ever to have been to a dentist. Possible reasons for these findings include differences in exposure to natural fluoride in drinking water, dietary differences, access to professional care, and cultural beliefs and practices.

When refugee children were compared with US children, while taking race into account, the African refugee children had only half the caries experience of either white or African American children. African refugee children had similar likelihood of having untreated dental caries as compared with African American children, despite that very few African refugee children had previous access to professional dental care. Our results are in agreement with the low rates of dental caries observed in Ethiopian refugee children in Israel without previous access to a dentist,<sup>17</sup> as well as with the generally lower caries prevalence in many parts of Africa.<sup>18</sup>

In contrast, children from Eastern Europe were almost 3 times as likely to have caries experience compared with US children and were 9.4 times as likely to have untreated caries as white US children. In addition, Eastern European children were 5.6 times more likely to have caries experience and 4.7 times more likely to have untreated caries compared with African refugee children, despite generally greater access to dentists than was found among African refugees. This high rate of dental caries among Eastern European refugee children confirms previous studies that noted high caries prevalence among refugees from the former Yugoslavia in Italy<sup>15</sup> and a poorer state of oral health<sup>13</sup> that subsequently worsened as a result of war.<sup>14</sup>

Differing levels of fluoride in the drinking water supply may contribute to the differences in the caries experience between African and Eastern European

refugee children. It has been well documented that fluoride at an optimal range of 0.7 to 1.2 ppm reduces dental caries; however, it does not eliminate risk of the disease.<sup>23</sup> In 2001, Project Hope Bosnia conducted water sampling for fluoride content in parts of the former Yugoslavia. Unpublished data from Project Hope indicated that in a number of districts of Sarajevo and adjacent areas, fluoride levels were below 0.3 ppm (I. L. Dogon, LDS, RCS, DMD, written communication, May 12, 2003). In contrast, many Eastern African countries have naturally occurring optimal levels of fluoride in drinking water with some areas actually having very high fluoride levels.<sup>24,25</sup>

However, a more likely explanation for the differences in caries prevalence is the variations in diet. In particular, refined sugars are the most important dietary factor in the development of dental caries.<sup>26</sup> The relationship between dental caries and refined sugar consumption has been well documented, in both developed and developing countries. In the latter, as socioeconomic levels rise, so does the amount of sugar in the diet, typically with corresponding increases in dental caries.<sup>27</sup> Annual per capita sugar consumption exceeding 15 kg has been associated with increased prevalence of dental caries.<sup>27</sup> The African countries from which the refugee children in this study originated have annual per capita sugar consumptions ranging from 3.1 kg in Liberia to 14.6 in Sudan and 17.8 in Somalia. In contrast, Bosnia, the primary origin of Eastern European refugee children in this study, had an annual per capita sugar consumption of 24.9 kg.<sup>27</sup> In the United States, per capita sugar consumption is among the highest at 32.6 kg. Detailed nutritional data on the refugees were not obtained in this study; therefore, we are not able to address directly the role of diet in explaining the variation in caries prevalence. Nevertheless, our findings clearly justify the need to collect such nutritional data prospectively to better understand caries risk factors in refugee children and their families.

Culture plays an important role in determining oral health status, primarily through the effects on oral hygiene practices, dietary patterns, and access and utilization of professional dental care services. In particular, refugees face important cultural as well as

socioeconomic barriers to gaining access to care.<sup>28</sup> Between 1980 and 2002, almost 2 million refugees were permanently resettled in the United States.<sup>5</sup> With the large number of refugees continuing to be resettled in the United States, health professionals will be increasingly called on to understand refugees' past experiences regarding health care and their cultural concepts of disease to deliver effective care. For example, traditional oral hygiene practices vary widely in different parts of the world. Chewing sticks are a common practice in many parts of Africa, the Middle East, and Asia. When properly used, chewing sticks are effective in removing plaque.<sup>29</sup> A recent report suggested that "miswak" chewing sticks may have an inhibitory effect on the levels of oral streptococci and, thus, lower the risk of dental caries.<sup>30</sup> Such a finding could be particularly noteworthy, as many refugees prefer using chewing sticks as part of their daily oral hygiene regimen rather than adopting the use of a toothbrush.

Primary care physicians can play a crucial role in educating newly arrived refugees about personal oral hygiene practices, the role of fluoride, and use of preventive oral health services. In addition, these physicians can often facilitate referrals to dental services for the initiation of care. Although some refugee groups may actually have lower rates of caries than the US population, they will often have other needs and issues. For example, many Sudanese refugees have had ritual extraction of incisors and canines and as a consequence of the resulting tongue thrusting have significant problems with speech articulation, malocclusion, and simple biting and chewing. Also, the process of acculturation may lead to adoption of deleterious habits such as a diet with a high content of refined sugar. In contrast, refugees such as those from Eastern Europe may have urgent oral pathology, including severe caries, that require early and ongoing dental intervention coupled with education about hygiene and personal practices.

Health education and community outreach efforts are important elements of successful refugee resettlement programs. The infusion of targeted information on appropriate oral health practices and the facilitation of access to dental care services can benefit existing programs. One key component could focus on counseling refugees about nutrition, changing dietary patterns, and the increased susceptibility to dental caries as the result of increased sugar consumption. The introduction of new oral hygiene practices for preventing dental caries and periodontal disease could be coordinated into other health education efforts aimed at enhancing various preventive self-care health behaviors. Last, information about the value of regular professional dental care services in children could be integrated into related health promotion efforts, such as vaccination programs and well-child care visits.

The PROH, in collaboration with the Massachusetts Department of Public Health's Refugee and Immigrant Health Program, has provided a critical link between oral health care and the refugee community. In particular, through community outreach educators, oral health has been incorporated into home

visits and other community outreach activities throughout Massachusetts. Oral health assessments of newly arrived refugee are an essential component of all refugees' health assessments. PROH has effectively integrated oral health into existing medical care settings to enhance an interdisciplinary approach to providing client services and patient care. In particular, the oral examination method that we have used (Basic Screening Survey) is based on a simple, visual intra-oral assessment that can be implemented by nondental professionals (eg, nurses and physicians).

One important limitation of this study is that it assessed the oral health status of refugee children at only 1 point in time, shortly after their arrival in the United States. As discussed earlier, it is plausible that the refugees' dietary patterns and increased exposure to refined sugars in the United States may result in increased caries risk. Ideally, these children should be monitored prospectively to assess changing nutritional patterns and health behaviors that may have an impact on caries incidence. Studies using data from the National Vital Statistics System and National Health Interview Survey revealed an increased risk of disability and chronic disease morbidity with an increasing length of residence in the United States.<sup>31</sup> By additional investigation of these refugees prospectively, we should be able to develop a more comprehensive understanding of their dental caries risk factors so that culturally appropriate prevention strategies can be established.

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## Dental Caries of Refugee Children Compared With US Children

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